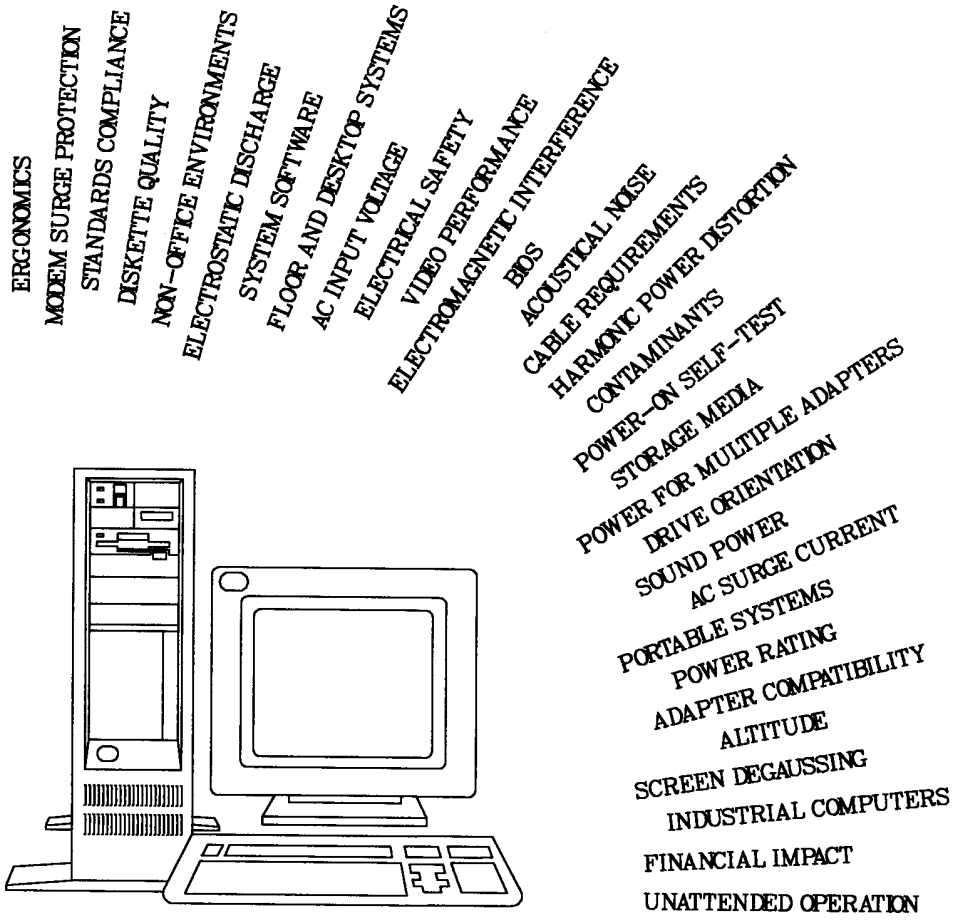
Personal System/2
Installation Planning
...*and Beyond!*

G41G-2927-00



Personal System/2 Installation Planning

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First Edition (February 1992)

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Contents

Notices vii

Preface ix
Customer Responsibilities ix
List of Contacts ix
Task Table x

Chapter 1. Health and Safety 1-1
Displays 1-1
Ergonomics 1-2
Back Strain 1-2
Odors 1-3
Electrical Safety 1-3
Connecting and Disconnecting Cables 1-4

Chapter 2. Physical Specifications 2-1
PS/2 Family 2-1
Floor and Desktop Systems 2-2
Portable Systems 2-2
Displays 2-2
Printers 2-3
Keyboards 2-4
Cable Requirements 2-4
Industrial Computers 2-4
Displays 2-5
Keyboards 2-5

Chapter 3. Power Requirements 3-1
Power Supplies 3-1
Industrial Computers 3-1
AC Input Voltage 3-2
Crest Factor 3-2
AC Surge Current 3-2
Harmonic Power Distortion 3-3
Problems Caused by Harmonics 3-4
Diagnosis 3-4
Solutions 3-4
Power Outlet Considerations 3-5
Power Distribution System 3-5
Power Cords 3-6
Computer System Grounding 3-7
Power Rating/Label Plate and Power Profiles 3-7
Planning for Electrical Power 3-7
Power for Multiple Adapters 3-12

Chapter 4. Surge Protection 4-1
Lightning Protection 4-1
Surge Suppressors 4-1
Modem Lightning Protection 4-2

Chapter 5. Environment 5-1
Airflow 5-1

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Internal Fans 5-2
Acoustical Energy 5-2
Sound Power versus Sound Pressure 5-2
Noise Declaration Table 5-3
Recommendations for Typical Installations 5-4
Displays 5-5
Constant Power-On Operation 5-5
Video Performance 5-6
Video Adjustments 5-6
Screen Degaussing 5-7
System Unit Operation 5-7
Financial Impact 5-7
Heat Factor 5-8
Particulates and Gases 5-8
Altitude 5-9
Vibration and Shock 5-9
Earthquake Effects 5-9
Horizontal Orientation of Systems 5-10
Drive Orientation 5-10

Chapter 6. Electrostatic Discharge 6-1
Handling System Boards 6-1
Handling Adapter Cards 6-2

Chapter 7. Electromagnetic Interference and Susceptibility 7-1

Chapter 8. PS/2 System Software 8-1
Hardware 8-2
BIOS Interface 8-3
Operating System 8-4
Application Programs 8-5
System Software 8-5
Adapter Cards 8-7
POST Operations 8-7
Exception POST, Including Setup 8-9
Normal POST 8-19

Chapter 9. Adapter Considerations 9-1
Compatibility 9-1
SCSI Bus Termination 9-2

Chapter 10. Storage Media and Devices 10-1
Media 10-1
Diskette 10-1
Compact Disk - Read-Only Memory (CD-ROM) 10-3
Tape Cartridge 10-5
Optical Cartridge 10-5
Devices 10-5
Diskette Drive 10-6
Hard Disk Drive 10-6
CD-ROM Drive 10-7
Tape Drive 10-7
Optical Drive 10-7

Appendix A. Line Current Calculation A-1

Appendix B. External Agencies B-1
Underwriters Laboratories B-1
Canadian Standards Association B-1
Common Market Requirements B-1
Nordic Countries and Austria B-1
Standards Compliance List B-1

Appendix C. Non-Office Computer Environments C-1
Continuous and Reliable Operation C-1
AC Power Fluctuations C-1
Extended Environment C-2
  Contaminants C-2
  Shock and Vibration C-2
  Electrical Interference C-2
  DC Operation C-3
ECC Memory C-3
Packaging Configurations C-3
  Bench Top C-3
  Rack Mount C-3
  Enclosure or Wall Mount C-3
Unattended Operation C-4
Power C-4
Serviceability C-5
Office and Industrial Systems Comparison C-6

Glossary X-1

Index X-3

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Preface

The purpose of this manual is to assist the IBM Customer and servicer in planning the IBM Personal System/2* installation. This document is helpful whether installing one stand-alone system or a complex network. While many PS/2* systems have been successfully installed by first-time users without benefit of site planning, careful attention to the installation planning task helps assure reliable system performance and enhanced customer satisfaction.

Customer Responsibilities

Installation planning should start with a clear understanding of the system size and usage. It is the customer's responsibility to provide the necessary environmental needs and facilities, such as proper electrical power, temperature, physical space, and clearances. While the installation of a single small desktop system is generally easy for the novice, large numbers of PS/2 systems of all sizes and types, interconnected by Local Area Networks (LANs), on multiple floors of a large commercial building can be quite complex and probably require the services of professionals.

List of Contacts

This is a list of contacts that you may need, as you plan for your system. Work with your marketing representative to develop your list and keep it current. Many of the hotlines require identification, so be prepared with the appropriate identification (usually a dealer, store, or customer number).

Table 0-1. IBM Telephone Numbers — Domestic Only

Contact	Phone Number
Authorized PS/2 Dealer Locator	800-426-3333
Authorized Industrial Distributor Locator	800-526-6602
Desktop Software	800-IBM-7699
Direct	800-426-2468
Disabled and Special Needs	800-IBM-2133
General Information	800-426-3333
Hardware Service	800-IBM-SERV
Health Effects Research	303-924-5621
Information Network	800-727-2222
PS Customer Satisfaction Center	800-PS2-2227
Safety Information (chemical accounts)	800-IBM-4333
Service Information	800-IBM-7378
Software Support	800-237-5511
Supplies Technical Hotline	800-IBM-1484

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Task Table

Use the following table to determine which book to use to perform the tasks listed. Contact your IBM representative to obtain these publications and other information.

Table 0-2. Publications Task Table

If You Want To...	Refer To The...
Evaluate the use of uninterruptible power supplies for your installation	*Uninterruptible Power Supply Planning Manual, GA34-0316*
Compare the features and specifications of the PS/2 family	*Personal System/2 Reference Guide, G360-2669*
Peruse a list of hardware and software technical bulletins	*Bibliography of International Technical Support Center Technical Bulletins, ZZ10-9984*
Learn about the components of Micro Channel* and their functions	*A Plain Man's View of the IBM Micro Channel, GG24-3584*
Implement Bus Master cards on Micro Channel	*Micro Channel Architecture, Bus Master Release 1.1, GG24-3477*
Evaluate IBM Industrial Computers for your business environment	*IBM 7546 Industrial Computer, G348-0077; IBM GEARBOX* Model 800, G348-0088; IBM 3561 and 3562 Industrial Computers, G348-0089; IBM 7537 Industrial Computer, G348-0073*
Learn about small computer system interface (SCSI) devices	*International Technical Support Centers, SCSI Architecture and Implementation, GG24-3507*
Understand the PS/2 basic input/output system (BIOS) interface	*PS/2 BIOS Interface and Technical Reference Manual, S68X-2341*
Install the IBM Model 55 SX LS	*PS/2 Models 95, XP 486, 90 XP 486, 55 LS and P75 486 Fundamentals, GG24-3616*
Minimize muscular discomfort in the workplace	*Comfort and You, G360-2050*
Decrease visual discomfort in the workplace	*The VDT Workstation and Vision, SV04-0309*
Modify your building for lightning protection	*NFPA 78 Lightning Protection Code, available from: NFPA, 1 Batterymarch Pk, PO Box 9146, Quincy, MA 02269-9904*

Chapter 1. Health and Safety

Displays

IBM, as both a major manufacturer and user of displays, has a responsibility to provide products that are safe and ergonomically well designed. In keeping with this objective, IBM supports and monitors relevant research conducted worldwide on displays.

Based on our examination of available scientific evidence and on the conclusions of national and international health organizations, we believe our displays are safe. However, we recognize that some people who use displays may have concerns about health effects. IBM's position regarding these concerns, follows:

Scientific research has not established a cause and effect relationship between displays and reproductive problems. This position is supported by the World Health Organization, the American Medical Association, the American College of Obstetricians and Gynecologists, the National Institute for Occupational Safety and Health (NIOSH), and other health agencies worldwide which have evaluated this subject.

Some concerns have been expressed about eye strain and fatigue. Performing any visually demanding task, including reading, knitting, or viewing a display, for a prolonged period may cause eye fatigue. This discomfort is temporary and harmless. The American Academy of Ophthalmology considers displays to be safe for normal use and to present no hazard to vision or damage to the eye.

Similarly, musculoskeletal discomfort (sore muscles or joints) may result from any job or activity where a person stays in a fixed position or repeats the same movement over a long period. This is not unique to display usage. Both eye fatigue and musculoskeletal discomfort usually will be reduced by modifying work practices, such as taking rest breaks or rotating tasks, and by adjusting the workstation, lighting, and chair height.

Concerns have also been raised about extremely low frequency (ELF) electromagnetic fields from such sources as power lines and electrical appliances, including displays. We concur with the International Radiation Protection Association which, in conjunction with the World Health Organization, stated that available epidemiological data "do not provide any basis for health risk assessment useful for the development of exposure limits." It further stated that laboratory studies of ELF fields are still exploratory and "have not established any human health risk from exposure to these fields."

IBM's display products are built to be safe and ergonomically sound. We encourage the use of sound principles of ergonomics in the work environment. As long as there are questions about the possible health effects of our displays, IBM will continue to review the issues, support and monitor appropriate research, and act responsibly to help ensure the health and safety of our employees and our customers.

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Ergonomics

Your chair should be adjusted for comfort, making sure your back is supported and the seat pan is at a height so that your thighs are horizontal and your feet are flat on the floor. Work materials should be within easy reach.

The ideal work position is to have your arms hanging relaxed from your shoulders. If you use a keyboard, your arms should be bent at right angles at the elbow, with your hands held in a straight line with the forearm and your elbows close to the body. Your head should be in line with your body and slightly forward.

If you work at a visual display, the top of the screen should be at, or just slightly below, eye level. This allows your eyes to see the screen at a comfortable angle, without having to tilt your head or move your back muscles.

Avoid glare by positioning your screen away from light sources. Glare can usually be modified by lowering ambient light, drawing window covers against bright light, wearing less reflective garments, choosing more appropriate task lighting, and cleaning the display screen. Additionally, neutral-density or micromesh filters may be helpful in enhancing contrast or reducing glare.

Back Strain

To avoid back strain:

- Keep the head in line with the spine at all times.
- Bend from the hips and knees, never from the waist only.
- Always face the object you are lifting.
- Exhale when lifting.
- Lift and move slowly, not suddenly.
- Lift and hold heavy objects close to your body.
- Never lift a heavy object higher than your waist.
- Avoid carrying unbalanced loads.
- Get assistance for heavy loads. Use the following table as a guide.

Weight Range	Actions
Below 18 kg (39.7 lb)	No special action required.
18 – 32 kg (39.7 – 70.5 lb)	Two or more persons lift, using the handholds provided.
32 – 55 kg (70.5 – 121.2 lb)	Three or more persons lift, using the handholds provided.

Odors

Odors are common to most new electronic equipment and are associated with circuit boards and plastics used in product manufacture. Odors associated with new equipment are most noticeable in poorly ventilated environments and usually disappear after a short period of product usage.

IBM has dedicated significant resources to understand the source and nature of these odors. The materials used in manufacture are well understood and have been selected for functional, environmental, human health, and safety concerns. None of the odor components are present in quantities that exceed any regulatory or consensus standards or are known to cause adverse health affects. However, because some individuals may be sensitive to odors, we recommend that any equipment should be used in a well ventilated area. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends currently a minimum indoor air quality standard of 20 cubic feet per minute per person of outdoor makeup for office environments (ASHRAE 62-1989). Other federal, state, and local regulations may also provide further guidance on indoor air quality issues.

Thermal, odor, and ventilation factors should be considered when planning any installation involving electronic equipment. Ignoring these factors may result in complaints about air quality when:

- Computer equipment is used in small, enclosed, and poorly ventilated work environments.
- Simultaneous operation of multiple workstations occurs in a confined and poorly ventilated work environment (computer classrooms and labs).
- Users are seated such that the system exhaust is directed toward them.

While indoor environments are complex, providing adequate ventilation often prevents these types of complaints. In each of the conditions described above, it is the employer's or user's responsibility to assure a work environment that meets regulatory and comfort requirements. IBM is committed to provide hardware and software solutions that are safe and enhance productivity. Should you have additional questions regarding IBM products, supplies, and human health, please contact IBM Health Effects Research (see Table 0-1 on page ix).

Electrical Safety

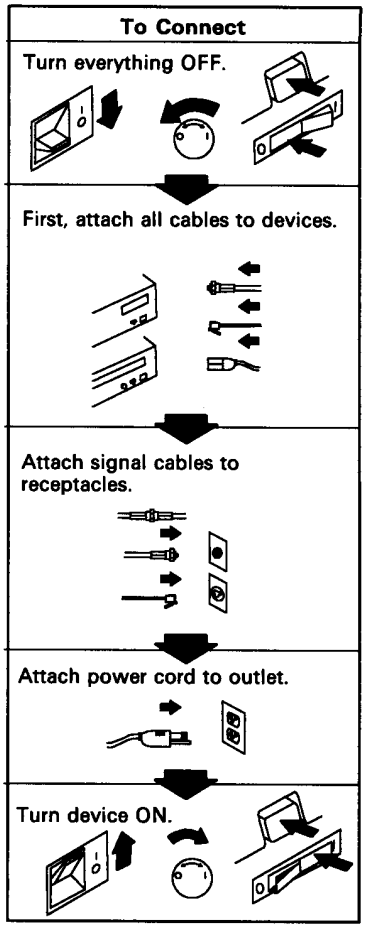
All PS/2 systems are designed with a three-wire ac line cord, the third wire (green with yellow stripe) being chassis ground. In the event of a short circuit to the chassis, the ground wire will conduct the fault current to the building ground to protect a user from the hazardous voltage.

When the external covers are removed from PS/2 systems, the interior is a customer accessible area with no exposure to hazardous voltages. The power supply contains hazardous voltages within its covers and should never be opened. It has no replaceable parts and is sealed with tamper-proof fasteners to prevent entry. If defective, the entire power supply must be replaced.

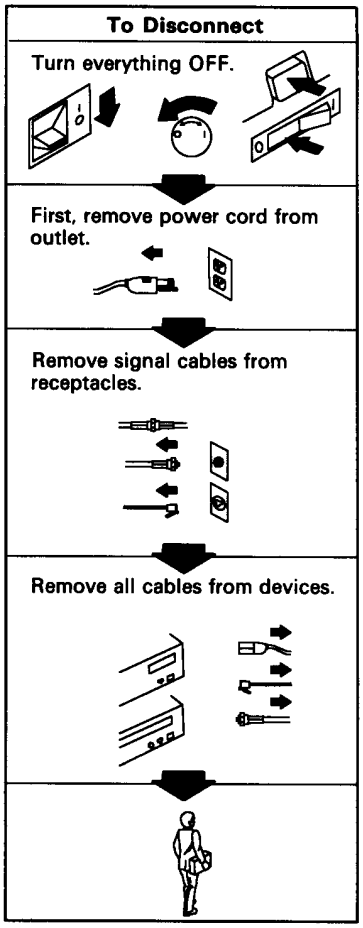
> As an added precaution, make sure that you **always** remove ac power from the system unit before removing the external covers.

Connecting and Disconnecting Cables

DANGER:
Electrical current from power, telephone, and communication cables is hazardous. To avoid shock hazard, connect and disconnect cables as shown below when installing, moving or opening the covers of this product or attached devices. The power cord must be used with a properly-grounded outlet.



Note: In the U.K., by law, the telephone cable must be connected after the power cord.



Note: In the U.K., by law, the power cord must be disconnected after the telephone line cable.

Chapter 2. Physical Specifications

Providing space for the PS/2 system depends on which system is installed. Several tables in this chapter provide the dimensions and weight of the IBM PS/2 and Industrial Computer offerings:

- Table 2-1, PS/2 System Units
- Table 2-2 on page 2-3, PS/2 Displays
- Table 2-3 on page 2-3, PS/2 Printers
- Table 2-4 on page 2-4, PS/2 Keyboards
- Table 2-5 on page 2-5, Industrial System Units
- Table 2-6 on page 2-5, Industrial Displays
- Table 2-7 on page 2-5, Industrial Keyboards.

PS/2 Family

PS/2 system units are desktop, floor-standing, or portable. Some of the dimensions increase when feet are extended or the unit is placed in a stand. The following table identifies the placement, dimensions, and weight of each PS/2 system unit.

Table 2-1. PS/2 System Units

Type	Placement	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
8525	desktop	319 (12.5 in.)	375 (14.7 in.)	384 (15.1 in.)	12.7 – 16.8 (28 – 38 lb)
8530	desktop	406 (16 in.)	398 (15.7 in.)	104 (4 in.)	7.4 (16.5 lb)
8535 SX 8535 LS 8556	desktop	438 (17.2 in.)	394 (15.5 in.)	165 (6.5 in.)	17.2 (38 lb)
8540 8557	desktop	438 (17.2 in.)	394 (15.5 in.)	165 (6.5 in.)	15.0 (33 lb)
8543	portable	272 (10.7 in.)	53 (2.1 in.)	325 (12.8 in.)	3.5 (7.7 lb)
8550	desktop	360 (14.1 in.)	420 (16.5 in.)	140 (5.5 in.)	9 – 11 (20 – 24 lb)
8555 SX 8555 LS	desktop	406 (16 in.)	397 (15.6 in.)	102 (4 in.)	8.6 (19 lb)
8560	floor	482 (19 in.)	597 (23.5 in.)	165 (6.5 in.)	19 – 26 (42 – 58 lb)
8565 8580	floor	482 (19 in.)	597 (23.5 in.)	165 (6.5 in.)	21 – 26 (46 – 58 lb)
8570	desktop	360 (14.2 in.)	420 (16.5 in.)	140 (5.5 in.)	9 – 11 (20 – 24 lb)
8573	portable	465 (18.3 in.)	127 (5 in.)	305 (12 in.)	9 (20 lb)
8575	portable	465 (18.3 in.)	155 (6.1 in.)	308 (12.1 in.)	10 (22 lb)
8590	desktop	439 (17.3 in.)	429 (16.9 in.)	140 (5.5 in.)	12.3 (25 lb)
8595	floor	203 (8 in.)	508 (20 in.)	502 (19.7 in.)	27.2 (51 lb)

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Floor and Desktop Systems

Due to the various approval agencies under which these systems are certified, IBM does not recommend mounting floor and desktop systems in any position other than that for which the unit was designed. Mounting a desktop unit in a vertical position may violate the Underwriter's Laboratories (UL), Canadian Standards Association (CSA), and other certifications.

See "Horizontal Orientation of Systems" on page 5-10.

Portable Systems

Portable systems usually require no installation planning due to their portability, however, it may be desirable to use them in an established location *between trips*, in which case a certain amount of planning may be desirable. Docking stations are available for the 8573 and 8575 to serve this purpose.

Displays

Particular attention should be given to the physical location of displays to assure that they are not subject to interference from fluctuating low frequency magnetic fields. These magnetic fields are generally present around transformers, small appliances, and nearby fluorescent light fixtures. Other displays located in close proximity may also cause image *wiggle* or other distortion. Distances of less than 12 inches between displays should be avoided.

If you suspect a problem with the display or the location of the display, use the display diagnostics to determine if the display is functioning properly. Only the display diagnostics are valid to determine the serviceability of a display, as other software is an unknown. Software may cause a display to appear defective. Remember, only Advanced Diagnostics Video tests can be used to evaluate the quality and performance of IBM displays.

Displays exhibiting discolorations or unusual color patterns may need to be degaussed. All PS/2 displays are auto-degaussing and perform this function each time the display is powered off for approximately 30 minutes. A degaussing coil, such as is used by television servicers, may be used in an extreme situations. Displays that are physically moved after power-on may exhibit discolorations. This symptom is normal and is remedied after the first degaussing cycle.

Displays may cause diskette read/write problems in PS/2 systems if placed in very close proximity to a diskette drive. Distance between displays and diskette drives should be at least 3 inches.

If displays exhibit distortion, waviness, discoloration or other similar but unexpected symptoms, relocate the display or system to another part of the room or building and compare the performance. Some locations may be subject to powerful low frequency fluctuating magnetic fields such as those produced by large transformers found in *power facility* rooms of large buildings. Other than relocating the affected equipment, there is no method of preventing interference of this type. Generally, there is no practical method of shielding displays and other equipment from this type of interference.

Occasionally, in certain geographical areas, there are large static geo-magnetic disturbances which can cause distortion in displays. If you suspect this to be a cause of problems in a particular location, a compass, such as is used by hikers, or a low altitude aeronautical chart such as is used by pilots, may be helpful to confirm the

problem. Other than equipment relocation, no solution is available for these environmental problems.

Note: IBM color displays are aligned (color converged) relative to the geographical region of intended use. Displays marketed for use in the southern hemisphere are not compatible to the earth's magnetic field in the northern hemisphere. The variation in the earth's magnetic field is sufficient to make this a requirement. Displays moved from lower hemisphere latitudes, will probably experience color variations and other convergence problems if moved to far northern latitudes, for example, Australia to Norway.

