Software and Hardware Diagnostic Tools

Diagnostic software, the kind that comes with your computer as well as the types of available third-party software, is vitally important to you any time your computer malfunctions or you begin the process of upgrading a system component or adding a new device. Even when you attempt a simple procedure, such as adding a new adapter card, or begin the sometimes tedious process of troubleshooting a hardware problem that causes a system crash or lockup when you are working, you need to know more about your system than you can learn from the packing list sent with the system. Diagnostic software provides the portal through which you can examine your system hardware and the way your components are working.

This chapter describes three levels of diagnostic software (POST, system, and advanced) included with many computers, or available from your computer manufacturer. The chapter describes how you can get the most from this software. The chapter also details IBM's audio codes and error codes, which are similar to the error codes used by most computer manufacturers, and examines aftermarket diagnostics and public-domain diagnostic software.

Diagnostic Software

Several types of diagnostic software are available for IBM-compatible PCs, as well as the IBM PC, XT, AT, and PS/2. This software, some of which is included with the system when purchased, assists users in identifying many problems that can occur with a computer's components. In many cases, these programs can do most of the work in determining which PC component is defective. Three programs that can help you locate a problem are available; each program is more complex and powerful than the preceding one. The diagnostic programs include the following three items:

■ *POST*. The Power-On Self Test operates whenever any PC is powered up (switched on).

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■ *General diagnostic software.* A suite of tests that thoroughly examines the system. IBM's general diagnostic software is on the diagnostics disk. Its accompanying problem-determination procedures are outlined in the guide-to-operations manual for each system. Many IBM-compatible systems come with their own manufacturer's version of this diagnostic software. Dell, for example, includes a diagnostics disk with each system.

■ *Advanced diagnostic software.* This is included with IBM OS/2 systems in the hardware-maintenance service manual, but rarely included with other IBM systems or most IBM-compatible systems. However, the Advanced Diagnostics disk can be obtained from IBM for PC/XT and AT-type systems. To help IBM-compatible users fill this diagnostic software gap, this chapter covers software utilities such as Symantic's Norton Utilities 8, which provides detailed diagnostics of any IBM-compatible PC systems. The chapter also covers software from numerous other companies.

Many computer operators use the first and last of these software systems to test and troubleshoot most systems—the POST tests and either the IBM advanced diagnostic software or a third-party diagnostic package.

The IBM Advanced Diagnostics disk is included with the hardware-maintenance service manual. The manual and disk, along with the accompanying hardware-maintenance reference and assorted updates to both manuals, cost more than $400. Although this price might seem expensive, anyone supporting more than just a single IBM PC system quickly can recoup the expense in labor costs saved and avoid the trouble of carry-in service. Appendix A includes a catalog of these manuals.

Although the IBM service manuals are expensive, they are complete and represent the definitive work on the subject. Unlike many computer manufacturers, IBM provides truly in-depth system documentation. Indeed, this documentation is one of the primary reasons for the success of the IBM systems as the industry standard.

The Power-On Self Test (POST)

When IBM first began shipping the IBM PC in 1981, it included safety features that had never been seen in a personal computer. These features were the POST and parity-checked memory. The parity-checking feature is explained in Chapter 7, "Memory." The following sections provide much more detail on the POST, a series of program routines buried in the motherboard ROM-BIOS chip that tests all the main system components at power-on time. This program series causes the delay when you turn on an IBM-compatible system; the POST is executed before the computer loads the operating system.

What Is Tested?
Whenever you start up your computer, the computer automatically performs a series of tests that checks various components—the primary components—in your system.

Items such as the CPU, ROM, motherboard support circuitry, memory, and major peripherals (such as an expansion chassis) are tested. These tests are brief and not very thorough compared with available disk-based diagnostics. The POST process provides error or warning messages whenever a faulty component is encountered.

Although the diagnostics performed by the system POST are not always very thorough, they are the first line of defense, especially in handling severe motherboard problems. If the POST encounters a problem severe enough to keep the system from operating properly, it halts bootup of the system and produces an error message that often leads you directly to the cause of the problem. Such POST-detected problems are sometimes called *fatal errors*. The POST tests normally provide three types of output messages: audio codes, display-screen messages, and hexadecimal numeric codes to an I/O port address.

POST Audio Error Codes

POST audio error codes usually are audio codes consisting of a number of beeps that identifies the faulty component. If your computer is functioning normally, you hear one short beep when the system starts up. If a problem is detected, a different number of beeps sounds—sometimes in a combination of short and long beeps. These BIOS-dependent codes can vary among different BIOS manufacturers. Table 19.1 lists the beep codes for IBM systems and the problem indicated by each series of beeps.

