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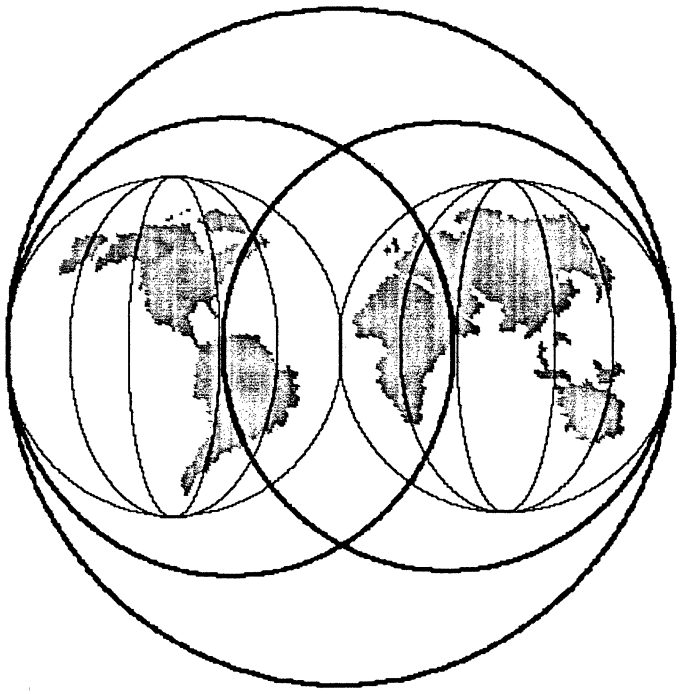

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This edition applies to Version 1 of Small Computer System Interface (SCSI).

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Abstract

This bulletin offers information on the Small Computer Systems Architecture (SCSI) and how IBM has implemented SCSI.

Technical details on new Personal Systems/2s to include SCSI as the standard DASD subsystem are discussed.

The contents of this document is designed as reference material for IBM customers and system engineers as a reference to SCSI.

PSYS (76 pages)

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Preface

The purpose of this document is to provide an overview of the Small Computer Systems Architecture (SCSI). It contains details on SCSI from an architectural point of view and continues by explaining how IBM has implemented SCSI in the Personal System/2 range.

It also covers the new additions to the Personal System/2 range. These are the Model 8565 (061 and 121) and the Model 8580 (A21/31 and 121/321).

Audience

The intended readers of this document are IBM system engineers and IBM customers who have a need to understand what SCSI is and how IBM has implemented it. The document has been written to give both a basic and in depth understanding depending on the particular reader. The reader should be familiar with basic computer hardware concepts.

Structure

This document is divided into the following major sections:

- Chapter 1.0, "What is SCSI" on page 1 describes SCSI from an architectural point of view. It describes the various functions and features that SCSI provides and how they all work together.
- Chapter 2.0, "IBM Implementation of SCSI" on page 17 describes the IBM SCSI adapter. A complete overview of the IBM SCSI implementation is given covering specifications, installation and operating system support.
- Chapter 3.0, "IBM Micro Channel SCSI Adapter with Cache" on page 31 describes the IBM 32-Bit SCSI Adapter with cache. All of the differences between this adapter and the 16-Bit SCSI adapter are highlighted.
- Chapter 4.0, "New IBM PS/2 8580 Systems" on page 33 covers the new additions to the PS/2 Model 80 range. The PS/2s covered are the 8580-A21, A31, 121 and 321.
- Chapter 5.0, "New IBM PS/2 8565 Systems" on page 41 covers the new PS/2 Model 8565. This is a new floor-standing PS/2 using the 80386SX processor.
- Appendix A, "SCSI Devices: Specifications and Installation" on page 49 covers the presently available IBM SCSI devices. Specifications and installation information is given.
- Appendix B, "IBM SCSI POST Error Codes" on page 61 gives information on the error codes that may occur in the IBM SCSI environment.

Publications

The following publications are considered particularly suitable for a more detailed discussion of the topics covered in this document.

SCSI Adapter Technical Reference Manual

IBM CD-ROM Technical Reference Manual

IBM 320Mb Fixed Disk Drive Technical Reference Manual

IBM 120Mb Fixed Disk Drive Technical Reference Manual

IBM 60Mb Fixed Disk Drive Technical Reference Manual

IBM 8565 BIOS Interface Technical Reference Manual Update

IBM 8580 BIOS Interface Technical Reference Manual Update

Related Publications

IBM Hardware Interface Technical Reference Manual

IBM BIOS Interface Technical Reference Manual

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1.0 What is SCSI

This chapter explains the Small Computer Systems Interface (SCSI), what it is capable of and how it compares to the current interfaces on the market.

1.1 SCSI - A Brief Overview

SCSI (usually pronounced "Scuzzy") stands for Small Computer Systems Interface. It is fully documented in ANSI standard X3.131-1986.

SCSI is a standard interface bus through which computers may communicate with attached intelligent peripheral devices such as fixed disks, CD-ROMs, printers, plotters, scanners, etc.

With SCSI, a large number of devices of different types can be connected to the system unit via a single SCSI bus cable and a SCSI attachment feature. This SCSI attachment feature may be in the form of an adapter or an integrated unit on the planar board. The SCSI interface is also device independent, allowing the user to attach intelligent devices of any form that adhere to the SCSI standard. Overall SCSI means less cabling and saves valuable attachment space in the personal computer by having one SCSI attachment feature to support multiple devices.

Up to a maximum of seven devices can be directly attached to the SCSI bus cable and each of these devices can support up to eight more. This means that it is possible for one SCSI attachment feature to support up to 56 devices. This gives the user the benefit of an extremely flexible method of attaching peripheral devices to his system unit.

Other features of SCSI, such as arbitration and disconnect/reconnect, allow several devices to be operating concurrently and to efficiently share the SCSI bus. This is an obvious benefit in a multitasking environment.

With the SCSI interface, high data transfer rates allow enhanced performance over current, non-SCSI systems. Despite these higher rates, the maximum distance between SCSI attachment feature and device, has been greatly increased to 6 meters. This gives the user much more flexibility when they come to positioning their system unit and devices.

1.2 What Type of Interface is SCSI

A normal personal computer setup for SCSI consists of a SCSI attachment feature and one cable connecting it to multiple intelligent devices. Both the SCSI attachment feature and the attached devices must conform to the SCSI ANSI standard X3.131-1986. The SCSI interface is the "means of communication" between the SCSI attachment feature and the attached intelligent devices.

There are two main types of interfaces for attaching devices. These are device level interfaces and bus level interfaces.

1.2.1 Device Level Interface

With a device level interface such as ESDI or ST-506 for fixed disks, the controlling circuitry is held on a separate adapter away from the physical drive. This means that the formatting, head select, error detection etc. is done on the adapter and NOT on the device itself, in this case a fixed disk. All the device does is the actual mechanical operation of reading and writing the data. Figure 1 shows a device level interface.

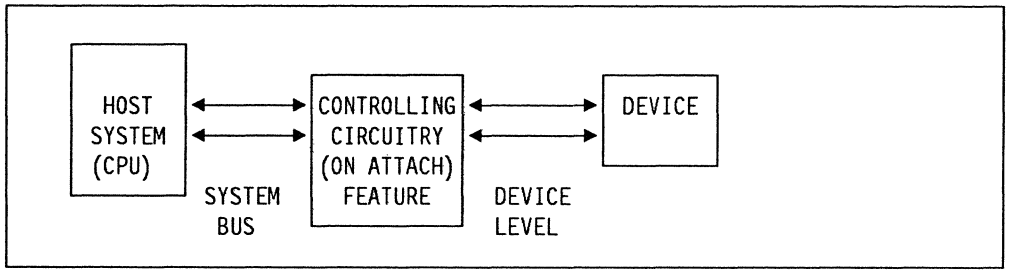

Figure 1. Device Level Interface

This makes it very hard to create new devices as what the device can do is determined by what the controller will allow it to do. Plus, the type of device that you can attach to one controller is limited. This is because it would be impossible for one controller to hold all of the circuitry to control CD-ROMS, fixed disks etc. This means that in order to attach multiple devices you will need multiple adapters, which is both expensive and takes up valuable attachment space on a personal computer.

1.2.2 Bus Level Interface

With a bus level interface, the controlling circuitry is built into the devices own electronics. This means that the drive itself has most of the intelligence for formatting, error detection etc.

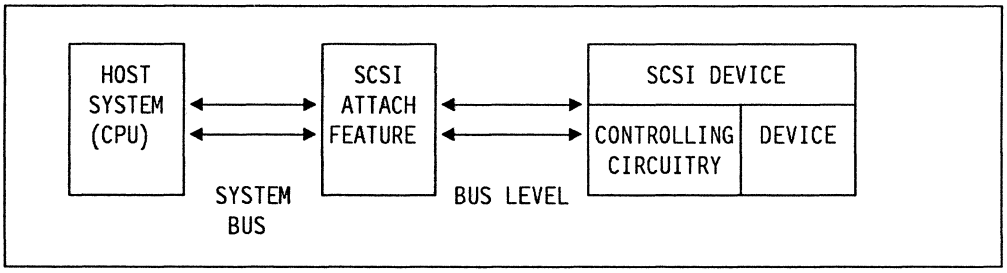

Figure 2. A Bus Level Interface

SCSI is a bus level interface. It describes the interface between a SCSI attachment feature and an attached intelligent device. This gives device independence and allows devices of any nature to be attached to one attachment feature. As SCSI is also a defined ANSI standard, it minimizes the integration problems often found on today's non-SCSI systems.

There are various other advantages that are covered later in section 1.9, "SCSI versus ESDI" on page 12.

1.3 SCSI "Overall" Configuration

The basic SCSI configuration is as follows.

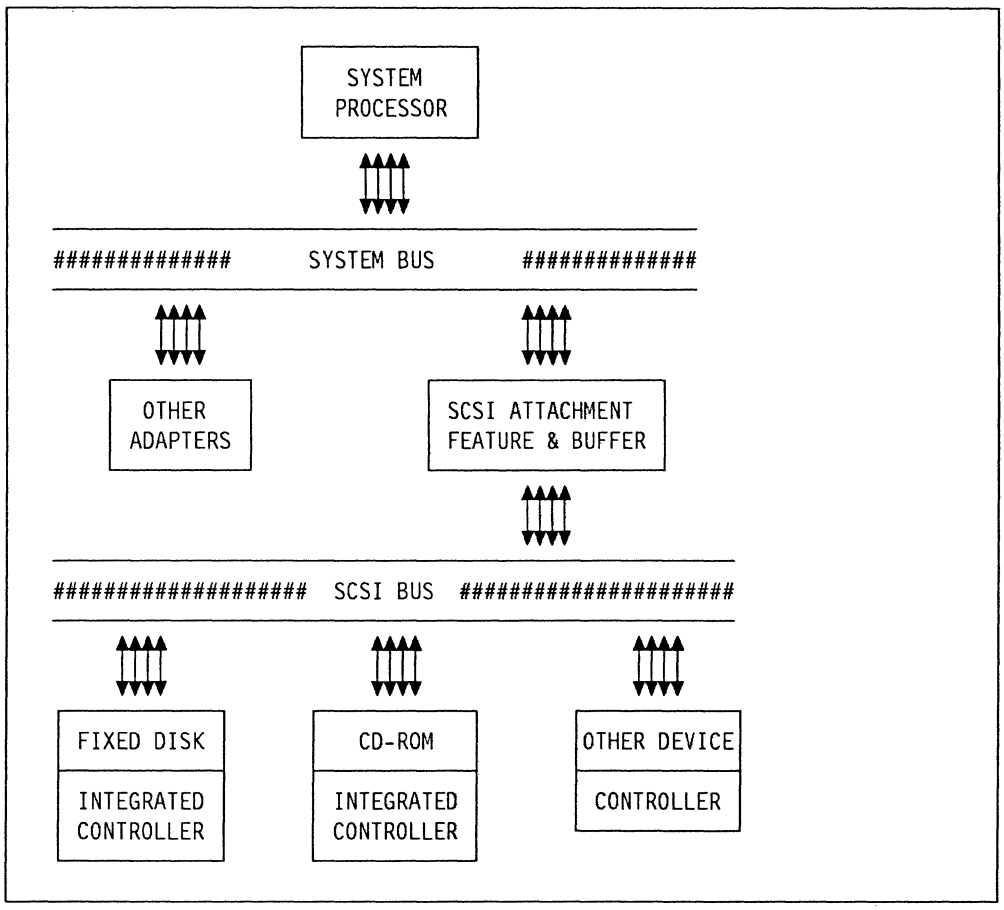

Figure 3. SCSI Overall Configuration

A SCSI attachment feature is connected to the system bus.

Attached to the SCSI attachment feature are multiple intelligent peripheral devices such as fixed disks, CD-ROMs, printers etc. They are connected via a single 50-conductor cable commonly known as the "SCSI bus". This SCSI bus is an 8-bit parallel bus monitored by logic on the SCSI attachment feature.

Each of the devices attached to the SCSI bus and the SCSI attachment feature itself conform to the ANSI standard X3.131-1986. This ANSI standard specifies the mechanical, electrical and functional requirements and the command sets used by devices in the SCSI setup.

1.4 SCSI Physical Configuration

The physical configuration of SCSI includes at least one SCSI attachment feature, a 50-conductor connecting cable (the "SCSI bus") and one or more SCSI devices up to the maxima defined in Figure 4 on page 4.

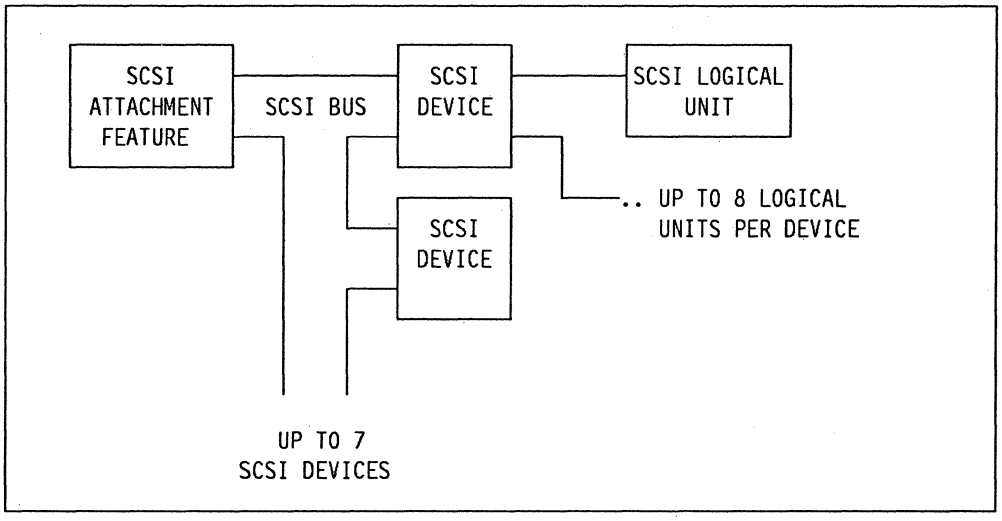

Figure 4. SCSI Physical Configuration

1.4.1 The 50-conductor Cable or "SCSI Bus"

In Figure 4 the SCSI bus is the 50-conductor cable. This cable consists of a set of eight data lines, a data parity line and various control lines. All of the signals carried on this cable are defined in the SCSI ANSI specifications. In all SCSI configurations this bus must be terminated at both ends. In the case where there is an internal and an external bus, logically it is all seen as one long bus and so termination points will only be at the end of the internal bus and the end of the external bus.

The 50-conductor cable itself daisy-chains the various devices. This means that each device has a cable going into and coming out of it (plus a power cable), apart from the last device in the chain which has the incoming cable plus a terminator at the outgoing connector.

The maximum length supported for the SCSI bus is six meters. This means that the distance between the SCSI attachment feature and the last SCSI device on the SCSI bus can be no longer than six meters. This is because most SCSI attachment features on personal computers support a "single-ended" bus, which uses a voltage line that changes between 0-5 volts. With such a small range of change, six meters is the longest distance before the bus may be affected by noise.

You may hear of SCSI attachment features that support a "differential" bus. These can have much longer buses (up to 25 meters) because they use a much wider voltage change range (above or below 0 volts). They are however much more expensive and not common in the personal computer arena.

1.4.2 SCSI Devices - Configuration

Each of the devices directly attached to the SCSI bus is known as a SCSI device. Each one has an ID number which is unique on its bus and is called the SCSI ID. This is set via hardware switches or jumpers located on the SCSI device. The SCSI attachment feature itself also has a SCSI ID number (section 1.5.1, "SCSI Device Addressing" on page 5 describes the function of these ID numbers).

Each SCSI attachment feature supports up to seven SCSI devices. In addition, each SCSI device can support up to eight logical units. This means that each SCSI attachment feature can support up to 56 devices (see section 1.5.2, "Logical Unit Numbers (LUNs)" on page 6 which describes LUNs).

1.5 SCSI Logical Configuration

The following sections describe the internal workings of SCSI, including it addresses the various SCSI devices, command signals and other features of the interface.

1.5.1 SCSI Device Addressing

Each device attached directly to the SCSI bus is known as a SCSI device. It is assigned a SCSI ID number from 0 to 7. This ID has two main uses:

1. Allows devices to be selected.

   With each SCSI device and the SCSI attachment feature being assigned a unique ID it is impossible for a device to receive commands that are really meant for another device. It enables, for example, the SCSI attachment feature to talk easily to any SCSI device attached to the SCSI bus.

2. Sets the priority of the device during arbitration.

   As there are many devices wishing to use the SCSI bus, a scheme has to be used to work out who can use the bus at any one time. This is called arbitration and will be covered in section 1.5.5, "SCSI Bus Arbitration" on page 7. The SCSI ID determines the priority of the device during arbitration. Usually the SCSI attachment feature is given the highest priority ID of 7.

NOTE : The SCSI attachment feature is usually assigned a SCSI ID of 7.