Table 2-2. PS/2 Displays

Type	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
8503	321 (12.6 in.)	311 (12.2 in.)	277 (10.9 in.)	8.5 (18.8 lb)
8504	305 (12.0 in.)	310 (12.1 in.)	290 (11.5 in.)	7.5 (16.5 lb)
8506	334 (13.2 in.)	371 (14.6 in.)	470 (18.5 in.)	22.0 (48.5 lb)
8507	475 (18.75 in.)	432 (17.0 in.)	450 (17.75 in.)	23.5 (51.7 lb)
8508	476 (18.75 in.)	432 (17.0 in.)	451 (17.75 in.)	23.5 (51.7 lb)
8512	355 (14 in.)	394 (15.5 in.)	304 (12.0 in.)	15.0 (33 lb)
8513	321 (12.6 in.)	362 (14.5 in.)	277 (10.9 in.)	10.5 (23 lb)
8514	400 (15.7 in.)	415 (16.3 in.)	320 (12.6 in.)	18.5 (41 lb)
8515	355 (14.0 in.)	389 (15.3 in.)	345 (13.6 in.)	17.0 (37.4 lb)
8516	355 (14.0 in.)	389 (15.3 in.)	345 (13.6 in.)	17.5 (38.5 lb)
8518	353 (13.9 in.)	391 (15.4 in.)	345 (13.6 in.)	13.0 (28.6 lb)

Note: These dimensions exclude the display stand available with some models.

Printers

The following printers are available for PS/2 Systems:

Table 2-3 (Page 1 of 2). PS/2 Printers

Type	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
2205	406 (16.0 in.)	343 (13.5 in.)	133 (5.25 in.)	8.3 (18.2 lb)
2380, 2390	498 (19.6 in.)	287 (11.3 in.)	191 (7.5 in.)	6.7 (14.8 lb)
2381, 2391	640 (25.2 in.)	287 (11.3 in.)	191 (7.5 in.)	8.5 (18.7 lb)
4019, 4019E	361 (14.2 in.)	521 (20.5 in.)	259 (10.2 in.)	15.2 (33.6 lb)
4028	361 (14.2 in.)	523 (20.6 in.)	307 (12.1 in.)	15.4 (34 lb)
4029-010, 4029-020, 4029-030	361 (14.2 in.)	523 (20.6 in.)	259 (10.2 in.)	15.2 (33.6 lb)
4029-040	361 (14.2 in.)	523 (20.6 in.)	427 (16.8 in.)	19.5 (43 lb)
4072	617 (24.3 in.)	343 (13.5 in.)	152 (5.9 in.)	8.6 (19 lb)
4201-1	419 (16.5 in.)	356 (14.0 in.)	133 (5.25 in.)	7.9 (17.5 lb)
4201-2, 4201-3	406 (16.0 in.)	343 (13.5 in.)	133 (5.25 in.)	8.6 (19 lb)
4202-1	574 (22.6 in.)	363 (14.3 in.)	133 (5.25 in.)	10.7 (23.6 lb)
4202-2, 4202-3	559 (22.0 in.)	343 (13.5 in.)	133 (5.25 in.)	10.9 (24 lb)
4207-1	419 (16.5 in.)	356 (14.0 in.)	133 (5.25 in.)	7.9 (17.5 lb)

Table 2-3 (Page 2 of 2). PS/2 Printers				
Type	**Width (mm)**	**Depth (mm)**	**Height (mm)**	**Weight (kg)**
4207-2	406 (16.0 in.)	343 (13.5 in.)	133 (5.25 in.)	9.1 (20 lb)
4208-1	574 (22.6 in.)	363 (14.3 in.)	133 (5.25 in.)	10.7 (23.6 lb)
4208-2	559 (22 in.)	343 (13.5 in.)	133 (5.25 in.)	11.3 (25 lb)
4212	425 (16.75 in.)	343 (13.5 in.)	133 (5.25 in.)	8.3 (18.2 lb)
4226	243 (25.3 in.)	279 (11.0 in.)	272 (10.7 in.)	20.9 (46 lb)
5201	541 (21.3 in.)	366 (14.4 in.)	165 (6.5 in.)	10.0 (22.0 lb)
5202	551 (21.7 in.)	381 (15.0 in.)	180 (7.1 in.)	10.9 (24 lb)
5204	549 (21.6 in.)	363 (14.3 in.)	188 (7.4 in.)	12.5 (27.5 lb)

Keyboards

Three PS/2 keyboards are available. The height dimension is measured with the feet extended.

Table 2-4. PS/2 Keyboards				
Type	**Width (mm)**	**Depth (mm)**	**Height (mm)**	**Weight (kg)**
84 keys	406 (16.0 in.)	190 (7.5 in.)	58 (2.3 in.)	1.9 (4.2 lb)
101 keys	492 (19.4 in.)	210 (8.3 in.)	44 (1.7 in.)	2.25 (5.0 lb)
122 keys	532 (20.9 in.)	215 (8.5 in.)	70 (2.8 in.)	2.3 (5.1 lb)

Cable Requirements

Only IBM manufactured cables in the lengths supplied by IBM, are tested and supported on PS/2 systems. The performance of non-IBM and locally fabricated cables are the customer's or supplier's responsibility.

The use of non-IBM manufactured cables attached to a display, serial, parallel, keyboard, and mouse ports, may cause unpredictable and difficult to diagnose system problems. This can be caused by factors associated with data signals (such as cable impedance and reactance, causing degradation of signal quality) which must be measured with special testing equipment.

A simple dc resistance check, normally done by a Volt-Ohm meter, is insufficient to determine that a cable will function correctly during system operation.

Extended length and/or improperly shielded cables may also radiate signals beyond acceptable Federal Communications Commission (FCC) Class B standards. This may cause interference problems with other non-associated electrical equipment.

See Chapter 9, "Adapter Considerations" on page 9-1 for further information.

Industrial Computers

Some applications require that the computer be located with other equipment in a rack, or where horizontal space is scarce. Some IBM Industrial Computers can be rack mounted. Multiple computers can be mounted in a vertical rack. In addition, the GEARBOX Model 800 can be mounted on a wall or in a panel, taking no floor space.

IBM Industrial Computers are desktop, floor standing, or rack and panel mounted. Table 2-5 on page 2-5 identifies the placement, dimensions, and weight of each industrial system unit.

Table 2-5. Industrial System Units

Type	Placement	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
7531	floor	266 (10.5 in.)	600 (23.6 in.)	650 (25.6 in.)	38.6 (85.1 lb)
7532	rack	437 (17.2 in.)	513 (20.2 in.)	221 (8.7 in.)	23.6 (52.1 lb)
7537 7546	desktop	440 (17.3 in.)	450 (17.7 in.)	170 (6.7 in.)	15.9 (35 lb)
7537 7546	rack	483 (19.0 in.)	448 (17.6 in.)	177 (7.0 in.)	15.9 (35 lb)
7541	desktop	436 (17.2 in.)	420 (16.5 in.)	146 (5.75 in.)	12.1 (26.6 lb)
7542	rack	487 (19.0 in.)	627 (24.5 in.)	267 (10.5 in.)	24 (52 lb)
7552	rack/panel	482 (19.0 in.)	256 (10.0 in.)	533 (21.0 in.)	18.9 (41.6 lb)
7561	desktop	436 (17.2 in.)	420 (16.5 in.)	146 (5.75 in.)	12.4 (27.3 lb)
7562	rack	487 (19.2 in.)	627 (24.5 in.)	267 (10.5 in.)	27.6 (60.7 lb)
7568	rack/panel	482 (19.0 in.)	256 (10.0 in.)	533 (21.0 in.)	19.1 (42 lb)

Displays

Rack mounting kits are available for the industrial displays listed in Table 2-6. Desktop stands are available for some of the displays.

Table 2-6. Industrial Displays

Type	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
5532	392 (15.4 in.)	407 (15.6 in.)	297 (11.7 in.)	12.3 (27.0 lb)
7534	392 (15.4 in.)	407 (15.6 in.)	297 (11.7 in.)	13.4 (29.5 lb)
7544	392 (15.4 in.)	432 (17.0 in.)	292 (11.5 in.)	15.9 (35.0 lb)
7554	451 (17.8 in.)	476 (18.8 in.)	400 (15.8 in.)	29.4 (65.0 lb)

Keyboards

Keyboards can be rack mounted as a separate option, or as part of the initial package. Table 2-7 shows the keyboard offering for the industrial computer.

Table 2-7. Industrial Keyboards

Type	Width (mm)	Depth (mm)	Height (mm)	Weight (kg)
101 key	500 (19.6 in.)	200 (7.9 in.)	57 (2.2 in.)	2.4 (5.3 lb)

Chapter 3. Power Requirements

Power Supplies

Some IBM PS/2 systems automatically select the proper ac voltage range when plugged in to the ac power line. Others have a switch located at the rear of the system that must be set to the low or high voltage range before the PS/2 is connected to the ac outlet. The PS/2 systems have the power supply wattage and ac voltage selection shown in Table 3-1.

Table 3-1. Power Supplies of the IBM PS/2 Systems

Machine Type	Power Supply	AC Voltage Selection
8525 mono	90W	110/220 switch
8525 color	115, 124W	110/220 switch
8525 SX	124W	110/220 switch
8525-286	124W	110/220 switch
8530-286	90W	110/220 switch
8535 SX, LS	118W	Autosensing
8540 SX	197W	110/220 switch
8550	94W	Autosensing
8555 SX, LS	90W	110/220 switch
8556	118W	Autosensing
8557	197W	110/220 switch
8560	207, 225, 250W	Autosensing
8565	250W	Autosensing
8570	132W	Autosensing
8573-386	85W	Autosensing
8573-486	120W	Autosensing
8580	225, 240, 250W	Autosensing
8590	194W	Autosensing
8595	335W	110/220 switch

Industrial Computers

The power supply in the Industrial Computer continues to function when there are temporary voltage sags. The battery allows the system to continue running up to 10 seconds during a power outage. The GEARBOX Model 800 can switch to external dc power, such as two automotive batteries, and continue running up to 3 hours without ac power.

Table 3-2 on page 3-2 shows the operate wattage and features of the industrial power supplies.

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Table 3-2. Industrial Power Supplies

Machine Type	Operate Wattage	AC Voltage Selection	10-second Brownout Protection	DC Start-up and Operation
7531, 7532	192W	110/220 switch	No	No
7537	197W 205W	110/220 switch Autosensing	No Optional	No No
7541, 7542, 7561, 7562	180W	Autosensing	Optional	No
7546	197W 205W	110/220 switch Autosensing	No Optional	No No
7552	170W	Autosensing	Yes	DC operation
7568	300W	Autosensing	Yes	DC start-up and operation

AC Input Voltage

PS/2 systems operate over a low voltage range of 90 V ac to 137 V ac and a high voltage range of 180 V ac to 265 V ac, 50 or 60 Hz ±3 Hz with automatic or manual range switching. A sine-wave input voltage is required.

The maximum harmonic content of the power system voltage waveform at the wall outlet **must** not exceed ±5% when the equipment is not operating.

Crest Factor

For a normal sine wave, the crest factor (the ratio of instantaneous value to the RMS value) is 1.414. High crest factors for the current indicate the presence of harmonic currents in the wave form. The IBM PS/2 systems have an input current with a crest factor between 3.0 and 3.6 with the typical being 3.3.

AC Surge Current

PS/2 systems generate a surge current of short duration at power-on. Surge current is higher than the normal operating current. It charges the system capacitors to operational voltage levels.

The amplitude and duration of surge currents are factors to consider when sizing circuit breakers or uninterruptible power systems. The maximum surge currents for single PS/2 systems are shown in Table 3-3 on page 3-3. These currents are additive when multiple systems power-on at the same time.

Table 3-3. IBM PS/2 Surge Currents		
Machine Type	**AC Current Peak (amperes)**	**Base Width Duration (milliseconds)**
8525	27	2.5
8525-286, SX	34	3.0
8530-286	56	2.5
8535 SX, LS	12	5.0
8540	60	2.5
8550	24	2.5
8555 SX, LS	70	2.0
8556	12	5.0
8557	56	2.5
8560	25	2.5
8565	38	3.0
8570	17	3.0
8573-386	14	2.5
8573-486	8	3.2
8580	40	3.0
8590	15	3.0
8595	30	2.5

Harmonic Power Distortion

The following information is general in nature and intended for instructional purposes only. Experienced, qualified experts in this field should be consulted for additional information if you suspect harmonic distortion problems are being experienced.

The demand for small, efficient, well-regulated, low cost power supplies for electronic equipment has resulted in the proliferation of switch-mode power supplies (SMPS) for world-wide use. These power supplies are used in most types of electronic equipment, from table radios, stereos, and office copiers, to personal computers.

Harmonic power distortion is caused by harmonic currents generated by all types of ac-to-dc converters, such as motor speed controllers and rectifiers for dc loads, fluorescent lamps, motor driven computer peripherals, and the SMPS used in almost all computer and entertainment equipment. These non-linear loads can cause excessive current to be returned on the neutral wire.

In theory, the neutral current in a balanced linear load system (three-phase wire) is zero. Prior practice allowed the neutral wire for building and branch circuit wiring to be smaller (50%) than phase wires. The National Electric Code now requires the same size wiring for phase and neutral wiring for electronic computer/data processing or similar equipment, although some consultants are recommending up to twice the wire size for the neutral with these types of loads.

A linear load produces a current that is directly proportional to the line voltage and at the same sine-wave frequency. Motors, incandescent lamps, and resistors are examples of linear loads.

A non-linear load produces a current that is not directly proportional to the line voltage and is not a sine-wave of the same frequency. Non-linear loads cause heating due to unplanned currents on the smaller neutral wire.

Problems Caused by Harmonics

When large numbers of personal systems are installed in a building, the triplen (odd multiples of the third harmonic...3rd, 9th, 15th...) harmonic currents add to those of other non-linear loads creating unexpected electrical facilities problems such as:

- Failure of neutral conductors
- Intermittent electrical noise
- Transformer overheating
- Nuisance tripping of circuit breakers
- Power factor correction capacitor overheating or damage.

Diagnosis

Measurement of **true RMS** current on the neutral conductor at the transformer by a qualified, licensed electrician will indicate the presence of higher than expected currents, and the possibility of harmonic current distortion.

Solutions

Blocking the harmonics from the neutral wire and re-routing them down the current phases of the wiring is usually the least expensive solution. These are generically known as filter traps with more specific names, such as zero-sequence or zigzag transformer filters. These filters are placed between the three-phase transformer and the loads.

If a new installation is being planned, the power transformers may be designed with a zigzag filter internal to the transformer at a small additional cost.

Other possible solutions are:

- Passive filters
- Active filters
- Derating the distribution transformer
- New transformer
- Rewiring.

Usually, the lowest-cost solution is a combination of the solutions described. There should be a periodic inspection of the electrical system, especially after additions of hardware or changes in the system configurations. These inspections should include measurements of phase and neutral currents, and temperatures of transformers, their connections, and the connections in the total distribution system. Filter traps should also be considered when system configurations change, because the amount of current could possibly exceed its ratings.

Power Outlet Considerations

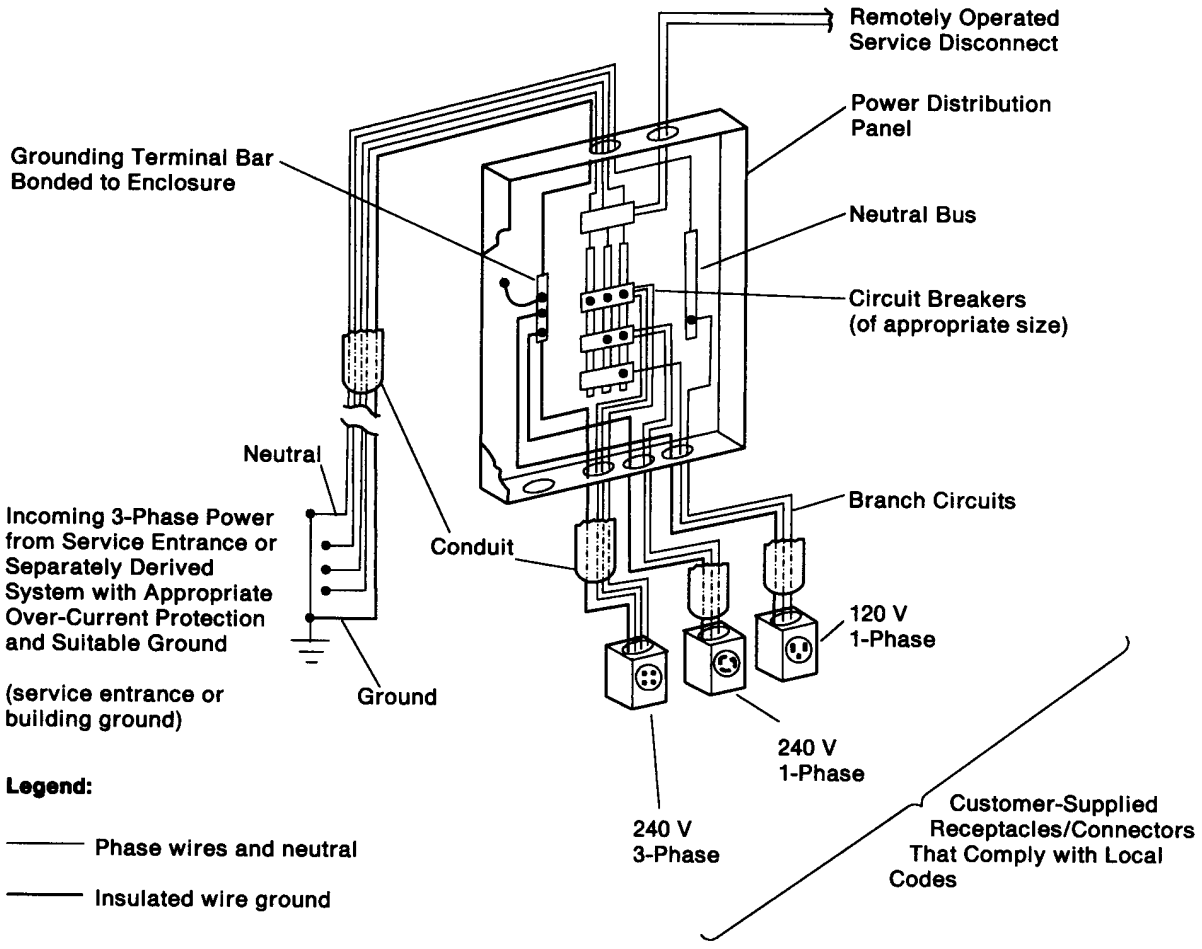
Planning for PS/2 power requirements is important regardless of the size of your power system. Correct planning for power helps minimize problems at installation time.

Electrical grounding for the PS/2 system is important both for the safety of people and for correct operation of the system. Follow your national and local electrical codes when installing electrical wiring, outlets, and power panels. Proper grounding of the outlet can be verified by a certified electrician.

The diagram on page 3-5 shows a typical commercial power distribution panel in the USA. Follow the details in the diagram with respect to the grounding of the outlets for the system. Remember that your national and local electrical codes must be followed and that those codes take precedence over the diagram if a conflict should arise.

Power Distribution System

This is a typical commercial power distribution system (in the USA) that is grounded properly.



Power Cords

For your safety, IBM provides a power cord with a grounded attachment plug to use with the IBM PS/2 system. To avoid electrical shock, use the power cord and plug with a properly grounded electrical outlet. Proper grounding of the outlet can be verified by a certified electrician.

IBM power cords used in the United States and Canada are listed by UL and certified by the CSA. These power cords consist of:

- Electrical cables type SVT or SJT
- Attachment plugs complying with National Electric Manufacturers Association (NEMA) 5-15P
- Appliance couplers complying with International Electrotechnical Commission (IEC) Standard 320, Sheet C13.

IBM power cords used in all other countries consist of:

- Electrical cables type HD21
- Attachment plugs approved by the appropriate testing organization for the specific countries where they are to be used
- Appliance couplers complying with International Electrotechnical Commission (IEC) Standard 320, Sheet C13.

IBM power cords for a specific country are usually available only in that country. See Table 3-4 for the correct part number.

Warning: Use the power cord certified for your country.

Table 3-4. PS/2 Power Cords

Part Number	Use in these Countries
62X0663	Bahamas, Barbados, Bermuda, Bolivia, Brazil, Canada, Cayman Islands, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Japan. Korea (South), Mexico, Netherlands Antilles, Nicaragua, Panama, Peru, Philippines, Saudi Arabia, Surinam, Taiwan, Trinidad (West Indies), United States of America, Venezuela
13F9940	Australia, Argentina, New Guinea, New Zealand, Papua, Paraguay, Uruguay
1838574	Thailand
13F9979	Austria, Belgium, Bulgaria, Czechoslovakia, Egypt, Finland, France, Germany, Greece, Hungary, Iceland, Indonesia, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Turkey, Yugoslavia
13F9997	Denmark
14F0015	Bangladesh, Pakistan, South Africa, Sri Lanka
14F0033	Abu Dhabi, Albania, Antigua, Bahrain, Brunel, Dubai, Fiji, Hong Kong, India, Ireland, Kenya, Kuwait, Macau, Malaysia, Nigeria, Oman, People's Republic of China, Qatar, Singapore, United Kingdom
14F0051	Switzerland
14F0069	Chile, Italy
14F0087	Israel

Computer System Grounding

Power cords have a green-with-yellow-stripe grounding conductor for equipment ground. The recommended branch circuit receptacles have a matching equipment ground. The customer supplied branch circuits must have an insulated wire conductor, at least equal to the size of the phase conductor, for the purpose of grounding the equipment.

The branch circuit grounding wire must be tied to a common ground point at the distribution panel, and a single grounding wire must run from the distribution panel ground point to service ground or to the common ground point of the separately derived source. Conduit grounds are not recommended for data processing equipment, even though it may conform to local and national electrical codes.

Power Rating/Label Plate and Power Profiles

The power rating/label plate conforms to **all** of the safety agency requirements. For IBM, this is worldwide. It is mandatory that the current rating be the maximum that the product can pull from the power line. Therefore, the label rating covers the maximum configuration (see Table 3-5 on page 3-9) with all options included. Do not use this information to determine your power requirements.

The IBM Corporate power profiles are available from CABANE at KGNVMZ (tie line 695-4007). These power profiles are developed from systems having all options filled, but not necessarily to the maximum power loads.

"As Shipped" Configuration

The term "as shipped" defines the PS/2 system unit configuration without additional storage devices, adapters, or memory. When the shipping container is *first* opened, the "as shipped" level is what you unpack.

The installer should understand that the "as shipped" configuration:

- needs less current from the wall plug than the maximum configuration
- generates less heat than the maximum configuration
- requires less air conditioning to keep it within its temperature ratings.

Planning for Electrical Power

Determining your large installation power requirements is important. Consideration for future requirements should be included in the power assessment. Tighter limits may be placed on the power allocated for a controlled and limited system application usage (banking) than for an engineering development area. Use the following steps to plan for your electrical power needs:

1. Generate lists of hardware requirements:
   a. List all of the different IBM system units, displays, printers, and so on, with the quantities of each.
   b. List additional storage devices and adapters that will be installed, with the quantities of each.
   c. List future machine types, storage devices, and adapters that could be added.
2. Determine the "as shipped" line current of the system units, displays, and printers in your installation for the line voltage of your country. (See Table 3-5 on page 3-9.) To obtain the line current, divide the kilovolt amperes (kVA) by your country line voltage and multiply by 1000.

3. Determine the dc wattage of the additional storage devices and adapters that will be installed in a system unit, and from that determine the line current to be added to the "as shipped" unit. The dc wattage of these options should be the operate levels and not a standby level. Generally, if only a single level is defined, it is the operate level. (See Table 3-6 on page 3-10 and Table 3-7 on page 3-11.)

   The dc wattage of the added option is used with Figure 3-1 to determine the additional line current for the system unit. If the dc wattage of the added option exceeds the wattage in Figure 3-1, break it into two or more groups. If the line voltage is other than 120 V or 230 V, the line current can be adjusted to the new line voltage by the following equation:

   $I_{new} = (I_{old} \times V_{old}) / V_{new}$

   If you are working in kVA, multiply the line current found in Figure 3-1 by its respective line voltage to get kVA.

4. Determine the dc wattage or line current or kVA that should be planned for future system expansion. You should also plan for future system unit installations for added users.

5. Divide the dc wattage found in Figure 3-1 by 0.62, to get the ac input watts to add to the Typical Heat Output in Table 3-5 on page 3-9. To convert ac input watts to BTU/hr, multiply watts by 3.41.

6. A general tolerance should be added to allow for unit-to-unit variation. A 20% tolerance should provide adequate margin.

See Appendix A, "Line Current Calculation" on page A-1 for an example.