Table 19.1 IBM POST Audio Error Codes and Indicated Problem		
Audio Code	**Sound**	**Problem (Fault domain)**
1 short beep	.	Normal POST-system OK
2 short beeps	..	POST error-error code
No beep		Power supply, system board
Continuous beep	————	Power supply, system board
Repeating short beeps	......	Power supply, system board
One long, one short beep	-.	System board
One long, two short beeps	-..	Display adapter (MDA, CGA)
One long, three short beeps	-...	Enhanced Graphics Adapter (EGA)
Three long beeps	- - -	3270 keyboard card

. = *short beep*
- = *long beep*

Appendix A in this book lists the audio POST codes for the AMI BIOS and Phoenix BIOS, both of which have a much more detailed set of audio error codes than IBM's, which are much more helpful in diagnosing problems with a system motherboard. In particular,

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the Phoenix BIOS POST is so well done that many times I do not need to use any other diagnostics to isolate a problem—the BIOS does it for me. The sophisticated POST procedure is one of the reasons I like the Phoenix BIOS.

POST Visual Error Codes

On the XT, AT, PS/2, and most compatibles, the POST also displays on the system monitor the test of system memory. The last number displayed is the amount of memory that tested properly. For example, an XT might display the following:

```
640K OK
```

The number displayed by the memory test should agree with the total amount of memory installed on your system motherboard, including conventional and extended memory. On a system with 32M of memory, the POST displays `32768KB 0K`. The RAM on an expanded memory card is not tested by the POST and does not count in the numbers reported. However, if you are using an expanded memory driver such as EMM386.EXE or Quarterdeck's QEMM to configure extended memory installed on the motherboard as expanded, the POST executes before this driver is loaded so that all installed memory is counted. If the POST memory test stops short of the expected total, then the number displayed often indicates how far into system memory a memory error lies. This number alone is a valuable troubleshooting aid.

If an error is detected during the POST procedures, an error message is displayed on-screen. These messages usually are in the form of a numeric code several digits long; for example, `1790-Disk 0 Error`. The information in the hardware-maintenance service manual identifies the malfunctioning component. I have researched all available IBM documentation and have included an abbreviated list of the on-screen error codes in this chapter, as well as a complete list in Appendix A. By looking in the error-code chart in Appendix A, you can see that a 1790 error code indicates a read error on the diagnostics cylinder for hard disk drive 0.

I/O Port POST Codes

A less-well-known feature of the POST is that at the beginning of each POST, the BIOS sends test codes to a special I/O port address. These POST codes can be read only by a special adapter card plugged into one of the system slots. These cards originally were designed to be used by the system manufacturers for burn-in testing of the motherboard during system manufacturing without the need for a video display adapter or display. Several companies now make these cards available to technicians. Micro 2000, Landmark, JDR Microdevices, Data Depot, Ultra-X, and MicroSystems Development (MSD) are just a few manufacturers of these POST cards.

When one of these adapter cards is plugged into a slot, during the POST you see two-digit hexadecimal numbers flash on a display on the card. If the system stops unexpectedly or hangs, you can just look at the two-digit display on the card for the code indicating the test in progress during the hang. This step usually identifies the failed part. A complete list of these POST codes is in Appendix A; the list covers several different manufacturers' BIOS, including IBM, AMI, Award, and Phoenix.

Most BIOS on the market that are in systems with an ISA or EISA bus output the POST codes to I/O port address 80h. Compaq is different; its systems send codes to port 84h. IBM PS/2 models with ISA bus slots, such as the Model 25 and 30, send codes to port 90h. Some EISA systems send codes to port 300h (most EISA systems also send the same codes to 80h). IBM MCA bus systems universally send codes to port 680h.

Several cards read only port address 80h. This port address is certainly the most commonly used and works in most situations, but the cards do not work in Compaq systems, some EISA systems, and IBM PS/2 systems. A POST card designed specifically for the PS/2 MCA bus needs to read only port address 680h because the card cannot be used in ISA or EISA bus systems anyway. With all these different addresses, make sure that the card you purchase reads the port addresses you need.

The two most common types of POST cards are those that plug into the 8-bit connector that is a part of the ISA or EISA bus, and those that plug into the MCA bus. Some companies offer both types of POST cards—one for MCA bus systems and one for ISA/EISA bus systems. Micro 2000 does not offer a separate card; rather, it includes with its POST Probe card a unique slot adapter that enables the card to work in MCA bus systems as well as in ISA and EISA systems. Most other companies offer only ISA/EISA POST cards and ignore the MCA bus.

To read a port address, a POST card needs to have only an 8-bit design; it does not have to be a 16-bit or 32-bit card. At least one manufacturer sells a separate EISA card that it claims is designed specifically for the EISA bus. However, because the EISA bus was designed to enable the use of 8-bit and 16-bit ISA adapter cards as well as 32-bit EISA cards, and only the 8-bit portion of the ISA bus is needed to read the required port addresses, it is unnecessary to have a separate card specific to EISA bus systems. As long as an ISA card is properly designed to latch the correct port addresses, there is no reason for it not to function perfectly in both ISA and EISA bus systems. There is absolutely no need for this separate (and expensive) EISA card.