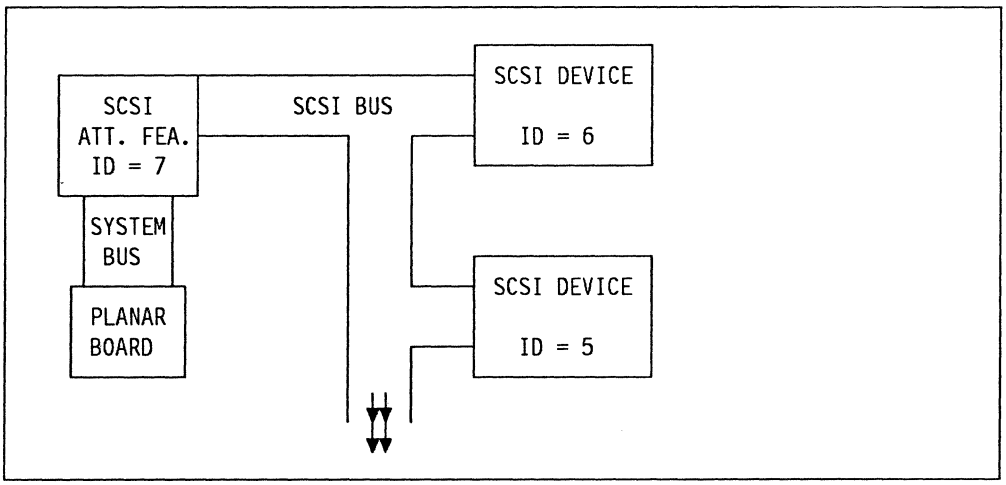

Figure 5. SCSI Device Addressing

The ID number of a particular SCSI device is set during configuration of the particular device. As we saw in 1.4.2, "SCSI Devices - Configuration" on page 4 this is set by hardware switches on the device.

1.5.2 Logical Unit Numbers (LUNs)

The SCSI attachment feature may allow each SCSI device to have attached up to eight logical units. These logical units are controlled by a SCSI device. The logical units are NOT attached directly to the SCSI bus. Instead they are attached to a SCSI device.

Figure 6 serves as an example.

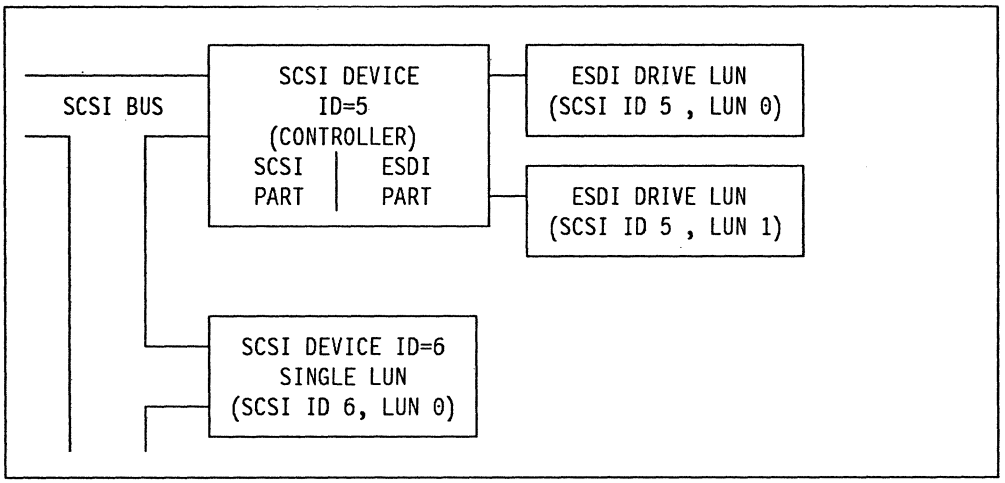

Figure 6. SCSI Logical Units

SCSI device 5 in Figure 6 is a SCSI to ESDI controller. This means that the controller would be attached to the SCSI bus as a SCSI device and then the ESDI part of the controller would attach to up to eight ESDI drives. None of these ESDI drives would be attached directly to the SCSI bus. They would be attached to the SCSI device. Therefore they would NOT be SCSI devices, they would be LUNs.

It is easiest to think of the controllers as the SCSI device (or the controlling circuitry as the SCSI device) and the device itself (that is, a disk actuator, as the logical unit. In order for any device to be accessed you will need a pair of addresses: a SCSI device number and a logical unit number.

As an example, here is how a SCSI attachment feature would send a command across the SCSI bus to the second ESDI drive.

1. The SCSI attachment feature selects a SCSI device. In this example it selects SCSI device 5.
2. The SCSI attachment feature then sends a command to SCSI devices.
3. The command contains a 3-bit field, which indicates a logical unit number. In this case the 3-bit field would contain the number 1.
4. When SCSI device 5 receives the command it reads the 3-bit field and passes on the command instructions to the logical unit number specified. In this example it would be logical unit number 1.

In the case of a single integrated unit where it is impossible to distinguish between controller circuitry and device circuitry, this form of addressing still applies. It is the same even though it does not support any extra LUNs. For

example a write command for SCSI device 6 in Figure 6 would be sent to SCSI device 6, LUN 0.

NOTE : The LUNs defined here bear no relationship to LUNS referred to in a Systems Network Architecture[1] communications environment.

1.5.3 Initiators and Targets

When two SCSI devices talk to each other on the SCSI bus, one sends out a command and one acts upon it. The SCSI device that sends out the commands is called an *initiator*. The SCSI device that processes the command is called the *target*.

1.5.4 Device-Level Copying

With SCSI, it is possible to have more than one initiator attached to the SCSI bus. This means that two devices can talk to each other on the SCSI bus without the SCSI attachment feature doing the data transfer.

For example, assume you have a SCSI device such as a tape drive, that is capable of being an initiator and a target. The SCSI attachment feature could send the tape drive a command to copy information from the tape to a fixed disk also attached to the SCSI bus (at this point the tape drive will be a target). Once it has read the data from the tape it than can become an initiator and send a write command to the fixed disk in order to write the tape data to the fixed disk. This is all done *without* further involvement of the SCSI attachment feature.

1.5.5 SCSI Bus Arbitration

SCSI, because of the nature of its design, specifies a scheme for bus arbitration. Bus arbitration is required where multiple devices attached to a bus (in this case the SCSI bus) can bid to gain control of the bus and perform their data transfer.

On the SCSI bus, arbitration is controlled by logic on the SCSI attachment feature. Arbitration on the SCSI bus can be initiated by any SCSI device on the bus provided that it has this capability built in.

Arbitration works as follows: The SCSI device that wants to use the SCSI bus puts its SCSI ID number onto the bus. It checks to see if there is a device with a higher SCSI ID bidding for the bus. If there is no SCSI ID higher, the SCSI device gains control of the bus. If a higher SCSI ID was on the SCSI bus, then the other SCSI device would gain control of the SCSI bus.

More information on arbitration can be found in section Figure 9 on page 10.

1.5.6 Disconnect/Reconnect and Overlapped Command Processing

As soon as a target has received a command, it can disconnect from the bus. This means that an initiator is free to send commands to another target while the previous target is still processing the commands it received before.

Figure 7 on page 8 below shows the various stages in a common disconnect and reconnect cycle.

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[1] Systems Network Architecture is a trade mark of the International Business Machines Corporation.

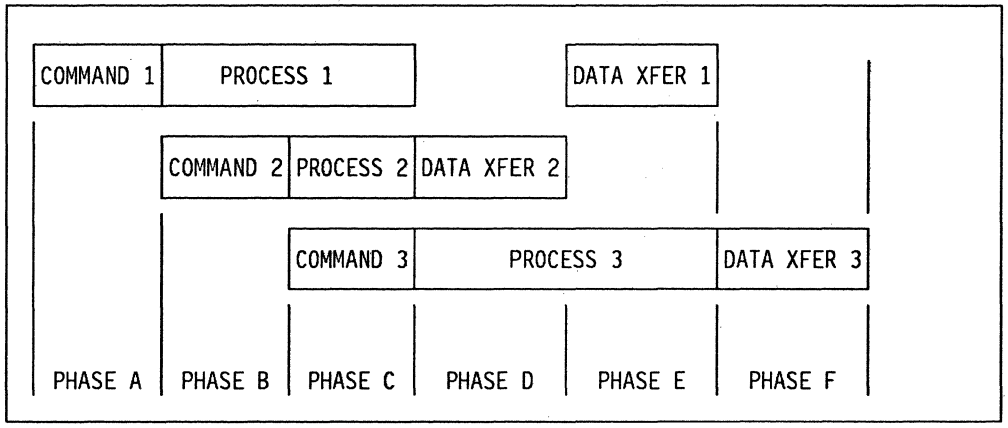


Figure 7. Overlapped Command Processing on the SCSI Bus

PHASE A: The SCSI attachment feature sends a command to SCSI device 1. After device 1 has received the command, device 1 disconnects from the SCSI bus.

PHASE B: The SCSI attachment feature now sends a command to SCSI device 2. After device 2 has received the command device 2 disconnects from the SCSI bus. At the same time SCSI device 1 is still processing its command.

PHASE C: The SCSI attachment feature now sends a command to SCSI device 3. After device 3 has received the command device 3 disconnects from the SCSI bus. At the same time SCSI devices 1 and 2 are still processing their commands.

PHASE D: SCSI devices 1 and 2 both finish their processing and arbitrate for the SCSI bus, in order to reconnect to it and perform a data transfer. SCSI device 2 wins as it has the higher ID number and device 2 performs its data transfer. SCSI device 3 is still processing its command.

PHASE E: SCSI device 1 now arbitrates for the bus and takes control in order to do its data transfer. SCSI device 3 is still processing its command.

PHASE F: SCSI device 3 now arbitrates for the bus, wins and performs its data transfer.

This processing of multiple commands at a time is known as overlapped command processing. Many SCSI attachment features only support overlapped command processing of a certain number of commands. For example the IBM SCSI attachment feature supports overlapped command processing for up to 15 logical units. This means that the maximum number of devices that can be processing commands at any one time is 15.

1.5.7 Synchronous and Asynchronous Data Transfer

There are two modes of data transfer supported across the SCSI interface. These are asynchronous and synchronous modes of data transfer.

- Asynchronous mode

  In this mode each byte of data sent between the initiator and the target must be requested and acknowledged. For example, an initiator cannot send another byte of data until the target acknowledges that it has received the

previous one. This series of "handshakes" makes this the slower of the two modes with maximum transfer rates across the SCSI bus of around 3MBps.

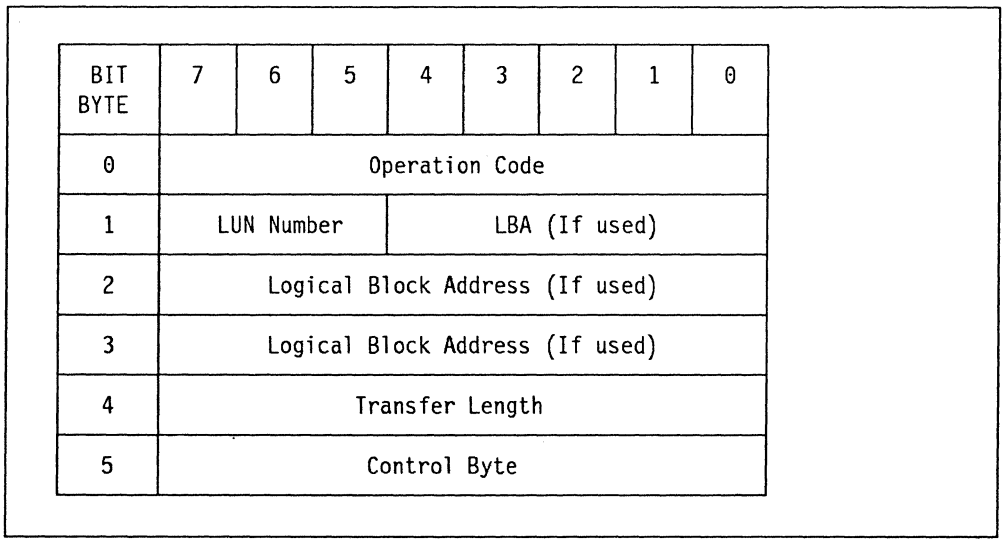
- Synchronous mode

  In this mode multiple bytes of data can be transferred before acknowledgments are received. For example, 512 bytes of data can be transferred and during these transfers acknowledgements are being received, but not at a regular interval, as with the asynchronous mode. At the end of the transfer, the number of acknowledgments received is counted and provided there are 512 of them the transfer is regarded as being successful. This mode is much faster and allows for data transfer speeds across the SCSI bus of up to 5Mbps.

  It is up to the initiator to check to see if the target is capable of doing synchronous transfers. Most of the SCSI attachment features do support synchronous transfers, but a lot of SCSI devices only support the asynchronous mode of data transfer.

1.6 Commands Sent Across the SCSI Bus

For a target to perform an operation, an initiator must successfully arbitrate for use of the bus, select the appropriate SCSI device and transfer the command to be executed. The command transferred across the SCSI bus is known as a SCSI Command. The format that it takes is that of a Command Descriptor Block. The diagram below shows a typical block layout.



BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	LUN Number			LBA (If used)				
2	Logical Block Address (If used)							
3	Logical Block Address (If used)							
4	Transfer Length							
5	Control Byte							

Figure 8. SCSI 6-Byte Command

Figure 8 shows the layout for a 6-byte SCSI command. The layout is also similar for 10-byte SCSI commands.

The 10-byte SCSI commands are known as extended commands. They are used when information being passed to the target will not fit in the normal 6-byte command block.

SCSI commands are precisely defined instructions in the SCSI ANSI standard. When SCSI was first defined there a large number of SCSI commands were defined. The number was considered too many for a common standard to be set

so a subset of them was used as a standard for direct access storage devices. This suite of commands is known as the SCSI common command set or CCS.

With the SCSI commands the user does not have to know how each of the different SCSI devices function internally. Knowledge of which SCSI commands the device understands is enough to be able to use the device at SCSI device level.

Many devices will support commands not included in the CCS and it is up to the individual to check that both the SCSI attachment feature and the target device support these extra commands.

1.7 How Does the SCSI Bus Work

The SCSI bus is similar to a personal computer bus capable of many different states. These states are known as phases and the SCSI bus is architected to include seven distinct phases. The SCSI bus can never be in more than one phase at any given time.

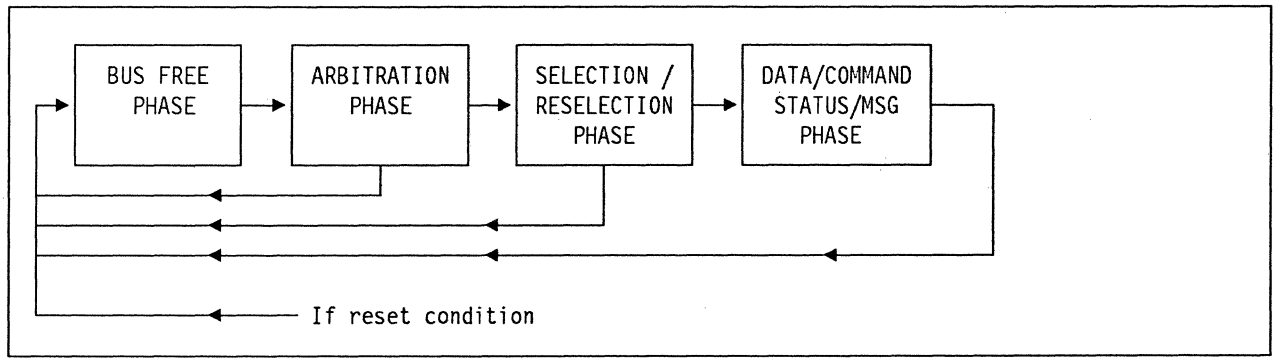


Figure 9. SCSI Bus Phases

During each of the phases shown in Figure 9 the devices attached to the SCSI bus are able to perform certain tasks. These phases are described below in detail.

Bus-free phase: When the SCSI bus is in this phase it indicates that no SCSI device (initiator or target) is using the SCSI bus and that it is available for any user. Any interaction that is to take place on the bus between SCSI devices can begin only when the SCSI bus is in the bus-free phase.

Arbitration phase: This phase allows one SCSI device to gain control of the SCSI bus so that it can assume the role of an initiator or a target. How it gains control of the bus is as follows:

1. The device waits for the bus free phase to occur.
2. The device now arbitrates for the SCSI bus by doing two things. It changes the status of the busy line on the SCSI bus to busy. At the same time it activates one of the lines of the data bus on the SCSI bus. Because the SCSI bus can carry eight bits of data at a time there are eight data lines. This means that each SCSI device can use one of these lines during arbitration. For example if the SCSI device with an ID of 6 was arbitrating for the SCSI bus, the sixth data line would be activated.

3. The device then waits for a period (an arbitration delay), during which it examines the SCSI data bus. If a higher priority SCSI ID is on the bus (where 7 is the highest) the device has lost the arbitration and must start again at point 1. If no higher priority SCSI device ID was found on the data bus, the SCSI device has won arbitration, gained control of the SCSI bus and proceeds to the selection or reselection phase.

Selection/Reselection Phase: The device that has control of the SCSI bus will place its own ID and that of the target SCSI device on the bus. The target device will automatically recognize that it has been selected when it detects a certain bus condition and that its own SCSI ID is represented on the data bus. It then confirms to the initiator that it has been successfully selected and allows the initiator to enter the message or command phase.

Command Phase: This is the phase during which there is a transfer of information from the initiator to the target. It is ALWAYS from the initiator to the target. The target requests information and the initiator puts the necessary values onto the SCSI data bus. The target then reads the data off the data bus.

The target continues to request more data in this way until it has read the specified number of bytes of information. This number is always the first part of the command descriptor block (see Figure 8 on page 9).

Data In/Out Phase: This is when the DATA transfer takes place. Data is sent either from the initiator to the target or from the target to the initiator.

Status Phase: In this phase the target sends a status byte to the initiator. This byte indicates the completion of the command.

Message Phase: In this phase the target and initiator MAY pass messages to each other. These messages convey information about the SCSI bus and how the devices will be talking to each other. Examples would be :

- A message may be sent from the initiator to the target advising it to abort the current command.
- Messages may be sent between the initiator and the target to establish the speed at which the data transfer is to take place.
- An identifier message is normally sent to the target after selection, prior to sending of the command to specify which LUN is being selected.

1.8 SCSI - Performance

There are many different figures given in a SCSI environment relating to the speed of data transfer.

SCSI Interface Data Transfer Rate: This figure indicates how quickly data can be transferred between the SCSI attachment feature and the devices that are attached to it. The maximum supported by the SCSI interface is 5Mbps.

NOTE : The SCSI device itself can determine this rate. This may not always be the SCSI bus maximum of 5Mbps. This means that data is transferred from the buffer on different SCSI devices across the SCSI bus to the SCSI attachment feature at different speeds.

SCSI Device Data Transfer Rate: The SCSI device transfers its data into its own buffer before transferring it across the SCSI bus.

It is very important to understand that the figures quoted are all at various stages of one request for information. Be careful when looking at benchmarks for SCSI versus ESDI. It is important that bench marks are done to pick up the advantages of a SCSI environment such as multiple devices all working at the same time.

1.9 SCSI versus ESDI

This section intends to explain the differences between a common current device interface, Enhanced Small Device Interface (ESDI) and the new Small Computer Systems Interface (SCSI). It explains how ESDI works and compares this to how SCSI works. Advantages and disadvantages of both are given.

1.9.1 Position of Controlling Circuitry

1. ESDI (Enhanced Small Device Interface)

   ESDI is a device-level interface. This means that it specifies the interface between the controlling circuitry for the device and the device itself. This means that error detection, formatting, etc. is all performed by the controller and NOT by the device.