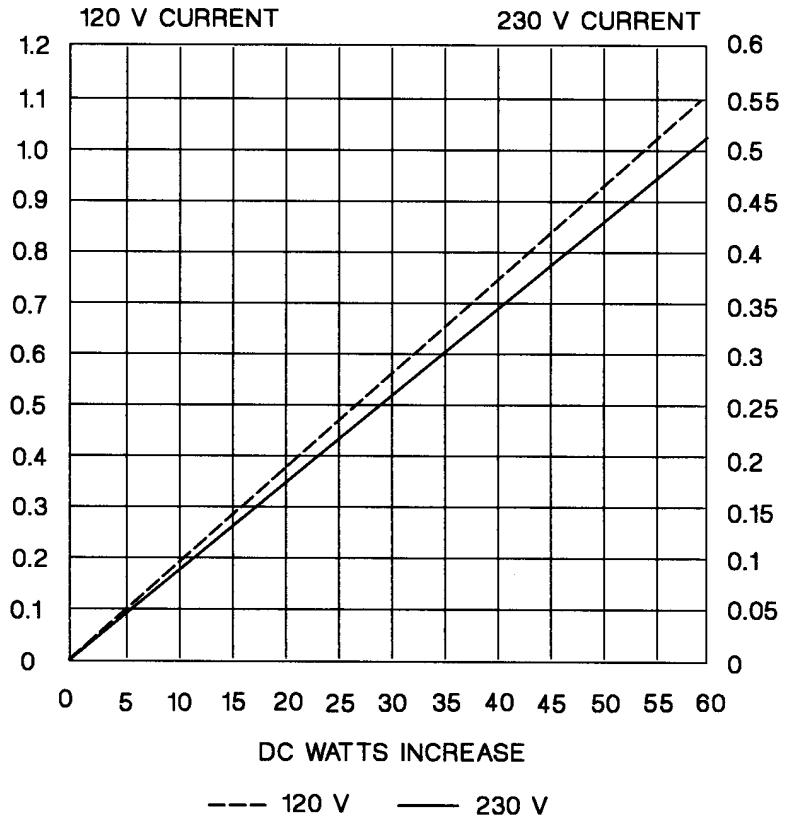


Figure 3-1. Line Current (Amperes)

Table 3-5. IBM System Units, Displays, and Printers

Equipment	As Shipped kVA	As Shipped BTU/hr	Max. Config. kVA	Max. Config. BTU/hr
2380, 2381	(Note 1)	140 (Note 2)	N/A	N/A
2390, 2391	(Note 1)	140 (Note 2)	N/A	N/A
3812	1.3	3069 (900W) operate	N/A	N/A
4019	(Note 3)	(Note 3)	N/A	N/A
4028, 4029	(Note 3)	(Note 3)	N/A	N/A
4201, 4202	(Note 1)	307 (Note 2)	N/A	N/A
4208-1	(Note 1)	338 (Note 2)	N/A	N/A
4208-2	(Note 1)	307 (Note 2)	N/A	N/A
4212	(Note 1)	307 (Note 2)	N/A	N/A
4226	(Note 1)	307 (Note 2)	N/A	N/A
5202	(Note 1)	307 (Note 2)	N/A	N/A
8503	0.08	188 (55W)	N/A	N/A
8504	0.072	135 (40W)	N/A	N/A
8506	0.12	290 (85W)	N/A	N/A
8507	0.12	290 (85W)	N/A	N/A
8508	0.12	290 (85W)	N/A	N/A
8512	0.10	325 (95W)	N/A	N/A
8513	0.10	273 (80W)	N/A	N/A
8514	0.20	273 (80W)	N/A	N/A
8515-021	0.095	341 (100W)	N/A	N/A
8516	0.11	341 (100W)	N/A	N/A
8518	0.072	256 (75W)	N/A	N/A
8525	0.11	232 (68W)	0.28	648 (190W)
8525-286	0.11	252 (74W)	0.30	648 (190W)
8525 SX	0.13	273 (80W)	0.30	648 (190W)
8530-286	0.05	89 (26W)	0.15	471 (138W)
8535	0.08	153 (45W)	0.30	672 (197W)
8540	0.06	116 (34W)	0.50	1024 (300W)
8550	0.11	160 (47W)	0.25	512 (150W)
8555	0.08	150 (44W)	0.24	477 (140W)
8557	0.07	116 (34W)	0.60	1024 (300W)
8560	0.10	300 (88W)	0.53 0.58 0.65	1100 (320W) 1200 (350W) 1330 (390W)
8565	0.10	211 (62W)	0.65	1330 (390W)
8570	0.13	262 (77W)	0.36	733 (215W)
8573-386	0.13	273 (80W)	0.2	512 (150W)
8573-486	0.15	307 (90W)	0.35	750 (220W)
8580	0.18	409 (120W)	0.58 0.62 0.65	1194 (350W) 1279 (375W) 1330 (390W)
8590	0.15	297 (87W)	0.48	1125 (330W)
8595	0.18	358 (105W)	0.83	1903 (558W)

See notes on next page.

Notes:

1. Call 800-IBM-1484
2. 25% duty cycle
3. 119 BTU and 0.384 kVA with power saver on; 235 BTU and 0.069 kVA at idle time; 1310 BTU and 0.035 kVA when printing.

Table 3-6 and Table 3-7 on page 3-11 list some of the IBM options available for the PS/2 product line. There are hundreds of non-IBM options that can be used in PS/2 products. Contact the manufacturer to obtain the dc wattage and current for each option.

Table 3-6. Typical DC Wattage and Current for IBM Storage Device Options

Marketing Part #	Description	Operate DC Wattage	Typical Current +5V	+12V
78X8958	20MB (PS/2-25 80ms)	14.5	0.5A	1.0A
6451075	20MB (PS/2-25-286 27ms)	6.65	0.25A	0.45A
6451071	30MB (PS/2-25-286 27ms)	6.65	0.25A	0.45A
6451076	30MB (PS/2-25 19ms)	11.9	0.8A	0.66A
6451086	40MB (PS/2-55 17ms)	6.65	0.25A	0.45A
6451047	40MB (PS/2-55-286 17ms)	6.65	0.25A	0.45A
6451084	60MB (PS/2-55 23ms)	15.5	0.7A	1.0A
6451043	80MB (PS/2-55 17ms)	15.5	0.7A	1.0A
6451073	40MB (PS/2-35/40 17ms)	6.65	0.25A	0.45A
6451074	80MB (PS/2-35/40 17ms)	6.65	0.25A	0.45A
6451113	Internal CD-ROM (380ms)	24.9	0.9A	1.7A
6451049	60MB SCSI Hard Disk, 23ms	15.3	0.66A	1.0A
6451050	120MB SCSI Hard Disk, 23ms	15.3	0.66A	1.0A
6451045	80MB SCSI Hard Disk, 17ms	9.6	0.5A	0.8A
6451046	160 MB SCSI Hard Disk, 16ms	9.6	0.5A	0.8A
6451108	320MB SCSI Hard Disk, 12.5ms	15.3	0.66A	1.0A
6451081	400MB SCSI Hard Disk, 11.5ms	17.9	0.7A	1.2A
6450162	3.5" Rewritable Optical Drive	18.4	0.87A	1.17A
6451006	5.25" 1.2MB Int Diskette Drive	13.4	1.0A	0.7A
**	5.25" 1.2MB Int Diskette Drive	3.68	0.16A	0.28A
**	3.5", 720KB Int Diskette Drive	3.85	0.18A	0.25A
**	3.5", 1.44MB Int Diskette Drive	3.85	0.18A	0.25A
**	3.5", 1.44MB Int Dkt Drive, 1" high	3.35	0.13A	0.23A
6451106	3.5", 2.88MB Int Dkt Drive, 1" high	2.0	0.4A	0.0A
30F5279	Internal Tape Backup Unit	8.6	0.4A	0.55A
6451120	2.3GB SCSI Int Tape Drive, 8mm	14.8	2.0A	0.4A

Note: ** More than one part number for this option.

Table 3-7. Typical DC Wattage and Current for IBM Adapter Options

Marketing Part #	Adapter Description	Operate DC Wattage	Operate Current +5V	+12V	−12V	−5V
64F7351	PS/2 Wizard	28.60	4.700	0.425	-	-
6451091	Ethernet Adapter/A	8.660	1.360	0.155	-	-
6450685	1-8MB 80286 Memory Expansion	9.450	1.890	-	-	-
74F5130	Token Ring Network 16/4 Trace and Performance Adapter/A	3.400	0.680	-	-	-
69X8138	Token Ring Adapter/A	2.125	0.425	-	-	-
1887972	Display Adapter 8514/A	10.00	2.000	-	-	-
1501222	PC Network Broadband Adapter II/A	7.970	0.970	0.260	-	-
**	RIC Multiport	8.840	1.600	0.070	-	-
1501223	PC Network Baseband Adapter/A	5.560	1.100	-	0.005	-
6451003	Multi-Protocol Adapter/A	6.852	1.200	0.037	0.034	-
6451109	Micro Channel SCSI Adapter	6.35	1.27	-	-	-
94X2415	3119 Page Scanner Adapter/A	6.920	1.360	0.005	0.005	-
30F5383	Enhanced 5250 Emulation	5.040	0.840	-	0.070	-
6451110	Micro Channel SCSI Adapter w/Cache	5.35	1.07	-	-	-
65X1925	3117 Page Scanner Adapter/A	5.740	1.100	0.010	0.010	-
6451013	Dual Async Adapter/A	3.588	0.630	0.030	0.004	-
65X1810	3118 Page Scanner Adapter/A	3.924	0.780	-	0.002	-
94X1755	300/1200/2400 Internal Modem/A	2.812	0.500	-	0.026	-
74F3465	3270 Connection	2.750	0.550	-	-	-
74F4140	Token Ring Network 16/4 Busmaster Server Adapter/A	6.000	1.200	-	-	-
16F1133	Token Ring Network 16/4 Adapter/A	3.600	0.720	-	-	-
75X5887	XGA Display Adapter	5.525	1.105	-	-	-
09F1897	RIC Multiport/2 (base)	7.225	1.445	-	-	-
53F2601	RIC Portmaster Adapter/A (base)	8.925	1.785	-	-	-
83X8187	Store Controller	6.400	1.280	-	-	-
94X2530	FAX Concentrator Adapter/A	8.993	1.360	0.149	0.034	-
1674899	System 370 Emulator	8.250	1.650	-	-	-
16F1858	X.25 Interface Coprocessor/2	8.010	1.445	0.030	0.036	-
44F9914	Image Adapter/A 1MB	3.825	0.765	-	-	-
44F9919	Image Adapter/A 3MB	4.888	0.978	-	-	-
44F9921	Image Adapter/A 3MB	4.888	0.978	-	-	-
95F1091	Enhanced M-Motion Video Adapter/A	10.13	1.450	0.190	0.050	-

Note: ** More than one part number for this option.

Table 3-8. IBM Memory

Marketing Part #	Description	Memory Speed	Standby* DC Watts
6450603	1MB Single Inline Memory Module (SIMM)	85 ns	0.76
6450604	2MB SIMM	85 ns	1.52
34F2933	4MB SIMM	85 ns	1.12
6450608	2MB SIMM	80 ns	1.22
6450902	2MB SIMM	70 ns	0.86
6450128	4MB SIMM	70 ns	1.12
6450130	8MB SIMM	70 ns	1.90
87F9977	4MB SIMM	80 ns	1.12
6450129	8MB SIMM	80 ns	1.90
78X8955	128KB Memory Expansion Kit	150 ns	**
30F5348	512KB Memory Expansion Kit	120 ns	0.45
30F5360	2MB Memory Expansion Kit	120 ns	0.45
79F0999	2MB Memory Expansion Kit	80 ns	**
79F1000	4MB Memory Expansion Kit	80 ns	1.90
79F1001	8MB Memory Expansion Kit	80 ns	**
6450379	2MB Memory Adapter	80 ns	1.52
6451060	4MB Memory Adapter	80 ns	2.44

Note: * Standby watts is used for these products, as operate watts is included with the standard memory in the system. ** Not available.

Power for Multiple Adapters

Some adapters require a lot of power. IBM Industrial Computers have larger power supplies that make it possible for larger numbers of communications adapters like the IBM Token Ring and Realtime Interface Coprocessor (RIC) to be used. In fact, the GEARBOX Model 800 can support six RIC adapters and an IBM Token Ring adapter with its 300 Watt power supply. In some installations this makes it possible for an application to be handled by one GEARBOX instead of two of some other type of computer.

Chapter 4. Surge Protection

Lightning Protection

Surges on a power line can be natural or man made. A natural surge is lightning, which does not have to strike the power line directly to cause problems. Most lightning surges are caused by cloud-to-cloud discharge or cloud-to-ground discharge which can induce tens of thousands of volts on a power line. A direct strike on the power lines will activate the utility surge arrestors, clamping the lines to a surge voltage dependent on the amount of current available in the surge. A 13 kV distribution system would be clamped to about 39 kV on a high current surge. A 25 kV distribution system would be clamped to a higher voltage level. These surges can get through the distribution transformers provided by the utility and appear at the service entrance of the building. It is usually the responsibility of the building occupant to provide service entrance arrestors and internal subpanel arrestors to clamp to lower levels.

Man-made surges are the result of the rapid release of stored energy in motors, such as air conditioners, elevators, refrigerators, oil burners, and machinery on a manufacturing line. These are usually in the hundreds to thousands of volts range.

The standard wall outlet in the U.S. has a flashover level of approximately 6000 Volts (6 kV). Even though the energy source may try to induce higher voltage levels, the wall outlet will limit what is applied to the Personal System product.

The Institute of Electrical and Electronic Engineers (IEEE) has published a standard (#587) which describes the surge environment. In a medium exposure environment (systems in geographical areas known for high lightning activity with frequent and severe switching transients), the number of surges at 6 kV is less than one per year and the number of surges at 2.5−3 kV at ten per year. The numbers for a low exposure environment are: 2.5−3 kV at 0.01 per year, 0.9−1 kV at 1 per year. High exposure is essentially an outdoor environment.

Lightning strikes injecting thousands of amperes of surge current into the earth ground can create thousands of volts difference between electronic loads located between buildings or even within a building. These potential differences need to be considered for the communicating circuits. See "Modem Lightning Protection" on page 4-2.

Surge Suppressors

External surge suppressors are not required on IBM PC and PS/2 systems. These systems have been designed to meet the IBM corporate requirements that include levels considered adequate for product protection.

External surge suppression equipment have been known to be the source of difficult to diagnose system problems. No design or performance standards have been established. There is no easy way to test them.

The three basic types of surge protecting devices used in surge suppression equipment are:

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1. Silicon avalanche devices—are very fast acting semiconductor devices with relatively low energy clamping capability.
2. Metal oxide varistors—(MOV) are reasonably fast acting devices with relatively good energy clamping capability. The larger the device, the greater the peak current and energy that can be handled. MOVs have a failure mode of shorting when subjected to surges beyond their peak current/energy ratings. They also have a pulse rating chart that shows one pulse (pulses expected during the life of the equipment) or multiple pulses. Depending on the number of pulses you select, the peak current can be derated by a factor up to 100. Therefore, these devices are not the panacea for surge protection.
3. Gas discharge tubes—provide a different type of protection for surges than the voltage clamping devices above. Gas tubes breakdown at their voltage rating and then step the voltage down to just a few tens of volts. They can handle large surge currents, but the tube can be destroyed by follow or holdover current supplied by the power line after the actual surge has disappeared, if other protection is not included.

Commercial surge suppressors often employ more than one type of surge protecting devices. However, a well-designed product will provide protection over the life of the product.

Modem Lightning Protection

Although the system power supply is designed to provide adequate protection from power surges on the commercial power grid, another entry point is available to potentially harmful power surges. This is through the internally connected modem and telephone lines it accesses. The customer should review the modem documentation to identify the protective features employed in the modem. If none are identified, there are a number of surge protection devices available from retail outlets that will provide this additional protection.

Chapter 5. Environment

The temperature and humidity ranges for the PS/2 systems vary according to the following table.

PS/2 Machine Type	Operating Temperature	Non-Operating Temperature	Operating Humidity, Non-Condensing	Non-Operating Humidity, Non-Condensing
8525, 8530, 8550, 8570	15.6–32.2°C (60–90°F)	10–43°C (50–110°F)	8–80% RH	20–80% RH
8535, 8540, 8565	10.0–35°C (50–95°F)	10–43°C (50–110°F)	8–80% RH	8–80% RH
8555, 8560, 8580	15.6–32.2°C (60–90°F)	10–43°C (50–110°F)	8–80% RH	5–80% RH
8557	10.6–35°C (50–95°F)	10–43°C (50–110°F)	8–85% RH	5–85% RH
8590, 8595	10.6–32.2°C (50–90°F)	10–43°C (50–110°F)	8–80% RH	5–80% RH
8573	10.6–35°C (50–95°F)	5–60°C (41–140°F)	8–80% RH	5–95% RH
8557	10.0–35°C (50–95°F)	10–43°C (50–110°F)	8–85% RH	5–85% RH

IBM Industrial Computers are designed to perform reliably in more extreme temperatures and higher humidity. Office environments can reach higher temperatures when the air conditioning is powered off, or if the computer is located in an unventilated closet. The Industrial Computer types are identified below:

Industrial Machine Type	Operating Temperature	Non-Operating Temperature	Operating Humidity, Non-Condensing	Non-Operating Humidity, Non-Condensing
7537, 7546, 7561, 7562	0–50°C (32–122°F)	0–55°C (32–131°F)	5–95% RH	5–95% RH
7541, 7542	4–46.1°C (39.2–115°F)	0–55°C (32–131°F)	8–85% RH	8–85% RH
7568	0–60°C (32–140°F)	–55–85°C (–67–185°F)	5–95% RH	5–95% RH

Airflow

Most machines are designed with a certain standard installation in mind. However, there are almost as many different system installation combinations as there are users. Users install systems to suit their needs and space limitations. One of the most important aspects of an efficient installation is that a two-inch (51 mm) clearance be maintained at all vents to provide airflow to the system unit and various peripherals. This is especially critical where custom installations are devised which place the units in secondary enclosures and cabinets. Space must also be provided for cables and cable bends for power and signal lines attached to the various I/O ports of the machine.

Maintain at least two inches (51 mm) of clearance to adjacent walls and surfaces, and at least three inches (76 mm) between adjacent systems.

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This distance is required for adequate air circulation and cooling inside the system. Also avoid placing the PS/2 system unit near the exhaust of other electrical equipment.

Another consideration is providing space for accessing the interior of the unit. Room must be available for:

- Removal of external covers
- Easy access to the interior of the machine
- Installing and removing devices contained in the system.

Internal Fans

Most PS/2 system units rely on forced convection for cooling. In these units, natural convection is not adequate for the amount of heat dissipation required. A single fan is used, typically as part of the power supply. An exception is the 8550 which has a free-standing fan assembly, separate from the power supply. The 8590 and 8595 have a second fan, also separate from the power supply.

Acoustical Energy

Sound is the propagation of (acoustical) energy through a medium. For the purposes of this manual, we will assume that the medium is air. Under nominal conditions of 20°C and atmospheric pressure, sound waves propagate at a speed of approximately 343 meters per second, or 767 miles per hour. A "sound wave" is simply a disturbance of the air particles. This disturbance either compresses or expands the air as it passes a fixed point in space, thus effecting a temporary change in the localized pressure. It is the *disturbance* which propagates at the speed of sound, not the air particles themselves. The velocity of the particles is typically quite small (for example, 0.001 m/s for an 86 dB sound pressure level plane wave). When this disturbance impinges on your ear drum, a mechanical, chemical, and physiological process takes place that results in your perception of that disturbance as sound. In the case of music, the gentle roll of ocean waves, or rustling leaves, these sounds can be welcome and often quite pleasant. Another class of sound that is not welcome, but rather is obtrusive and sometimes annoying, is termed *noise*. Unfortunately, cooling fans, printer mechanisms, and other electromechanical moving parts of personal computer systems emit sounds that are generally perceived as noise.

Sound Power versus Sound Pressure

The amplitude or intensity of sound is the increase or decrease in the local sound pressure. The larger the change in the local pressure as the sound wave impinges on your eardrum, the louder the sound. Because of the tremendous range of sound amplitudes our ears can detect, and because our hearing responds in approximately an exponential manner, sound levels are almost always expressed using logarithmic quantities. That is, sound pressure levels are designated in decibels (dB) and sound power levels are often expressed in bels (B), both relative to their respective usual reference quantities. For example, a sound pressure wave that has an amplitude of 1 pascal has a sound pressure level of 94 decibels, and a sound source that emits a sound power of 1 watt has a sound power level of 12 bels.

Sound pressure is a field quantity that can be detected at a single point in space using a microphone (or your ears). Sound power, on the other hand, is the amount of sound energy emitted by a noise source per unit of time, and is a fundamental characteristic of the noise source. The sound pressure near a source depends on

the acoustical characteristics of the environment as well as the source; however, the sound power of the source is independent of the environment. The simplest analogy is that of a light bulb—the power emitted by the light source (for example, 50 watts) is a characteristic of the bulb, and is independent of whether the surrounding walls are black or white; in this case, the bulb brightness is analogous to sound pressure—as source-to-receiver distance increases, brightness (or pressure) decreases.

Dealing with two very different quantities (pressure and power), both expressed in logarithmic units, can lead to confusion. For example, it is mathematically true that 1 bel = 10 decibels, but that is not to say that sound power levels and sound pressure levels are related by a factor of 10! By convention, sound pressure levels are expressed in terms of decibels, and sound power levels in terms of bels, primarily to avoid this confusion. To express sound power levels in terms of decibels, then a simple factor of 10 can be used. However, to obtain the sound pressure level a given distance from a source of known sound power level, the conversion is more complex—it requires extensive knowledge of the acoustics of the source and the environment in which the sound pressure is to be measured.

Noise Declaration Table

An example of a product noise emission declaration table is given in Table 5-1. The data in this table are reported in a format that is in accordance with American national and international standards. Acoustical information similar to that shown in Table 5-1 is furnished in the Technical Reference Manuals for most IBM PS/2 systems.

Table 5-1. Example of a Noise Declaration Table

Declaration of IBM Product Acoustical Noise Emission Values

Machine Type	Description	L_{WAd}		L_{pAm}		$<L_{pA}>_m$	
		Operating (bels)	Idling (bels)	Operating (dB)	Idling (dB)	Operating (dB)	Idling (dB)
8557	PS/2 Model 57 SX	5.0	5.0	41	41	36	35
8595	PS/2 Model 95	5.3	5.3	35	35	36	36

Notes:

L_{WAd} is the declared (upper limit) sound power level for a random sample of machines.

L_{pAm} is the mean value of the A-weighted sound pressure levels at the operator position (if any) for a random sample of machines.

$<L_{pA}>_m$ is the mean value of the A-weighted sound pressure levels at the one-meter bystander positions for a random sample of machines.

All measurements made in accordance with American National Standards Institute (ANSI) S12.10, International Organization for Standards (ISO) 7779, and ISO 9296.

Both sound power and sound pressure level data are reported. The preferred descriptor for product noise emissions is sound power, simply because it represents an inherent characteristic of the acoustical nature of the source, independent of the environment in which the source (PS/2) is placed. Sound power is also useful in combining noise levels from several sources. For example, often a *necessary* ingredient for prediction of installation noise levels is the sound power of all of the noise sources in the installation. Additional information is needed for noise level

prediction, such as the physical and acoustical characteristics of the room and the locations of all noise sources to be installed in the room, hence source sound power may be necessary, but not sufficient information for prediction of installation sound pressure levels.

Sound Pressure Levels

The two sound pressure levels appearing in Table 5-1 on page 5-3 are for the operator position (L_{pAm}) and for the one-meter bystander positions ($<L_{pA}>_m$). These locations are defined in ISO 7779 for all computer and business equipment, but in simple terms, as applied to a PS/2 for example, the operator position data is measured at the location of a typical PS/2 user. For desktop PS/2 systems (for example, Model 57 SX), the PS/2 is installed on a standard test table and the microphone is placed at the position of a typical seated user. For floor-standing systems (for example, Model 95), the unit is installed directly on the floor, with an assumed operator position of a seated user. Note that the term "system" normally refers to the computer base unit only; noise from displays, keyboards, printers, and other ancillary equipment is not included in this declaration. All such equipment are considered individual functional units, thus the noise levels are declared separately for each unit.

When the customer wants to know what noise levels to expect when operating a PS/2 system, the operator position sound pressure level data comes closest to answering, provided there are no other noise sources in close proximity to the user, *and* the effects of nearby room boundaries are negligible. These two conditions are frequently violated, thus typical operator position noise levels are often greater than those found in the noise declaration table. Therefore, it is a good idea to treat the sound *pressure* level data provided in the noise declaration table as a lower limit of what can be expected in a real installation. Again it is important to note that sound power is, for all practical purposes, a characteristic of the source, and is independent of what environment that source is installed in. It is clear that this does not hold true for sound pressure levels.