POST-code cards are invaluable in diagnosing systems where the motherboard seems dead even though the power supply comes on (you can hear the fan). Just pop the card into a slot and observe the code on the card's display. Then look up the code in a list corresponding to the specific BIOS on the motherboard. These cards also can be very helpful with tough problems such as a memory-bit failure in Bank 0, which does not allow error codes to be displayed on a CRT in most EGA or VGA systems.

An important feature that separates the many POST cards on the market is that some provide extensive documentation of different BIOS, and others do not. Each computer manufacturer's BIOS runs different tests in a different sequence and even outputs different code numbers for the same tests. Therefore, without the proper documentation specific to the BIOS on the motherboard you are testing, the numbers shown on the POST card are meaningless.

The documentation supplied with the Micro 2000, Landmark, Data Depot, and Ultra-X cards offers excellent information covering a wide variety of different BIOS manufacturers' codes. One company, MicroSystems Development (MSD) supplies its POST Card

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documentation both in printed form and on a disk with a built-in POST code lookup program. This method is unique and desirable especially if you carry a laptop or portable system with you when you troubleshoot. The JDR Microdevices card offers less than most of the others in the way of documentation, but is also the least expensive card by a wide margin. Another thing that distinguishes the JDR card is that it is designed to be left in a system permanently. The two-digit display can be moved to the back bracket of the card so that it can be read outside the system. There is also a connector for an external two-digit display. The other cards have the display on the card only, which is impossible to read unless you open the system case.

Some cards have additional features worth mentioning. The Micro 2000 card (called the POST Probe) includes a built-in logic probe for testing signals on the major motherboard components. The POST Probe includes a series of separate LED readouts for several important bus signals as well as power-supply voltage levels. The separate LEDs enable these bus signals to be monitored simultaneously. Sometimes you can help to determine the cause of a failure by noting which bus LED is lit at a certain time. The power-supply LEDs verify the output of the +5, -5, +12, and -12 volt signals from the supply. Another feature is meter-probe attachment points on which you can easily connect a voltmeter to the card for more accurate measurements.

The Micro 2000 POST Probe is the only one that functions in every system on the market. The basic card functions in all ISA bus and EISA bus systems because of its capability to monitor all port addresses used for BIOS test codes. As mentioned, this card includes a unique adapter that enables it to function in MCA bus systems as well. The extensive documentation not only covers the expected POST codes for different BIOS versions, but also includes a detailed reference to the bus signals monitored by the card. A reference in the documentation enables even novices to use the included logic probe for some more-sophisticated motherboard tests. This card offers more features than others on the market.

The Data Depot Pocket POST is a unique card that includes an LED for monitoring bus signals. It can monitor a single signal at a time, which is selected by a jumper. The card includes LEDs for testing power-supply voltage levels and includes attachment points for a voltmeter as well. The Pocket POST is designed for ISA and EISA bus systems and can connect to any port addresses used in these systems for POST codes. As its name suggests, the card is small compared to most others, and therefore is easy to carry around. The entire package, including the comprehensive manual, fits in a standard (included) floppy disk case.

Ultra-X has two cards: the Quick-POST PC for ISA/EISA bus systems and the Quick-POST PS/2 for MCA bus systems. Because the Quick-POST cards monitor only one port address each—80h for the PC card and 680h for the PS/2 card—the ISA/EISA version is less flexible than some others. The included documentation is excellent and covers a variety of BIOS versions. Both cards also include LEDs used to monitor power-supply voltages.

As mentioned, the MicroSystems Development (MSD) card is unique because of its on-disk documentation. A printed manual is supplied also. This POST Code Master is

capable of monitoring either port address 80h or 84h. It also includes voltage-test LEDS for checking the power supply.

A second type of diagnostics card goes beyond the function of a basic POST-code card. In addition to monitoring POST codes, these cards include an on-board ROM chip that contains a more sophisticated diagnostics program than the suite of tests in the motherboard ROM BIOS. Among the cards that offer this function are the Kickstart II card by Landmark and the RACER II card by Ultra-X. Both cards monitor POST codes as well as use their own on-board ROM-based diagnostics program. Because of the extra expense of having these programs and other options on-board, the cards are more expensive than the standard POST-code cards.

Although a higher-level diagnostics card can be handy, I normally do not recommend them because the standard POST-code cards provide 95 percent of the capabilities of these cards with no BIOS conflicts or other problems. In many cases, before you can use a higher-level diagnostics card, other adapters must be removed from the system to eliminate conflicts with ROMs on other cards. Although these cards are quite capable and function as a basic POST-code card if necessary, I find it more valuable to spend the extra money on a disk-based diagnostics program and stick to the basic POST-code cards. This way, I get the most functionality for my money.

IBM Diagnostics

IBM systems usually have two levels of diagnostics software. One is a general purpose diagnostics that is more user-oriented, and the second is a technician-level program that can be somewhat cryptic at times. In many cases, both of these programs are provided free with the system when it is purchased, and in some cases, the diagnostics and documentation have to be purchased separately. Since the troubleshooting procedures for most systems these days are fairly simple, most people have no problems running the diagnostics software without any official documentation. IBM runs a BBS system that has virtually all of its general and advanced diagnostics available free for downloading. You can find the number for this BBS in Appendix B. The following sections discuss the IBM diagnostics.