   So with ESDI, the controlling circuitry is on an attachment feature, which is usually separate from the device itself. This means that any device attached to the controller can do only what the controller will allow it to do.

   ESDI is really designed only to support fixed disks This is because it would be expensive, if not impossible, to put all of the circuitry needed to support CD-ROM drives, fixed disks, printers, etc. onto one attachment feature.

   Another disadvantage is that the drives are often manufactured completely separately from the controller manufacturer. This means that not all ESDI drives are certain to work with the controller you have.

   ESDI also never became a true standard. Although used widely across the personal computer arena, it was never a truly defined ANSI standard.

2. SCSI (Small Computer Systems Interface)

   SCSI is a bus-level interface. This means that it defines an interface between a SCSI attachment feature and intelligent devices.

   This gives you many advantages.

   - With the intelligence for functions such as error detection, formatting etc. being placed with the device itself there is a significant drop in the restrictions imposed by the attachment feature. This means that manufacturers can develop SCSI devices to perform any function without relying on the attachment feature for all of the support.

     This is made easier under SCSI with the SCSI Common Command Set (see Figure 8 on page 9). The CCS means that manufacturers of SCSI devices can make their SCSI device be or do anything, provided that they understand this basic set of commands.

   - For the user this means that any SCSI device that conforms to the SCSI ANSI standard will work with their SCSI attachment feature.

- As SCSI is such a high-level interface, the devices attached to the SCSI attachment feature can be any peripheral device type. For example you could attach CD-ROM drives, scanners and printers all to the same SCSI attachment feature at the same time.

1.9.2 Physical Configuration

1. ESDI (Enhanced Small Device Interface)

   In an ESDI environment, each drive is attached to the attachment feature by three cables. These are a data cable, a control cable and a power cable. With this number of cables the ESDI environment can lead to a congested personal computer with too much cabling.

   The maximum distance between the ESDI controller and an ESDI device is three meters (10 feet). The maximum number of devices supported by an ESDI controller is 7.

2. SCSI (Small Computer Systems Interface)

   In a SCSI environment each SCSI device is attached to the SCSI attachment feature with one daisy chained cable. This means that your personal computer only has one long cable and a daisy chained power cable which removes congestion from the system.

   The maximum distance supported under SCSI is six meters. This means that the total length of the SCSI bus can be six meters.

   The maximum number of devices that one SCSI attachment feature will support is 56. This not only saves the cost of multiple attachment features but also valuable attachment space in the personal computer.

1.9.3 Performance

1. ESDI (Enhanced Small Device Interface)

   The rate at which data can be transferred across the IBM ESDI interface is 10 Mbps. This maximum can been increased but this is not usual for the ESDI interface.

   The device, as we have discussed, is reliant on the ESDI controller. The actual data transfer rate of the device MUST be equal to that of the controller. So if you have a controller that transfers data at 10 Mbps the drive must send/receive data at 10 Mbps. There are DASD devices available now that can transfer data at up to 24 Mbps.

   Because the device is reliant on the ESDI controller, when the ESDI controller is transferring data to/from the device, it has to wait until that device has finished processing that command before it can talk to another device. Only commands such as seeks which do not transfer data can be overlapped.

   The ESDI interface is also being outgrown by the speeds of the new systems. It is only designed for use in personal computers with a clock speed up to 25MHz.

2. SCSI (Small Computer Systems Interface)

   The maximum data transfer rate across the SCSI Interface is 40 Mbps. This is five times faster than ESDI.

However, because the SCSI devices are all independent of the SCSI attachment feature, they do not have to transfer data at the same rate. The disconnect/reconnect feature of SCSI means that devices can receive a command and process it in its own time. So, for example, if the printer can only receive data at 10 Mbps, it would disconnect from the SCSI bus and perform its task leaving the SCSI attachment feature and SCSI bus free for other devices to use.

The disconnect/reconnect also enables multiple SCSI devices to be working concurrently. This is a major advantage in a multitasking environment.

The SCSI interface is also designed to work in personal computers with clock speeds well in excess of 25MHz.

1.9.4 Other Advantages of SCSI

1. Since SCSI is a defined ANSI standard it will be much easier to build up a versatile peripheral subsystem without having the current integration problems.
2. With such intelligent devices it will be possible for devices in your subsystem to do things independently of the main SCSI attachment feature. For example a fixed disk could dump requested data directly to a tape drive.

1.10 Summary

SCSI stands for Small Computer Systems Interface. It is a fully documented ANSI standard number X3.131-1986.

SCSI is a standard interface bus through which computers may communicate with attached intelligent devices such as fixed disks, CD-ROMs, etc.

With SCSI, a large number of devices of different types can be connected to the system unit via a single SCSI bus cable and a SCSI attachment feature. This SCSI attachment feature may be in the form of an adapter or integrated on the planar board. The SCSI interface is also device independent, allowing the user to attach intelligent devices of any form that adhere to the SCSI standard. Overall SCSI means less cabling and saves valuable attachment space in the personal computer by having one SCSI attachment feature to support multiple devices.

Up to a maximum of seven devices can be directly attached to the SCSI bus cable and each of these devices can support up to eight more. This means that it is possible for one SCSI attachment feature to support up to 56 devices.

All of the SCSI devices attached to the SCSI bus compete to share the bus. This is known as arbitration. If an SCSI device wins control of the bus and is an initiator, it can send commands to another device known as a target. When a target has got a command it can disconnect from the bus. This means the initiator can then send a command to another target. When the target has finished its task it reconnects to the bus. This enables multiple devices to be working concurrently on the SCSI bus enabling the initiator (normally the SCSI attachment feature) to perform other tasks.

With the SCSI interface, high-data transfer rates allow enhanced performance over current, non-SCSI systems. A maximum data transfer speed of 5 Mbps is

supported across the SCSI bus. The maximum distance for device positioning devices away from the SCSI attachment feature is six meters.

2.0 IBM Implementation of SCSI

This chapter will describe how IBM[2] has implemented SCSI in its Personal System/2[3] systems.

2.1 IBM SCSI Adapter

This section briefly describes the IBM SCSI adapter and its specifications.

2.1.1 Brief Descriptive Overview

The IBM SCSI adapter is a 16-bit Micro Channel[4] adapter that comes standard in the PS/2[5] Models 8565-061, 8565-121, 8580-121, 8580-321, 8580-A21 and 8580-A31. It is also available as an option for any of the current PS/2 Micro Channel systems. The IBM SCSI adapter provides an intelligent SCSI device interface capable of transferring data rapidly to a number of devices such as fixed disks, CD-ROMs, printers etc.

The IBM SCSI adapter has an internal SCSI bus connector. This enables you to attach internal SCSI devices with an appropriate cable. It also has an external SCSI bus connector to which a special option cable can be attached to allow for external SCSI device support.

The highlights of the IBM SCSI adapter are:

- Bus master adapter.
- Conforms to SCSI ANSI standard X3.131-1986 for attached devices.
- Asynchronous and synchronous device support.
- Supports attachment of up to seven SCSI devices.
- Each SCSI device can support eight logical units.
- Overlapped command processing for up to 15 devices.
- Disconnect and reconnect features.
- SCSI bus arbitration.
- 16-bit data bus (Micro Channel bus).
- A 24- or 32-bit address bus (automatically configurable).

2 IBM is a trademark of the International Business Machines Corporation.

3 Personal System/2 is a trademark of the International Business Machines Corporation.

4 Micro Channel is a trademark of the International Business Machines Corporation.

5 PS/2 is a trademark of the International Business Machines Corporation.

2.1.2 SCSI Options Available

The options available from IBM for attachment to the IBM SCSI adapter are:

- IBM 320Mb, 120Mb and 60Mb SCSI internal fixed disks.
- Hard disk kit to support additional internal fixed disks.
- IBM CD-ROM drives (internal and external).
- CD-ROM kit to support internal CD-ROMs.
- An external device attachment cable.
- A terminating resistor for external devices.
- A daisy-chain cable to connect external devices one to each other.

2.2 IBM SCSI Adapter Physical Configuration

This section describes the physical aspects of the IBM SCSI adapter and how the IBM SCSI adapter should be installed.

2.2.1 Adapter Physical Design

The IBM SCSI adapter is a 16-bit Micro Channel adapter. Looking at the IBM SCSI adapter one will note that it has a 32-bit Micro Channel extension. This extension enables the adapter to have 32-bit addressing capabilities when installed in a 32-bit slot. The data signal pins for 32-bit data transfers are not implemented.

2.2.2 Adapter Installation

The adapter is installed just like any other PS/2 Micro Channel adapter. There are no switch settings or jumpers to set. It can fit in any 16 or 32-bit slot on the planar board.

The IBM SCSI adapter, if ordered as an option, comes with a set of five reference diskettes. These are as follows:

- PS/2 Model 50/60 Reference Diskette Version 1.05 or higher
- PS/2 Model 55/65 Reference Diskette Version 1.02 or higher
- PS/2 Model 70/80 Reference Diskette Version 1.09 or higher
- PS/2 Model P70 Reference Diskette Version 1.03 or higher
- PS/2 Model 70-486 Reference Diskette Version 1.03 or higher.

These are complete reference diskettes and should be used instead of the current reference diskette you are using to configure your PS/2 system.

There is no option diskette for the IBM SCSI adapter. The mentioned versions of the reference diskettes contain the necessary files to support the IBM SCSI adapter. These include diagnostic files and the ADF file for the IBM SCSI adapter which is @8EFE.ADF.

From the Set Configuration menu of the reference diskette the following options can be set:

1. IBM SCSI adapter I/O addresses. This allows you to choose the I/O address for the IBM SCSI adapter. There are eight different sets to choose from. These range from (3540H to 3547H) to (3578H to 357FH).
2. The DMA Arbitration level. This sets the arbitration level for the IBM SCSI adapter DMA bus master features. This will determine the priority of the IBM SCSI adapter during an arbitration cycle on the Micro Channel bus. Levels 1 through E can be chosen excluding levels 2 and 4. The normal level should be C.
3. Fairness ON or OFF. This should always be set to ON. This controls whether or not IBM SCSI adapter will release control of the Micro Channel bus when it has been using it exclusively.
4. ROM Wait State Disable. This allows you to set whether a wait state is added to accesses of the ROM on the IBM SCSI adapter. Performance of the IBM SCSI adapter could be degraded if this is set to "NO wait state".
5. IBM SCSI adapter SCSI ID number. This should normally be set to 7. This makes the IBM SCSI adapter the highest priority device on the SCSI bus. If you decide not to use 7, the ID can be anywhere in the range 0 to 7.

2.2.3 IBM SCSI Adapter BIOS Location

The IBM SCSI adapter uses a 32Kb block of memory for BIOS. This is located above the 640Kb memory address boundary. The location of this 32Kb block of memory is not configurable with the reference diskette.

The configuration program on the new reference diskettes intelligently locates the 32Kb block for the IBM SCSI adapter BIOS around the other adapters installed in the PS/2 system. This is to provide support for the ESDI or ST506 drives which may be already installed in the system. Normally the default location for this BIOS is memory location D800. If you wish to check that this is where the SCSI adapter BIOS has been located, use the memory map option from the reference diskette main menu.

Of the 32Kb of IBM SCSI adapter BIOS, 16Kb is only used during POST. After POST has been completed the top 16Kb are released for use by applications such as LIM EMS device drivers. If for example the 32Kb of BIOS was situated from D800 to E000 during POST, after POST was completed the memory from DC00 to E000 would be released. This 16Kb, however, cannot be used by other adapters in the system.

2.3 Attachment of SCSI Devices

SCSI devices can be attached to the IBM SCSI adapter both internally and externally.

The IBM SCSI adapter is designed with two SCSI interface connectors. One is a pin edge connector mounted on the top edge of the card. This connector allows the attachment of SCSI devices mounted internally in the system unit via a flat ribbon cable. For attaching external SCSI devices a shielded female 60 pin connector is mounted on the end of the card, for a cable to extend from the rear of the system unit.

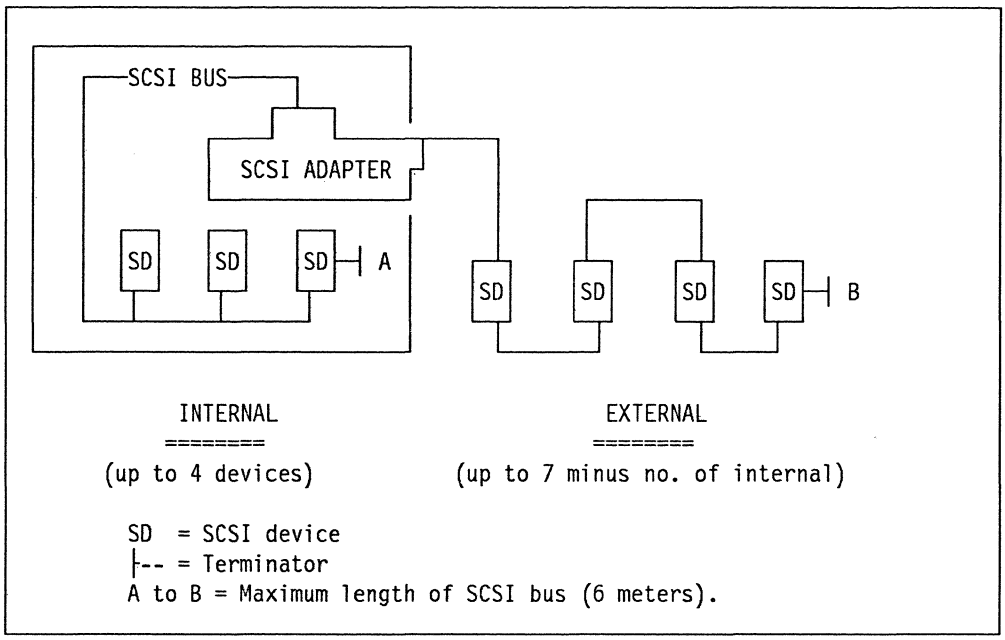


Figure 10. SCSI Device Attachments

2.3.1 Internal Connections

Note: The internal devices mentioned here are for floor-standing PS/2 systems only. No internal SCSI devices can be installed in desktop PS/2 systems.

To fit SCSI devices internally into an 8560, 8565 or 8580 you need two things in addition to the IBM SCSI adapter: an internal cable option to attach the device to the IBM SCSI adapter and a special mounting bracket. Please note that the maximum number of devices supported internally is four, due to space constraints.

There are two installation kits available that contain parts for installing extra internal SCSI devices.

1. Fixed disk installation kit A consists of:
   - Power cable with two connectors
   - SCSI cable with two connectors
   - SCSI cable with four connectors
   - One mounting bracket with screws.
2. CD-ROM drive installation kit A consists of:
   - Power cable with one connector.
   - SCSI cable with one connector.
   - Front plate.

Cables: The internal cables contain a connector to attach to the IBM SCSI adapter's internal connector and a number of connectors for attaching SCSI devices.

Models 8580-A21 and A31 and Models 8565-061 and 121 have a cable with three SCSI device connectors as standard. If you wish to install three or four hard disks into Models 8580-A21 and A31 or Models 8565-061 and 121, you will need the fixed disk installation kit A. If you are installing any internal SCSI fixed disk drives on the current PS/2 Model 60s or 80s, you will also need the fixed disk installation kit.

If you are installing an internal CD-ROM drive in any of the floor-standing PS/2 Systems you will need the CD-ROM installation kit.

Mounting Brackets: Internally on the 8560, 8565 and 8580, there are two 5.25″ peripheral bays. As the IBM SCSI fixed disk drives are all 3.5″ in size, a mounting bracket is needed to support them in these 5.25″ bays. One mounting bracket supports two IBM SCSI fixed disks.

The Models 8580-A21 and A31 and Models 8561-061 and 121 already have one bracket with one SCSI fixed disk installed. An additional fixed disk can be installed by attaching it to this bracket. If you wish to install a third or fourth fixed disk in one of these systems, or install SCSI drives in the current 60s or 80s, you will need fixed disk installation kit A.

The internal CD-ROM drive takes up the whole front bay of any PS/2 floor-standing systems. You will still need to order the CD-ROM installation kit A to install it.

The SCSI devices that you attach to the SCSI cable can be in any order provided that one of the SCSI devices is attached to the last connector on the internal SCSI cable. This SCSI device must have a terminator installed (See Section 2.3.3, "Terminator Positioning").

2.3.2 External Connections

A 60-pin to 50-pin cable connects the external connector on the adapter to the first external option. The next SCSI device is connected via a 50-pin to 50-pin cable which comes out of the first option and into the second. The last option attached must have an external terminator attached to it.

A maximum of seven SCSI devices can be attached up to the IBM SCSI adapter. This includes both internal and external devices. So if you had only one internal device attached you could have up to six devices attached externally and so on.

Both the internal and external cables will often be referred to as the "SCSI bus" The total length of the SCSI bus must not exceed 6 meters.

2.3.3 Terminator Positioning

In order for the SCSI bus to function correctly you will need a terminator at each end of the SCSI bus. There are three main types of terminator:

Internal Terminators: These come with each device and differ in the way that they are implemented. Do not mix the terminators.

SCSI Adapter Terminator: The IBM SCSI adapter comes with a terminator installed. This is in the form of a small orange rectangle plugged into the adapter. If it needs to be removed do so carefully with a chip puller or similar tool.

External Terminator: This terminator is the same for all external SCSI devices. It attaches to the back of the last SCSI device attached externally.

In each of the figures below the following key is used to show which type of terminator should be installed where.

- E = External terminator
- A = IBM SCSI adapter terminator
- I = Internal SCSI device terminator

The following four diagrams show the terminator and device positions that must be adhered to where attaching SCSI devices the IBM SCSI adapter.