Declared Sound Power Level

The *declared* sound power level (L_{WAd}) is a statistically-based term, taken from international standard ISO 9296, which indicates an upper limit sound power level below which a large proportion of the sound power levels of a batch of machines are stated to lie. The verification procedures in clause 6 of ISO 9296 are designed such that there is a 95% probability of acceptance if no more than 6.5% of the equipment in a batch has sound power levels greater than the declared noise emission value L_{WAd}. Use of this statistical approach protects the consumer from situations where machine noise levels may vary widely due to production variations, but only the average level is reported.

Recommendations for Typical Installations

There is only a limited amount of noise control that can be done by the end user; the most effective noise control measures have already been taken (by the design team) before the system is shipped from the factory. However, in some installations, depending on room size, wall composition, and PS/2 locations, a modest amount of acoustical absorption can reduce noise levels. Following are some general concepts that may be helpful when planning an installation.

Since nearly all PS/2 installations are in relatively small, quiet office environments, it is important to review some basics of the behavior of sound in enclosed spaces. The sound pressure at any point in a room is comprised of contributions from both the direct wave and waves reflected from room boundaries (for example, the walls).

The strength of the direct wave is dependent on the sound power and directional characteristics of the source, and the distance from source (PS/2) to receiver (your ears). The strength of the reflected or reverberant energy depends on the size of the room and the absorption of the room boundaries. The relative contribution of the direct energy decreases with distance from the source until, in the far field reverberant energy dominates.

Room treatment, such as absorptive panels attached to walls or acoustical ceiling tile, will reduce the strength of the reverberant energy, but will have no effect on the direct sound. Thus, noise level reductions achieved by adding absorption to the walls will be most pronounced well away from the noise source. One exception to this rule is if a PS/2 is installed near a room boundary (near a wall or corner). In this case, the reflected sound can be relatively strong very close to the source, thus a noticeable noise level reduction can sometimes be achieved by adding absorptive panels to the walls nearest the PS/2. When in doubt, experiment!

Displays

During product development, engineering design specifications for display products assume operation in typical office environments. As with most PS/2 products, displays are designed for single shift, 5 days per week operation in areas that are not environmentally hostile to equipment or operators. Ambient room temperatures range from 68 to 90°F within normal office humidity range, and no moisture, toxic or otherwise harsh elements come into contact with the equipment. Based on these assumptions, PS/2 displays are designed to provide a high reliability factor and operational longevity (front-of-screen performance acceptability) that hopefully satisfies the more demanding customers.

The chosen design point assumptions of any electronic equipment provide a specific Mean Time to Failure (MTTF) for that design. MTTF is not the end of life of a product, but the arithmetic mean (of the total build of the product) projection of time before a failure might occur in the product. The time to fail projected by MTTF does not imply that all products with the same design will fail at precisely that point in its life. Naturally, a given machine could fail at initial installation; it might fail at the mean estimate. Conversely, a machine may never fail during it's useful life.

Constant Power-On Operation

Constant power-on operation of displays consumes product life at a much accelerated rate, as does operation in hostile environments. Improper adjustment of brightness and contrast controls also have an adverse affect on useful life of all displays.

In the case of displays, the time to failure, or the time to the end of operationally useful life of the display (when the screen becomes too dim to be easily read or the phosphor burns appear on the screen), or the MTTF of the display can be shortened significantly by improper adjustment or unnecessary operation.

As an example, in an environment where the display is actually used from 8:00 AM to 5:00 PM Monday to Friday, but is left powered on 24 hours per day and 7 days per week, the MTTF might be shortened by a factor of approximately 300%. (Assuming an MTTF of 10 years under normal 8 hours per day and 5 days per week operation, if left powered on continually the MTTF might decrease to 3 – 4 years.) If it is also subjected to harsh environments such as high ambient temperatures, the MTTF decreases further. Theoretically, this being the case, the number of failures that would normally have occurred over a 3 – 4 year period in an account might be

incurred within the first year of operation, or the failures that would have occurred over a ten year period might be experienced within the first two or three years.

Industrial Computer Displays

IBM Industrial Displays are designed to operate 24 hours per day and 7 days per week. When they are used in an environment where the display is powered on less time than that, the associated MTTF increases.

> The industrial display must remain powered off for approximately 30 minutes, to maximize the automatic degaussing circuitry at power-on.

Video Performance

Another detrimental effect of leaving a display powered on unnecessarily is the possible degradation in front-of-screen (FOS) performance. Depending on what is displayed on the screen when the system is not in use, there might be "burning" or darkening of specific areas of the screen, or a general overall dimness of the screen.

Both conditions could be avoided by the use of screen saver software which turns off the video signal, resulting in a completely blank screen, after a specific time period of keyboard inactivity. Please note that although screen saver software can be a very positive factor in minimizing the FOS impact incurred when the display is left powered on continuously, it does not significantly reduce the negative impact to MTTF incurred by allowing a display to remain on continuously. Screen savers are useful, even in 8 hours per day and 5 days per week operation, because they can extend the FOS performance characteristics of the display.

Video Adjustments

FOS performance can also be detrimentally affected by improper adjustment of the brightness and contrast controls, to levels higher than necessary for comfortable viewing. By adjusting the controls to improperly high levels for extended periods, the cathode ray tube (CRT) phosphor can be burned, making it appear less bright over time. Additionally, high level settings cause the CRT cathode to overdrive, which results in premature reduction in cathode emission and decreased brightness of the phosphor.

All IBM displays are designed to have adequate additional brightness and contrast capacity remaining in the adjustment controls, when adjusted as recommended in the installation guide. This additional capacity is provided so the original proper viewing brightness levels can be maintained over time with the normal aging of the CRT. If the controls are incorrectly adjusted to their highest possible settings at initial installation time, the CRT phosphor and cathode emission will suffer the effects of being constantly overdriven and the screen will prematurely dim. Since the controls were set to their highest levels, there is no longer any further adjustment available in the controls to counteract this dimming.

Constant power-on situations should be avoided where possible. This ensures maximum reliability and FOS performance of the displays.

Screen Degaussing

Degaussing circuits are activated only at power-on time. Degaussing allows the display to automatically adjust for electromagnetic influences and electrostatic buildup. In some cases, without degaussing, the colors presented can become different than intended. The colors may also become uneven, blotchy, or washed out.

> Daily auto degaussing by powering the display off at night and on in the morning helps an IBM display maintain the sharp accurate colors.

It is not necessary to power-off the display while the operator is on breaks, or even at lunch. Continuous heating and cooling cycles created by powering the display off and on repeatedly during the day can also be detrimental to lifetime reliability. If the display will not be used for three or four hours, it is probably best to power it off. Shorter cycles than that could be detrimental.

System Unit Operation

Field experience indicates that system units may not be adversely affected by constant power-on operation. In part, this is due to the existence of a built-in fan providing positive airflow, and the absence of factors such as brightness/contrast controls. However, hard disks and internal fans are electromechanical devices that may wear prematurely with continued power-on. Heat and humidity are also factors.

A subtle but important item to consider is that the power-on self-tests (POST) are never run during constant power-on. This can allow a potential fault to go unnoticed until the failing function is attempted, thereby incurring a failure which would have been detected by POST, and the system unit repaired prior to incurring the actual failure. In an account where constant power-on operation is the normal practice, some failures may become evident if the POST is run by powering the system units off, then on. Unfortunately this may provide erroneous reinforcement indication to the customer that the system failed because it was powered off and on, when in reality, the potential problem was present for some time, and may have been failing during normal customer operation with no indication of failure to the user.

Industrial Computers

Some customer applications cannot be powered off. These "mission critical" applications impart a financial impact when the system is not operating, rather than when it is operating continuously. Industrial Computers are an excellent choice for mission-critical applications because they are designed for high power-on-hours, and their internal batteries allow operation even through power outages.

Financial Impact

It can safely be assumed that an average desktop system unit and a display use approximately 150 watts of energy when powered on. If both units were powered off every evening and powered on in the morning in an environment where the workday is 8:00AM to 5:00PM, Monday to Friday, rather than leaving both units on continuously, the following energy savings could be realized, assuming an electricity rate of $.10 per kilowatt hour:

Number of system/display combinations installed		Annual savings
100	=	$ 9,200
1000	=	$ 92,000
5000	=	$460,000
10000	=	$920,000

Naturally, floor-standing system units, or system units with high wattage option cards or peripherals installed will realize higher savings if powered off when not in use.

If it is necessary to leave the system unit powered on due to network installations, approximately 50% of the above savings could be realized if the displays are powered off overnight.

The above estimate does not consider the air conditioning costs avoided by not having to cool the office air made warm by unnecessary power-on of unused equipment. In cases where offices are being heated because the outside temperatures are low, heating units designed for space heating are significantly more efficient at providing that heat than are computer equipment.

Heat Factor

At some installation sites, the air conditioning may be shut down over holidays or weekends, or at the end of the business day. If computer equipment is continually powered on, the increase in ambient room temperatures may cause temperatures to rise above maximum recommended operating temperatures, which can adversely affect reliability. Room temperatures can exceed outside temperatures due to added heat from the computer equipment operating in the room. This is especially true in small offices, window offices where solar heat buildup can occur, and in areas with multiple computer systems powered on, such as data centers and classrooms. The increase in temperature caused by air conditioning shutdown will normally not result in temperatures high enough for non-operating equipment to be damaged. If the equipment remains on, however, increased ambient temperature could damage the equipment. A good rule of thumb is: for every 8 to 10 °C rise in temperature, the reliability of the device is derated by a factor of two.

Industrial Computers

IBM Industrial Computers are designed to be operated 24 hours per day and 7 days per week, in harsh temperature and humidity environments. They have forced positive air cooling that keeps the internal system components cooler than similar internal components of an office machine in an office environment. This translates into less component failure caused by heat.

Particulates and Gases

IBM Industrial Computers are designed to operate in harsh environments. They have fans that pull the cooling air in over filters and then force it over internal components. This forced air exits the machines through openings like the diskette drive slot. This prevents particulates from entering the diskette drive. Harsh environments may exist in areas than a manufacturing floor, since dust and dirt are common particulates. Industrial computers can be used in toll booths, in warehouses, on loading docks, and in baggage handling areas of airports.

Altitude

All IBM PS/2 systems are designed for use at a maximum altitude of 2133.6 meters (7000 ft) above sea level. Use at higher altitudes could cause overheating due to reduced air density.

Vibration and Shock

IBM PS/2 systems are designed to withstand the shock and vibration encountered during transportation *and* anticipated in a typical office environment. To further reduce the likelihood of damage from shock or vibration, the following checklist should be followed:

1. Before you apply power to your system:
   a. Verify that all option cards are plugged in and secured by the locking mechanism.
   b. Check to make sure that covers are securely fastened to the machine frame.
   c. Ensure that all attached cables and connectors are firmly seated in their respective sockets. Check that all screws are tightened.
   d. Locate your system away from high traffic areas or areas that are subject to significant vibration and shock, if possible.
2. Avoid frequent movement of your system.
3. If you have to move your system, first park the head(s) on your hard disk drive(s) and remove power from all equipment.

Earthquake Effects

There is no guarantee against computer damage in an earthquake. Many factors influence the seismic forces experienced by computer equipment, including:

- Intensity and duration of an earthquake
- Structural strength and fragility of equipment
- Building type and soil conditions at a site
- Location of equipment within a building
- Equipment installation method.

Guarantees of equipment reliability cannot be made for all future earthquakes and conditions. The damaging effects of an earthquake are minimized by appropriate installation and planning techniques. These are:

1. Significant sliding and rocking of computers during an earthquake may directly or indirectly result in damage. Minimize the damage potential, by taking the following steps:
   a. Locate equipment sufficiently distant from walls or other equipment to minimize damage from collision.
   b. Power and accessory cables to equipment should be long enough to accommodate some sliding in the equipment during an earthquake. Also, check that cable clamps or other strain reliefs are properly secured to the equipment.

c. The stability of tall, slender equipment, which has a potential for overturning in a severe earthquake, can be improved by tying several of these items together to form a more stable structure.

2. Desktop computers are most likely to be damaged in a fall. Several restraining methods that can be applied include:

   a. Restraining desktop equipment to the table surface by means of brackets, clamps, cables, or some other tethering device of appropriate size and strength.

   b. Adding a mat of high friction/damping material to the surface on which the computer is placed to reduce slippage.

   c. Providing an edge guard or lip along the edges of the table to minimize the risk of equipment sliding off.

Horizontal Orientation of Systems

Based on the requirements of various approval agencies to which our products are certified, most PS/2 desktop machines should not be used in orientations other than horizontal. If a desktop machine is mounted in a vertical position, IBM's concerns are threefold:

1. Without a stabilizing stand, the physical stability of the machines does not meet UL safety standards.
2. The side cover louvers do not meet top enclosure requirements designed to restrict introduction of conductive materials (such as paper clips) into the machine enclosure.
3. The side cover louvers do not meet bottom enclosure requirements designed to prevent the escape of molten materials from a machine that has been subject to an internal fire or severe electrical short circuit.

Customers who mount desktop machines in an orientation other than horizontal should be aware that such use may invalidate UL and/or CSA safety listings. The vertical position does not allow proper airflow to components unless the system unit is supported by an approved stand.

The 8530-286 and 8555 can be mounted vertically with an IBM designed, UL approved, and CSA certified floor stand. This stand can be obtained directly from Advanced Fabrication Technologies in Oxford, North Carolina. The stand part number is 91F8282 and the installation instructions are part number 85F0495.

The 8540 and 8557 can be mounted vertically with an IBM designed, UL listed, CSA certified floor stand (part number 91F7592), which is part of the ship group.

The 8535 and 8556 can be mounted vertically with an IBM designed, UL listed, CSA certified floor stand (part number 95F5607) that is ordered separately.

Drive Orientation

Typically, Direct Access Storage Devices (DASD) are designed to operate in either a horizontal or a vertical position with no degradation in performance. Notable exceptions are the optical drives which have shock mounting schemes to protect sensitive components optimized for horizontal mounting.

- The 5.25-inch CD-ROM drive can be operated vertically on its left side (as viewed from the front), but not on its right side.

- The 3.5-inch read/write optical drive is not intended for operation in a vertical mode.

Difficulties may arise with dual mode operation, that is, operation in a secondary orientation 90° from its design point orientation. Although this may be readily accomplished with the "as shipped" configuration of the system unit, certain added DASD options could preclude successful operation in the secondary mode.

Chapter 6. Electrostatic Discharge

Handling System Boards

Warning: Static electricity can damage the system board if the proper handling procedures are not followed.

1. Power off the system.
2. Disconnect all external devices from the system unit.
3. Unplug the power cord at the wall outlet.
4. Remove the cover from the system unit.
5. Touch the static-protective bag to any of the metal expansion slot covers in the rear of the system unit. This reduces static electricity from the package.

   Note: If you are not sure where the metal expansion slot covers are located, refer to the *Quick Reference* for your system.
6. Touch a metal expansion slot cover with your hand. This reduces the static electricity from your body. IBM personnel are required to use the electrostatic discharge (ESD) kit (part number 6428316) and wrist band (part number 6405959).
7. Open the bag and remove the system board, holding it by the edges. Limit your movement, because movement can cause static electricity buildup.
8. If you must lay the system board down, place it inside the static-protective bag on a flat, non-metal surface. Do not place it on the system cover.
9. Establish personal grounding (see step 6) if you handle other objects or leave the system unit.
10. Install the system board according to the product instructions. Tighten all screws to establish a good ground and mechanical soundness, as well as minimize the effects of static discharge to the system board and intermittent failures.
11. Be sure to tighten all screws that were loosened to access the system board.

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Handling Adapter Cards

Warning: Static electricity can damage the adapter card if the proper handling procedures are not followed.

1. Power off the system.
2. Unplug the power cord at the wall outlet.
3. Remove the system unit cover.
4. Touch the static-protective bag to any of the metal expansion slot covers in the rear of the system unit. This reduces static electricity from the package.

   Note: If you are not sure where the metal expansion slot covers are located, refer to the *Quick Reference* for your system.
5. Touch a metal expansion slot cover with your hand. This reduces the static electricity from your body. IBM personnel are required to use the ESD kit (part number 6428316) and wrist band (part number 6405959).
6. Open the bag and remove the adapter card, holding it by the edges. Limit your movement, because movement can cause static electricity buildup.
7. If you must lay the adapter card down, place it inside the static-protective bag on a flat, non-metal surface. Do not place it on the system cover.
8. Establish personal grounding (see step 5) if you handle other objects or leave the system unit.
9. Install the adapter card and tighten all screws to avoid static discharge problems.
10. Replace the system unit cover.

Chapter 7. Electromagnetic Interference and Susceptibility

Electromagnetic Interference (EMI) is an electrical noise that can create a disturbance or undesired response in other electrical equipment, including computers. Susceptibility of electrical equipment is the measured amount of EMI that is required to cause an undesired response, such as an error in computers.

IBM PS/2 systems are designed with low susceptibility to electrical noise or EMI. This ensures error-free operation when used in close proximity to radio and television stations, microwave or radar sources, static discharge, and lightning.

In addition, IBM PS/2 systems are designed and tested to be very low emitters of electrical noise. Therefore they are not a significant source of EMI. In fact, IBM PS/2 systems comply with worldwide electromagnetic interference standards. In the USA, PS/2 meets FCC Class B levels. In Canada, it meets Class B Radio Interference Requirements. In Japan, it meets VCCI; in Europe, CISPR 22; and in Korea, M.O.C. Class B.

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Chapter 8. PS/2 System Software

As shown in Figure 8-1 all PS/2 systems consist of four elements:

1. Hardware
2. Basic Input/Output System (BIOS) interface
3. Operating system
4. Application programs.

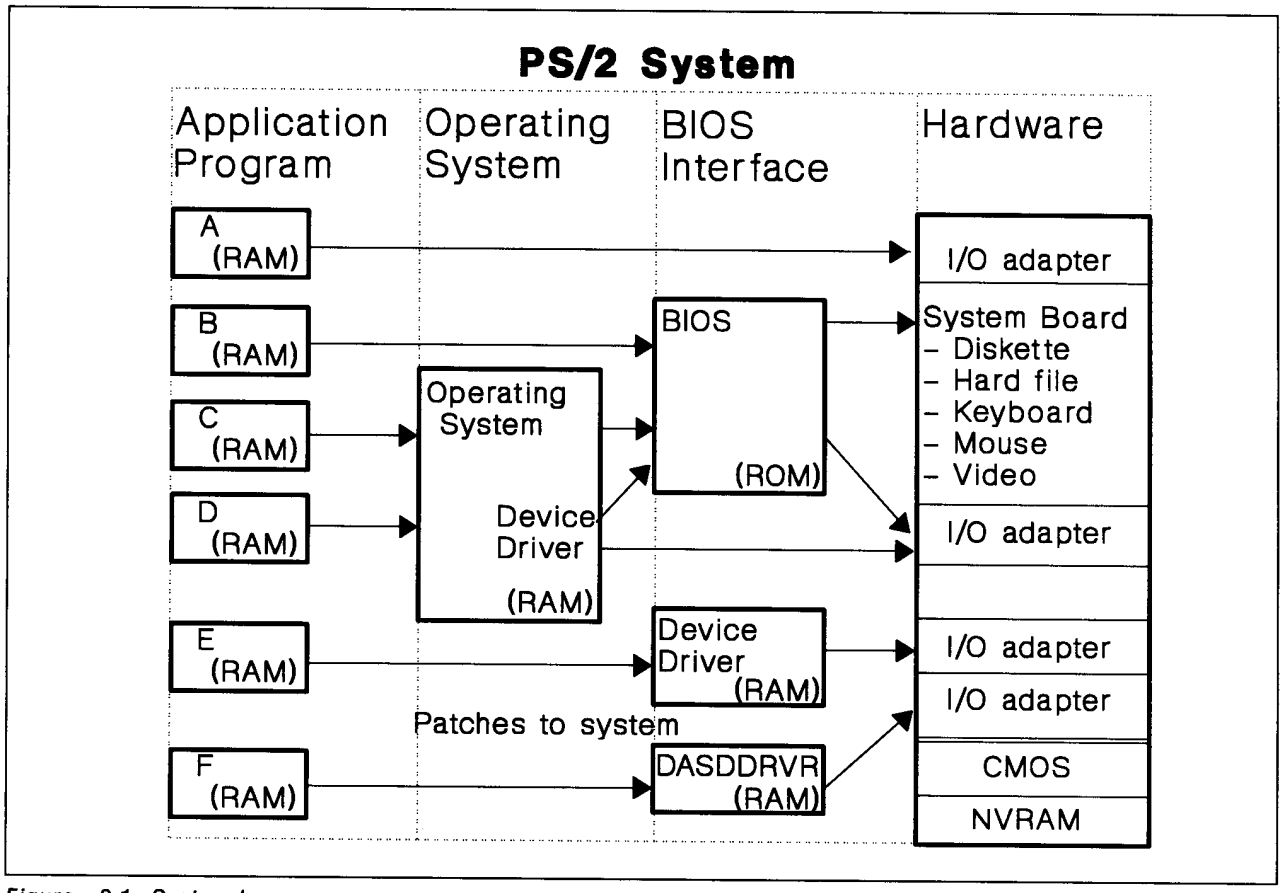

Figure 8-1. System Layers

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Hardware

The PS/2 hardware provides the following:

- Microprocessor and co-processor
- Read Only Memory (ROM)
- Random Access Memory (RAM)
- Three multipurpose timers
- Programmable Interrupt Controller
- Diskette controller
- Parallel port logic
- Serial port controller
- Direct Memory Access (DMA)
- Memory controller
- Complementary metal oxide semiconductor non-volatile random access memory (CMOS/NVRAM)
- Micro Channel Architecture support logic (Family II systems)

  Programmable Option Select registers (POS) registers reside on both the system board and on each input/output (I/O) adapter card. These registers are used by systems that conform to the Micro Channel Architecture (Family II systems). The following POS registers are available for I/O adapter card use:

  POS register 0, Adapter identification byte (low byte)
  POS register 1, Adapter identification byte (high byte)
  POS register 2, Option Select Data Byte 1, read/write
  POS register 3, Option Select Data Byte 2, read/write
  POS register 4, Option Select Data Byte 3, read/write
  POS register 5, Option Select Data Byte 4, read/write
  POS register 6, Subaddress Extension (low byte)
  POS register 7, Subaddress Extension (low byte)

  Further information on these registers may be obtained from the *IBM Personal System/2 Hardware Interface Technical Reference* manual.
- System Board Video Graphics Array (except the IBM 8590)
- I/O adapter card slots.

  Each of the devices responds to a specific I/O port address. Hexadecimal values are written to and read from the appropriate I/O port. These values are based on the function to be performed. Power-On Self-Test (POST) sets these ports to the initial value. POST may test or evaluate the ability of these ports to respond to program instructions. If an unexpected condition is detected an error message is displayed (POST error code). BIOS, device drivers, or application programs access devices through these I/O ports. For additional information on programming these ports, refer to the *IBM Personal System/2 Hardware Interface Technical Reference* manual.

BIOS Interface

All PS/2 systems have BIOS built into the system units. BIOS is a layer of software which acts as an interface between the system hardware and the user application software and operating system. BIOS guarantees compatibility of software across a family of computers, such as the PS/2 family of processors. BIOS also provides flexibility, by compensating for minor variations in hardware which may exist from system to system. Many optional adapters, available from IBM and other vendors, have their own built-in BIOS routines which provide for additional compatibility and flexibility.

Programmers who choose to use the BIOS routines built into the PS/2 systems are able to write software more quickly and with fewer problems, since BIOS contains error-handling routines for commonly occurring situations. There are two types of BIOS to choose from:

- Compatibility BIOS (CBIOS) for systems using Disk Operating System (DOS) is designed to handle a single I/O function.
- Advanced BIOS (ABIOS) for systems using Operating System/2 is designed to handle multiple I/O functions (multi-task).

Use of BIOS by programmers is not mandatory. In some cases it is necessary for programmers to write software routines which don't use BIOS (direct drivers) and interact directly with the system hardware. This is because BIOS routines may not be available for all hardware options. Two examples of these are:

- IBM Multiprotocol Adapter/A (MPCA)
- IBM 6157 External Tape Adapter/A.

Entire operating systems may be written without the use of BIOS routines. The IBM AIX* operating system is an example of an operating system which uses direct hardware drivers. IBM OS/2 and DOS utilize the BIOS routines. Certain efficiencies are gained by software which utilize direct drivers.

However, there are trade-offs. Direct drivers which bypass BIOS may have the advantage of faster throughput, but the disadvantage of limited error handling, and reduced software and hardware compatibility and flexibility. See Table 8-1 on page 8-5 for further information on direct drivers. Refer to *PS/2 BIOS Interface and Technical Reference*, under "Introduction to BIOS", Form S04G-3283.