IBM System Diagnostics

Every IBM computer comes with a Guide To Operations (GTO) or Quick Reference manual. The GTO manual is in a reddish-purple binder; it includes a diagnostics disk to assist you in identifying problems. PS/2 computers are supplied with a much smaller quick-reference guide that includes a reference disk. The disk contains both the regular and advanced diagnostics, as well as the normal SETUP program.

The diagnostics disk and corresponding manual provide step-by-step instructions for testing various parts of the computer system, including the system unit and many installed options, such as the expansion unit, keyboard, display, and printer. Unfortunately, these diagnostics are a crippled version of the much more powerful advanced diagnostics IBM sells. Intended for use by customers who are not particularly technically

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oriented, the GTO diagnostics are lacking in many respects. For example, the tests cannot be run individually; whenever you start the tests you must always run all of them.

Many compatible-system vendors do not segregate the diagnostics software like IBM does; many include an advanced-type diagnostics disk free with the system. For example, AST includes its diagnostics program, called ASTute, free with every system. This program is similar to the IBM Advanced Diagnostics.

Before running the GTO tests, you must boot from the IBM diagnostics disk because a special version of DOS resides on the diagnostics disk. This DOS version suppresses memory parity checking during the boot process. Disabling parity checking might enable a defective system to limp through the diagnostics in a case where the system continually locks up with a parity-check error message. After the disk is loaded, the main diagnostics menu is displayed. The opening menu looks something like the following:

```
The IBM Personal Computer
DIAGNOSTICS
Version 2.06
Copyright IBM Corp. 1981,1986

SELECT AN OPTION
0 - SYSTEM CHECKOUT
1 - FORMAT DISKETTE
2 - COPY DISKETTE
3 - PREPARE SYSTEM FOR MOVING
4 - SETUP
9 - END DIAGNOSTICS
SELECT THE ACTION DESIRED
?
```

Options 0, 1, and 2 on the IBM diagnostics screen are part of the diagnostics procedures. These options, as well as options 3, 4, and 9, are detailed in the following paragraphs:

- *Option 0.* This option is used for general testing. When this option is selected, the diagnostics software loads from the disk various modules that perform a presence test to see whether the device to which the module corresponds is in the system. The option presents a list of installed devices, and you are asked whether the list is correct.

- *Option 1.* This option formats a disk with a special format to create a special scratch disk used by the diagnostics program when it is running tests on your system. The format is different from a normal DOS format and should not be used to format disks for normal use under DOS. Among other things, differences exist in the construction of the boot sector of the diagnostics scratch disk and a normal DOS disk.

- *Option 2.* Used to copy a disk, Option 2 creates a mirror-image copy of a disk using the same process as the DOS DISKCOPY command. This option is intended for copying the diagnostics disk that is used to boot your system before you run the GTO tests. (The diagnostics disk includes system files that enable the computer to boot without the presence of DOS.) The original diagnostics disk should not be used for testing. Instead, use a copy and place the original in a safe location.

The diagnostics disks can be copied by using DISKCOPY or a similar utility because these disks are not copy-protected, enabling you to make proper backups and keep the master disks safe.

- *Option 3.* This option is used to park, or secure, the heads on a hard disk so that the system unit can be moved safely without damaging the disk or its contents.

- *Option 4.* Present only on the AT version of the diagnostics, this option is used on the AT to identify installed options when you first set up your system.

- *Option 9.* This option is used to quit the diagnostics software and restart your system. You must remove the diagnostics disk from your floppy drive.

For several reasons, the list of installed devices does not always match the actual system configuration. The way the tests are designed, an installed device appears in the list only if a software module is included on the disk that can be used to test the device. For example, the IBM Token Ring network adapter does not appear in the list of installed devices even if you have this network card installed. This is because the diagnostics disk does not contain a module for testing an IBM Token Ring network adapter installed in your system. IBM provides a separate diagnostics program on a separate disk for this adapter.

Most standard devices should show up on the list, however, even if the particular device was not made by IBM. Your hard disk controller should show up, as should your video board, serial and parallel ports, conventional and extended memory, floppy drives, and motherboard. If you purchase a newer type of expansion item, such as a VGA graphics card, the diagnostics might instead identify this board as an EGA board, if the VGA testing module is not present on the disk. Because modules are not available for most expanded-memory boards, these boards almost never appear on the list, with the exception of IBM's XMA card. Nonstandard communications boards (boards containing other than normal serial or parallel ports) normally are not listed either.

If an installed device does not appear in the list and you know that the diagnostics software normally would find it, then it is safe to assume that the device is configured incorrectly or has a serious problem. In such a case, signify that the list is incorrect by answering No when you are asked whether the installed device list is correct. Then add the item to the list. If an item appears that is not installed, use the same procedure to remove the item from the list. This list represents all the tests that can be run; the only way you can test an item is to have it appear on this list.