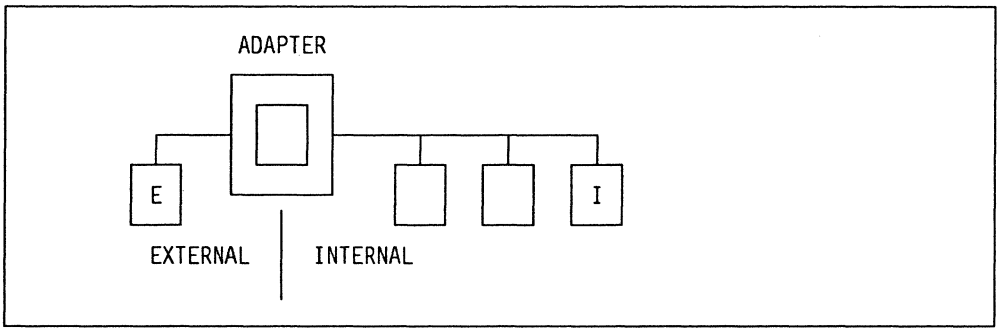


Figure 11. Terminator Positions: Internal and External Devices

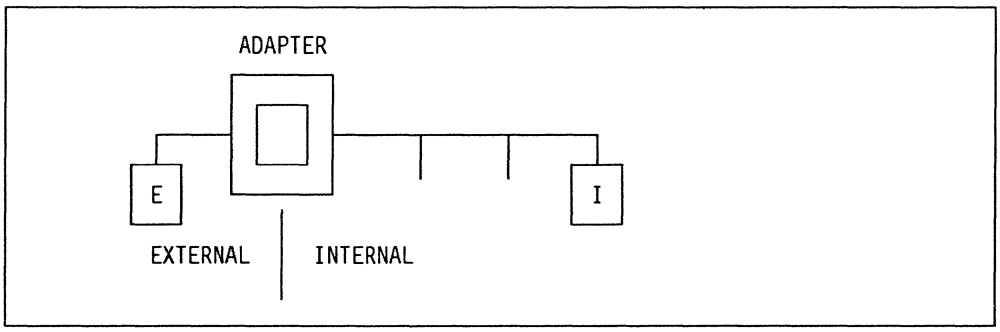


Figure 12. Terminator Positions: One Internal Device and External Device

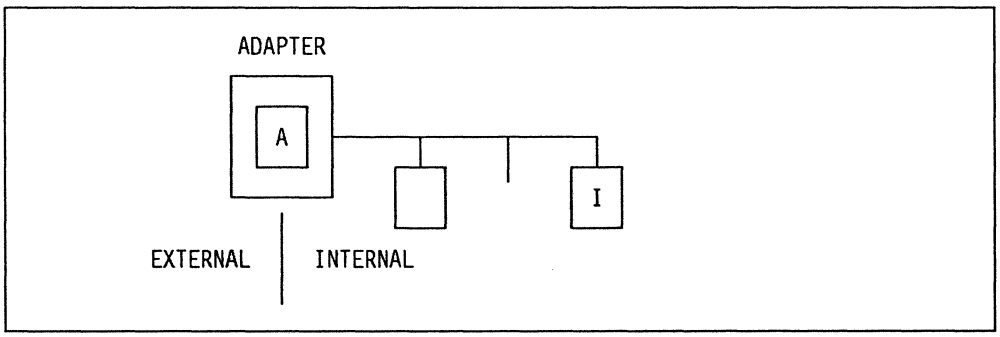


Figure 13. Terminator Positions: Internal Devices Only

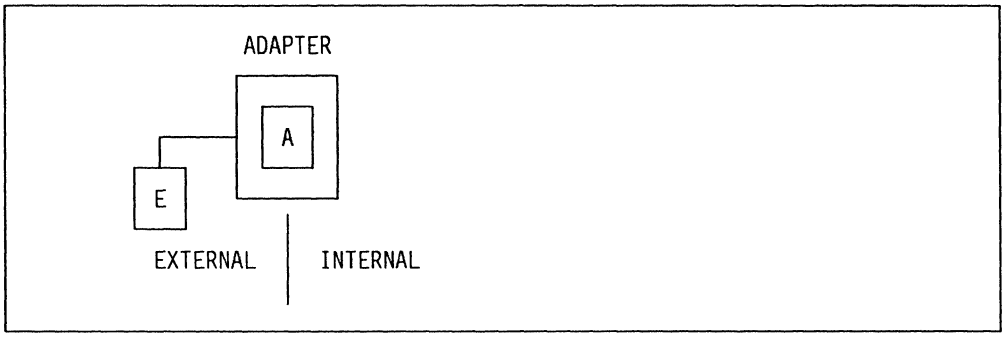


Figure 14. Terminator Positions: External Device Only

2.3.4 What SCSI Devices can be Attached

The connectors on the internal SCSI bus and the external SCSI bus cables will enable you to attach any SCSI device that conforms to the ANSI standard X3.131-1986. They must also support the mandatory commands and messages specified in Addendum 4.B to the ANSI specification, known as the SCSI Common Command Set (CCS).

The maximum number of SCSI devices that can be attached to the IBM SCSI adapter is seven.

2.4 Configuration of the SCSI Devices

This section explains how SCSI devices are configured so that they can be accessed by the IBM SCSI adapter.

2.4.1 Physical Configuration

Each SCSI device attached to the SCSI bus must be assigned a unique SCSI ID number. This number is in the range 0 to 7 and allows each SCSI device to be addressed.

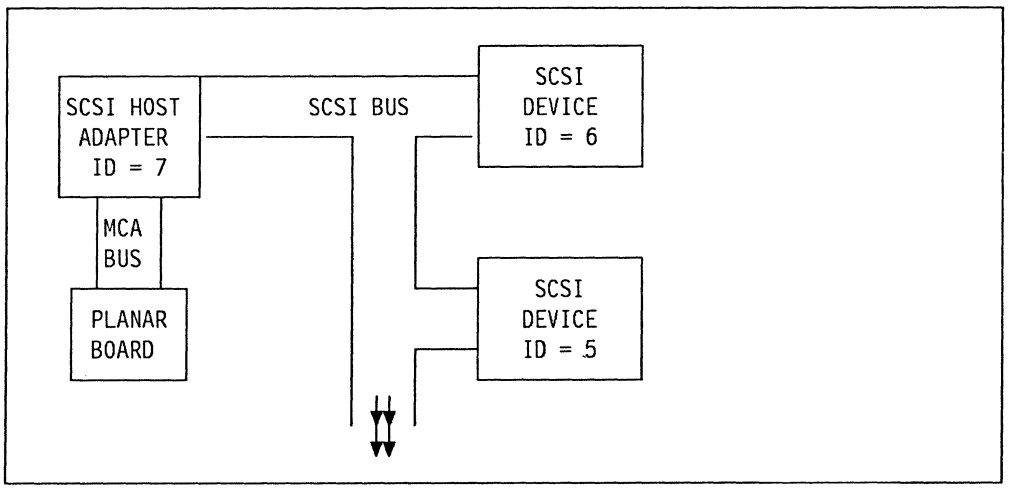


Figure 15. SCSI Physical Configuration

The SCSI ID number of a particular SCSI device is set during configuration of the particular device. For example, on the IBM 320Mb SCSI fixed disk a series of jumpers determines the ID number of the drive.

The SCSI ID number not only acts as a number by which the device can be recognized, it also determines the priority of the device on the SCSI bus during arbitration (see 1.5.5, "SCSI Bus Arbitration" on page 7).

The ID also determines the device that will be used as the bootable drive (effectively your C: drive). The fixed disk connected to the SCSI adapter in the lowest numbered slot will become the bootable drive, unless an ESDI or ST506 drive is installed in the system. This is why a fixed disk must be assigned a high-priority ID such as 6 or 5.

NOTE: For details on the different SCSI device jumper and switch settings, see Appendix A, "SCSI Devices: Specifications and Installation" on page 49.

2.4.2 Reference Diskette Configuration

Once the SCSI ID has been set on the device itself, you must reconfigure the system using the reference diskette. This will tell the IBM SCSI adapter which devices it has attached and how to address them.

When you view the SCSI configuration it will show for each SCSI device a number like 6,0. The 6 indicates the SCSI device ID you have just set on the device itself and the second is a logical unit number or LUN.

2.4.3 Logical Units (LUNs)

For a full definition of logical units see 1.5.2, "Logical Unit Numbers (LUNs)" on page 6.

The IBM SCSI adapter allows each SCSI device to have attached to it, up to eight Logical Units (LUNs). These LUNs are controlled by the SCSI device.

NOTE: The IBM SCSI adapter will only support a total of 15 LUNs at any one time through its BIOS. If you have more than 15 LUNS attached to one IBM SCSI adapter the 15 LUNs used are determined as follows:

The BIOS scans the SCSI bus from the highest to the lowest SCSI device ID. After each SCSI device is located on the SCSI bus it checks to see if that device has any LUNs attached. If the device has some LUNs, these are set up first and so on until 15 LUNS have been configured. The additional LUNS will not be accessible through BIOS.

IBM does not presently market any SCSI devices that allow multiple LUNs to be attached. All of the IBM SCSI devices are single LUN devices.

The following diagram will serve as an example of how the IBM SCSI adapter would address an IBM 320Mb SCSI fixed disk.

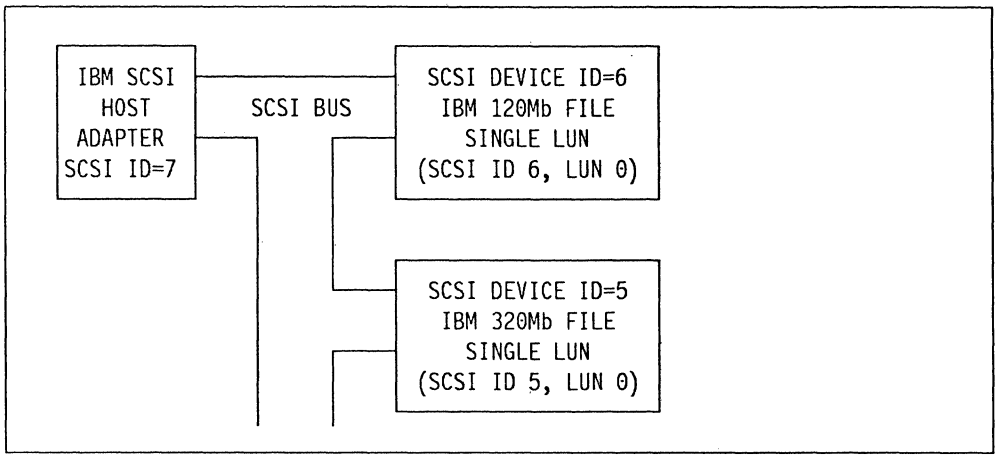


Figure 16. SCSI Logical Units

1. The IBM SCSI adapter selects the IBM 320Mb SCSI fixed disk using the SCSI ID, which in this case is 5.
2. It then sends an identify message to select LUN 0.
3. Then, it sends a command to the IBM 320Mb SCSI fixed disk. In this case the 3-bit field would contain the number 0.
4. When the SCSI device receives the command it passes on the instructions to the logical unit, in this case LUN 0.
5. The drive will then perform its read or write as specified by the SCSI device.

For a layout of the SCSI commands see Figure 8 on page 9.

2.5 Other Features of the IBM SCSI Adapter

This section describes other functions of the IBM SCSI adapter. For detailed explanations on any points please refer to Chapter 1.0, "What is SCSI" on page 1.

2.5.1 Initiators and Targets

When two SCSI devices talk to each other on the SCSI bus, one sends out a command and one acts upon it. The SCSI device that sends out the commands (which is most likely to be the IBM SCSI adapter) is called an **initiator**. The SCSI device that processes the command is called the **target**. All of the IBM SCSI devices available at the moment are targets.

The IBM SCSI adapter supports the ability to have multiple initiators on its SCSI bus. This allows for functions such as device level copying. None of the current IBM SCSI devices support this function.

The IBM SCSI adapter cannot be accessed as a target by another initiator.

2.5.2 SCSI Bus Arbitration

Details on arbitration can be found in Section 1.5.5, "SCSI Bus Arbitration" on page 7.

On the SCSI bus, arbitration is controlled by logic on the IBM SCSI adapter. Arbitration on the SCSI bus can be initiated by any SCSI device on the bus provided that it has the capability to do so. The SCSI device ID is used as the arbitration level.

2.5.3 Disconnect/Reconnect and Overlapped Command Processing

All of the IBM SCSI devices have the ability to arbitrate for the SCSI bus. This is so that they can perform the disconnect/reconnect function. This means that as soon as a SCSI device (for instance, a IBM 320Mb SCSI fixed disk) has received a command it can disconnect from the SCSI bus. The IBM SCSI adapter can then send a command to another SCSI device. This means multiple devices can be working concurrently. When the IBM 320Mb SCSI fixed disk has completed the command it arbitrates for the SCSI bus and reconnects to tell the IBM SCSI adapter that it has finished.

This processing of multiple commands at a time is known as overlapped command processing. The IBM SCSI adapter supports overlapped command processing for up to 15 logical units.

2.5.4 Synchronous and Asynchronous

There are two modes of data transfer across the SCSI interface. These are asynchronous and synchronous modes.

The IBM SCSI adapter supports both of these data transfer modes. It intelligently checks, before doing a data transfer, which mode the SCSI device can use. The type of transfer and speed of transfer is not set during configuration of the device. It is done during the message phase of the SCSI bus. Please refer to Figure 7 on page 8 for more details.

The IBM CD-ROM drive, the 60Mb and the 120Mb SCSI disk drives are all asynchronous devices. The 320Mb SCSI disk is a synchronous device.

2.5.5 Multiple SCSI Adapters In One System

A maximum of four IBM SCSI adapters are supported in the PS/2 system units. When installed each will be assigned a unique set of I/O addresses but they will all use the same 32Kb of address space for their BIOS.

In order to determine which adapter will have the bootable C: drive attached to it the SCSI BIOS initialization works as follows.

- The BIOS scans for adapters from the lowest to the highest numbered slots.
- After an adapter is located, the SCSI bus is scanned from the highest to the lowest SCSI device ID.
- The highest SCSI device ID found will be the bootable drive.

In summary the bootable device will be that with the highest ID attached to the IBM SCSI adapter in the lowest slot.

2.5.6 Installing a SCSI Adapter in Current PS/2's

When you install the IBM SCSI adapter in a current floor-standing PS/2 system you install it in addition to the already installed ESDI or ST-506 controller and drive(s).

If you leave the ESDI or ST-506 adapter and drive(s) installed, the bootable drive attached to that adapter will remain as the bootable drive. It will not be possible to make any of the SCSI fixed disk drives the bootable C: drive.

If you install the IBM SCSI adapter in a desktop PS/2 system you will only be able to attach external devices to the IBM SCSI adapter.

2.6 Operating System Support

The IBM SCSI adapter contains both CBIOS and ABIOS routines. This means that it is supported under both DOS and OS/2[6]. The BIOS gives support more specifically to hard disks. It also contains a generic BIOS that can be used by other devices such as the IBM CD-ROM in conjunction with a device driver.

1. Operating System/2[7]. Both versions of OS/2 V1.1 (Standard Edition and Extended Edition) support up to a maximum of two disks (mixture of SCSI and non-SCSI). Both versions of OS/2 V1.2 (Standard Edition and Extended Edition) support up to seven disks (mixture of SCSI and non-SCSI).
2. Disk Operating System. DOS 3.3 and DOS 4.0X support up to two SCSI devices. If you apply fix UR27164 to DOS 4.0X it will enable you to boot your system with more than two SCSI disks installed. This is in case you have more than two SCSI disks in your system. However, you cannot access more than the two disks supported under DOS. A Corrective Service Diskette (CSD) is needed to provide support for up to seven disk drives (mixture of SCSI and non-SCSI).
3. Advanced Interactive Executive[8] PS/2 (AIX[9] PS/2) supports the IBM SCSI adapter in a future release.
4. CD-ROM drives are supported under a separate device support (see Appendix A.4.5, "Installing CD-ROM Device Drivers" on page 55).

2.6.1 How the Operating System Views SCSI

The following section explains how the IBM SCSI adapter is addressed by the Operating System and how each SCSI device is addressed.

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6 OS/2 is a trademark of the International Business Machines Corporation.

7 Operating System/2 is a trademark of the International Business Machines Corporation.

8 Advanced Interactive Executive is a trademark of the International Business Machines Corporation.

9 AIX is a trademark of the International Business Machines Corporation.

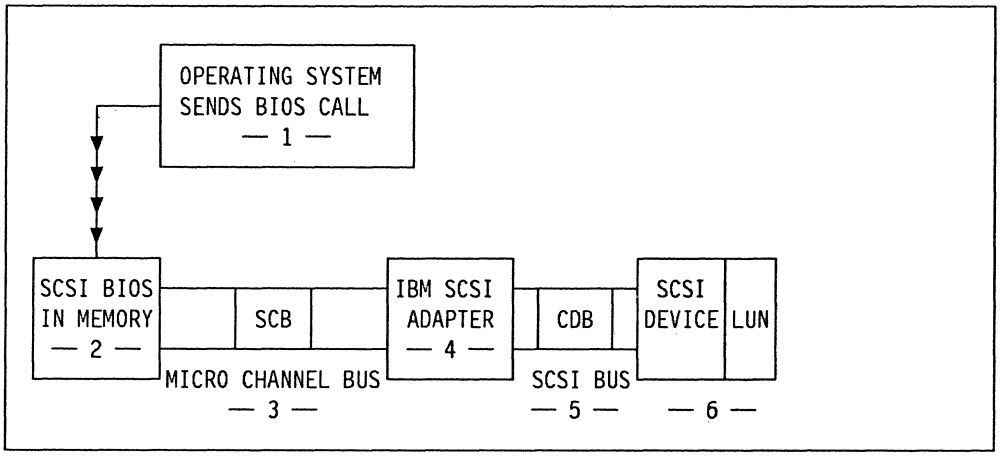

Figure 17. SCSI Addressing from the Operating System

1. Operating system sends BIOS call. The operating system makes a call to BIOS for data to be read from a fixed disk into memory. The SCSI BIOS for the fixed disks is compatible with that used for the current PS/2 systems. Therefore any application that uses BIOS to address the fixed disks will work on the SCSI drives.

2. The SCSI BIOS (which has been mapped into a memory address space) builds a subsystem control block that defines all of the information necessary to perform the request, such as memory location for data, the actual data requested etc.

   It also contains a logical device number which translates to the SCSI device ID and Logical Unit number for which the command is for.

3. The SCB is then requested by the IBM SCSI adapter and sent across the Micro Channel bus by the bus master controller on the IBM SCSI adapter (for more details on subsystem control block architecture please refer to the *PS/2 Hardware Interface Technical Reference Manual*).

4. The IBM SCSI adapter then decodes certain parts of this subsystem control block and the logical device number, and sends a command descriptor block across the SCSI bus to the appropriate SCSI device.

5. The SCSI device then reads the CDB and requests the LUN specified in the 3-bit field of the CDB to perform the task.

   For an example of a command descriptor block please see Figure 8 on page 9.

2.7 SCSI Security

Small Computer System Interface (SCSI), as defined in the American National Standard Institute (ANSI) standard X3.131-1986 provides a port for the attachment of external devices. The IBM PS/2 SCSI adapter is in conformance with this standard and has an external port.

A data security exposure exists, even with power-on password installed, since external SCSI controllers can attach through the external SCSI port and gain undetected read or write access to data stored on internal and external SCSI devices.

Physical access to the system and external SCSI devices must be controlled to limit this exposure.

2.8 IBM SCSI Adapter Performance

The IBM SCSI adapter is a 16-bit Micro Channel bus master. The figures relating to its performance are shown in Figure 18. What each of the figures means is explained below the table.