In summary, software which does not utilize the BIOS routines:

- Is generally more difficult to install
- Is more sensitive to minor variations in hardware
- May experience compatibility problems when:
  - Migrated to different system units
  - Hardware adapters are added or removed from a system unit.

The compatibility problems may appear to be hardware failures.

Operating System

The operating system creates an environment on the computer that provides for the execution of application programs. The operating system works through BIOS to access the hardware and coordinate system function.

Note: The IBM AIX operating system (and other operating systems) access the hardware directly without using BIOS.

Each PS/2 system has BIOS support provided by the system. This code only provides programs with *physical* access to the I/O devices in the system.

An example of this interaction follows:

The operating system:

- Calls BIOS to get drive and media information
- Sets the media parameters through BIOS prior to the format
- Sets up sector and track table
- Issues BIOS call to recalibrate drive
- Issues BIOS call to format one track
- Repeats the above step for each track to be formatted
- Issues BIOS call to recalibrate drive
- Uses BIOS to perform a verify for each formatted track

Additional information can be obtained from the operating system Technical Reference Manual.

Application Programs

Application programs are used in conjunction with a specific operating system to perform a specified user task. An application program can access the system using one or more methods. This is illustrated in Table 8-1. The applications shown in Figure 8-1 on page 8-1 (at the left) are described.

Table 8-1. Program Interfaces

Application	Interface	Advantages	Disadvantages	Compatibility
A	Hardware	• Speed	• Compatibility with other machines • Application must accommodate variation in hardware • Other applications may not access the same device in a similar manner	Poor
B	BIOS	• Consistent interface to perform I/O • Record keeping for I/O devices	• Speed • Support for new features not always available	Good
C	Operating system	• Consistent interface for all applications to use • Hardware differences are detected and accommodated by the operating system	• Speed • Selection of the operating system is dependant on the desired support	Excellent
D	• Same as C • Operating system uses a device driver	• Support for a customized or advanced function device is provided for • Consistent interface for all applications to use	• May require additional RAM space for the device driver • Typically these are loaded by CONFIG.SYS. Installation procedure is needed • All loadable media must contain their own copy of CONFIG.SYS.	Excellent
E	Application uses a device driver exclusively	• Speed • Customized interface specifically designed for the target hardware adapter	• Requires additional RAM space for the device driver • Typically these are loaded by CONFIG.SYS. Installation procedure is needed • Other applications may not use this device driver • All loadable media must contain their own copy of CONFIG.SYS.	Good
F	Application was written to use BIOS. The patch has redirected the BIOS calls to itself	• BIOS problems can be corrected by this method • Turnaround from problem identification to correction by patch method is quicker than new ROMs	• Typically a single DASDDRVR.SYS file contains several patches. This may requires more RAM to be used. • Typically these are loaded by CONFIG.SYS. Installation procedure is needed • All loadable media must contain their own copy of CONFIG.SYS.	N/A

System Software

The operation of a Micro Channel Architecture PS/2 system is used to describe how the various system software components interact with each other. This description starts at power-on and includes:

1. Operation of a PS/2 that has not been configured
2. Execution of the Setup program
3. Operation of a PS/2 system that has been configured
4. Interaction of the operating system with the PS/2 system.

The basic system software components (excluding adapters) are shown in Figure 8-2.

1. Software contained in system board read only memory (ROM) or in an initial microcode load (IML) disk image.
   - POST — is responsible for:
     - Initialization of the system
     - Identifying the system configuration
     - Loading either the reference diskette or operating system.
   - BIOS — provides a uniform interface to the system hardware for the operating system.
     - Compatibility BIOS (CBIOS) for DOS type systems
     - Advanced BIOS (ABIOS) for OS/2 type systems
   - BASIC

     On older PS/2 systems this code consisted of ROM-resident interpreted BASIC routines that occupies 32KB of space. On newer PS/2 systems (such as the 8557) this code consists of a stub that occupies about 5KB of space.

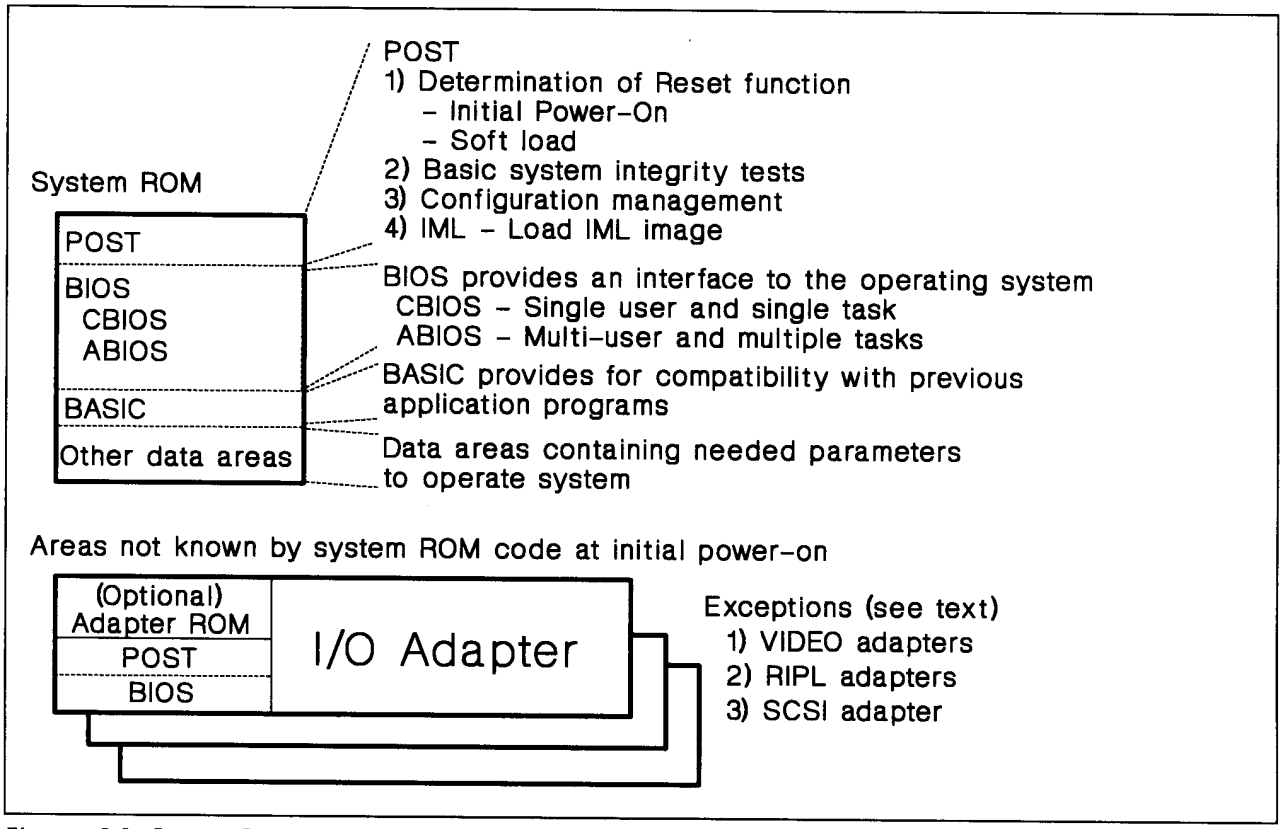

Figure 8-2. System Code Areas

2. Reference Diskette
   - Setup — is used on Micro Channel architected machines to configure the system before use by the operating system.
   - Diagnostics — are test routines used to identify problems with system hardware.
   - Utilities — are designed to:
     - Create a backup copy of the reference diskette
     - Add new adapters
     - Provide a means to update the programs and data on the reference diskette.

Adapter Cards

Adapters either enhance I/O devices that are standard on the system board, such as video; or add function to the system, such as Local Area Network (LAN) adapters.

Typically the following functions are required for an I/O device to operate in a system:

- Initialize the adapter hardware
- Detect and report any errors that may prevent proper operation
- Provide a program interface to the adapter.

To accomplish these functions the adapter requires the allocation of system resources to the adapter. Setup allocates these resources to the adapter. See page 8-16. Examples of these resources are:

- Memory addresses and sizes required
- I/O addresses
- Interrupt levels
- Arbitration level
- Fairness enable/disable.

POST Operations

The purpose of POST is to:

1. Initialize the system. This code sets the various system board and I/O adapter hardware registers to known values for proper system operation.
2. Perform a series of basic tests of the system. Examples of these tests are shown in Figure 8-3 on page 8-8. If an error condition is detected, it is reported by a POST error code. This is done before loading the operating system, since further operations may not be possible.
3. Initiate the loading of an operating system such as AIX, DOS, OS/2, or the IBM Reference Diskette.

- Determine cold or warm load to be performed
- Basic processor tests
- CMOS basic operation tests — see Figure 8-4 on page 8-10, item [1.1]
- Wait for channel reset
- ROM checksum test — see Figure 8-4 on page 8-10, item [1.2]
- Enable base video functions
- DMA initialization and register tests — see Figure 8-4 on page 8-10, item [1.3]
- Storage refresh operation
- Keyboard mouse controller initialization — see Figure 8-4 on page 8-10, item [1.4]
- Test bottom 64KB of memory — see Figure 8-4 on page 8-10, item [1.5]
- Verify real and protected processor modes
- Verify CMOS/NVRAM checksum — It is determined whether CMOS/NVRAM contains Setup data. — see Figure 8-5 on page 8-11, item [2.1]
- Initialize LOW RAM area of memory — see Figure 8-4 on page 8-10, item [1.6]
- Test address lines
- Test video functions
- Storage tests greater than 64KB
- Memory configuration test
- Timer tests
- Interrupt controller
- Diskette controller and drive tests
- Diskette configuration test
- Async port test
- Enable timer interrupts
- Additional configuration test
- (If configured) Initialize I/O adapters — see Figure 8-5 on page 8-11, item [2.2]
- Display any error message to user
- Boot the operating system. POST uses CBIOS **Interrupt 19H** call to load the operating system. — see Figure 8-6 on page 8-12, items 3.1, 3.2, and 3.3

Figure 8-3. Sample of POST Sequence

POST can be divided into two functional modes:

1. Exception POST
2. Normal POST

Exception POST, Including Setup

Exception POST is run if one or more of the following conditions exist:

- System has not been configured. A system must be configured when one or more of the following conditions exist:
  - System is initially received and POST error code 161 occurs
  - System board feature, such as memory, has changed
  - An I/O adapter has either been installed or removed.
- Configuration stored in CMOS/NVRAM does not match detected configuration due to:
  - Failure of an adapter to respond. This may be due to the adapter not being correctly installed or a malfunction of the adapter.
  - Human intervention.
- Unexpected condition(s) such as:
  - Stuck keyboard key
  - Memory error
  - Any other hardware error.
- Failure of CMOS/NVRAM power source
- Application program erroneously accessed CMOS/NVRAM and altered system configuration.

The purpose of this mode is to prepare the system to run either Setup or diagnostics.

The following section describes the basic operations of POST. Exception POST is executed when the system is first received and needs to be configured. Since this POST is executed at initial power, the following description starts at initial power-on.

In a system that requires Setup to be run, because of some unexpected error, POST may not recognize I/O adapters. POST does not attempt to either assign or resolve any possible conflicts between the I/O adapters. Setup carries out this function. Prior to PS/2 systems, the person installing the adapters had to perform this task. PS/2 systems automated this through the implementation of the Micro Channel Architecture.

The purpose of POST now is to provide the user a means to run Setup.

After the power has been applied to the system, the power supply returns the 'Power Good' signal line to the system board. This causes the processor to begin executing the POST code.

POST performs the tests shown in Figure 8-4 on page 8-10.

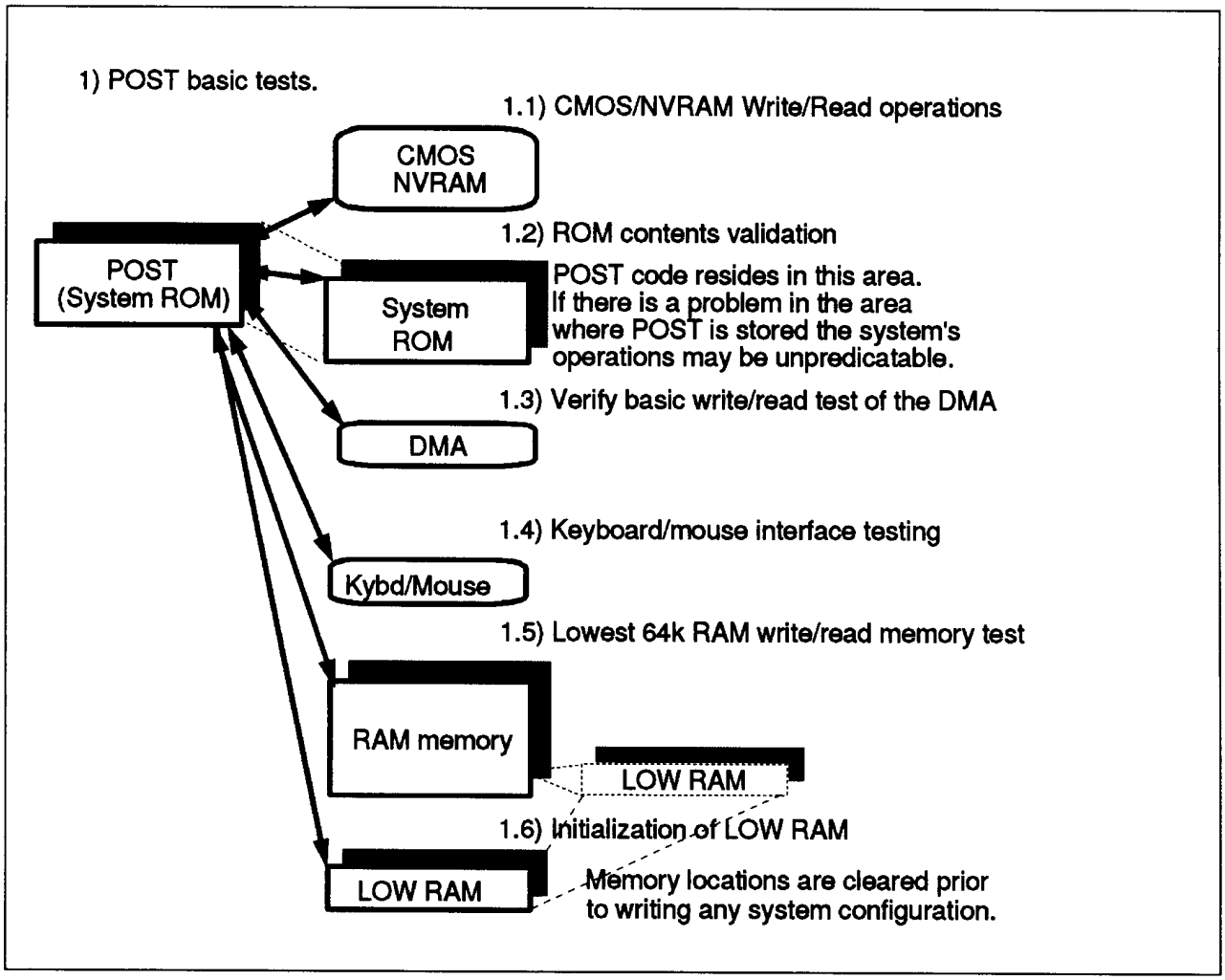

Figure 8-4. POST Basic Testing

Besides the tests shown in Figure 8-4, the following tests are also performed:

- Address lines
- Interrupt tests
- Video
- Memory testing above the base 64KB memory
- Initialization of the Extended BIOS Data Area (EBDA)
- Diskette

Figure 8-5 shows the sequence of operations POST takes to determine if the contents of CMOS/NVRAM contains valid data.

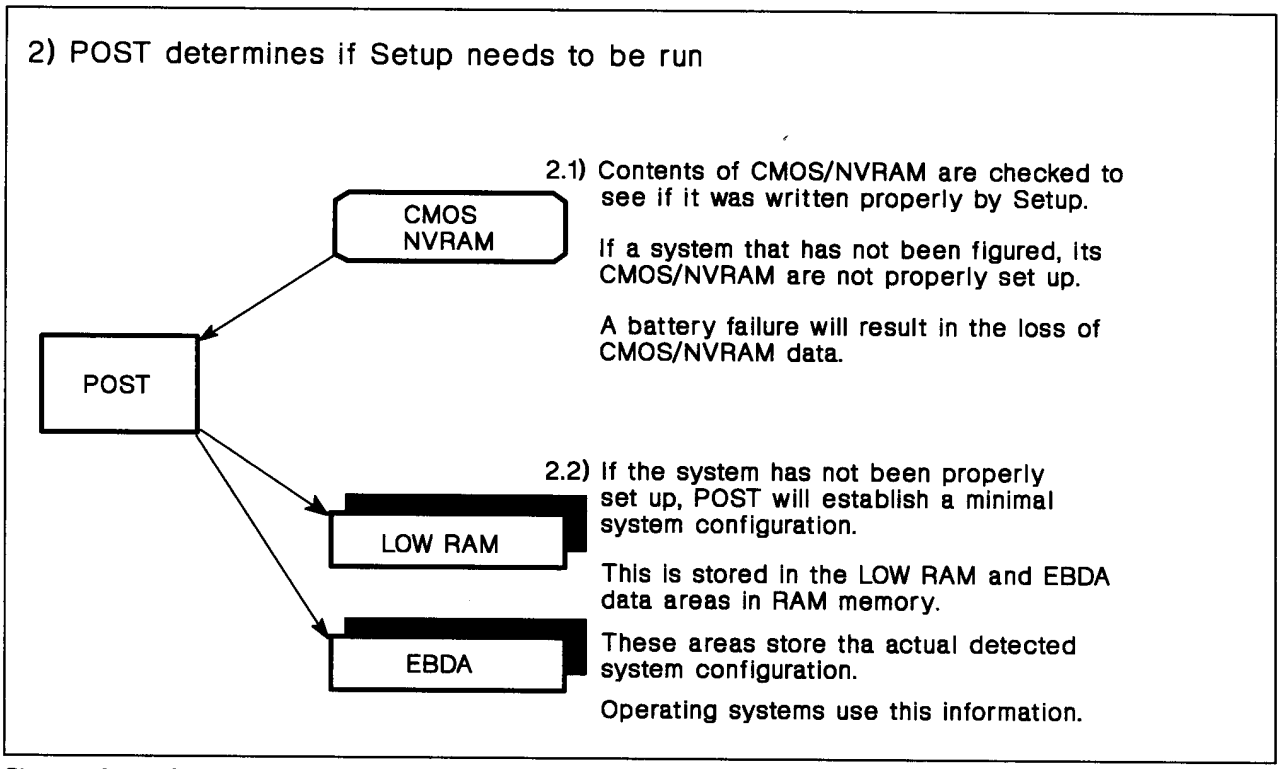

Figure 8-5. POST Examination of CMOS/NVRAM

At step 2.2, the configuration of the system is checked. POST checks the configuration by comparing the POS IDs of the adapters against POS IDs stored in CMOS/NVRAM for each slot.

If these all match, the information stored in CMOS/NVRAM is then copied to POS registers on I/O adapters. This information was written by the reference diskette Setup program. POST does not store any system configuration data to CMOS/NVRAM for permanent use. If the POS IDs do not match, POST will use default values for video and disk in order to run Setup.

From this information POST identifies the system components and stores this information into LOW RAM or into EBDA.

When POST has completed the initialization of the system, POST requests CBIOS to load the reference diskette. See Figure 8-6 for the steps. In non-IML systems the reference diskette must be inserted into diskette drive A.

On IML systems the reference diskette programs resides on the hard disk in the system partition.

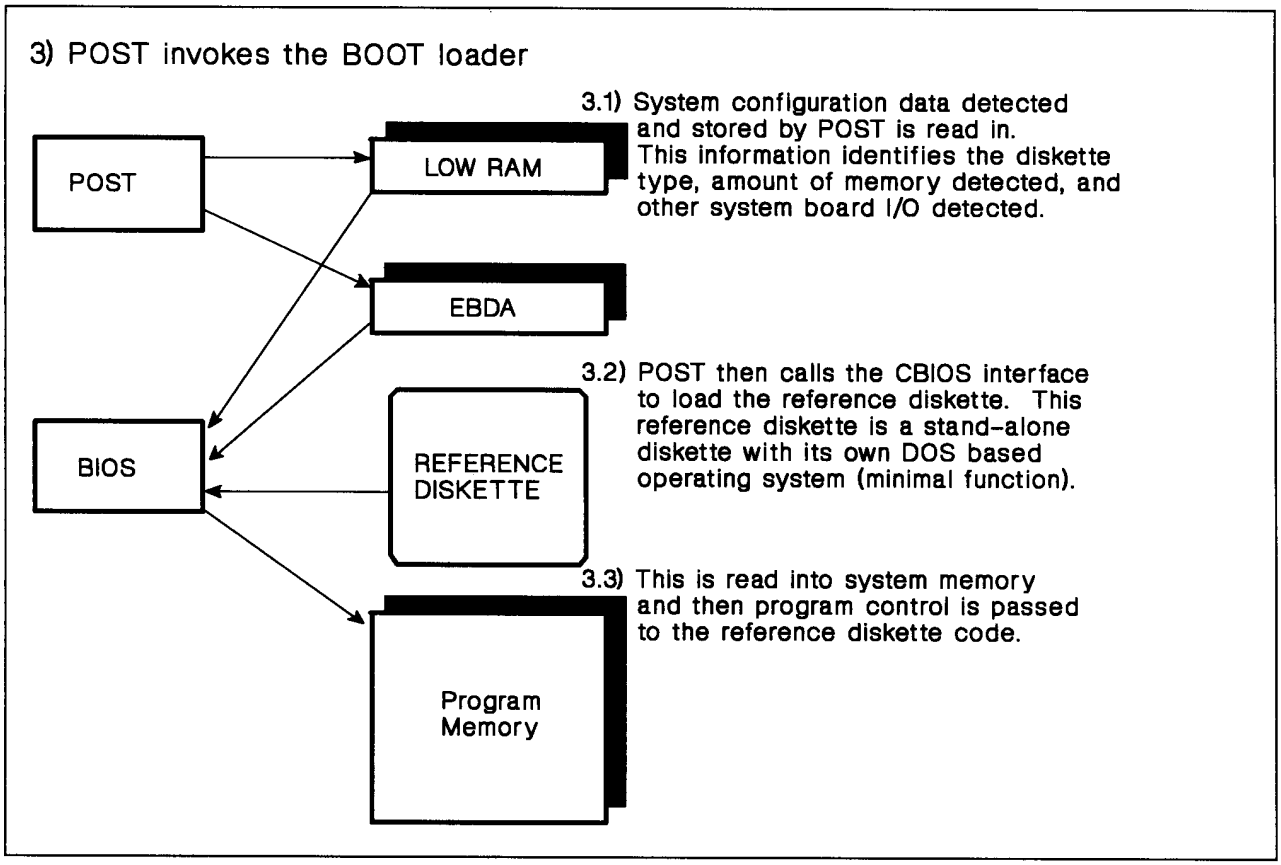

Figure 8-6. Loading the Reference Diskette to Run Setup

Once loaded, the reference diskette code is executed as shown in Figure 8-7. The system is configured through either the **Automatic Configuration** or **Change Configuration** option.