After going through the installed-devices list, you see another menu, similar to this one:

```
0 - RUN TESTS ONE TIME
1 - RUN TESTS MULTIPLE TIMES
2 - LOG UTILITIES
3 - END SYSTEM CHECKOUT
```

Select Option 0 to test the devices installed in the system. Option 1 enables you to test these devices repetitively, as many times as you want, or forever. The forever option is

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handy because it enables you to run the diagnostics continuously overnight or over a weekend to find particularly troublesome problems. This method can be an easy way to identify the cause of an intermittent problem. To record errors that occur while you're not present, you first select Option 2, which can be used to set up an error log. The log records the date, time, and error message to a floppy disk or printer so that you can review them at a later time.

If an error occurs while these tests are running, a numerical error message appears along with the date and time. These numbers, listed in this chapter and in Appendix A, follow the same conventions as the numbers displayed by the POST, and are the same numbers in some cases. The diagnostic tests usually are much more powerful than the tests run in the POST.

Although the diagnostics do an excellent job of identifying specific problem areas or problem components, they provide limited assistance in telling you how to correct the cause of the errors. Little documentation is provided with these diagnostics; and, in fact, most often the advice provided on solving any problem is to have your system or the problem device serviced, which, if you want to service the system yourself, is akin to no advice at all. These diagnostics are a crippled version of the real diagnostics, which are part of the *Hardware Maintenance Service Manual*. If you plan to troubleshoot or upgrade your own system, or if you plan to administer a number of PCs, you should be using the advanced diagnostics; they are the diagnostics to which the remainder of this book refers.

IBM Advanced Diagnostics

For technician-level diagnostics, IBM sells hardware-maintenance and service manuals for each system, which include the Advanced Diagnostics disks for that system. These disks contain the real diagnostics programs and, combined with the hardware-maintenance service manuals, represent the de facto standard diagnostics information and software for IBM and compatible systems. For PS/2 machines, IBM includes the Advanced Diagnostics on the Reference Disk that comes with the system; however, the instructions for using the diagnostics are still found in the separately available service manuals.

If you need a copy of the Advanced Diagnostics for any IBM system, check the IBM National Support Center (NSC) Bulletin Board System (BBS). The IBM BBS has virtually all of the IBM Advanced Diagnostics and Reference Disks available for download at no charge! They are stored on the BBS in a compressed disk image format, and you will need one of two utilities to uncompress the file depending on how it was originally compressed. Follow the instructions presented on-line for more information on which uncompress program you need. The phone number for the IBM NSC BBS is listed in Appendix B under the IBM PC Company.

These programs produce error messages in the form of numbers you can use to identify the cause of a wide range of problems. The number codes used are the same as those used in the POST and general-diagnostics software. The meaning of the numbers is consistent across all IBM diagnostic programs. This section explores the Advanced Diagnostics and lists most of the known error-code meanings. IBM constantly adds to this error-code list as it introduces new equipment.

Using IBM Advanced Diagnostics. If you have a PS/2 system with the MCA (Micro Channel Architecture) bus slots (models produced later than the Models 25 to 40), you may already have IBM's Advanced Diagnostics, even if you don't know it. These diagnostics are usually hidden on the PS/2 Reference Disk. To access these diagnostics, boot the PS/2 Reference Disk. When the main menu is displayed, press Ctrl-A (for Advanced). The program changes to the Advanced Diagnostics menu. In some of the PS/2 systems, the Advanced Diagnostics were large enough to require a separate disk or disks. All of the PS/2 Reference and Diagnostics disks are available for downloading on the IBM NSC BBS (see Appendix B).

Hiding Advanced Diagnostics from average users is probably a good idea. For example, inexperienced users can easily wipe out all of their data by using this disk's option of low-level formatting the hard disk.

The PS/2 service manuals are fairly skimpy because the average PS/2 system doesn't have that many parts, and they are easy to repair. One drawback of the PS/2 service manuals is that they often end a troubleshooting session with this advice: Replace the system board. Although I recommend the hardware-maintenance and service manuals, if all you are looking for is the Advanced Diagnostics software (and you have a PS/2 system with the MCA bus), you already have it and do not need to purchase any additional items.

Non-MCA systems, such as the PS/2 25 to 40 systems, come with a Starter Disk, equivalent to the Setup and Diagnostics Disk that came with the original AT system. This Starter Disk includes the Setup program and limited diagnostics that lack many functions found in the Advanced Diagnostics. You get the Advanced Diagnostics for these systems included with the PS/2 *Hardware Maintenance and Service* (HMS) *Manual*, which includes the Advanced Diagnostics disks for Models 25, 30, and 30-286. If you want the diagnostics for later systems, such as Models 35 or 40, you must purchase the respective update package for the PS/2 HMS manual. These updates usually cost about $30. If all you need are the Advanced Diagnostics disks, they can be downloaded at no charge from the IBM NSC BBS (see the vendor list).