Figure 18. IBM SCSI Adapter Specifications.	
System bus Interface	16-bit data bus width
System Data Transfer Rate	8.3Mbps (burst mode)
SCSI Interface Transfer Rate	5Mbps (maximum)
SCSI Device Data Transfer Rate	Dependent on device

System Bus Interface: This indicates the maximum data bus width supported by the IBM SCSI adapter. It is the maximum width at which data can be transferred from adapter to real memory in the system unit.

System Data Transfer Rate: This figure indicates how quickly data can be transferred from the IBM SCSI adapter across the Micro Channel bus. This figure relates to the adapter and NOT SCSI itself. This figure is achieved when the bus master controller on the IBM SCSI adapter is performing a burst transfer across the Micro Channel bus.

SCSI Interface Data Transfer Rate: This figure indicates how quickly data can be transferred between the IBM SCSI adapter and the SCSI devices that are attached to it. The maximum supported by the SCSI interface is 5Mbps. This is the figure that the IBM SCSI adapter supports.

NOTE: The SCSI device itself determines this rate. This may not always be the SCSI bus maximum of 5Mbps. This means that data is transferred from the buffer on the SCSI device across the SCSI bus to the IBM SCSI adapter at different speeds.

SCSI Device Data Transfer Rate: The SCSI device transfers its data into its own buffer before transferring it across the SCSI bus.

It is important to note that the figures quoted are all parts of one overall data transfer.

2.8.1 Bus Master Adapter

There are many advantages that a bus master adapter has over a DMA slave in the Micro Channel environment. The main advantage is that of system processor relief. As the bus master is an intelligent device it can perform its data and command transfers without the help of the main central processor. This means that the processor will be free to perform other tasks. Other advantages can be found in the *PS/2 Hardware Interface Technical Reference Manual*.

2.8.2 Benchmarks.

A lot of benchmarks will be used to test the performance of the IBM SCSI adapter to other device controllers such as the IBM ESDI controller. This benchmarks may give unreliable results. This is because they may not be written to test the SCSI characteristics of the IBM SCSI adapter. A good benchmark must test SCSI in the environment it was designed for. This is a multitasking environment where multiple devices are working concurrently. Also the main system processor relief must be taken into consideration during any tests.

Overall, any benchmarks must be carefully analyzed and the other benefits of SCSI taken into consideration before a decision is made on which system will best suit the user.

2.9 Quick Installation Guide

This section gives a quick overview of how you install SCSI devices in a PS/2 system.

Installing Adapter: To use the IBM SCSI adapter you must configure your system using one of the new reference diskettes. There is no option diskette for the IBM SCSI adapter.

Internal or External Devices: The IBM SCSI adapter lets you attach internal and external devices. Internal devices cannot be attached externally to any PS/2 systems or internally in the desktop PS/2 systems.

On floor-standing PS/2 systems there are two 5.25″ internal DASD bays. Each of these can take two SCSI fixed disks. Alternatively the front bay can take one internal CD-ROM drive.

To install an internal SCSI fixed disk you need a mounting bracket. One mounting bracket will enable you to install two SCSI fixed disks in one 5.25″ bay. The PS/2 Model 65s and new Model 80s come standard with one bracket. Additional brackets come with the installation kits.

Installing SCSI Devices: Before installing any SCSI devices you must set its SCSI ID. Check by booting on the reference diskette to see which SCSI ID numbers are not being used. Remember, read/write devices have a high SCSI ID and read-only devices have a low SCSI ID.

When the SCSI ID is set check that the terminators are installed correctly. Then boot up the PS/2 with the new reference diskette. You will get a 162 POST error code and need to run automatic configuration.

Which Drive Will Boot: The PS/2 will boot off the SCSI device that has the highest SCSI ID and is attached to the IBM SCSI adapter installed in the lowest numbered slot.

3.0 IBM Micro Channel SCSI Adapter with Cache

3.1 Overview

The "IBM Micro Channel SCSI Adapter with Cache" is a 32-bit SCSI bus master adapter. It has exactly the same function as the 16-bit SCSI adapter detailed in Chapter 2.0, "IBM Implementation of SCSI" on page 17. It also adheres to the discussions in Chapter 1.0, "What is SCSI" on page 1. Any differences are outlined in this chapter.

The IBM SCSI adapter with cache has the following additional features:

- 32-bit addressing and data capabilities
- 512Kb on board cache
- 16.7Mbps Micro Channel data transfer rate.

The IBM SCSI adapter with cache can be installed in any 16 or 32-bit slot. You will of course have increased performance when the IBM SCSI adapter with cache is installed in a 32-Bit adapter slot.

All of the other features of the IBM SCSI adapter with cache as described in Chapter 2.0, "IBM Implementation of SCSI" on page 17.

3.2 512KB Cache

The IBM SCSI adapter with cache comes with 512Kb of cache as standard installed. This cache memory cannot be upgraded or removed and used on other adapters. It is NOT supported on the 16-bit SCSI adapter or other IBM memory adapters.

This on-board cache will improve system performances as memory will not have to be set aside for system caches. If you also install a system cache this will improve performance of the IBM SCSI adapter with cache rather than cause double caching.

3.3 IBM SCSI Adapter with Cache Internal Terminator

An internal terminator is shipped with the IBM SCSI Adapter with cache. It must be connected to the internal connector on the adapter if there are no internal devices attached to this adapter.

3.4 IBM SCSI Adapter with Cache External Terminator

The terminator for the IBM SCSI adapter with cache is in the form of a 60-pin external plug. This must be installed when no external devices are attached. If there are no internal devices and some external devices you do not need to use this terminator. However the last external device must have a terminator installed.

4.0 New IBM PS/2 8580 Systems

This chapter describes the new Model 8580 Personal System/2s.

4.1 Model Types

The IBM 8580-121, IBM 8580-321, IBM 8580-A21 and IBM 8580-A31 are floor-standing Micro Channel systems. Externally they look exactly the same as the current Model 80 systems.

Figure 19. New Model 80 Systems

Model Name	Processor	Fixed Disk
8580 - 121	20Mhz - 80386	120Mb SCSI
8580 - 321	20Mhz - 80386	320Mb SCSI
8580 - A21	25Mhz - 80386	120Mb SCSI
8580 - A31	25Mhz - 80386	320Mb SCSI

Apart from the differences outlined above there are some enhancements on the planar board for the Models 8580-A21 and A31 systems. These include DMA parallel print, four 32-bit adapter slots, 64Kb cache controller and two video extensions.

4.2 Common Features

The new IBM 8580 models include many features common to the PS/2 range :

- 3.5" 1.44Mb diskette drive.
- PS/2 mouse port and keyboard port.
- Integrated video (VGA), serial and parallel port connectors.

All of these are functionally equivalent to the current range of PS/2 systems. The parallel port on the Models 8580-A21 and A31 is also functionally equivalent but has some additional enhancements.

The only external distinguishing feature between one of the new IBM 8580 models and the current Model 80 systems is the label on the front of the system unit.

4.3 Power Supply

The new IBM 8580 models use a 242-watt automatic voltage-sensing power supply that changes between the ranges (100 - 125 VAC) and (200 - 240 VAC).

4.4 Microprocessor and Mathematical Co-Processor

Models 8580-121 and 321 use a 20MHz Intel[10] 80386 processor. Models 8580-A21 and A31 use a 25MHz Intel 80386 processor with a 64Kb cache controller.

Models 8580-121 and 321 use the 20MHz Intel 80387 mathematical co-processor and Models 8580-A21 and A31 use the 25MHz 80387.

4.5 Expansion Bus

Models 8580-121 and 321 and Models 8580-A21 and A31 all have a 32-bit I/O bus. Models 8580-121 and 321 use the same planar board as the current model 80-311. They have three 32-bit slots and five 16-bit slots. One of the 16-bit slots has a video extension.

Models 8580-A21 and A31 use a new planar board which has four 32-bit slots and four 16-bit slots. Two of these 16-bit slots have video extensions. However, only one 8514/A adapter is supported in the Models 8580-A21 and A31.

4.6 DASD

This section describes the various disk and diskette storage devices that come standard or as options on the new IBM 8580 systems.

4.6.1 Diskette Drive

All of the new Model 80 systems are fitted with one 1.44Mb 3.5″ diskette drive. This is supported by a diskette drive cable that attaches directly into the planar board. This cable can support two 3.5″ diskette drives or one diskette drive and an internal tape backup unit.

To install a second one-inch-high 1.44Mb diskette drive you will need the one-inch-high 1.44Mb diskette drive installation Kit.

This kit contains a bezel and installation instructions.

4.6.2 IBM SCSI Adapter

In the new IBM 8580 systems the fixed disk controller is the IBM SCSI adapter.

Please refer to Chapter 2.0, "IBM Implementation of SCSI" on page 17 where the IBM SCSI adapter is discussed in more detail.

4.6.3 SCSI Fixed Disks

Models 8580-121 and 321 and Models 8580-A21 and A31 come with either a 120Mb SCSI fixed or a 320Mb fixed disk. The specifications are as follows.

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10 Intel is a trade mark of the Intel Corporation.

Figure 20. Fixed Disk Drive Specifications

	120Mb Disk	320Mb Disk
Formatted Capacity	120Mb	320Mb
Bytes/Sector	512	512
Sectors/Track	32	48
Cylinders	920	949
Sector Buffer Size	32K	64K
No. of Data Heads	4	14
Data Transfer Rate	1.25Mbps	4Mbps
Average Seek Time	23ms	12.5ms
Average latency	8.3ms	6.95ms
Sector Interleave	1:1	1:1

All of the SCSI fixed disk drives are 3.5″ drives. They are for internal installation only. More details on the drives can be found in Appendix A, "SCSI Devices: Specifications and Installation" on page 49.

4.6.4 Fixed Disk Upgrades

All of the new IBM 8580 models can be upgraded using any of the IBM SCSI options. These are the 60Mb, 120Mb and 320Mb SCSI fixed disks. There is also a CD-ROM drive which comes in two models. One is for internal attachment and one is for external attachment. The maximum hard disk capacity that you could have on any of the new IBM 8580 systems is 1280Mb. This however, will be possible on the 8580-121 and 8580-A21 only if you remove the 120Mb SCSI fixed disk already installed.

4.7 Other Peripheral Devices

This section describes how other storage media may be attached to the new IBM 8580 systems.

4.7.1 IBM 5.25″ Diskette Drives

Only the IBM high-capacity 5.25″ diskette drive adapter is supported in the new IBM 8580 systems. However, this will let you attach both models of the IBM external 5.25″ diskette drive. Model 1 is the low capacity model supporting 360Kb diskettes and Model 2 is a high capacity drive supporting 1.2Mb diskettes (Model 2 will also support low-capacity diskettes).

You can attach both models of the IBM 6157 tape unit to the new IBM 8580 systems.

4.7.2 IBM 6157 Streaming Tape Device

Both models of the IBM 6157 tape streaming device are supported on the new Model 8580 systems. The 6157-001 gives a tape capacity of 60Mb and 6157-002 gives 150Mb tape capacity. Both tape units use the same IBM 6157 adapter.

4.7.3 Optical Disk Units

You can attach the IBM Optical Disk unit A11 to Models 8580-121 and 321 and Models 8580-A21 and A31. You can increase the number of optical disks attached to the same adapter by using the IBM-B01 model of the optical drive.

4.7.4 Internal Tape Backup Unit

Models 8580-121 and 321 and Models 8580-A21 and A31 support the IBM internal tape backup unit. In order to install it you will need both the internal tape backup unit and the internal tape backup unit Installation kit A.

This kit consists of a 1.7" cable, which connects at one end to the tape backup unit connector and at the other end to the diskette attachment cable.

4.8 Graphics

The new IBM 8580 systems include full VGA functions on the planar board.

On Models 8580-121 and 321 the 8514/A adapter is supported when plugged into the 16-bit slot with the video extension.

On Models 8580-A21 and A31 the 8514/A adapter is supported in either of the 16-bit slots with the video extension. It is not possible to install two 8514/A adapters.

4.9 BIOS and Hardware Compatibility

Models 8580-A21 and A31 and Models 8580-121 and 321 have both the normal CBIOS and ABIOS routines. The 128Kb ROM is fully compatible with the other PS/2 Models 50, 60, 70 and 80. This ROM contains BASIC, POST routines, etc. as well as the BIOS mentioned below.

CBIOS (compatibility BIOS) provides the interrupt call structure required by PC-DOS. It is a single tasking BIOS (that is, the processor has to wait for all I/O to complete before executing any other instructions).

ABIOS (advanced BIOS) is the BIOS that supports multitasking and as such frees the processor to perform other functions while waiting for I/O. OS/2 uses ABIOS.

Programs that use only documented BIOS calls, and do not directly address hardware ports or absolute memory locations, should run on the new Model 8580 systems (and indeed any PS/2 system). Programs that do not follow these guidelines and depend on specific hardware features may fail, or not operate as expected.

4.10 Serial Port

The serial port is exactly the same as the type 2 port found on some of the other, later, PS/2 systems.

Additional serial ports may be installed using either the IBM multi-protocol adapter (ensure that you use the latest version of this adapter) or the IBM dual async adapter.

4.11 Parallel Port

The parallel port in the Models 8580-121 and 321 is fully compatible with the current parallel ports, supporting bi-directional input and output.

4.11.1 DMA - Parallel Print

The parallel port on Models 8580-A21 and A31 has additional capabilities for DMA data transfer. This DMA parallel support allows high-speed data transfer between system memory and devices attached to the parallel port. The parallel port on Models 8580-A21 and A31 is hardware compatible with the current PS/2 parallel port. Operating system support for DMA parallel is provided in OS/2 SE and EE Version 1.2. The Advanced Interactive Executive Personal System/2 (AIX PS/2) will contain DMA parallel support in a future release. DOS applications will only be able to use the new DMA capability through the BIOS interface.

The DMA level of the parallel port is set at level 6 and CANNOT be changed.

4.12 Security

Models 8580-A21 and A31 and Models 8580-121 and 321 implement two security features:

- A mechanical lock to allow the user to lock the system unit cover ONLY.
- An optional password stored in CMOS RAM, which, when set, will be prompted for at power on, and will not boot the operating system until the correct password is entered. LAN server password mode can also be set.

4.12.1 SCSI Security

There is a security issue with the IBM SCSI adapter. Please refer to 2.7, "SCSI Security" on page 28 for more details.

4.13 Memory

This section describes how much memory comes standard and how it can be expanded on the new IBM 8580 systems.

4.13.1 Planar Memory

The planar board of Models 8580-121 and 321 have two 32-bit memory connectors. Both of these connectors will take the current Model 80 planar board 2Mb memory expansion board. However, Models 8580-121 and 321 have standard 4Mb of memory on the planar board.

The planar board of the Models 8580-A21 and A31 has two 32-bit memory connectors. The systems come with one 4Mb board installed and one additional 4Mb board may be installed. The current Model 80 planar board memory boards are not supported. This means that planar board can either be left at 4Mb or expanded to 8Mb.

NOTE: In order for the Models 8580-A21 and A31 to run, they must have a 4Mb card in connector one on the planar board. Connector 1 is the one nearest the power supply. Provided this is installed, connector 2 can be left empty if you want to install extra memory using memory adapters.

4.13.2 Memory Adapter Cards Supported

The new IBM 8580 systems support the following memory adapters.

Figure 21. Memory Adapters Supported

Memory Adapter	Memory Speed	Adapter Type
IBM 80386 2-6 Mb memory expansion option	80ns	32-bit
IBM 80386 2-8 Mb memory expansion option	85ns	32-bit
IBM 80386 2-16 Mb Enhanced memory option	85ns	32-bit
IBM 80386 4-16 Mb Enhanced memory option	85ns	32-bit

All of these adapters are supported only when installed in the 32-bit slots. Each of the 32-bit slots has the matched memory cycle extensions. Please make sure that when you install these adapters, the option diskette is copied to the reference diskette using the *copy an option diskette* option and NOT DOS copy.

4.13.3 Memory Maximums

The new IBM 8580 systems use 128Kb of RAM to hold a copy of the ROM BIOS programs. This is to speed up the access to the ROM BIOS programs. The memory available on the new IBM 8580 systems will always be 128Kb less than the memory installed.

When 16Mb of memory is installed an extra 256Kb of memory is used by the system. This is in addition to the 128Kb already used.

4.13.4 Cache Controller

The Models 8580-A21 and A31 both have an 82385 cache controller. The cache is used to move instructions and data from and to memory at the greatest possible speed.

The cache controller controls 64Kb of static RAM (SRAM). This is high-speed memory running at 25ns. The way it works is as follows:

1. Processor sees if memory addressed is already in the cache. If it is, data is obtained with 0 wait states.
2. If data is not in the cache, data is moved from memory into the cache and to the processor. At the same time as this, a special *read ahead* algorithm reads in the next set of instructions assuming that the processor will be using them next. It is estimated that a minimum of 95% of all memory accesses will be satisfied by the 64Kb of cache.

If data is actually obtained from memory the following wait states apply.

Figure 22. Wait States With Cache

Operation	**Wait States**
Read (cache hit)	0 wait states
Write (cache hit)	0 wait states
Read (cache miss, page hit)	0-2 waits states
Write (cache miss, page hit)	0 wait states
Read (cache miss, page miss)	3 wait states
Write (cache miss, page miss)	0 wait states

A *page hit* is a reference to the page mode memory capabilities of the Models 8580-A21 and A31. It means that when data is first addressed, the address lines have to be set up and the data received/sent. When the next area of data is addressed, if it is within 2Kb of the previous data, then most of the address lines can be left as they were and a quicker memory access is achieved.

4.14 Battery and CMOS RAM

The battery on the Models 8580-A21 and A31 is integrated with the real time clock and CMOS RAM and placed into a pluggable module on the planar board.

The unit contains the battery and the normal 64 bytes of Complementary Metal Oxide Semiconductor RAM (CMOS RAM). It also contains the Real-time clock and a 2K nonvolatile RAM extension to hold system information and configuration. Functionally, every part of this unit is EXACTLY the same as the other PS/2 Micro Channel systems.

The battery and CMOS RAM setup is the same as that found on the current Model 8580 systems.

5.0 New IBM PS/2 8565 Systems

5.1 Model Types

The IBM PS/2 Model 8565 is a Micro Channel system that is marketed in two models. It is a floor-standing system using the Intel 80386SX processor.

- Model 65-061 (60Mb fixed disk)
- Model 65-121 (120Mb fixed disk)

The only difference between the two is the size of fixed disk.

5.2 Common Features

Models 8565-061 and 121 include many features common to the PS/2 family:

- 3.5" 1.44Mb diskette drive
- PS/2 keyboard and mouse ports.
- Integrated video (VGA), serial and parallel port controllers
- Extensive use of surface-mount technology and IBM gate arrays for small footprint and high reliability.