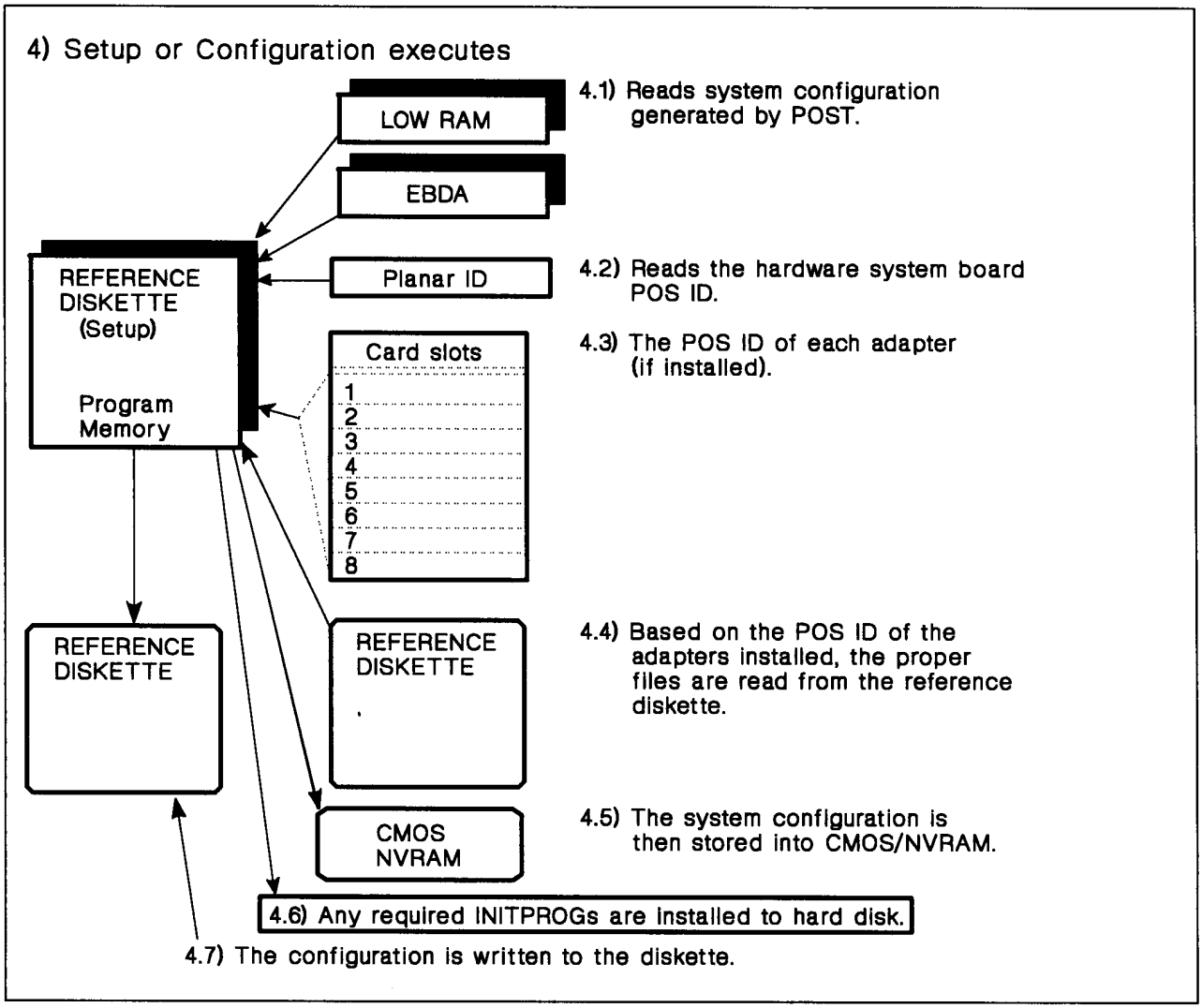

Figure 8-7. Execution of the Reference Diskette Setup Code

Before configuring the system, Setup must identify:

- System board features
  - Amount of memory installed
  - Number of parallel and serial ports
  - Any other unique requirements
- Installed I/O adapter requirements

Setup reads in the minimal system configuration created by POST in LOW RAM and EBDA.

The needs of the system board and the I/O adapters are described in files contained on the reference and option diskettes.

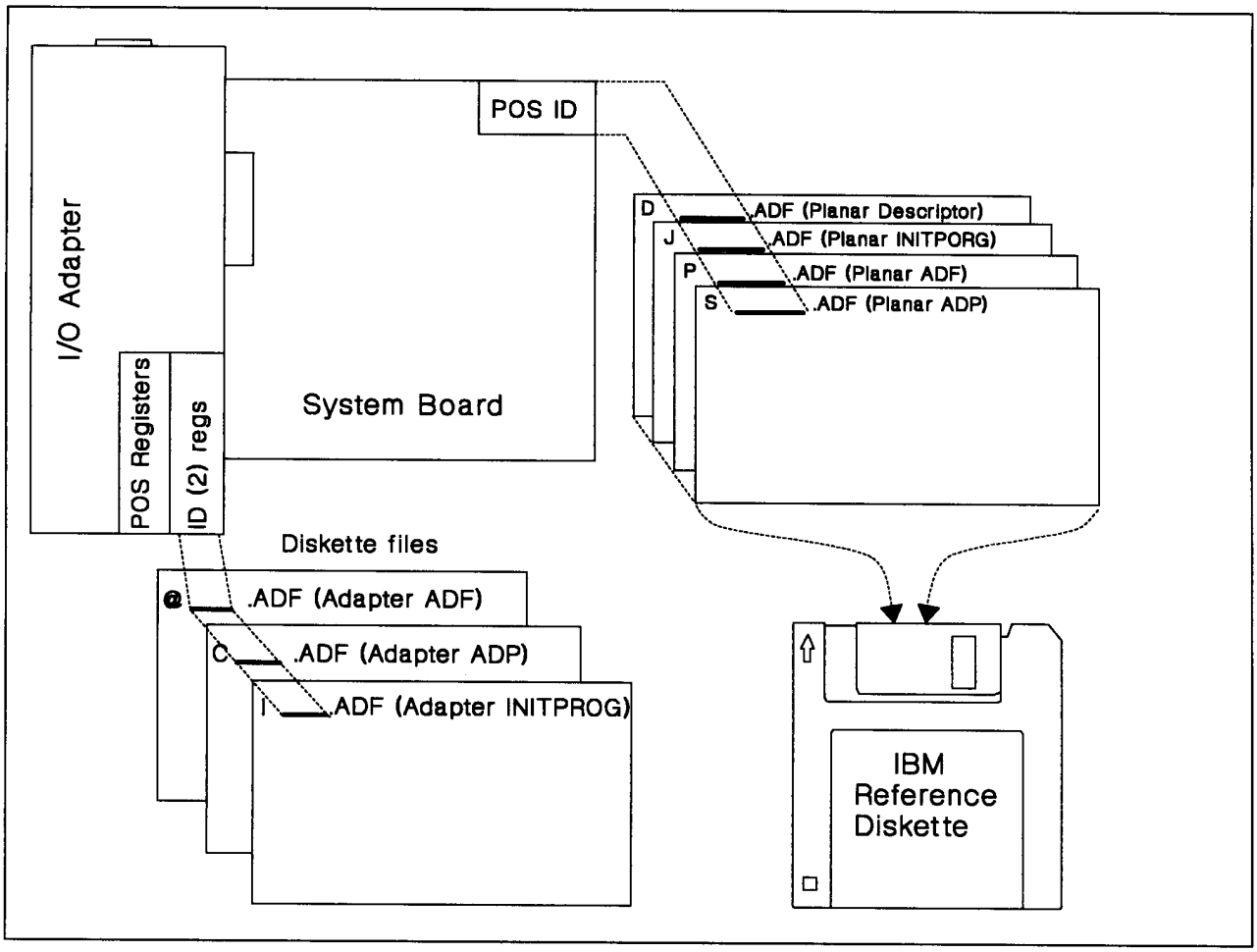

Figure 8-8. Reference Diskette Identification of Required Files

Setup uses the **planar ID** or adapter **POS ID** to generate a DOS file name with the file extension of .ADF. The first letter of the file name is used to select one of the following files:

- System board files

  D___.ADF Planar descriptor file. This is an ASCII text file.

  J___.ADF Planar Initialization Program or INITPROG.

  P___.ADF Planar ADF file. This is an ASCII text file.

  S___.ADF Planar ADP program file. This is an executable program used by Setup.

- I/O adapter files

  @___.ADF I/O adapter ADF file. This is an ASCII text file.

  C___.ADF Adapter ADP program file. This is an executable program used by Setup.

  I___.ADF Adapter Initialization Program or INITPROG.

These files provide Setup with the resource requirements of the system board and I/O adapters.

Note that all *valid and tested* choices are contained in these files. When Setup configures the system, all of these choices are considered for the system board and adapters. ADF files provides a list of choices for Setup to choose from.

An ADP program is executed by Setup to process memory information or to verify an ADF selection. ADP programs are used whenever additional functions are required to set-up the system or I/O adapter.

An example of an I/O adapter ADF file is shown in Figure 8-9.

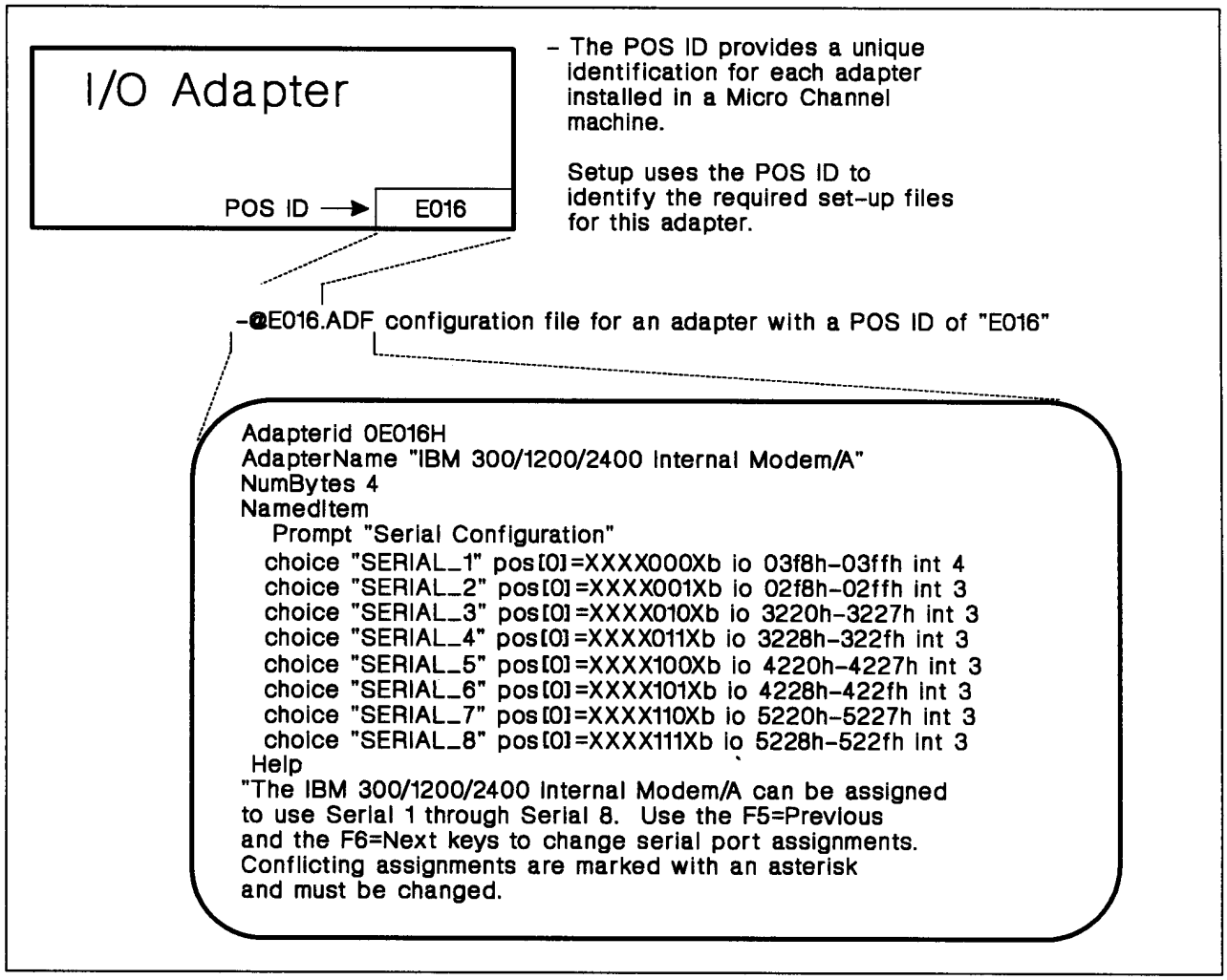

Figure 8-9. Example of an I/O Adapter ADF File

For each adapter in the system, Setup:

- Allocates an unique memory address for each adapter requiring memory
- Assigns interrupt levels
- Assigns arbitration levels where required
- Assigns unique I/O addresses
- Enables/disables other features where indicated
- INITPROG installation.

  If an adapter requires the use of an INITPROG, Setup installs it onto the hard disk unit 0 (Drive "80") during system configuration.

The configuration is stored into the non-volatile storage provided by CMOS/NVRAM. This provides for permanent storage of the system configuration. Also this information can be stored on the reference diskette for future use by Setup in the event the system needs to be configured because of servicing. This information stored on the reference diskette only applies to the system which Setup was run on. If this information is used on another system that is configured differently unpredictable results may occur.

Problems

In some environments either the operating system or application programs may have a unique requirement on the system configuration. Setup is unable to detect this requirement and does not consider this during the **Automatic** configuration of the system.

If this is the case, the person installing the operating system or application must use the **Change Configuration** option of the reference diskette to address this requirement. This will be known as a *customized system configuration*. The reason for this customized configuration needs to be communicated to others who may need to reconfigure the system.

If this is not communicated and someone generates a configuration that does not satisfy those unique requirements, the following may occur:

- Memory, I/O addresses, or interrupts are not where they are expected
- The application program may not function as desired.
- Another adapter (other than the one expected) may not be usable.
- Unexpected operations may occur (maybe intermittently)
- The system may hang.

Another concern for DOS environments is the result of using a memory manager. The main purpose of using a memory manager is to allow DOS users to use more of their memory in the first megabyte. (Figure 8-10 on page 8-17 shows the data areas of the first megabyte of system memory.) To do this, the memory manager must know how the system is configured.

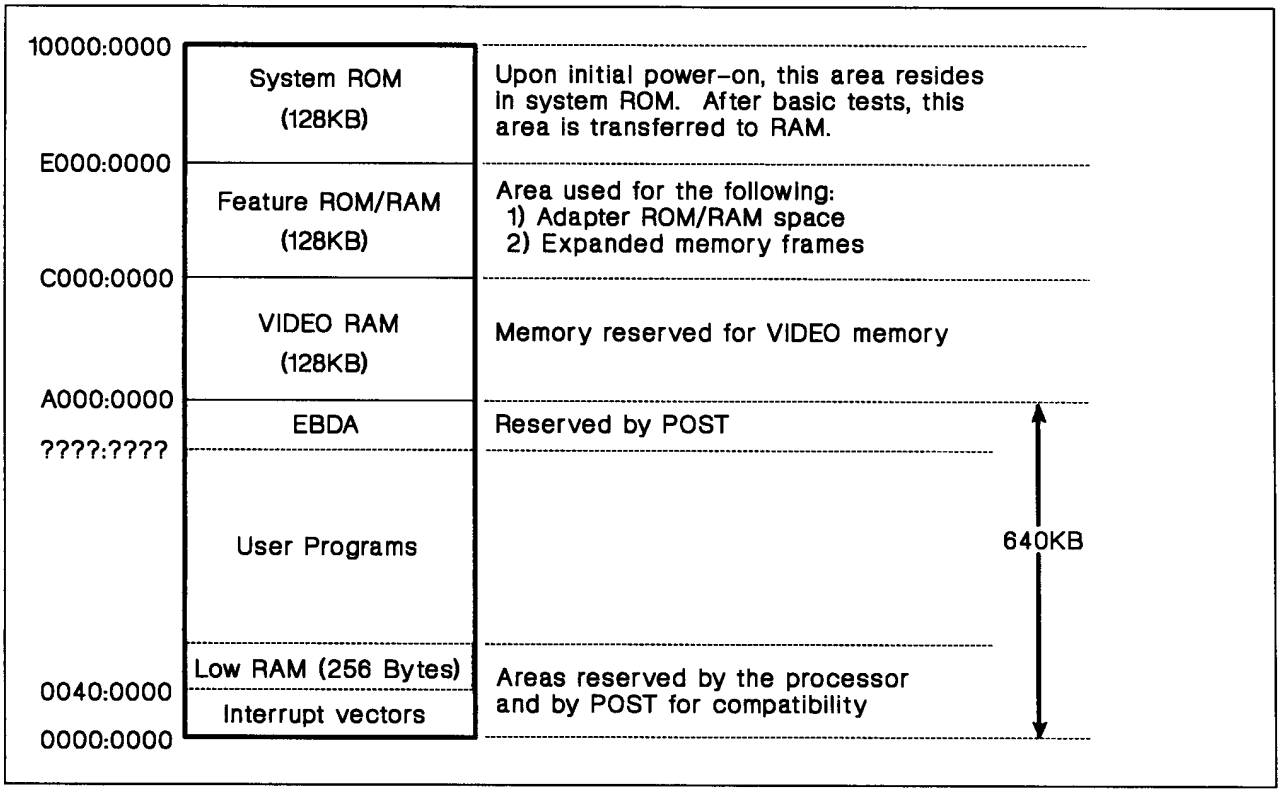

Figure 8-10. System Memory Data Areas

When being installed, several memory manager programs detect and record in a file, how the system is configured at the time of installation. On some occasions the installation process of the memory manager may reconfigure the system differently from how the IBM reference diskette configured the system.

Note: An indication of this is when the installation process requests the user to insert their IBM reference diskette into the diskette drive.

In Figure 8-11, the installation process of the memory manager has created line 1 of the CONFIG.SYS file. On this line it invokes the memory manager. This line also specifies a file name and extension of PROFILE.PRO. This file can contain information on how the system was configured when the memory manager was installed.

```
CONFIG.SYS
 1: DEVICE=C:\memmang\memmang.sys pro=profile.pro
 2: DEVICE=C:\DOS\SETVER.EXE
 3: BREAK=ON
```

Figure 8-11. Memory Manager Sample CONFIG.SYS Entry

The problem occurs when the system is reconfigured. This can create a configuration that is different from what the memory manager is expecting. This may result in one or more of the following conditions:

- Inability to access desired memory areas. Possible indications are:
  - Slow response (may be heavy disk usage).

- Inability to use specific application programs. These applications may require memory that the memory manager has not made available.

- System hangs
  - When initially loading the operating system.
  - When applications are loaded. This may only occur when a certain combination of applications are loaded.
- Unpredictable system operations. Some memory managers incorrectly use portions of memory already used by adapters. In these cases, applications which require use of the adapter may hang or cause incorrect system operation.

Possible solutions are:

- Re-run the appropriate memory manager configuration program.
- Edit the memory manager configuration file. This file name is typically specified on the CONFIG.SYS line that invokes the memory manager. These parameters should be described in the documentation supplied with the memory manager.
- Remove the CONFIG.SYS memory manager entry. This may require the re-installation of the memory manager.

Note: Some of the possible solutions may require a loadable diskette containing the operating system and a text editor to change the CONFIG.SYS file entries.

Adapter Data Areas

I/O adapters may have unique requirements depending on how the adapter interfaces with the system. Code to support these adapters may be located in one or more of the following areas:

1. System ROM — Part of the system board ROM.
2. Code in ROM installed on the adapter — Setup must allocate a unique memory range to the adapter.
3. Device driver — Device drivers are typically dependent on a specific operating system. A device driver would normally exist in the user's memory space. These programs are typically called *Terminate and Stay Resident* or TSR programs, in a DOS system.

   The person setting up the programming applications would be required to install these type of programs.
4. INITPROG — resides on the hard disk. The program is executed before loading of the operating system. The problem with INITPROGs is that they are **not** loaded when the system is loaded from a source other than the hard disk the INITPROG was installed on. Here normal system operation may not be possible. To overcome this problem a device driver can be used. This may be found on the option diskette that came with the adapter.

   The INITPROG is installed on the system by Setup.
5. Application program — Support for the adapter is built into an application program.

Diagnostics

Diagnostics consists of two major components:

1. Diagnostic Control Program (DCP)
2. Individual diagnostics.

The DCP performs the following functions:

- Loads the diagnostic programs
- Communicates with the user through menu screens
- Executes the appropriate diagnostics.

Loading: When the DCP begins to execute, it loads and executes all files that have the file extension of .DGS, one file at a time. These diagnostics can be located on the reference diskette, on the fixed disk in the system reference partition, or I/O adapter option diskette. When executed, the individual diagnostic determines if it is required to test the system. This determination is made based on:

- Planar (system board) feature installed — Planar diagnostics are required since they initialize the appropriate planar function in addition to performing the diagnostic test.
- Installed optional I/O adapter(s).

Once the diagnostic determines that it is required, it remains in storage. Otherwise, the program terminates itself and free up any memory it was using.

The user program area, 640K in size, contains DCP and all related system diagnostic programs.

User Communication: This is accomplished through menus that provide the user with a set of choices such as:

- Verification of the system configuration
- Selection of diagnostics to be run.

Individual Diagnostic Programs: The diagnostic programs perform a set of tests to identify failing conditions. The diagnostic programs are an extension of the POST tests. POST detects any error that may prevent the system from loading an operating system. The diagnostics pinpoint errors not captured by POST. The resulting error message identifies the failing Field Replaceable Unit (FRU) to the servicer. These errors would typically be noticed by the user as the result of improper system operation. Diagnostic effectiveness may be limited in cases of intermittent system errors; because the operating system may exercise the hardware and or system in a sequence different than the diagnostics.

Normal POST

In this mode the following conditions exist:

1. Configuration data was previously stored by Setup in CMOS/NVRAM.
2. Detected configuration is as expected.
3. No errors are detected.

Configuration data is used by POST to:

- Configure the system board features

- Configure the I/O adapters

  The I/O adapters are configured one at a time. This process starts with I/O adapter card slot 1 and continues until all slots have been set-up.

  1. Read the I/O adapter configuration data from CMOS/NVRAM.
  2. Put the adapter card slot in Setup mode. This is defined by the Micro Channel Architecture.
  3. Write the stored configuration to the adapter. This data is written to the POS registers of the I/O adapter card.
  4. Take the I/O adapter out of Setup mode.
  5. The I/O adapter is now configured in the system. Now the adapter is enabled but, depending on the design of the adapter, it may not be initialized. All the system resources allocated to the adapter by Setup are now active.

POST continues with other tests at this point leaving the adapters in an enabled state. Later stages of POST search for I/O adapter ROMs in the feature ROM memory address range, see Figure 8-10 on page 8-17.

The Micro Channel Architecture specifies the layout of the data stored in I/O adapter feature ROMs. This architecture specifies the following for feature ROMs:

- Identification area and specific data pattern; feature ROMs have a specific data pattern stored at a specific offset.
- Code entry offsets for initialization routines.
- Verification data.

When a data pattern is found in this area, POST performs a basic verification of the I/O adapter ROM and then executes the initialization code of the adapter. The initialization code completes the steps to initialize the hardware of the adapter. Further, this code can:

- Change system interrupt vectors
- Alter data areas, such as LOW RAM or EBDA, as needed.

Upon completion of the feature ROM/RAM area scanning, POST has completed initialization of the adapters. POST then begins the loading of the operating system by issuing a CBIOS **Interrupt 19h** call. During loading of the operating system the system configuration may be required.

The operating system may require this information to load the programs that support the configuration of the system. This information is stored by POST in LOW RAM and in the EBDA. An operating system accesses this information through specific CBIOS and ABIOS system services call. These routines either returns the data to the operating system or provides the operating system with an address where the data is located.

For additional information refer to the *IBM Personal System/2 and Personal Computer BIOS Interface Technical Reference* manual.

Chapter 9. Adapter Considerations

Compatibility

Servicers may experience situations where Micro Channel or PC AT bus adapters function correctly in one or more models of PS/2, but the same adapter fails to function correctly in another PS/2 system.

The failures experienced may be due to configuration error, system board error, or adapter error. The diagnostics for the adapter in question may run error-free, but the system unit appears to fail when running the application software.

The servicer should not assume that a hardware failure has occurred on the host system if:

- Other adapters function correctly
- The system unit diagnostics run error-free
- Other applications/software function correctly with the suspect adapter removed.

This situation may occur when an adapter is moved from a slower PS/2 system unit (usually along with software) to a faster PS/2 unit (the converse may also be true), or during an initial installation. The cause may be one or more of the following:

- The adapter in question may not meet the appropriate interface specifications. The possible discrepancy is made apparent when the adapter is running on a faster system. On the slower system, the discrepancy may not be apparent.
- The adapter in question uses software which uses processor speed dependent code. Operation in a faster system unit causes failures due to the speed dependent code.
- Some adapters are not supported on all systems in the product line.

Known problems occur with specific models or engineering change levels of PS/2 systems and/or particular adapters or types of adapters. Before replacing FRUs, the IBM repair person should check through the IBM service network (RETAIN) for the PS/2 or adapter specific information.

In the absence of specific direction for the product set in question, and if the adapter is either an IBM adapter, or an IBM supported Other Equipment Manufacturer (OEM) adapter, the appropriate Level 2 support organization should be contacted for assistance.

If the adapter is not an IBM supported OEM adapter, the customer should be referred back to their OEM point of sale to determine if the adapter is supported (tested and works) on the system type in which the failures are being experienced.

For cabling considerations see "Cable Requirements" on page 2-4.