If you really want in-depth information about troubleshooting your system, you can purchase the IBM *Hardware Maintenance Service Manual*. This single book covers the earlier IBM systems, including the PC, XT, and AT. Updates cover the XT-286 and PS/2 Models 25 and 30. Later PS/2 systems have their own separate version of this book, called *PS/2 Hardware Maintenance and Service*. This book includes spare copies of the standard reference disks. The newer versions of the PS/2 book now cover also all PS/2 systems, those with ISA (Industry Standard Architecture) as well as MCA (Micro Channel Architecture) slots.

Although the guide-to-operations manual is good only for identifying a problem component, the HMS manual provides information for you to more accurately isolate and repair the failure of any field-replaceable unit (FRU).

The HMS manual includes an Advanced Diagnostics disk as well as provides maintenance-analysis procedures (MAPs), which are instructions to help you isolate and identify problem components. To run the advanced diagnostics tests, follow the procedures detailed in this section.

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After booting the Advanced Diagnostics disk for your particular system (PC or AT), a menu similar to this one appears:

```
The IBM Personal Computer
ADVANCED DIAGNOSTICS
Version 2.07
Copyright IBM Corp. 1981,1986

ROS P/N: 78X7462
ROS DATE: 04/21/86

SELECT AN OPTION

0 - SYSTEM CHECKOUT
1 - FORMAT DISKETTE
2 - COPY DISKETTE
3 - PREPARE SYSTEM FOR MOVING
4 - SETUP

9 - END DIAGNOSTICS

SELECT THE ACTION DESIRED

?
```

Note

If you are using the PC version, the fourth item is not displayed because PC systems do not have CMOS Setup memory.

The Advanced Diagnostics disks show the date of the ROM as well as the IBM part number for the particular chips in your system. The screen shows this information near the top as ROS (read-only software). The 04/21/86 date identifies the version of the ROM in this example. The date indicates an IBM XT Model 286. The part number, read directly from the ROM, is academic information because IBM does not sell the ROM chips separately—only with a complete motherboard swap.

After you select Option 0, which invokes the diagnostic routines, each module on the disk loads and executes a presence test to determine whether the applicable piece of hardware is truly in the system. In this example, the result looks like this:

```
THE INSTALLED DEVICES ARE

1 - SYSTEM BOARD
2 - 2688KB MEMORY
3 - KEYBOARD
6 - 2 DISKETTE DRIVE(S) AND ADAPTER
7 - MATH COPROCESSOR
9 - SERIAL/PARALLEL ADAPTER
9 - - PARALLEL PORT
11 - SERIAL/PARALLEL ADAPTER
11 - - SERIAL PORT
```

```
17 - 1 FIXED DISK DRIVE(S) AND ADAPTER
74 - PERSONAL SYSTEM/2 DISPLAY ADAPTER

IS THE LIST CORRECT (Y/N)

?
```

You then answer Yes or No depending on the accuracy of the list. Remember that not everything appears on this list. An IBM Token Ring network adapter never appears on this list because no software module designed for that option is present on the disk. The following list contains all items that could appear on the list as of version 2.07 of these diagnostics. This list is different for other versions.

```
 1  SYSTEM BOARD
 2  MEMORY
 3  KEYBOARD
 4  MONOCHROME & PRINTER ADAPTER
 5  COLOR/GRAPHICS MONITOR ADAPTER
 6  DISKETTE DRIVE(S)
 7  MATH COPROCESSOR
 9  SERIAL/PARALLEL ADAPTER - PARALLEL PORT
10 ALTERNATE SERIAL/PARALLEL ADAPTER - PARALLEL PORT
11 SERIAL/PARALLEL ADAPTER - SERIAL PORT
12 ALTERNATE SERIAL/PARALLEL ADAPTER - SERIAL PORT
13 GAME CONTROL ADAPTER
14 MATRIX PRINTER
15 SDLC COMMUNICATIONS ADAPTER
17 FIXED DISK DRIVE(S) AND ADAPTER
20 BSC COMMUNICATIONS ADAPTER
21 ALT BSC COMMUNICATIONS ADAPTER
22 CLUSTER ADAPTER(S)
24 ENHANCED GRAPHICS ADAPTER
29 COLOR PRINTER
30 PC NETWORK ADAPTER
31 ALT. PC NETWORK ADAPTER
36 GPIB ADAPTER(S)
38 DATA ACQUISITION ADAPTER(S)
39 PROFESSIONAL GRAPHICS CONTROLLER
71 VOICE COMMUNICATIONS ADAPTER
73 3.5" EXTERNAL DISKETTE DRIVE AND ADAPTER
74 PERSONAL SYSTEM/2 DISPLAY ADAPTER
85 EXPANDED MEMORY ADAPTER - 2 MB -
89 MUSIC FEATURE CARD(S)
```

After certifying that the list is correct, or adding or deleting items as necessary to make it correct, you can begin testing each item listed.

The tests performed by the Advanced Diagnostics disk are far more detailed and precise than the tests on the general diagnostics disk in the GTO. In addition to identifying the problem component, the Advanced Diagnostics further attempt to identify the specific malfunctioning part of the device.