5.3 System Unit Externals

Externally, the Models 8565-061 and 121 system units appear identical to a PS/2 Model 60. The only way to distinguish between the two systems is by the label on the front of the system unit.

5.4 Power Supply

Models 8565-061 and 121 use an auto-sensing 250-watt power supply. It automatically switches between (90 to 137 VAC) and (180 to 265 VAC) at 50 or 60Hz.

5.5 Microprocessor

Models 8565-061 and 121 use an Intel 80386SX processor clocked at 16 MHz. The 80386SX processor is quoted by Intel to be 70% as efficient as a full 80386 processor and 20% more efficient than the 80286.

The 80386SX processor is a subset of the 80386 processor. It has full 32-bit processing capabilities just like a full 80386 processor.

The main difference between the 80386SX and the 80386 is the size of the address and data buses on the 80386SX processor.

- The 80386SX has a 24 bit address bus (32 bit on the 80386)
- The 80386SX has a 16 bit data bus (32 bit on the 80386)

For these reasons an operating system or application running on the 80386SX processor must be aware of this 16Mb physical address limit. However as the maximum memory available in any PS/2 is 16Mb this will not cause a problem.

As an option a mathematical co-processor (Intel 80387SX) is available.

5.6 DASD

This section describes the various disk and diskette drives that come as standard or as options for Models 8565-061 and 121.

5.6.1 Diskette drive

Models 8565-061 and 121 are fitted with one 1.44Mb 3.5″ diskette drive. This is supported by a diskette drive cable that attaches directly to the planar board. It is a type 1 diskette controller. The cable can support two 3.5″ diskette drives or one diskette drive and an IBM internal tape backup unit.

NOTE: The signals on the Models 8565-061 and 121 diskette connector differ slightly from those outlined in the *PS/2 Hardware Interface Technical Reference Manual Models 8565-061 and 121 Update* to this manual explains the differences.

The drive can read, write and format HC (720Kb) diskettes.

5.6.2 IBM SCSI Adapter

In Models 8565-061 and 121 the IBM SCSI adapter is used as the fixed disk controller. For more details on the IBM SCSI adapter please refer to Chapter 2.0, "IBM Implementation of SCSI" on page 17

5.6.3 SCSI Fixed Disks

The Models 8565-061 and 121 both come with SCSI fixed disks. The 061 has a 60Mb drive and the 121 a 120Mb drive. The specifications are as follows.

Figure 23. Fixed Disk Drive Specifications

	120Mb Disk	**60Mb Disk**
Formatted Capacity	60Mb	120Mb
Bytes/Sector	512	512
Sectors/Track	32	32
Cylinders	920	920
Sector Buffer Size	32K	32K
No. of Data Heads	4	8
Data Transfer Rate	1.25Mbps	1.25Mbps
Average Seek Time	23ms	23ms
Average latency	8.3ms	8.3ms
Sector Interleave	1:1	1:1

Both of the drives use an asynchronous mode for data transfer across the SCSI bus. They are both 3.5″ disks. One internal bay in Models 8565-061 and 121 supports two SCSI fixed disks (with the installed mounting bracket).

5.6.4 Fixed Disk Upgrades

The Models 8565-061 and 121 can be upgraded using any of the IBM SCSI options. These are the 60Mb, 120Mb or 320Mb SCSI fixed disks. There is also a SCSI CD-ROM drive that comes in two models: A model for internal attachment and a model for external attachment. The maximum hard disk capacity that you could install internally on Models 8565-061 and 121 is 1280Mb. However, in order to achieve this capacity one would have to remove the SCSI fixed disk that comes as standard in the model 8565.

5.7 Other Peripheral Devices

This section describes other storage devices that can be connected to the PS/2 model 8565.

5.7.1 5.25″ Diskette Drives

Only the high capacity 5.25″ diskette drive adapter is supported in the Models 8565-061 and 121. However, this will let you attach both models of the IBM external diskette drive (Model 1 is the low-capacity model supporting 360Kb diskettes and Model 2 is a high-capacity drive supporting 1.2Mb diskettes and 360Kb diskettes), and the internal 5.25″ drive.

5.7.2 Tape Units

You can attach both models of the IBM 6157 Tape Unit to Models 8565-061 and 121. 6157-001 of the tape unit gives a tape capacity of 60Mb and 6157-002 gives 150Mb tape capacity . Both tape units use the same IBM 6157 adapter.

5.7.3 Optical Disk Units

You can attach the IBM Optical Disk unit A11 to Models 8565-061 and 121. You can increase the number of optical disks attached to the same adapter by using the IBM B01 model of the optical disk drive.

5.7.4 IBM Internal Tape Backup Unit

Models 8565-061 and 121 both support the IBM Internal Tape Backup Unit. However, in order to install it you will need both the IBM Internal Tape Backup Unit and the IBM internal tape backup unit installation kit A.

This kit consists of a 1.7″ cable that connects at one end to the tape backup unit connector and at the other end to the diskette attachment cable.

5.8 Graphics

Models 8565-061 and 121 include full VGA function on the planar board. The 8514/A adapter is supported and should be fitted in slot 6, which has the video extension.

5.9 BIOS and Hardware Compatibility

The Models 8565-061 and 121 has both the normal CBIOS and ABIOS routines. The 128Kb of ROM is fully compatible with the PS/2 Models 50,60,70 and 80. This ROM contains basic, POST routines etc. as well as the normal BIOS routines.

5.10 Serial Port

The serial port is a type 2 serial interface. It can only be assigned as COM1 or COM2. This applies even when you have extra serial ports attached. As with most of the PS/2 serial ports, there are slight variations and a programmer using the serial port should read the *8565 BIOS Interface Technical Reference Manual*.

Additional serial ports may be installed using either the IBM Multi-protocol adapter (please ensure that you are using the latest version of this adapter) or the IBM Dual Async Adapter. A maximum of eight serial ports are supported.

5.11 Parallel Port

In common with the rest of the PS/2 family, the parallel port is bi-directional, so it can receive data via the Data Migration Facility, as well as driving a parallel printer. It does not have the DMA parallel feature.

5.12 Security

Models 8565-061 and 121 implement two security features.

- A mechanical lock to allow the user to lock the system unit cover ONLY.
- An optional password stored in CMOS RAM, which, when set, will be prompted for at power on, and will not boot the operating system until the correct password is entered. LAN server password mode can also be set.

5.12.1 Password Forgotten

If the user forgets the password, he/she no longer has to remove the battery to remove the password. It can be done by locating the speaker connector on the planar board, removing and rotating it 180 degrees and reinstalling it. Before doing this, all power and full length adapters must be removed.

5.12.2 SCSI Security

A security issue exists with SCSI and is explained in detail in section 2.7, "SCSI Security" on page 28.

5.13 Expansion Bus

Models 8565-061 and 121 have eight 16-bit Micro Channel I/O slots, slot 6 of which has a video extension for the 8514/A adapter. As discussed earlier the I/O slots will not accept 32-bit adapters. As with all PS/2 systems, care must be taken when installing and removing adapters.

All current Micro Channel adapters are supported in the Models 8565-061 and 121 except for Version 1 of the IBM multi protocol adapter and the 80386 memory options. Memory for Models 8565-061 and 121 will be covered in section 5.15, "Memory" on page 45.

Note: The 80286 memory adapters that have been withdrawn from marketing are not supported by IBM in the 8565 systems.

5.14 Battery and CMOS RAM

There are two battery-driven modules on Models 8565-061 and 121. These are as follows.

1. Real-time clock module.

   This module is a CMOS containing 64 bytes of RAM. This is used to keep track of the date, time and battery level. This data is kept active by a built-in battery even when the system is switched off.

2. NV-RAM module.

   The non-volatile RAM module is CMOS that contains an extra 2Kb of RAM. It is used to store system configuration and security information. This also has a built-in battery feature to keep the information after a system power off.

Functionally, every part of these units is EXACTLY the same as the other PS/2 Micro Channel systems.

5.15 Memory

This section describes how much memory is standard on the IBM PS/2 8565 and how that memory can be expanded.

5.15.1 Planar Board Memory

Both Models 8565-061 and 121 have two memory connectors on the planar board and are shipped with 2Mb already installed. This is in the form of one 2Mb memory module located in connector one with a speed of 100ns.

Both connectors can take either 1Mb, 2Mb or 4Mb memory SIMMs. This makes it possible to install up to 8Mb on the planar board (by removing the 2Mb module and installing two 4Mb modules). However the planar board is populated connector one must always have at least 2Mb installed. Both connectors do not have to be used before memory can be installed on adapters.

The only options supported on the planar board are as follows.

Figure 24. Model 8565 Planar Memory Supported

Model 8565 Planar Memory Options	**Access Time**
1Mb Module	85ns
2Mb Module	85ns/100ns
4Mb Module	80ns

5.15.2 Memory Options

Both models of the 8565 can be expanded up to 16Mb and to do so requires some memory expansion options. The memory expansion adapter supported on the Models 8565-061 and 121 is the IBM 80286 2-8Mb memory expansion option.

It contains dynamic RAM running at a speed of 85 nanoseconds. It comes with four SIMM sockets, one of which is filled with a 2Mb SIMM. The board can be expanded to between 3Mb and 8Mb by using a combination of 1Mb SIMMs and 2Mb SIMMs.

This adapter card comes with a LIM EMS 4.00 driver, which will enable you to use its memory and planar board memory for applications that adhere to LIM EMS 4.00. standards.

5.15.3 Memory and Wait States

Models 8565-061 and 121 implement 0 - 2 wait states. As with the 16MHz Intel 80386 processor the cycle time of the 80386SX is also 67.5 nanoseconds.

The reason that the system has 0-2 wait states is because memory is accessed using a technique called Page Mode Accessing (as on the 80-111 for example). This basically means that when you first address data in memory, the address lines have to be set up and the data received/sent. When the next area of data is addressed, if it is within 2K of the previous data, then most of the address lines can be left as they were and a quicker memory access is achieved. For these reasons the wait states are as follows.

Figure 25. Model 8565 Wait States

Page Mode Accessing	**Wait States**
Read from current page	0 wait states
Read outside current page	1 wait state
Write to current page	1 wait state
Write outside current page	2 wait states

More detailed information on the wait state and paging mechanism can be found in the *Technical Reference Manual Update for the IBM 8565.*

5.15.4 Total System Memory

Models 8565-061 and 121 use 128Kb of RAM to store a copy of the ROM BIOS programs. This is to speed up the access to the ROM BIOS programs. The memory available on Models 8565-061 and 121 will always be 128Kb less than the memory installed.

When a total of 16Mb is installed, a further 256Kb of RAM is used up by the system.

5.16 Comparing the 80386SX Processor

Figure 26. Processor Comparisons

	80286	80386SX	80386
Processor	16-bit	32-bit	32-bit
Register Size	16-bit	32-bit	32-bit
Data Bus	16-bit	16-bit	32-bit
Address Bus	24-bit	24-bit	32-bit
Physical Memory (real mode)	1Mb	1Mb	1Mb
Physical Memory (protect mode)	1Mb	1Mb	1Mb
Virtual address space	1Gb	64Tb	64Tb
Mips	1.2 - 2.0	2.5 - 3.5	3.2 - 6.0

5.17 Important Notes on the 80386SX

1. Full 32-bit internal architecture.
2. 32-bit internal registers.
3. Will run the same applications and operating systems as the Intel 80386
4. 24-bit address bus not 32-bit like the 80386.
5. 16-bit data bus not 32-bit like 80386.

5.17.1 General Discussion of the 80386SX Processor

Both the 80386 and 80386SX processors have the same logical address space. The only difference is that the 80386 has a 32-bit physical address bus and the 80386SX has a 24-bit physical address bus. The 80386SX has a physical memory address space of up to 16 Mb instead of the 4 Gb available to the 80386. Therefore, in the 80386SX system, the operating system must be aware of this physical memory limit and should allocate memory for application programs within this limit.

If an 80386 processor based system uses only the lower 16 Mb of physical address space then there will be no extra effort required to migrate the 80386 software for use on an 80386SX system. Any application that uses more than the 16 Mb of memory can run on the 80386SX if the operating system utilizes the 80386SX's paging mechanism. In spite of this difference in physical address space, the 80386 processor and the 80386SX processor can run the same operating systems and applications within their respective physical memory constraints.

Appendix A. SCSI Devices: Specifications and Installation

IBM currently markets five SCSI devices for attachment to the IBM SCSI adapter. These are:

1. IBM 60Mb SCSI fixed disk
2. IBM 120Mb SCSI fixed disk
3. IBM 320Mb SCSI fixed disk
4. IBM Internal SCSI CD-ROM drive
5. IBM External SCSI CD-ROM drive

This document will provide specifications and configuration instructions for each of these SCSI devices.

A.1 SCSI Device Specification

The following section details the specifications for each of the IBM SCSI devices.

A.1.1 IBM SCSI Fixed Disk Drives

IBM offers three SCSI fixed disk drives. These are the 60Mb, 120Mb, and 320Mb fixed disk drives.

The specifications are as follows.

Figure 27. SCSI Fixed Disk Drive Specifications

	60Mb Disk	**120Mb Disk**	**320Mb Disk**
Formatted Capacity	60Mb	120Mb	320Mb
Bytes/Sector	512	512	512
Sectors/Track	32	32	48
Cylinders	920	920	949
Sector Buffer Size	32K	32K	64K
No. of Data Heads	8	4	14
Data Transfer Rate	1.25Mbps	1.25Mbps	4Mbps
Average Seek Time	23ms	23ms	12.5ms
Average Latency	8.3ms	8.3ms	6.95ms
Sector Interleave	1:1	1:1	1:1

A.1.1.1 IBM 60Mb and 120Mb SCSI Fixed Disk Drives

The IBM 60Mb and 120Mb SCSI fixed disk drives are both 3.5" SCSI devices. They conform to the ANSI Standard X3.131-1986 for SCSI devices. They both support SCSI asynchronous mode across the SCSI bus.

They can be installed in any of the PS/2 floor-standing systems (8560, 8565 and 8580). They cannot be installed externally to the PS/2 floor-standing systems or internally to the desktop PS/2 systems (8530, 8550, 8555 & 8570).

A.1.1.2 IBM 320Mb SCSI Fixed Disk Drive

This is a technologically advanced fixed disk drive. It is a 3.5" SCSI device and conforms to the ANSI Standard X3.131-1986 for SCSI devices. It supports SCSI synchronous mode across the SCSI bus.

Its performance is increased by a built-in 64KB look-ahead buffer. Performance of this drive will be further enhanced if a system cache is used.

It can be installed in all of the PS/2 floor-standing systems (8560, 8565 and 8580) but not in any of the desktop PS/2 systems. It cannot be installed as an external SCSI device.

A.1.1.3 IBM 320Mb Fixed Disk "Tapping" Noise

When you first power on the PS/2 floor-standing system with a 320Mb SCSI fixed disk installed you will notice that approximately every two minutes the disk will make a tapping sound. This will happen for the first 30 minutes and then approximately once every 60 minutes.

The tapping indicates that the drive is recalibrating to compensate for any changes in temperature that occur while it is warming up. During this warm-up period, the head assembly, platters etc. inside the drive physically change shape until they settle at a constant temperature.

The 320Mb SCSI drive also has heat sensors that will force a recalibration if the temperature around the drive changes by about three degrees.

The tapping does not indicate a faulty drive. It is purely an indication of the advanced technology used in the IBM SCSI 320Mb fixed disk drive.

A.1.1.4 IBM PS/2 SCSI Fixed Disk Drive Kit A

This supports the installation of two additional SCSI fixed disk drives in the PS/2 Models 8580, 8565 and 8560 with a PS/2 Micro Channel SCSI Adapter installed. The kit contains a mounting bracket, cables and installation instructions.

It is required for installing additional fixed disk drives in these models. Please see Section 2.3.1, "Internal Connections" on page 20 for more details.

A.1.2 IBM Compact Disc Read Only Media SCSI Device

IBM currently markets two models of CD-ROM drive. One is an internal device and one is for external attachment. Functionally they are the same. They differ only in their physical appearance and setup.

Both of the IBM CD-ROM drives have the following specifications:

- Supports the industry standard 600Mb compact disc

- Read-only devices
- Analog stereo output jack
- 380ms average access time
- 5.25″ half height form factor.

Each of the CD-ROM drives comes with a compact disc caddy, a compact disc for test purposes and an option/device driver diskette.

A.2 Configuration of SCSI Devices

The following section overviews the procedure for installing and configuring IBM SCSI devices.

A.2.1 Assigning SCSI IDs

Each SCSI device connected to the IBM SCSI adapter must be assigned, at the time of installation, a unique SCSI identification number (ID). The SCSI ID can be any number from 0 - 6. The SCSI ID you select determines the priority of the device. See Section 1.5.1, "SCSI Device Addressing" on page 5 for more details.

A.2.2 Selecting a SCSI ID

Before choosing the SCSI ID for your SCSI device you must first check to see what SCSI IDs are already being used. This is important as no two SCSI devices attached to the same IBM SCSI adapter can have the same SCSI ID number.

To find this information you must first boot the system with the reference diskette. Then select *Set Configuration* from the main menu and then select *SCSI Device Configuration*.

The SCSI ID for each installed SCSI device is displayed in the form of two numbers (for example 6,0). The first number is the SCSI ID assigned to the particular SCSI device.

If there are no SCSI devices connected to the SCSI adapter, the screen will show only the slot that the SCSI adapter is installed in, and the SCSI ID assigned to the IBM SCSI adapter, which is usually seven.

Choose a SCSI ID number for your new device and set the switches or jumpers as outlined in the section for your particular device.

A.3 SCSI Fixed Disk Drives - Setup Instructions

This section explains how the SCSI ID is set for each of the SCSI fixed disk drives.

A.3.1 IBM 60Mb/120Mb SCSI Fixed Disk Drive

A set of four switches are used to set the SCSI ID for these devices. These four switches are located towards the connector end of the fixed disk drive.

The "ON" position for each switch is toward the connector end of the drive.