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SCSI Bus Termination

Failure to properly terminate the SCSI bus can result in poor signal quality and noise on the bus. Errors caused by this condition may be intermittent, and difficult to diagnose. Improper SCSI bus termination also causes operating system load problems and IML failures.

The SCSI bus is a high-speed bus that operates at speeds up to 5 megabits per second. The bus **must be terminated properly at both ends** with resistor networks to minimize signal reflections on the bus and to insure proper voltage levels.

The following SCSI termination schemes may be encountered in the field:

- SCSI Adapter/A without cache — A T-RES terminator is on the adapter and is described in Rule 4.
- SCSI Adapter/A with cache — This adapter has no T-RES terminator onboard and is described in Rule 5.
- Integrated SCSI controller — A T-RES terminator is on the planar board and is described in Rule 6.

The following **rules** are a guide for proper SCSI termination:

1. The SCSI bus must always have a terminator on the device at the physical end of the SCSI bus. These devices include hard disks, tape drives, CD-ROM drives, and the SCSI adapter itself, if no devices are connected to one of the interfaces.
2. Terminators are installed only at the ends of the SCSI bus. Terminators installed on devices that are not at the end of the bus must be removed from the devices. Failure to do so, results in excessive current on the SCSI bus. This can cause early life failure of any attached SCSI device, if operated for extended periods of time. The point of failure is the bus drivers on the SCSI devices, which break down due to excessive power dissipation.
3. When installing SCSI devices on the internal interface, always attach a device to the last physical connector on the cable.
4. For the IBM PS/2 SCSI Adapter/A with the onboard T-RES terminator, termination of the adapter is accomplished when the 20-pin T-RES terminator is in its socket. (The terminator is usually orange in color.) The T-RES terminator must be removed from the adapter if both internal and external devices are attached to the adapter. In this situation, the SCSI bus is terminated at the last device on the internal cable *and* the last device on the external cable.
5. For the IBM PS/2 SCSI Adapter/A with cache (no onboard terminator), termination of the adapter is done in one of the following ways:
   a. If only external devices are connected to the adapter, attach the internal terminator to the edge card connector on top of the adapter *and* terminate the last device on the external SCSI cable.
   b. If only internal devices are connected to the adapter, attach the external terminator to the connector at the rear of the adapter *and* terminate the last device on the internal SCSI cable.
   c. If both internal and external devices are connected, termination is done on the last device on the internal cable *and* the last device on the external cable.
6. For the SCSI controller built into the system board, there is a T-RES terminator on the system board. (Refer to the *Hardware Maintenance Reference* manual for the exact location.) The termination of the SCSI bus is accomplished when the

20-pin T-RES terminator (usually orange in color) is in its socket. The T-RES terminator must be removed when both internal and external devices are attached to the controller. In this situation the SCSI bus is terminated at the last device on the internal cable *and* the last device on the external cable.

A useful publication for systems using SCSI devices is *International Technical Support Centers, SCSI Architecture and Implementation*, GG24-3507-00.

Chapter 10. Storage Media and Devices

Media

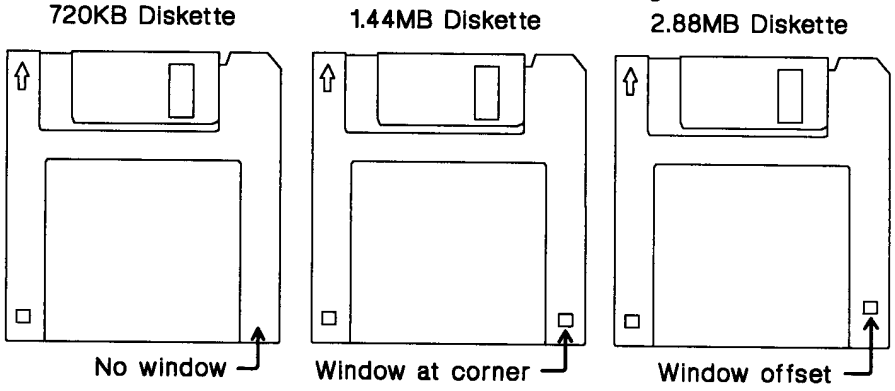
Storage media for the PS/2 family includes:

- 3.5-inch diskette
- Compact disk - read only memory (CD-ROM)
- Tape cartridge
- Optical cartridge.

Diskette

IBM 3.5-inch diskettes can be purchased formatted or unformatted. Unformatted diskettes contain no data, and no track or sector information. These diskettes have 1.0, 2.0, and 4.0 megabytes of space. When formatted, these same diskettes have 720KB, 1.44MB, and 2.88MB of usable space.

Identify 3.5-inch diskettes by the window in the lower right corner of each diskette.



The recording surface of the diskette is protected by a non-removable plastic cover and metal slide.

Maintain a dust-free environment wherever diskette drives and diskettes are used:

- Keep floors clean.
- Clean or replace air conditioning filters regularly.
- Avoid locations where air blows into the diskette drive opening.
- Store diskette media in enclosed containers.
- If the diskette drive has no door, place an unformatted diskette in the drive slot whenever the system is not being used; this prevents dust from accumulating between the heads.
- Minimize the use of carpets on floors and walls, as fibers break off when these surfaces are brushed.
- Handle media with clean hands to avoid the transfer of particles onto the diskette and into the diskette drive.
- Never touch the magnetic recording surface of the diskette media.

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Format

Format diskettes to their correct capacity as follows:

Diskette Capacity of	Is Formatted to	on Drive Type
1.0MB (HC)	720KB	720KB, 1.44MB, or 2.88MB
2.0MB (HD)	1.44MB	1.44MB or 2.88MB
4.0MB (ED)	2.88MB	2.88MB

Format diskettes to their proper capacity to avoid data loss. Diskette drives and media have different characteristics:

- The recording surface *inside* the 2.0MB diskette is thinner than the recording surface of the 1.0MB diskettes.
- The magnetic coating on the recording surface of 2.0MB diskettes is thinner than the coating on 1.0MB diskettes.
- The magnetic coating used on various diskette types is different. Therefore, the ability to maintain magnetic information varies between diskettes.
- The 720KB drive uses a higher write current than the 1.44MB drive.

Many application programs contain diskette copy procedures that allow a backup only to a diskette of the same capacity as the original diskette.

DOS format version 3.3 and above will default to a 1.44MB format on a 1.44MB diskette drive regardless of the type of diskette used. To format a 1MB diskette to 720KB on a 1.44MB or 2.88MB drive, the DOS format command is:

```
FORMAT /N:9/T:80
```

When transferring diskettes between computers that have 720KB, 1.44MB, and 2.88MB diskette drives, use only 1.0MB capacity diskettes formatted to 720KB.

Write Protection

When you write-protect a diskette, you can read from the diskette but cannot write on it. This helps prevent formatting a diskette by mistake or accidentally writing information on it. Slide the plastic tab over the window when you want to alter the information on the diskette.

When the write-protect window in the lower left corner of the 3.5-inch diskette is open, the information is protected.

Labels

Diskette labels must be placed in the indentation only. Remove any glue buildup on the diskette from previous labels.

Do not overlay wrap-around labels; this may cause loading problems.

Inserting and Removing Diskettes

The top side of the diskette has the indentation for a label. There is an arrow to the left of the metal shutter. Insert the diskette with the label up and the arrow at the top left corner of the diskette.

The bottom side of the diskette shows the diskette hub, the write-protect tab, and cover alignment holes. Insert the diskette with this side facing the diskette drive eject button.

CAUTION:
If a 3.5-inch diskette is inserted up side down, the metal shutter may come off when the diskette is reinserted right side up.

Slide the diskette into the diskette drive until it *clicks* and drops into place. The diskette must be inserted parallel to the plane of the diskette opening. Do not remove the diskette while the in-use light is on; the light shows that the system is accessing information from the diskette media.

Press the eject button on the face of the diskette drive to remove a diskette. If the diskette is not ejected, press the diskette into the drive to reorient it. Then, press the eject button again to remove the diskette.

Diskettes should always be removed from the drive before moving the system to avoid damage to the media and the drive.

Quality
IBM 3.5-inch diskettes are engineered to provide the most reliable, trouble-free data storage media possible. The hard plastic protective cover and diskette cleaning liner promote reliability.

Surface Defects
Industry experience shows that the largest cause of diskette failure results from defects in the magnetic coating on the diskette surface. These defects can be caused by dirt, or other contamination, or by minute voids in the magnetic material.

Every IBM diskette is thoroughly tested at every bit position to ensure error-free use.

Diskette Hub
Read errors can occur because of misalignment between the read head and the recorded track. Misalignment most often occurs because of wear at the drive hub. The hubs on all IBM 3.5-inch diskettes are manufactured from stainless steel and then chrome plated. The chrome plating process produces a wear surface with a hardness that approaches that of a diamond.

Surface Wear
Because the heads on the drive contact the diskette surface, the magnetic coating wears as the diskette is used. IBM diskettes are tested for signal amplitude to standards that are more demanding than the ANSI specifications most commonly used.

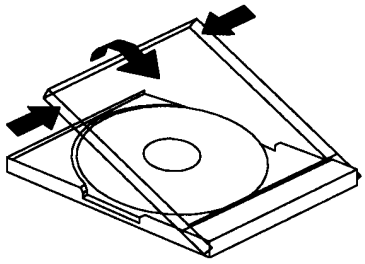
Compact Disk - Read-Only Memory (CD-ROM)
Use the following procedure to clean a CD-ROM:

Warning: *Do not* clean in a circular pattern. This may damage the CD-ROM, causing loss of data.

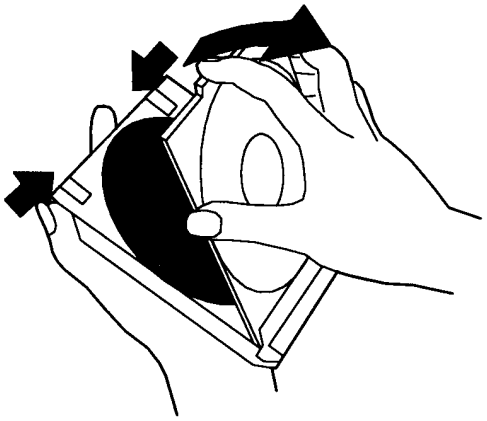
- Handle the CD-ROM disk by the edges only.
- Clean, with a lint-free cloth, from the center of the compact disk to the outer edge.

Use the following procedure to load and remove a CD-ROM.

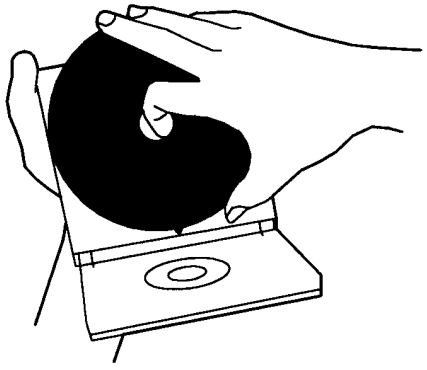
1. Open the protective case.



2. Remove the CD-ROM from the protective case by pressing down on the center hub while lifting the CD-ROM.
3. Open the CD-ROM caddy.

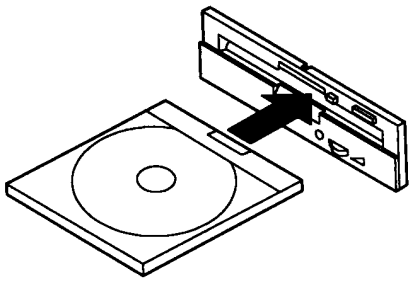


4. Insert the CD-ROM into the caddy. The printed side of the CD-ROM faces the transparent cover.



5. Close the caddy, and, with the arrow pointing toward the CD-drive slot, insert caddy in the slot.

   Note: The activity indicator operates when data is read or audio is played from the CD-ROM.



6. To eject the CD-ROM caddy, press and hold the eject button.
7. Remove the CD-ROM from the caddy and place it in a protective case.

Tape Cartridge

tape cartridges are twice as thick as the 3.5-inch diskettes described in the beginning of this chapter. The bottom side of a tape cartridge is metal, not plastic.

The tape cartridges used in the 2.3GB Tape Drive are IBM 8MM helical-scan data cartridges that meet the ANSI standard X3B5. Use of tape cartridges not meeting this standard can result in the tape breaking and accelerated read/write head wear.

Use tape cartridges in the following manner:

- If the cartridge is very cold, leave it at room temperature for at least one hour. Condensation on the tape may cause malfunction. Before use, expose the cartridge to the operating environment for a time equal to the time it has been out of the operating environment (to a maximum of 24 hours).
- Handle the cartridge **only** by the labelled edge.
- Avoid dust, sunlight, heat, moisture, and metal objects.
- Stickers are detachable; do not apply one over another.

Optical Cartridge

If the system loses power while an optical cartridge is loaded in the drive, the cartridge can be manually ejected. Insert a straight, non-metallic object through the opening in the cover plate and press. The optical cartridge will manually eject.

Devices

Storage devices for the PS/2 family include:

- Diskette drive (720KB, 1.44MB, 2.88MB)
- Hard disk drive (many storage sizes)
- CD-ROM drive
- Tape drive
- Optical drive.

Diskette Drive

Diskette drives are maintenance-free when used in the environment for which the system product was designed. Refer to the documentation shipped with your computer to ensure that you comply with these limitations.

The physical orientation of the diskette drive must be as originally installed in the system unit. For externally connected devices, the feet contact a flat surface (table top), or the unit may be on either side such that the diskette opening is perpendicular to the table top. In all cases, there must be adequate spacing for air circulation within the unit. See "Airflow" on page 5-1.

Eject Buttons

Diskette drives are identified by their blue eject button. The 720KB diskette drive has a button with no writing on its face. The 1.44MB diskette drive has an eject button with the number 1.44 written on its face. The 2.88MB diskette drive has a button with the number 2.88 written on its face.

Hard Disk Drive

For externally connected devices, the feet contact a flat surface (table top), or the unit may be on either side. In all cases, there must be adequate spacing for air circulation within the unit. See "Drive Orientation" on page 5-10. for more information. See "Airflow" on page 5-1.

Environment

Hard disk drives are ESD-sensitive devices. All ESD precautions should be observed when handling hard disk drives. See Chapter 6, "Electrostatic Discharge" on page 6-1.

Excessive damage to the surface and heads occur if the hard disk is dropped or shocked outside of its design specification.

Power On/Off Cycles

Hard disk drives are designed for continuous use without requiring preventative maintenance. However, the life of these electromechanical devices is extended by powering them off when not in use. The exception to this is a battery-operated drive which is designed for very high start/stop cycles.

The recommended operation of the product for maximum life is to power it off when not in use, but not routinely cycling it on and off more than twice each day.

Program Applications

Some programs write to the hard disk, bypassing BIOS to increase speed. Programs that write to BIOS instead, eliminate any hard disk differences. The user must ensure that any direct driver software installation does not violate BIOS protocols. See "BIOS Interface" on page 8-3.

Backup

The system owner must ensure that hard disks are backed up regularly. The media containing the backed up information should be stored at a location away from the system.

CD-ROM Drive

For proper operation of the CD-ROM drive, periodic cleaning of the optical-head lens and your compact disks may be required. If your CD-ROM drive fails, or is slow reading a compact disk, the optical-head lens may need cleaning. The IBM cleaning kit is part number 59F3562. Contact your place of purchase for cleaning kits.

Tape Drive

To insert or remove a data cartridge, press the load/unload button on the front of the tape drive. When the button is pressed, the tape-tray door opens for insertion or removal of a data cartridge. The time required to unload a cartridge is between 18 seconds and 3 minutes, because the drive is rewinding the tape before opening the door. After you insert or remove a data cartridge and close the door, the green in-use light turns on. The data cartridge takes about 25 seconds to finish loading.

The computer can still process commands while the data cartridge is loading. Commands that do not use the 2.3GB Tape Drive are run immediately. However, any commands that use the tape drive are run after the cartridge has finished loading.

Read/Write Heads

The read/write heads should be cleaned about once a month or every 30 hours of tape motion. More frequent cleaning may be required if the drive is operated in a dusty environment or in humid conditions. If the drive is not cleaned regularly, errors may result when the drive reads and writes data to the data cartridge.

Warning: Use of the wrong type of tape cleaning cartridge accelerates wear of the read/write heads. Use only IBM-recommended cleaning cartridges or their equivalent.

Cleaning Procedure

1. Insert an IBM-recommended cleaning cartridge into the drive.
2. Wait approximately 30 seconds for the drive to complete the cleaning operation, then unload the cleaning cartridge.
3. Keep track of the number of times the cleaning cartridge is used and replace it after it has been used 12 times.

Optical Drive

Contaminated optical lenses will cause the optical drive to be slow in reading from and writing to an optical cartridge. They also could cause a read or write failure. The Objective Lens Cleaning Cartridge (part number 85F0043) will correct most drive problems caused by a contaminated objective lens.

If the drive continues to be slow in performing a read or write function, the prism lens may require cleaning. Use the Prism Lens Cleaning Cartridge (part number (85F0054) to clean the prism lens.

For information about drive orientation ,see "Drive Orientation" on page 5-10.

Lens Cleaner

A lens cleaner (part number 38F8681) is used for periodic cleaning of the IBM 3.5-Inch Rewritable Optical Drive.

Take the following precautions when cleaning the drive:

- Ensure that there is no optical cartridge in the drive.
- Power-off the drive.
- Do not touch the brush.
- Do not use any solvent.
- Do not use or store this cleaner in a dusty or damp place.
- Use of this cleaner on any type of drive other than the IBM 3.5-Inch Rewritable Optical Drive might cause damage.
- Replace the cleaner after it has been used about 60 times, or if the tips of the brush become widened or discolored.

Cleaning Procedure

1. Remove the brush cover from the cleaner.
2. Position the cleaner so that the IBM logo faces:
   - Upward, if the drive is horizontal.
   - Left, if the drive is vertical.
3. Insert the cleaner into the drive.
4. Push in the cleaner *slowly and gently*, until it is stopped by the stopper.
5. Pull back the cleaner approximately 5 centimeters (2 inches).
6. Repeat steps 4 and 5 several times to complete the cleaning.
7. Remove the cleaner from the drive, replace the brush cover, and store the cleaner in a safe place.

Appendix A. Line Current Calculation

The following steps parallel the steps under "Planning for Electrical Power" on page 3-7 for 120-volt and 240-volt applications.

1 **Generate Hardware Requirements**

A customer buys a Model 8595 and adds initial expansion equipment not included in the "as shipped" configuration:

- Two additional 320MB SCSI hard disk drives
- One Wizard adapter
- One 16/4 Token Ring adapter.

Future expansion of the system will include:

- Four 8MB SIMM (memory)
- One 320MB SCSI hard disk drive
- One 16/4 Token Ring adapter

2 **Determine Line Current of the System**

The "as shipped" kVA of the Model 8595 is documented as 0.18 kVA (see Table 3-5 on page 3-9).

I_{120} = (0.18)(1000)/120 = 1.50A

I_{240} = (0.18)(1000)/240 = 0.75A

3 **Determine Wattage of Initial Expansion Hardware**

```
Two 320MB DASD:   15.3W x 2 = 30.6W   (See Table 3-6 on page 3-10.)
One Wizard:       28.6W x 1 = 28.6W   (See Table 3-7 on page 3-11.)
One Token-Ring:    6.5W x 1 =  6.5W   (See Table 3-7 on page 3-11.)
                      total = 65.7W   (Use 30W and 36W)
```

From Figure 3-1 on page 3-8, find 30W on the x-axis. Move vertically to the dashed line and then left to the y-axis to read the current.

I_{120} = 0.56A

For 240V, find 30W on the x-axis. Move vertically to the dashed line and then *right* to the y-axis to read the current.

I_{230} = 0.265A

Since the application is 240V, the 230V current from Figure 3-1 on page 3-8, has to be converted as follows:

I_{240} = (0.265A)(230V)/240V = 0.254A

Using Figure 3-1 on page 3-8 find 36W on the x-axis. Move vertically to the dashed line and then *left* to the y-axis to read the current.

I_{120} = 0.67A

For 240V, find 36W on the x-axis. Move vertically to the dashed line and then *right* to the y-axis to read the current.

I_{230} = 0.31A

Since the application is 240V, the 230V current from Figure 3-1 on page 3-8, has to be converted as follows:

I_{240} = (0.31A)(230V)/240V = 0.297A

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The total 65.7W line current for the initial expansion is:

$I = I_{30W} + I_{36W}$

$I_{120} = 0.56A + 0.67A = 1.23A$

$I_{240} = 0.254A + 0.297A = 0.551A$

4 Determine Wattage of Future Expansion Hardware

Four 8MB SIMM:	1.9W x 4 = 7.6W	(See Table 3-8 on page 3-12.)
One 320MB DASD:	15.3W x 1 = 15.3W	(See Table 3-6 on page 3-10.)
One Token-Ring:	6.5W x 1 = 6.5W	(See Table 3-7 on page 3-11.)
	total = 29.4W	(Use 30W)

Since 30W line currents were already calculated, the same numbers will be used here.

$I_{120} = 0.56A$
$I_{240} = 0.25A$

The total current for initial installation is:

I = "as shipped" + initial expansion

$I_{120} = 1.50A + 1.23A = 2.73A$

$I_{240} = 0.75A + 0.551A = 1.30A$

The total line current with future expansion is:

I = "as shipped" + initial expansion + future expansion

$I_{120} = 1.50A + 1.23A + 0.56A = 3.29A$

$I_{240} = 0.75A + 0.551A + 0.254A = 1.56A$

5 Determine AC Input Watts

Initial expansion = 65.7W / 0.62 = 106W
converted to heat output, 106W x 3.41 = 361.5 BTU/hr

Future expansion = 29.4W / 0.62 = 47.4W
converted to heat output, 47.4W x 3.41 = 161.6 BTU/hr

From Table 3-5 on page 3-9, "as shipped" BTU/hr is 358.

Total BTU for initial installation:
358 BTU "as shipped" + 361.5 BTU = 719.5 BTU/hr

Total BTU for future expansion:
358 BTU "as shipped" + 361.5 BTU + 161.6 BTU = 881 BTU/hr

6 Added Margin

Installation	Calculation	20% Margin
Initial I_{120}	2.73A	3.28A
Initial I_{240}	1.30A	1.56A
Total Heat Output	720 BTU/hr	863 BTU/hr
Future I_{120}	3.29A	3.95A
Future I_{240}	1.56A	1.87A
Future Heat Output	881 BTU/hr	1057 BTU/hr

Appendix B. External Agencies

Underwriters Laboratories

UL is the primary safety agency in the USA. A competitor, Engineering Test Laboratories (ETL) has begun testing and listing products to UL standards. UL, in conjunction with industry, develops standards and tests for compliance either at the manufacturer's site or at one of the four test laboratories in the USA.

UL Listings for products are not government mandated, although in some localities and hospital environments, some type of certification is required.

For business purposes, IBM requires UL or ETL Listing of all domestic products which may be directly connected to wall outlets.

Canadian Standards Association

Electrical products marketed in Canada must be intrinsically safe; products bearing the CSA logo meet the Canadian standards. CSA standards are similar to UL standards.

Common Market Requirements

Most Common Market Countries have national laws stating that products must be safe through compliance with the relevant International Electrotechnical Commission (IEC) or European Norm (EN) specification. Furthermore, the Common Market Low Voltage Directive states that if any one of the Common Market Countries has certified the product to its national standard (which for office products and computers will be a derivative of EN 60 950), no other common market country can, under most circumstances, refuse to import that product for reasons of safety due to design.

The German safety label or "GS" mark is also used as evidence of compliance to IEC-950 by some countries, such as Australia and New Zealand.

Nordic Countries and Austria

Denmark, Norway, Sweden, Finland, and Austria each have their own compliance requirements and deviations to IEC-950.

Standards Compliance List

The external standards that IBM PS/2 products must comply with, either fully or in part are:

- FCC Class B
- VCCI Electromagnetic Interference (Japan)
- M.O.C. Class B Electromagnetic Interference (Korea)
- UL 478 Fifth Edition Data Processing Machines

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- UL 1950 First Edition Information Technology Equipment
- CSA 220 Information Processing Equipment
- IEC-950 Information Processing Equipment
- EN 60 950 Information Processing Equipment (European Norm for IEC-950)
- IEC-65 Household Electronic Equipment
- ZH 1/618/10.80 West German Ergonomic Standard
- EMKO-TUE(12B) DK 203/89 - IEC-950 with Deviations for Norway and Sweden
- CISPR 22 Limits for Electromagnetic Interference Denmark and Finland
- British Standard BS 6301: 1982, 1987, 1989 Telecommunications Safety
- 21 CFR Subchapter J DHHS Radiation Limit for Video Displays.