After a problem is identified, the HMS manual provides detailed instructions for performing adjustments, preventive maintenance, and removal and replacement of the affected part. To help you, comprehensive hardware and design information is available, including parts lists that specify replacement-part numbers and internal design specifications.

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Examining Error Codes. Nearly all the personal computer error codes for the POST, general diagnostics, and advanced diagnostics are represented by the display of the device number followed by two digits other than 00. When the tests display the device number plus the number 00, it indicates a test was completed without an error being found.

The following list is a compilation from various sources including technical reference manuals, hardware-maintenance service manuals, and hardware-maintenance reference manuals. In each three-digit number, the first number indicates a device. The other two digits indicate the exact problem. For example, 7xx indicates the math coprocessor. A display of 700 means all is well. Any other number (701 to 799) indicates that the math coprocessor is bad or having problems. The last two digits (01 to 99) indicate what is wrong. Table 19.2 lists the basic error codes and their descriptions.

Table 19.2 Personal Computer Error Codes	
Code	**Description**
1xx	System Board errors
2xx	Memory (RAM) errors
3xx	Keyboard errors
4xx	Monochrome Display Adapter (MDA) errors
4xx	PS/2 System Board Parallel Port errors
5xx	Color Graphics Adapter (CGA) errors
6xx	Floppy Drive/Controller errors
7xx	Math Coprocessor errors
9xx	Parallel Printer adapter errors
10xx	Alternate Parallel Printer Adapter errors
11xx	Primary Async Communications (serial port COM1) errors
12xx	Alternate Async Communications (serial COM2, COM3, and COM4) errors
13xx	Game Control Adapter errors
14xx	Matrix Printer errors
15xx	Synchronous Data Link Control (SDLC) Communications Adapter errors
16xx	Display Station Emulation Adapter (DSEA) errors (5520, 525x)
17xx	ST-506/412 Fixed Disk and Controller errors
18xx	I/O Expansion Unit errors
19xx	3270 PC Attachment Card errors
20xx	Binary Synchronous Communications (BSC) Adapter errors
21xx	Alternate Binary Synchronous Communications (BSC) Adapter errors
22xx	Cluster Adapter errors
23xx	Plasma Monitor Adapter errors
24xx	Enhanced Graphics Adapter (EGA) errors
24xx	PS/2 System Board Video Graphics Array (VGA) errors
25xx	Alternate Enhanced Graphics Adapter (EGA) errors

Code	Description
26xx	XT or AT/370 370-M (Memory) and 370-P (Processor) Adapter errors
27xx	XT or AT/370 3277-EM (Emulation) Adapter errors
28xx	3278/79 Emulation Adapter or 3270 Connection Adapter errors
29xx	Color/Graphics Printer errors
30xx	Primary PC Network Adapter errors
31xx	Secondary PC Network Adapter errors
32xx	3270 PC or AT Display and Programmed Symbols Adapter errors
33xx	Compact Printer errors
35xx	Enhanced Display Station Emulation Adapter (EDSEA) errors
36xx	General Purpose Interface Bus (GPIB) Adapter errors
38xx	Data Acquisition Adapter errors
39xx	Professional Graphics Adapter (PGA) errors
44xx	5278 Display Attachment Unit and 5279 Display errors
45xx	IEEE Interface Adapter (IEEE-488) errors
46xx	A Real-Time Interface Coprocessor (ARTIC) Multiport/2 Adapter errors
48xx	Internal Modem errors
49xx	Alternate Internal Modem errors
50xx	PC Convertible LCD errors
51xx	PC Convertible Portable Printer errors
56xx	Financial Communication System errors
70xx	Phoenix BIOS/Chip Set Unique Error Codes
71xx	Voice Communications Adapter (VCA) errors
73xx	3 1/2-inch External Diskette Drive errors
74xx	IBM PS/2 Display Adapter (VGA card) errors
74xx	8514/A Display Adapter errors
76xx	4216 PagePrinter Adapter errors
84xx	PS/2 Speech Adapter errors
85xx	2M XMA Memory Adapter or Expanded Memory Adapter/A errors
86xx	PS/2 Pointing Device (Mouse) errors
89xx	Musical Instrument Digital Interface (MIDI) Adapter errors
91xx	IBM 3363 Write-Once Read Multiple (WORM) Optical Drive/Adapter errors
096xxxx	SCSI Adapter with Cache (32-bit) errors
100xx	Multiprotocol Adapter/A errors
101xx	300/1200bps Internal Modem/A errors
104xx	ESDI Fixed Disk or Adapter errors
107xx	5 1/4-inch External Diskette Drive or Adapter errors
112xxxx	SCSI Adapter (16-bit w/o Cache) errors
113xxxx	System Board SCSI Adapter (16-bit) errors
129xx	Model 70 Processor Board errors; Type 3 (25 MHz) System Board

(continues)