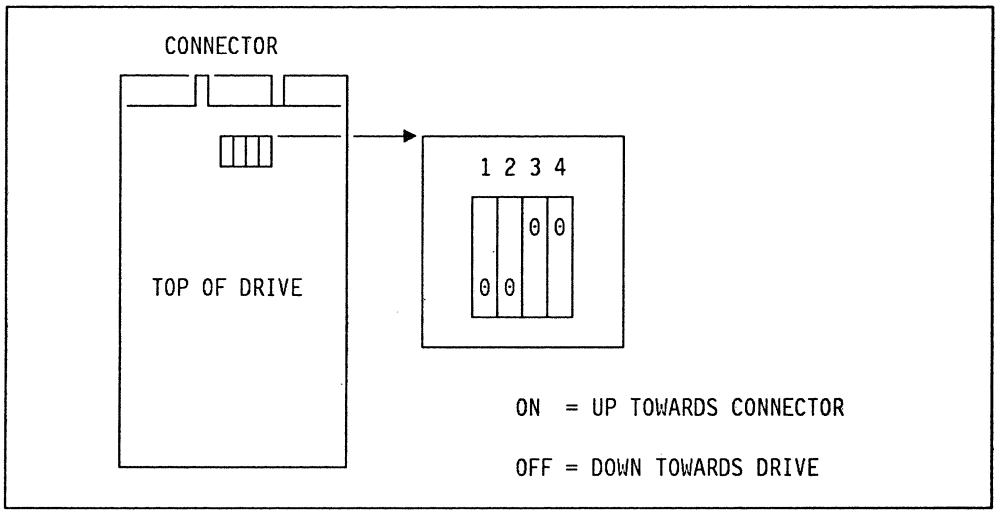

Figure 28. SCSI ID Switches for IBM 60Mb/120Mb SCSI Fixed Disk Drive

Figure 29 shows how these four switches should be set in order to determine the SCSI ID.

Figure 29. Switch Setting: IBM 60Mb/120Mb SCSI Fixed Disk Drive

SCSI ID	Switch 1	Switch 2	Switch 3	Switch 4
SCSI ID 6	OFF	ON	ON	ON
SCSI ID 5	ON	OFF	ON	ON
SCSI ID 4	OFF	OFF	ON	ON
SCSI ID 3	ON	ON	OFF	ON
SCSI ID 2	OFF	ON	OFF	ON
SCSI ID 1	ON	OFF	OFF	ON
SCSI ID 0	OFF	OFF	OFF	ON

- Check to see that switch 4 is set to the "ON" position. If switch 4 is not set to the "ON" position, set the switch to "ON".
- Set switches 1,2 and 3 to correspond to the SCSI ID you just assigned to this fixed disk drive. Remember, the "ON" position is toward the connector end of the drive.

Terminator: IMPORTANT: Refer to section 2.3.3, "Terminator Positioning" on page 21 for details on where terminators are to be installed.

The terminators for the 60Mb and 120Mb drives are located on the bottom of the drive. They are in the form of three tags marked *T-RES*. All three must be either installed or removed.

A.3.2 IBM 320Mb SCSI Fixed Disk Drive

The SCSI ID for the IBM 320Mb SCSI fixed disk drive is set by a combination of jumpers and three pairs of pins.

The pins are located on the connector end of the drive. The three vertical pairs of pins nearest the left-hand side of the drive are used to set the SCSI ID.

For example Figure 30 shows how jumper pin sets 2 and 3 set up the drive with a SCSI ID of 6.

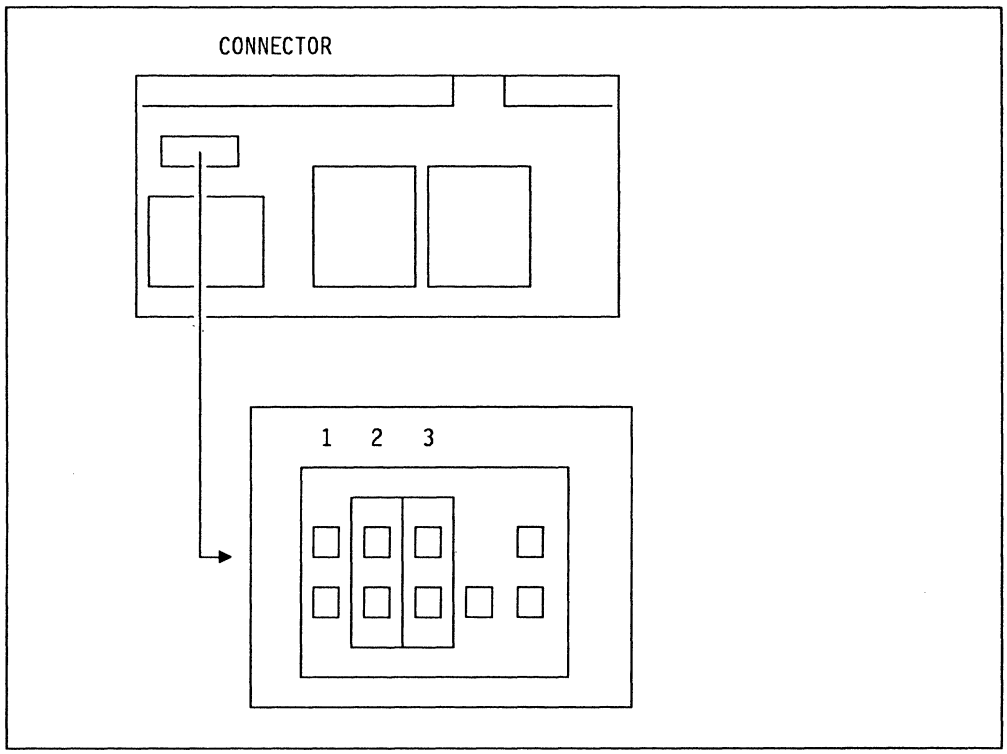

Figure 30. SCSI ID Jumpers for IBM 320Mb SCSI Fixed Disk Drive

Figure 31 shows how these three jumpers should be set in order to determine the SCSI ID. Refer to it to confirm that you have installed the jumpers correctly for the SCSI ID you assigned to this drive.

Figure 31. Switch Setting: IBM 320Mb SCSI Fixed Disk Drive

SCSI ID	Switch 1	Switch 2	Switch 3
SCSI ID 6		Jumper	Jumper
SCSI ID 5	Jumper		Jumper
SCSI ID 4			Jumper
SCSI ID 3	Jumper	Jumper	
SCSI ID 2		Jumper	
SCSI ID 1	Jumper		
SCSI ID 0			

- To remove a jumper, pull it horizontally away from the drive. To install a jumper, line up the two holes in the bottom of the jumper with the appropriate two pins on the drive. Then push the jumper down onto the pins until the jumper is completely seated and covers both pins.
- Store any jumpers you do not use in a safe place in case you need them for future configuration changes.

Terminator: IMPORTANT: Refer to section 2.3.3, "Terminator Positioning" on page 21 for details on where terminators are to be installed.

The terminator for the 320Mb drive plugs into the rear connector of the drive and then the SCSI cable plugs into the terminator. Do not use this terminator on any other device.

A.4 IBM SCSI CD-ROM Drives and Setup Instructions

This section explains how the CD-ROM drives and their drivers need to be set up.

A.4.1 IBM Internal CD-ROM Drive: Setting SCSI ID

Switches are used on the internal CD-ROM drive to set the SCSI ID. These are located at the connector end of the drive. The switches marked 1, 2 and 4 are used to set the SCSI ID.

The "1" position for each switch indicates that it is in the "ON" position.

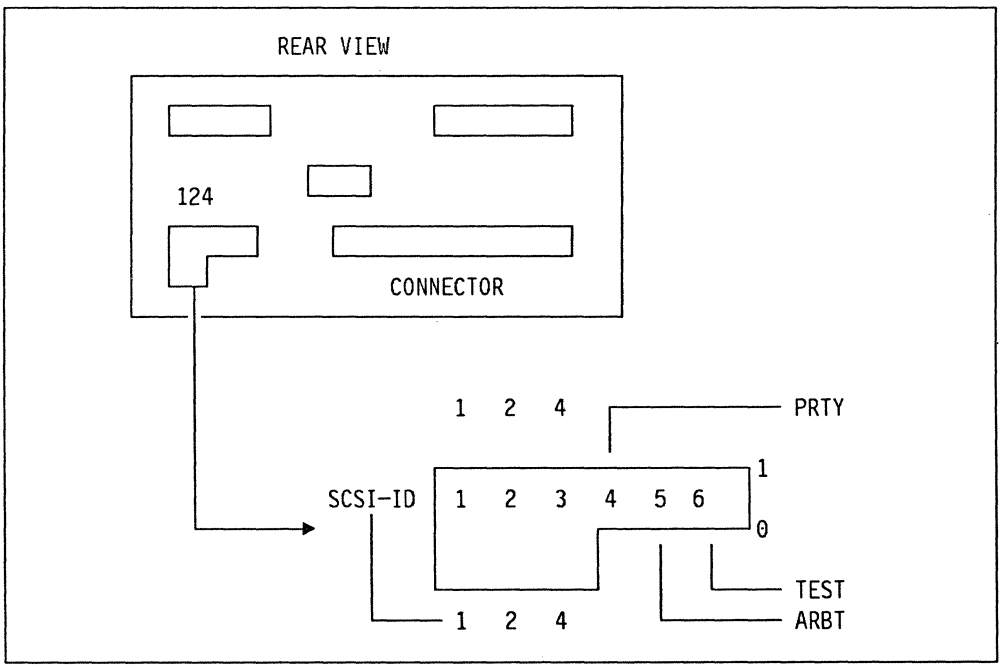

Figure 32. SCSI ID Switches for IBM Internal CD-ROM Drive

Figure 33 shows how switches 1,2, and 4 should be set in order to determine the SCSI ID.

Figure 33. Switch Setting: IBM Internal CD-ROM Drive			
SCSI ID	**Switch 1**	**Switch 2**	**Switch 4**
SCSI ID 6	ON	ON	ON
SCSI ID 5	ON	OFF	ON
SCSI ID 4	ON	ON	OFF
SCSI ID 3	ON	ON	OFF
SCSI ID 2	OFF	ON	OFF
SCSI ID 1	ON	OFF	OFF
SCSI ID 0	OFF	OFF	OFF

Set switches 1,2, and 4 to correspond to the SCSI ID that you wish to assign to the CD-ROM drive.

Terminator: IMPORTANT: Refer to section 2.3.3, "Terminator Positioning" on page 21 for details on where terminators are to be installed.

The terminator for the internal CD-ROM drive is located on the top of the drive under a plastic seal. Both of the tags marked *T-RES* must be either installed or removed.

A.4.2 IBM External CD-ROM Drive: Setting SCSI ID

Locate the only switch on the connector end of the drive. When you push the switch, the SCSI ID will rotate from 0 through 6. Stop at the SCSI ID you wish to assign to this drive.

Whenever the switch is changed the CD-ROM drive must be powered off.

A.4.3 Terminator

IMPORTANT: Refer to section 2.3.3, "Terminator Positioning" on page 21 for details on where terminators are to be installed.

The terminator for the external CD-ROM drive plugs into the bottom socket at the back of the drive.

A.4.4 Using Audio Compact Discs

When inserting an audio CD into either of the IBM CD-ROM drives it MUST be placed into the special caddy first. Inserting CD-ROM disks without the caddy may damage the CD and the IBM CD-ROM drive. Special programs are available both under DOS as well as under OS/2 to play audio CDs through the front headphone jack of the CD-ROM drive.

A.4.5 Installing CD-ROM Device Drivers

With both models of the IBM CD-ROM drives you get a special option/device driver diskette.

This diskette contains.

1. Diagnostic programs.

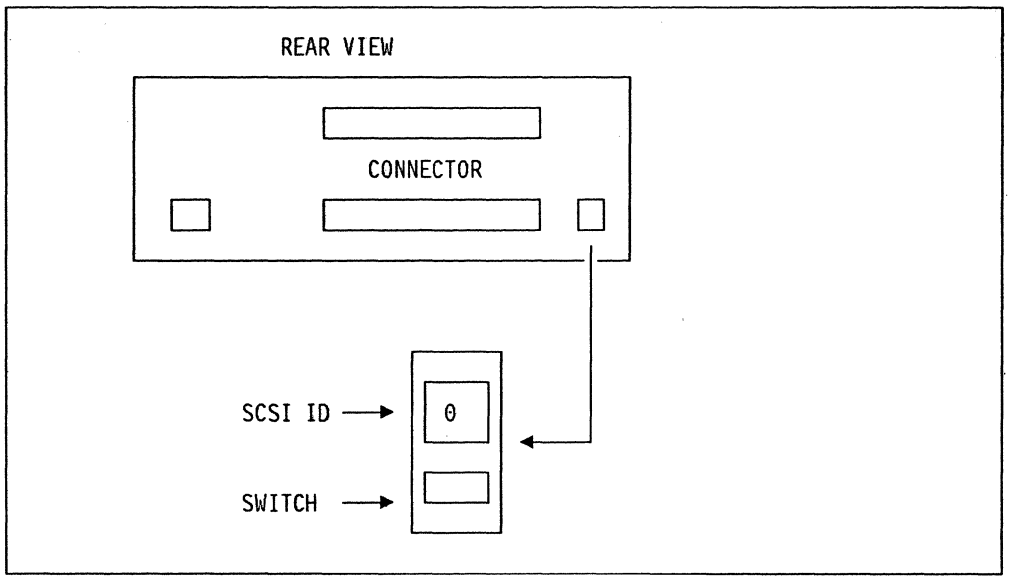

Figure 34. ID Switches for IBM External CD-ROM Drive

2. Support for DOS
   - An installation program for the device driver.
   - ROM BIOS extension for the CD-ROM to be used under DOS.
   - A device driver program.
   - A file called IBMCDPLY.EXE that allows you to play an audio CD under DOS.
3. Support for OS/2
   - ROM BIOS extension for the CD-ROM to be used under OS/2 V1.2.
   - .DLL and .MSG files to be used under OS/2.
   - A file called PLAYCD.EXE that allows you to play an audio CD under OS/2.

Before you can run diagnostics on the CD-ROM drive you must copy the option diskette onto your reference diskette. This must be done using the *copy an option diskette* option. Diagnostics files will be copied to the reference diskette.

A.4.5.1 Installation under DOS

To install the device drivers, at the C: prompt (with the option diskette in the A: drive) type *A:INSTALL*. The screen menus will then tell you how to install the drivers.

The installation program will add lines to your AUTOEXEC.BAT and your CONFIG.SYS. The following explains what these are:

AUTOEXEC.BAT: The installation program copies the line

\MSCDEX /D:IBMCD001

to your AUTOEXEC.BAT. Parameters can be added or removed to the MSCDEX program. They are as follows:

- /D:driver name.

This indicates the device driver that the program must use to access the CD-ROM player. The device driver that the IBM CD-ROM drives use is IBMCD001.

- /L:drive letter.

  Normally the IBM CD-ROM drive will be given the next available drive letter unless this parameter is used. It tells the system where to start assigning the IBM CD-ROM drives drive letters. So if you specified /L:T, the first IBM CD-ROM drive would be drive T and the following drives U, V, etc.

- /M:value.

  Indicates how much system memory is to be used for caching of the IBM CD-ROM drive information. The higher the value, the better the performance but the less memory is available for application programs. The "value" is just a normal number where 1 indicates 2KB of system memory.

- /V

  This passes information about memory usage to the user.

CONFIG.SYS: The installation program copies the line

Device= \IBMCDROM.SYS /D:IBMCD001

into your CONFIG.SYS file.

There are no parameters that can be added to this statement.

IBMCDPLY.EXE: This program enables you to play normal audio compact discs. It can only be run from the DOS prompt. To run the program type IBMCDPLY at the DOS prompt. On the screen you will be presented with a control panel for using the drive. Keys simulate the functions such as track number, eject etc. Volume is controlled with the control dial on the front of the drive.

A.4.5.2 Installation under OS/2

CD-ROM is only supported under OS/2 V1.2 (Standard and Extended Editions).

To install the OS/2 support, use the **DDINSTAL** utility that is part of OS/2 V1.2. Type "DDINSTAL" in an OS/2 window and follow the instructions given on the display. DOS programs running in the DOS compatibility box will work as long as they are using standard DOS file calls to access the device. If a program tests for MSCDEX (the DOS device driver) presence as a condition of operation, it will fail.

The installation program copies following files into your OS/2 system on disk:

- SCSI.SYS into C:\OS2
- CDROM.SYS into C:\OS2
- LPFS.IFS into C:\OS2
- DEV002.MSG into C:\OS2\SYSTEM
- PLAYCD.EXE into C:\

CONFIG.SYS: The installation program copies the following lines into your CONFIG.SYS file:

- DEVICE=C:\OS2\SCSI.SYS /N:4
- DEVICE=C:\OS2\CDROM.SYS /N:4
- IFS=C:\OS2\LPFS.IFS

The parametera are defined as follows:

- /N in DEVICE=SCSI.SYS

  Number of devices (default is 4).

  N may be any number from 1 to 4, as the maximum number of supported SCSI adapters is four.

- /N in DEVICE=CDROM.SYS

  Number of devices (default is 4).

  N may be any number from 1 to 7, as the maximum number of supported CD-ROM devices is seven. The CR-ROM device is accessed with the next available drive letter. For instance, if you have disk drives C: and D: generated in your system, the CD-ROM device will be allocated as the E: drive.

- LPFS.IFS is the filesystem which handles the CD-ROM file organization.

PLAYCD.EXE: This program enables you to play normal audio compact discs. It can be run from an OS/2 window or and OS/2 full screen session (but not from the DOS compatibility box). To run the program type PLAYCD at the command prompt. On the screen you will be presented with a control panel for using the drive. Keys simulate the functions such as track number, eject etc. Volume is controlled with the control dial on the front of the drive.

A.5 Installation Notes for DOS

If DOS is used on PS/2 systems with 80386, 80386SX or 80486 processor, following points should be carefully reviewed.

If an IBM CD-ROM is installed, proceed with Section A.5.3, "Update Program for CD-ROM" on page 59.

A.5.1 Update Program

If running DOS and using a 386, 386SX or 486 processor the user should run the update program supplied on the system reference diskette. If this program is NOT installed one may experience problems with the following:

- Multi-tasking DOS programs
- Programs using 80386 specfic instructions
- Programs using the 80386 in virtual 8086 mode
- Programs that use EMS or extended memory.

A.5.2 Installing the Update Program

Under the DOS prompt,insert the reference diskette into Drive A:and type A:INSTDBUF. Press enter. Follow the instructions on the screen to complete the installation.

This installation procedure copies the file DISK386.SYS from the reference diskette to the root directory of the boot disk. It also adds the statement DEVICE=\DISK386.SYS to the CONFIG.SYS file,

A.5.3 Update Program for CD-ROM

If an IBM CD-ROM drive is installed, do not install the above.

Instead install the GEN386.SYS program from the CD-ROM device driver diskette. To do this insert the CD-ROM Device Driver Diskette when you are under the DOS prompt. Type A:INSTGENS and press enter. Follow the instructions on the screen.

Appendix B. IBM SCSI POST Error Codes

This section contains a list of all IBM SCSI POST error codes. Codes here can be used to determine errors that occur on the IBM SCSI adapter and any attached SCSI devices. Further information can be found in the *IBM Hardware Maintenance and Service Manual* for the IBM SCSI adapter and the various SCSI devices.

B.1 Error Code Format

With the new IBM SCSI adapter and SCSI devices come a new set of error codes. The error codes that occur during POST have the format shown in Figure 35.