Appendix C. Non-Office Computer Environments

IBM Industrial Computers can solve many problems that you have. They are the correct platform when you need a computer to run in a non-office environment. Non-office environment can mean:

- non-air conditioned or particulates in the air
- that the computer has to be located someplace other than on a desk; for instance in a rack or on a wall
- an environment where the computer needs to run reliably even when used more than one shift per day and more than five days per week.

IBM Industrial Computers and Industrial Displays were designed for Computer Integrated Manufacturing solutions. The design points to meet the requirements of customers in the operational areas of manufacturing and process industries can also be important to customers in other industries such as food service, transportation, and banking. The hardware product family includes industrial computers, industrial displays, industrial operator input keyboards and display bezel, and industrial programmable terminals.

Continuous and Reliable Operation

Manufacturers rely on the computers that are used to produce goods in industries such as discrete manufacturing, and batch or continuous processing environments. Many are running three-shift operations. If a line or process is down because the associated computer cannot handle the job, the customer often counts losses in thousands of dollars per minute. Reliability is very important for:

- A network file server or a gateway/bridge for local networks
- Control center applications that provide 24-hour burglary detection or fire protection
- A turnpike plaza or a toll bridge environment.

To meet this requirement, IBM industrial hardware is designed and tested to run 7 days per week and 24 hours per day. Based on design, test, and field data, the Micro Channel bus computers are expected to operate more than five years without servicing.

AC Power Fluctuations

Most customers have some trouble with ac power outages. The outages can be short (less than 10 seconds), or much longer (hours). The 7541, 7542, 7561, and 7562 have a power supply that when used with its optional battery can keep the entire system up through short outages (power glitches). The 7537 and 7546 have a similar optional battery backed power supply (available 5/92). The 7552 GEARBOX has programmable length glitch protection and the ability to switch over to user-provided 24 V dc and continue without interruption. The GEARBOX 800 has this same programmable glitch protection, with the capability to switch to user 24 V, 48 V, or 60 V dc.

When there is no ac power, continuous computer operation must be ensured for critical manufacturing processes. Continuous operation is also desirable in a LAN server, a telephony satellite, or other communications concentrator. The only alter-

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native for most other computers to stay operational is for the user to provide his own uninterruptible power supply.

Where continuous operation of the computer is not so important, but controlled shutdown of process is, the GEARBOX products offer a special capability. When ac power is lost, the system can alert the user application using its language extension products. The user application can then save important data to disk and tell the system to shut itself off. On a start-up, the application is again given control and it can determine if a controlled shutdown was completed. The application can then restart the process from a controlled point, often with no loss of process or data.

Extended Environment

The environment in a discrete or continuous manufacturing process often has extremes of temperature and humidity. To perform in this difficult environment, the computers have fans that pull the ambient air into the system unit and force the air over the internal components for cooling. Forced air cooling keeps the internal temperature of the computer cooler than fans of an office computer in an air conditioned environment. Keeping components well within their specified temperature range means there is less chance that component failure will cause computer downtime.

Operation in extreme temperature is not limited to a plant floor. If the computer is a LAN bridge or LAN server located in a closet, operation in extreme temperature is assured. If the computer is in a structure that is partially open to outside air temperature like a toll booth or a warehouse dock, it is subjected to extremes of heat and cold as well as dust.

Contaminants

Manufacturing areas can have airborne dust and contaminants. These contaminants can be harmful to the inner mechanical and electrical parts of a computer. All the IBM Industrial Computers have filters in front of the cooling fans to trap particulates before they can cause damage. The air movement inside the industrial computers also produces positive air pressure to help keep dust out of the diskette drive. Each industrial computer and display model must survive an independent test laboratory's life cycle continuous operation in an extremely dirty environment.

Fried food restaurants have particulates (in the form of grease) or oil particles which can damage an office computer. The filter in an industrial computer can catch grease and oil before they are deposited on critical components.

Shock and Vibration

The industrial computers can be located close to the work that they support, even if adjacent equipment causes voltage surges, shock, and vibration.

Electrical Interference

Manufacturing and other enterprises can expect power surges, radiated energy, and electromagnetic interference to be generated by industrial equipment. The industrial computers have been subjected to power surges of up to +2500 volts. They are also put through extensive testing for other interference.

DC Operation

Some areas of a complex often run on dc power. Some applications are best run where the data is gathered, as is the case in processing seismographic readings in an oil field. Some installations have no ac power available, and so require dc operation. The GEARBOX 800 has the capability to start and run on 24 V, 48 V, or 60 V dc.

ECC Memory

No customer wants to lose data or have incorrect data. The GEARBOX products have memory that has error checking and correction (ECC). This means that the system corrects single bit errors or notifies applications of serious errors.

Packaging Configurations

Bench Top

Several versions of the industrial computers, industrial displays, and programmable terminals are designed for bench top or table use.

Rack Mount

Many operational areas of manufacturing, process, communications, and others require that the computers be located near the process they support. These computers cannot be restricted a table or work bench; they need to be mounted in 19-inch racks like other equipment. There is a rack mounting option for all the types of industrial computers and displays.

You may have requirements for rack mounting when multiple computers are necessary and horizontal space use must be kept at a minimum. There are also applications where other rack mounted equipment is installed and the computer must also be rack mounted.

Enclosure or Wall Mount

In addition to rack mounting, sometimes computers need to be mounted in an enclosure for further protection or security, or on a wall for space conservation. This is not industry specific. Although corrosive gases, or the necessity to "wash down the computer" would require enclosure mounting in a manufacturing area, non-manufacturing customers might require the security or space saving of an enclosure.

The requirements to enclose, panel mount, or wall mount a computer were the main mechanical design points for the GEARBOX products. Panel mounting requirements are:

- Depth of less than 12 inches (for NEMA panel or other enclosure)
- Must allow attachment to wall or panel
- Can be hard wired into a power supply
- Components are easily accessible
- Components must plug from the front
- Cables must exit downward from the computer

- Non-air conditioned environment
- Computer must be able to start up and run unattended
- Computer must be able to alert the operator to problems (from behind a locked door without a window).

The GEARBOX products are 10 inches deep. They have removable flanges on the sides that can be attached to the front for rack mounting and to the back for panel mounting. They have a power terminal that can be located on the back for rack mounting or on the side for panel/wall mounting and allows easy connections to the customer's power wiring.

The design of the GEARBOX products has all the components in protective cases or shrouds. Even the adapters that provide the function of the system board are in shrouds. There are empty shrouds for your adapters. The shrouds snap open and closed. There is no cover to remove to get to the shrouds, making all parts of the computer easily accessible. The shrouds hold the adapters in an orientation where cable access is from the bottom, simplifying facility installation.

The GEARBOX products are designed to run in the extreme temperatures that are found in a closed, non-air conditioned structure with the system producing heat. When mounted in a panel, filtering is not required. The customer can reverse the two cooling fans to pull air over the adapters instead of pushing air that has been warmed by the power supply.

The programmable terminals have a base that also can be oriented for wall mounting.

Unattended Operation

Computers are generally viewed as workstations, and so require a display and keyboard. When a computer is in a panel, it often is doing a job where no display, diskette, or keyboard is required. The BIOS of the GEARBOX products was upgraded so that the system unit would start-up and execute using the hard disk operating system and application without either display support, diskette, or keyboard.

The GEARBOX is aware of its environment, and its components. The internal status register keeps indicators of conditions such as: the system has lost ac power, the temperature maximum has been reached, or one of the cooling fans has failed. There are software products that provide extensions to the higher level languages to give the customer's application access to this status register. A user application can also take actions to alert an operator or networked computer to these abnormal conditions. Alert conditions can be passed using digital output to alarms outside the panel.

Power

The power supplies available in the industrial computers are designed to provide more power per adapter than office type computers. You may want to install multiple local area network (LAN) adapters for a LAN bridge. Other applications might use the computer as a communications or data concentrator using members of the Realtime Interface Coprocessor (RIC) family. The RIC adapters were designed to provide fast communications to non-office I/O that uses RS-232, RS-422, X.21, and V.35 connection. LAN adapter and RIC adapters require more power than other

adapters. When industrial computers are used, the customer is limited by how many slots the given computer has, instead of power consumption like with business computers. This means that you don't have to buy multiple systems to provide the same connection. The GEARBOX 800 can support 6 RIC adapters or a combination of two Token Ring adapters and five RIC adapters. If at least one Portmaster RIC adapter is used, the same system can support six RIC adapters and one Token Ring adapter.

Serviceability

The GEARBOX products are designed to have a long mean time to failure, but if the need arises they are easy to service. The expected average time to repair is less than 15 minutes. This is made possible by the packaging designs of the machines and by the built-in error diagnostics. No tool except a screw driver is needed to repair a system, and that is only needed for changing a fan, or to unscrew cables from adapters. The shrouds are easily removable using latches on the shrouds. These latches also hold the shrouds securely in place. A small plate covers the power supply; it is secured by latches that turn. The power supply is secured by thumb screws and has a self-locking power connection.

Although it is important to replace a failing part quickly, the time it takes to determine the problem is generally the greater impact to mission-critical operations. The GEARBOX has external and internal indicators that speed up the process:

- LEDs on the power supply and system unique cards give immediate indication as to which fan failed, or which adapter failed.
- Digital output points are activated, so that there can be indicators at some distance from the system, or just outside a paneled enclosure.
- The indicators are internal to the computer in the status word. A user application can be tuned in to these indicators, and can alert another application or operator at a second computer (that is connected on a network).
- The processor adapter has hexadecimal displays that are used during start-up to communicate check points of the extensive power-on diagnostics to maintenance personnel. If the power-on diagnostics do not complete, the hexadecimal displays show at which step they failed.
- The hexadecimal displays are also available to user programs to communicate error conditions or operator information.

Office and Industrial Systems Comparison

Table C-1 summarizes similarities and differences between a given office computer and its closest industrial counterpart. This comparison ignores the "hardening" aspects.

Table C-1. Similarities and Differences

Office System	Industrial System	Comments
PS/2 Model 50Z	7541 or 7542	Same (see breakout below)
	PF1123 (7541 RPQ)	No disk
	PF1126 (7542 RPQ)	No disk for rack mount
	7541-111	Same
	7542-111	Same for rack mount
	PF1235 (7541 RPQ)	Same with 60MB disk
	PF1232 (7542 RPQ)	Same with 60MB disk for rack mount
PS/2 Model 70	7561 or 7562	7561/2 has 8MB on planar, 4 slots
	PF1129 (7561 RPQ)	No disk
	PF1132 (7562 RPQ)	No disk for rack mount
	7541-111	80MB disk
	7542-111	80MB disk for rack mount
	PF1175 (7561 RPQ)	160MB disk
	PF1178 (7562 RPQ)	160MB disk for rack mount
PS/2 Model 40SX	7537	Same, optional rack mount
PS/2 Model 57SX	7546	Same, optional rack mount

The highest function PS/2 systems are compared to the highest function Industrial Computer, the GEARBOX Model 800 in Table C-2. Features that are applicable in an office environment are included.

Table C-2. Comparison

Feature	PS/2 Model 90	PS/2 Model 95	GEARBOX Model 800
Processor	80486 at 33MHz 80486 at 50Mhz	80486 at 33MHz 80486 at 50MHz	80386 at 25MHz 80486 at 25MHz
Maximum system memory	64MB	64MB	16MB
User slots	3	6	5 with storage devices 7 w/out storage devices
Maximum number high power adapters like RIC Portmaster	2	5	6 plus a Token Ring adapter
Maximum disk storage	1.2GB	2GB	640MB
System battery backup	No	No	Yes
Power supply	194W Autosensing	335W 110/220 switch	350W Worldwide autosensing
Rack or panel mount	No	No	Yes

Glossary

ABIOS. Advanced Basic Input Output Service. ABIOS provides operating systems the ability to process multiple I/O requests. IBM OS/2 uses this interface to perform its operations.

adapter data areas. Memory, ROM or RAM or both, used by an I/O adapter. These areas may contain program routines (such as POST and BIOS), data buffers, or control registers. These areas are described by the .ADF files of the I/O adapter. Setup assigns a specific address range to these areas during the setup process. This information is stored into CMOS/NVRAM.

adapter POS ID. The Micro Channel Architecture specifies that each adapter will support a series of I/O ports at specific I/O addresses. This Setup mode is defined by the Micro Channel Architecture. The first two addresses (100 and 101) contains a read-only register that contains a unique ID. This ID provides a unique identification of each I/O adapter. These IDs are requested by I/O adapter developers from IBM. If an adapter uses an ID other than what was assigned, normal system operations may not be possible.

ambient light. Light that surrounds an object.

application program. A program that is selected by the user of a system to perform or provide a specific service for the user. Spreadsheets, databases, games, and utilities programs are examples of application programs. Applications are written to operate with a specific operating system.

autosensing. System automatically selects the operating voltage range based on the voltage applied from the wall outlet.

BIOS. Basic Input Output Service generic term used to describe either ABIOS or CBIOS.

CBIOS. Compatibility Basic Input Output Service, or Compatibility BIOS. This code originated with the original IBM PC systems. CBIOS provides for devices to be used by one program at a time. DOS uses this interface for its operations.

CMOS. A device in the PS/2 system that provides nonvolatile RAM for the system. A battery is used to power CMOS after the system has been powered off. CMOS contains configuration data, work areas, and the power-on password. CMOS system configuration data is generated by Setup. This device also provides status I/O ports that POST can use to determine the battery status. POST also evaluates a specific address range to generate a checksum. This checksum is then compared to a stored checksum in CMOS. If both checksums are as expected, POST validates CMOS contents.

DASD. Direct access storage device. A device in which the access time is effectively independent of the location of the data; optical disk, floppy disk, and hard disk are examples.

degaussing. Removal of magnetic residual effect from the cathode ray tube.

device driver. A device driver is installed into the system by the operating system. Examples of device drivers are:

- access to an I/O adapter
- a different file system for the operating system to use
- virus detection/prevention program.

These programs are typically loaded as part of the operating system processing of the CONFIG.SYS file. These may be installed as part of an installation program or through the user manually inserting them into the CONFIG.SYS file.

DMA. Direct Memory Access provides the system I/O the ability to transfer data to or from the adapter and RAM memory. An address and a data count are required to be passed to DMA before the data transfer. The program passes a command to DMA and the I/O to start the data transfer. The transfer occurs independently of the processor. An interrupt is generated at the end of the data transfer. Data transfers having errors may result in the generation of a POST error code value of 113.

ergonomics. The application of biological and engineering data to the design of systems, programs, and devices in order to adapt them to human requirements, to the tasks they are to perform, and to the environments in which they are to be used.

exception POST. Exception POST is used to describe the operations of system POST whenever an unexpected condition is detected by POST. Examples of some unexpected conditions are:

- Setup has not been run
- Detected configuration does not match saved configuration
- System error.

extended BIOS data area. Area of storage located below the 640K line in the user's area. Additional system configuration data is stored in this area. This area is built by POST. The operating system can access information contained in this area by using BIOS System Services call.

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feature ROM/RAM area. Address range between hexadecimal C000:0000 and E000:0000 that is used by I/O adapters, memory managers, and EMS/LIM page frames.

flashover. Arcing

GEARBOX. An IBM Industrial Computer that is suited for non-standard operating environments *and* non-standard configurations (for instance, a situation where temperatures reach 60°C, only dc power is available, and wall-mount is required.

geo-magnetic disturbance. A natural anomaly in the normally uniform terrestrial magnetic field.

hardening. Design modification that allows the computer to operate reliably in a non-standard environment (for example, elevated temperature or particulate concentration).

harmonic current. Currents produced by a non-linear load that are not sinusoidal.

holdover current. Current change wherein initial level continues for a period of time.

impedance. The combined effect of resistance, inductance, and capacitance on a signal at a given frequency.

IML. See system ROM for description.

INITPROG. Program required by an I/O adapter to initialize the adapter before usage. These programs are installed by Setup onto the system hard disk. An INITPROG program is executed when the system is booted from the hard disk. An INITPROG is not needed for all adapters. When needed INITPROGs are shipped on the I/O adapter option diskette.

LOW RAM. The area of storage located in low RAM that contains system configuration data. This area is built by POST. The operating system can access information contained in this area by using BIOS System Services call.

NVRAM. Non-volatile RAM provides extended system configuration information. Like CMOS, a battery is used to maintain the contents of NVRAM. NVRAM setup data is generated by Setup.

reactance. Opposition to ac flow in a circuit caused by inductance and capacitance.

setup. The process that assigns system resources to the system board and I/O adapters installed in the system.

software layer. Usually used to describe a series of programs that provide the established interface for other programs to use. The use of BIOS by an operating system provides an example of this.

switching transients. Brief fluctuations in voltage caused by switching mechanisms (elevators, drills, and so on) powering off and on.

system ROM. (1) This area requires 128KB of memory starting at hexadecimal E000:0000. (2) Non-IML systems, System Read-Only Memory contains POST, ABIOS, CBIOS, BASIC, and data areas. On some systems, system POST copies the ROM data to system RAM for the purpose of increasing system performance. (3) IML systems, System ROM contains stage 1 POST, limited amount of BIOS, BASIC, and data areas. The remainder of the POST and BIOS routines are contained as part of the IML disk image. Stage 1 code copies the 128KB IML image to RAM memory.

user memory. (1) On a DOS system this memory starts at hexadecimal address 0000:0000 and is 640KB in length. This area contains device drivers, operating system, application programs, LOW RAM, EBDA, and data areas. With a memory manager this area can be increased by using the memory manager to relocate some of the programs in this area to memory greater than 1 megabyte. (2) On OS/2 systems this memory can include all system memory.

Index

A

acoustical energy 5-2
adapter cards 8-7
adapter compatibility 9-1
air quality 1-3
airflow 5-1
altitude 5-9
as shipped configuration 3-7
avoid back strain 1-2

B

back strain 1-2
BIOS 8-3
BIOS interface x
blocking harmonics 3-4
brightness 5-6
Bus Master cards x

C

clean a tape drive 10-7
clean an optical drive lens 10-8
clean R/W heads 10-7
CMOS/NVRAM 8-8, 8-9
comfort x
compact disk 10-3, 10-7
configuration error 9-1
connecting cables 1-4
constant power-on operation 5-5, 5-6
contaminants C-2
continuous operation C-1
contrast 5-6
crest factor 3-2
customer responsibilities ix
customized configuration 8-16

D

data integrity C-3
declared sound power level 5-4
desktop systems 2-2
diagnose harmonic problem 3-4
diagnostics 8-19
dim screen 5-5
dimensions 2-1
direct drivers 8-3
disconnecting cables 1-4
diskette
  capacity 10-2
  compatibility 10-2
  copy procedure 10-2
  drives 10-6
  eject button 10-3, 10-6
diskette *(continued)*
  format command 10-2
  hub 10-3
  inserting and removing 10-2
  labels 10-2
  orientation 10-6
  quality 10-3
  read/write problem 2-2
  surface defects 10-3
  surface wear 10-3
  warning 10-1
  write-protecting 10-2
display
  adjustment 5-6
  color problem 2-2
  considerations 2-2
  degaussing 5-7
  distorted 2-2
  electromagnetic fields 1-1
  product life 5-5
distorted display 2-2
DOS format 10-2
drive orientation 5-10, 10-6
dual mode operation 5-11
dust-free environment 10-1

E

earthquake effects 5-9
ECC memory C-3
eject button 10-3, 10-5, 10-6
electrical
  discharge 4-1
  grounding 3-5
  interference C-2
  noise 3-4
  safety 1-3
electromagnetic
  fields 1-1
  interference 7-1
electrostatic discharge 6-1
environment
  air quality 1-3
  dust-free 10-1
  earthquake 5-9
  hard disk 10-6
  harsh C-2
  humidity 5-1
  lightning 4-2
  magnetic field 2-3
  noise 5-3
  non-office C-1
  operating 5-5
  sound 5-2

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environment *(continued)*
temperature 5-1, 5-8
voltage 3-2
ergonomics 1-2
error handling routines 8-3
example of BIOS usage 8-4
exception POST 8-9
external hard disk 10-6
eye level of user 1-2
eye strain 1-1

F

fatigue 1-1
filters, power 3-4
floor stand 5-10
floor systems 2-2
forced convection cooling 5-2
formatted diskette 10-1
formatting diskettes 10-2

G

gas discharge tube 4-2
gases 5-8
GEARBOX C-4
geo-magnetic disturbances 2-2
glare from screen 1-2
ground discharge 4-1

H

hard disk drive 10-6
harmonics
electrical problems 3-4
power distortion 3-3
triplen 3-4
harsh environment C-2
head damage 10-6
heat factor 5-8
holdover current 4-2
humidity 5-1

I

I/O adapter data areas 8-18
identifying diskettes 10-1
impedence 2-4
in-use light 10-3, 10-7
Industrial Computers x
INITPROG 8-18
inserting diskettes 10-2
integrated controller 9-2
internal fans 5-2

L

label, diskette 10-2
length of cables 2-4
lens cleaner, optical 10-8
levels of sound pressure 5-4
lifting techniques 1-2
lightning protection x
lightning surges 4-1
linear load 3-3

M

machine energy discharge 4-1
magnetic
coating 10-2
field 2-2, 2-3
media 10-1
maximum configuration 3-7
metal oxide varistor 4-2
Micro Channel x
modem 4-2
moving the system 10-3
MTTF 5-5

N

neutral conductors 3-4
noise 5-3
non-linear load 3-3
non-supported adapter 9-1
Normal POST 8-19

O

odors 1-3
operating environment 5-5
optical drive 5-10, 10-7
optical lens 10-7
overheating transformer 3-4

P

packaging C-3
particulates 5-8, C-2
phosphor burns 5-5
physical specifications 2-1
portable systems 2-2
POS ID 8-14
positioning the hard disk 5-10
POST 8-7
power
distribution system 3-5
fluctuations C-1
ground 3-7
hard disk cycles 10-6
Industrial Computer 3-1
outlet considerations 3-5
profile 3-7
rating/label plate 3-7
savings 5-8
supplies 3-1, C-4

power *(continued)*
surge 4-1
power-on-hours 5-5
problem
adapter error 9-1
air quality 1-3
cable 2-4
conduit ground 3-7
display 2-2
dual mode operation 5-11
earthquake 5-9
ejecting diskette 10-3
electrical code 3-5
hemispherical 2-3
improper adjustment 5-5
known 9-1
noise 5-4
optical lens 10-7
screen glare 1-2
secondary enclosures 5-1
software compatibility 8-3
static electricity 6-1
surge suppressor 4-1
transferring diskettes 10-2
unnecessary operation 5-5
procedure
clean a compact disk 10-3
clean an optical drive lens 10-8
handling adapter cards 6-2
handling system boards 6-1
load a compact disk 10-4
tape cartridge 10-7
tape drive cleaning 10-7
profile, power 3-7
programs that bypass BIOS 10-6
publications x

Q

quality diskette 10-3

R

rack mount C-3
reactance 2-4
realtime interface coprocessor C-4
reference diskette file identification 8-14
reliability C-1
removing diskettes 10-2
RIC C-4
rules for SCSI termination 9-2

S

screen degaussing 2-2, 5-7
screen saver software 5-6
SCSI bus 9-2
SCSI devices x
secondary enclosures 5-1
service access 5-1
serviceability C-5
setup 8-13
shock 5-9, C-2
silicon avalanche device 4-1
software trade-off 8-3
sound 5-2
static sensitive components 6-1
storage devices 10-5
surface wear on a diskette 10-3
surge suppressor 4-1
susceptibility 7-1
switch-mode power supply 3-3
system
Industrial Computer 2-4
layers 8-1
orientation 5-10
PS/2 2-1

T

tape cartridge 10-5
tape drive 10-7
technical bulletins x
temperature 5-1, C-2
termination, SCSI bus 9-2
transferring diskettes 10-2
triplen harmonics 3-4
tripped circuit breaker 3-4

U

unattended operation C-4
unformatted diskette 10-1
uninterruptible power supply x

V

vibration 5-9, C-2
video performance 5-6
visual comfort x

W

wall mount C-3
wall outlet 4-1
warning 6-1, 10-7
windows in diskettes 10-1
write-protect 10-2

Z

zero-sequence filter 3-4
zigzag transformer filter 3-4

Acknowledgements

Jon Barber
Brad Brooks
Sherry Cato
Roger Cox
John Ferich
Dan Green
Jack Gulley
Duane Hardbarger
Bob Henley
Joe Holung
Bob Holsteen
Chris Kittelson
Bob Lloyd
Vern Rasmussen
Rich Rimmel
John Skobern
Jeff Sloan
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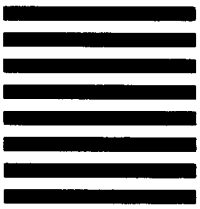

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