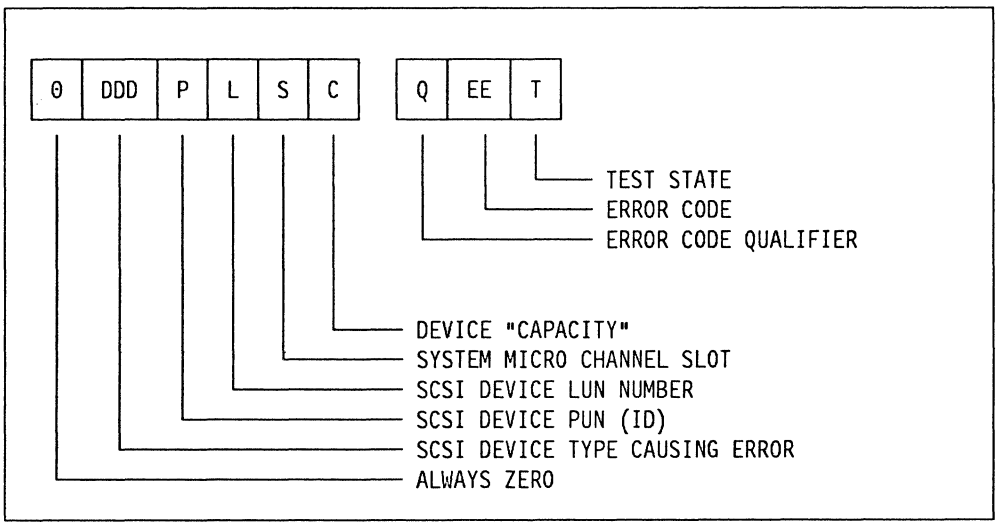

Figure 35. IBM SCSI POST Error Code Format

Figure 35 shows the error code format. The next few sections show what each part indicates.

"0" Always zero: This is the first digit of the error code and is always 0.

"DDD" SCSI device causing error: This part shows the SCSI device which causes the error. For example 112 indicates that a 16-bit non-cached SCSI adapter is causing the error. See B.1.1, "SCSI Device Causing Error" on page 62 for a list of what the device codes are.

"P" SCSI device PUN (ID): This part shows the SCSI device Physical Unit number or SCSI ID.

"L" SCSI Device LUN: This part shows the SCSI device Logical Unit number. For a SCSI adapter it will show zero.

"S" System Micro Channel slot: This part shows the Micro Channel slot number. If "S" equals 0 then DDD will be 096 or 112. You must go to B.1.2, "Generic Errors ("S" = 0)" on page 62 to determine the error. If "S" is not equal to 0 there is error on the adapter (or device attached to the adapter) in slot "S".

"Q" Error code qualifier: This part indicates the error code qualifier and can be 0 through 7. Go to section B.1.3, "Error Codes with "Q" = 0" on page 63 and choose the section which corresponds to the value of "Q" that you have.

B.1.1 SCSI Device Causing Error

This section decodes the DDD part of the error code.

```
DDD : 096 : 32-BIT CACHED SCSI ADAPTER
      112 : 16-BIT NON-CACHED SCSI ADAPTER

      208 : UNKNOWN SCSI DEVICE TYPE
      209 : DIRECT ACCESS - REMOVABLE MEDIA AND/OR
            OTHER THAN 512 BYTE BLOCKS
      210 : DIRECT ACCESS - NON REMOVABLE MEDIA. 512
            BYTE BLOCKS (FIXED DISK)
      211 : SEQUENTIAL ACCESS (IE. TAPE)
      212 : PRINTER
      213 : PROCESSOR
      214 : WRITE ONCE, READ MULTIPLE (W.O.R.M.)
      215 : READ ONLY (IE. CD-ROM)
      216 : SCANNER
      217 : OPTICAL MEMORY
      218 : CHANGER (IE. MULTIPLE TRAY CD-ROM OR JUKEBOX)
      219 : COMMUNICATIONS
```

Figure 36. SCSI Device Causing error

B.1.2 Generic Errors ("S" = 0)

When "S" is 0, DDD will be 096 or 112.

```
DDD0100 0000 : NO SETUP DATA AVAILABLE ON SYSTEMS WITH
               NVRAM.  THIS MEANS SCSI SETUP DATA WAS NOT
               LOCATED OR THE CHECKSUM DID NOT VERIFY.
               ON SYSTEMS WITHOUT NVRAM (MODEL 50 FOR
               EXAMPLE) SETUP DATA MUST BE ON 1ST
               NON-SCSI FIXED DISK.

DDD0200 0000 : NO FIXED DISK AT PUN 6. LUN 0 FOR 161,
               162, 165 SYSTEM ERROR PATH

DDD0300 0000 : NO SPACE AVAILABLE IN EXTENDED BIOS DATA
               AREA FOR SCSI DATA TABLE

DDD04Q0 0000 : ROM MODULES NOT FOUND ON ADAPTER

DDD0500 0000 : ROM CHECKSUM ERROR ON 2ND 16K PORTION OF
               32K ROM
```

Figure 37. Generic Errors (S=0)

B.1.3 Error Codes with "Q" = 0

A value of "-" in any of the following error codes may be any character.

```
 96---- 001- : 80188 ROM TEST FAILURE
 96---- 002- : LOCAL RAM TEST FAILURE
 96---- 003- : EXTERNAL TERMINATOR MISSING OR FUSE BAD
 96---- 004- : 80188 INTERNAL PERIPHERAL TEST FAILURE
 96---- 005- : BUFFER CONTROL CHIP TEST FAILURE
 96---- 006- : BUFFER RAM TEST FAILURE
 96---- 007- : SYSTEM INTERFACE CONTROL CHIP TEST FAILURE
 96---- 008- : SCSI INTERFACE TEST FAILURE

112---- 001- : 8032 ROM TEST FAILURE
112---- 002- : LOCAL RAM TEST FAILURE
112---- 003- : LOCAL RAM ADDRESS TEST FAILURE
112---- 004- : 8032 INTERNAL PERIPHERAL TEST FAILURE
112---- 005- : BUFFER CONTROL CHIP TEST FAILURE
112---- 006- : UNDEFINED ERROR CONDITION
112---- 007- : SYSTEM INTERFACE CONTROL CHIP TEST FAILURE
112---- 008- : SCSI INTERFACE TEST FAILURE
```

Figure 38. Error Codes with Q=0

B.1.4 Error Codes with "Q" = 1

```
QEE : 107 : ADAPTER HARDWARE FAILURE
      10C : COMMAND FAILED
      10E : COMMAND ERROR (INVALID COMMAND OR PARAMETER)
      10F : SEQUENCING ERROR
      180 : TIME OUT
      181 : ADAPTER BUSY ERROR
      182 : UNEXPECTED INTERRUPT PRESENTED BY ADAPTER
      183 : ADAPTER REGISTER TEST FAILURE
      184 : ADAPTER RESET (VIA BCR) FAILURE
      185 : ADAPTER BUFFER TEST FAILURE (CACHED
            ADAPTER ONLY)
      186 : ADAPTER RESET COUNT EXPIRED
      187 : ADAPTER REGISTERS NOT CLEARED ON RESET
            (POWER ON OR CHANNEL RESET)
      188 : CARD ID IN ADAPTER MICROCODE DID NOT MATCH
            ID IN POS REGISTERS
      190 : EXPECTED DEVICE DID NOT RESPOND (NOT POWERED
            ON AND SHOULD BE IF DEVICE NUMBER IS NOT 096
            OR 112)
      19X : DMA ARBITRATION LEVEL CONFLICT (IF DEVICE
            NUMBER IS 096 OR 112)
```

Figure 39. Error Codes with Q=1

B.1.5 Error Code with "Q" > 1

All error codes with "Q" > 1 are developed using information returned by either the adapter or a device. The "Q" value defines the origin of the "EE" code that is reported.

Error codes (EE) with "Q" = 4 or 5 may be reported that are not listed here or may actually have a different definition to those given. Those are dependent on the device.

The error codes defined here were obtained from the Common Command Set (Rev 4.B) of the ANSI SCSI-1 Specification. Error codes with "Q" = 2, 3, or 6 are defined in the IBM SCSI Adapter Technical Reference.

```
"Q" = 2 - Command Error field of Command Complete Status
          block returned by the adapter
    = 3 - SCSI Status field of the Command Complete
          Status  block or Command Error field values
          indicating software problems (less than 20H)
    = 4 - Sense Key value returned by a device
    = 5 - Additional Sense byte (byte 12) of Sense
          information from device
    = 6 - Device Error code field of Command Complete
          Status block
    = 7 - Device errors not normally considered an error
          but considered an error based on when the code
          was returned.
          (ie. Medium Corrupted error on device with non
          removable media)
```

Figure 40. Error Codes with Q>2

"Q" = 2

```
220 : ADAPTER HARDWARE ERROR
221 : GLOBAL TIMEOUT ON ADAPTER (DEVICE DID NOT RESPOND)
222 : ADAPTER DMA ERROR
223 : ADAPTER BUFFER DEFECTIVE
224 : COMMAND ABORTED BY ADAPTER
```

Figure 41. Error Codes with Q=2

"Q" = 3

```
301 : INVALID PARAMETER IN SCB
303 : COMMAND NOT SUPPORTED
304 : COMMAND ABORTED BY SYSTEM
305 : COMMAND REJECTED (BUFFER NOT DISABLED)
306 : COMMAND REJECTED (ADAPTER DIAGNOSTIC FAILURE)
307 : FORMAT REJECTED
308 : ASSIGN REJECTED (COMMAND IN PROGRESS)
309 : ASSIGN REJECTED (DEVICE ALREADY ASSIGNED)
30A : COMMAND REJECTED (DEVICE NOT ASSIGNED)
30B : COMMAND REJECTED (MAXIMUM LBA EXCEEDED)
30C : COMMAND REJECTED (16 BIT CARD SLOT ADDRESS EXCEEDED)
313 : INVALID DEVICE FOR COMMAND
3FF : STATUS NOT RETURNED BY ADAPTER (CCSB ALL 0)
```

Figure 42. Error Codes with Q=3

"Q" = 4

```
401 : RECOVERED ERROR (NOT CONSIDERED AN ERROR CONDITION)
402 : DEVICE NOT READY
403 : DEVICE MEDIUM ERROR
404 : DEVICE HARDWARE ERROR
405 : ILLEGAL REQUEST FOR DEVICE
406 : DEVICE UNIT ATTENTION WOULD NOT CLEAR
407 : DEVICE DATA PROTECT ERROR
409 : DEVICE VENDOR UNIQUE ERROR
40A : DEVICE COPY ABORTED
40B : DEVICE COMMAND ABORTED
40C : DEVICE SEARCH DATA COMMAND SATISFIED
40D : DEVICE VOLUME OVERFLOW (RESIDUAL DATA REMAINS IN
      BUFFER)
40E : DEVICE MISCOMPARE (SOURCE DATA DID NOT MATCH MEDIUM
      DATA)
```

Figure 43. Error Codes with Q=4

"Q" = 5

```
501 : NO INDEX OR SECTOR
502 : SEEK INCOMPLETE
503 : WRITE FAULT
504 : DRIVE NOT READY
505 : DRIVE NOT SELECTED
506 : NO TRACK ZERO FOUND
507 : MULTIPLE DRIVES SELECTED
508 : LOGICAL UNIT COMMUNICATION FAILURE
509 : HEAD POSITIONING ERROR (TRACK FOLLOWING ERROR)
510 : CRC OR ECC ERROR ON ID FIELD
511 : UNRECOVERABLE READ ERROR
512 : NO ADDRESS MARK (ID FIELD)
513 : NO ADDRESS MARK (DATA FIELD)
514 : RECORD NOT FOUND
515 : SEEK ERROR
516 : DATA SYNCHRONIZATION ERROR
517 : RECOVERABLE READ (WITHOUT ECC) ERROR
518 : ECC RECOVERED READ ERROR
519 : DEFECT LIST ERROR
51A : PARAMETER OVERRUN
51B : SYNCHRONOUS TRANSFER ERROR
51C : PRIMARY DEFECT LIST NOT FOUND
51D : COMPARE ERROR
520 : INVALID COMMAND
521 : ILLEGAL LOGICAL BLOCK ADDRESS (LBA)
522 : ILLEGAL FUNCTION FOR DEVICE TYPE
524 : ILLEGAL COMMAND BLOCK FIELD
525 : INVALID LUN
526 : ILLEGAL FIELD IN PARAMETER LIST
528 : MEDIA CHANGED
529 : POWER ON OR BUS DEVICE RESET OCCURRED (NOT AN
      ERROR)
52A : MODE SELECT PARAMETERS CHANGED (NOT AN ERROR)
531 : MEDIUM FORMAT CORRUPTED
532 : DEFECT SPARE LOCATION UNAVAILABLE
540 : DEVICE RAM FAILURE
541 : DATA PATH DIAGNOSTIC FAILURE
542 : POWER ON DIAGNOSTIC FAILURE
543 : MESSAGE REJECTED
544 : INTERNAL CONTROLLER ERROR
545 : DEVICE WAS UNABLE TO RE-CONNECT
547 : INTERFACE PARITY ERROR
548 : INITIATOR DETECTED ERROR
549 : ILLEGAL COMMAND OR COMMAND OUT OF SEQUENCE ERROR
5F0 : FORMAT IN PROGRESS (NOT AN ERROR)
5F1 : SPIN UP IN PROGRESS
```

Figure 44. Error Codes with Q=5

"Q" = 6

```
601 : SCSI BUS RESET OCCURRED
602 : SCSI INTERFACE FAULT
610 : SELECTION TIMEOUT ERROR (DEVICE NOT AVAILABLE)
611 : UNEXPECTED BUS FREE
612 : MANDATORY SCSI MESSAGE REJECTED
613 : INVALID SCSI PHASE SEQUENCE
620 : SHORT LENGTH RECORD ERROR
```

Figure 45. Error Codes with Q=6

"Q" = 7

```
702 : DEVICE NOT READY (REMOVABLE MEDIA DEVICES)
704 : DEVICE NOT READY (NON-REMOVABLE MEDIA DEVICES)
728 : MEDIA CHANGED ERROR WOULD NOT CLEAR
731 : MEDIUM FORMAT CORRUPTED
      (FORMAT UNIT INTERRUPTED - FORMAT MUST BE RE-ISSUED)
7F0 : FOMAT IN PROGRESS (PRIOR FORMAT UNIT ISSUED BEING
      COMPLETED)
7F1 : SPINUP IN PROGRESS
```

Figure 46. Error Codes with Q=7

B.1.6 Test State in Which Failure Occurred (T)

Please refer to the information below to see test state in which failure occurred.

```
0 : NOT APPLICABLE FOR ERROR CODE
A : ADAPTER INITIALIZATION
B : ADAPTER RESET
C : ADAPTER REGISTEK TESf
D : ADAPTER BUFFER TEST PHASE 1 (CACHED ADAPTER ONLY)
E : ADAPTER BUFFER TEST PHASE 2 (CACHED ADAPTER ONLY)
F : ADAPTER BUFFER TEST PHASE 3 (CACHED ADAPTER ONLY)
G : ADAPTER BUFFER TEST PHASE 4 (CACHED ADAPTER ONLY)
H : ADAPTER INFORMATION TEST STATE
    (BUFFER ENABLE. BUFFER SIZE, RETRY ENABLE, ETC.)
I : DEVICE ASSIGNMENT SEQUENCE
J : DEVICE NOT READY (ALSO INITIAL UNIT ATTENTION
    CLEARING)
K : DEVICE RESET
L : DEVICE STARTING PHASE (APPROPRIATE DEVICES ONLY)
M : DEVICE IN PROCESS OF STARTING (WAIT FOR DEVICE TO
    BECOME READY)
N : DEVICE BLOCK SIZE DETERMINATION
O : DEVICE SELF TEST
P : DEVICE SINGLE BLOCK (LBA) READ
Q : DEVICE DOUBLE BLOCK (LBA) READ
S : ERROR OCCURRED AFTER DEVICE TESTING HAD COMPLETED
```

Figure 47. Test State in which Error Occurred (T)

Glossary

A

arbitration. A method with which multiple devices attached to a single bus can bid to get control of that bus.

asynchronous. A mode of data transfer across the SCSI Bus where each byte of data transferred must be acknowledged as received by the target before the next byte can be sent. Maximum transfer rate possible 2Mbps.

B

Bus Master. An intelligent device that when attached to the Micro Channel bus can bid for and gain control of the Micro Channel bus to perform its specific task.

C

CCS. The SCSI Common Command Set. A set of SCSI commands that is specified in the ANSI standard that all SCSI device must be able to use in order to be fully compatible with the ANSI standard.

CD-ROM. Compact Disk Read Only Media is a disc that you can only read data from. Data cannot be written to CD-ROM.

D

Device Level Copying. When two devices attached to the SCSI Bus perform data transfers between each other across the SCSI Bus without using the attachment feature.

disconnect. When a device has received a command and disconnects from the SCSI Bus to enable other device to use the SCSI Bus while it processes its command.

DMA. Direct Memory Access. A method used to transfer data directly from device to system memory without using the main system processor.

I

initiator. A device attached to the SCSI Bus that sends a command to another device on the SCSI Bus. The device that receives that command is a Target.

L

logical unit. A device attached to a SCSI device and is NOT attached directly to the SCSI Bus.

LUN. Logical Unit Number. A number given to a device that is attached to a SCSI device and not directly to the SCSI Bus. The device is known as a Logical Unit.

P

PUN. Physical Unit Number. Another term used to describe a device attached directly to the SCSI Bus. Also known as a SCSI Device or SCSI ID.

R

reconnect. When a device that has finished processing a command arbitrates for the SCSI Bus in order to reconnect to it to perform its data transfer.

S

SCSI. Stands for Small Computer Systems Interface. Defines the interface between an attachment feature and intelligent devices.

SCSI Attachment Feature. The feature that attaches to the main system unit and the SCSI Bus. It is the controlling feature of the SCSI subsystem.

SCSI bus. A term used to describe the 50-Conductor cable that attaches intelligent devices to the SCSI attachment feature.

SCSI device. An intelligent device that is directly attached to the SCSI Bus. It conforms to the ANSI Standard X3.131-1986 for attached SCSI devices.

SCSI ID. A number configured on a SCSI device so that it can be accessed on the SCSI Bus. Each SCSI device has a unique SCSI ID number. It is in the range 0 t0 7.

synchronous. A mode of data transfer across the SCSI Bus where each byte of data transferred does not have to be acknowledged as received by the target device before the next byte can be sent. Maximum transfer rate possible 5 Mbps.

T

target. A device attached to the SCSI Bus that receives and processes commands sent from another device on the SCSI Bus. The device that sends the command is known as an Initiator.

terminator. A piece of hardware that must be attached to both ends of the 50-Conductor SCSI attachment cable (commonly known as the SCSI Bus).

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