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Table 19.2 Continued	
Code	**Description**
149xx	P70/P75 Plasma Display and Adapter errors
165xx	6157 Streaming Tape Drive or Tape Attachment Adapter errors
166xx	Primary Token Ring Network Adapter errors
167xx	Alternate Token Ring Network Adapter errors
180xx	PS/2 Wizard Adapter errors
194xx	80286 Memory Expansion Option Memory Module errors
208xxxx	Unknown SCSI Device errors
209xxxx	SCSI Removable Disk errors
210xxxx	SCSI Fixed Disk errors
211xxxx	SCSI Tape Drive errors
212xxxx	SCSI Printer errors
213xxxx	SCSI Processor errors
214xxxx	SCSI Write-Once Read Multiple (WORM) Drive errors
215xxxx	SCSI CD-ROM Drive errors
216xxxx	SCSI Scanner errors
217xxxx	SCSI Optical Memory errors
218xxxx	SCSI Jukebox Changer errors
219xxxx	SCSI Communications errors

Appendix A in this book contains a detailed list of every IBM error code I have encountered. Also listed are charts I developed concerning SCSI errors. The SCSI interface has introduced a whole new set of error codes because of the large number and variety of devices that can be attached.

General Purpose Diagnostics Programs

One way to determine whether a system is fully IBM-compatible is to see whether it runs IBM's AT Advanced Diagnostics. IBM's diagnostics programs work just fine on fully compatible PCs produced by other manufacturers. Many system manufacturers offer their own diagnostics. Zenith, AT&T, and Tandy, for example, offer their own versions of service manuals and diagnostics programs for their systems. Many other system manufacturers include a version of a third-party diagnostic utilities package when you purchase their systems.

A large number of third-party diagnostics programs are available for IBM and compatible systems. Specific programs are available also to test memory, floppy drives, hard disks, video boards, and most other areas of the system. Although some of these utility packages should be considered essential in any tool kit, many fall short of the level needed by professional-level troubleshooters. Many products, geared more toward end users, lack the accuracy, features, and capabilities needed by technically proficient people who are

serious about troubleshooting. In this section I present information about some of the diagnostics programs I recommend.

Most of the better diagnostics on the market offer several advantages over the IBM diagnostics. They usually are better at determining where a problem lies within a system, especially in IBM-compatible systems. Serial- and parallel-port loopback connectors, or *wrap plugs*, are often included in these packages, or are available for a separate charge. The plugs are required to properly diagnose and test serial and parallel ports. (IBM always charges extra for these plugs.)

Many of these programs can be run in a batch mode, which enables a series of tests to be run from the command line without operator intervention. You then can set up automated test suites, which can be especially useful in burning in a system or executing the same tests on many systems.

These programs test all types of memory including conventional (base) memory, extended memory, and expanded memory. Failures can usually be identified down to the individual chip or SIMM (bank and bit) level.

One question I commonly receive is about which diagnostic program I would recommend above all others. This is impossible to answer! There are so many programs available, and each seem to have strengths in some areas and weaknesses in others. I almost never rely on the "opinion" of one program, and usually try several to see if they corroborate the diagnosis. Having a second or third opinion in some cases is a good idea before replacing an expensive piece of equipment or getting involved in a lengthy repair procedure. Although many of these programs can be somewhat expensive for casual troubleshooters, if you work in a service or support role, then these professional-level programs can save you money in the long run with increased accuracy and capabilities in troubleshooting and servicing your systems.

The remainder of this section describes some of the different diagnostics programs I recommend.

AMIDiag

AMI (American Megatrends, Inc.) makes the most popular PC ROM BIOS software in use today. The AMI BIOS can be found on the majority of newer IBM-compatible systems that are currently being sold. If you have seen the AMI BIOS, then you know that most versions have a built-in diagnostics program. Few people know that AMI now markets an enhanced disk-based version of the same diagnostics that is built into the AMI ROM.

AMIDiag, as the program is called, has numerous features and enhancements not found in the simpler ROM version. AMIDiag is a comprehensive, general purpose diagnostics program that is designed for any IBM-compatible system, not just those with an AMI ROM BIOS.

Checkit Pro

Touchstone Software Corp.'s Checkit products offer an excellent suite of testing capabilities, including tests of the system CPU; conventional, extended and expanded memory;

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hard and floppy drives; and video card and monitor (including VESA-standard cards and monitors, mouse, and keyboard). Several versions of the Checkit product are available—Checkit Pro Deluxe is the company's most complete hardware diagnostics program. Checkit Pro Analyst for Windows performs Windows-based diagnostics. Checkit Plus, which is included by some system manufacturers with their systems, is less complete.

Checkit Pro Deluxe provides limited benchmarking capabilities but gives detailed information about your system hardware such as the following: total installed memory, hard drive type and size, current memory allocation (including upper memory usage), IRQ availability and usage, modem/fax modem speed, and a variety of other tests important to someone troubleshooting a PC. Checkit Pro Deluxe includes a text-editing module that opens automatically to CONFIG.SYS and AUTOEXEC.BAT. If you use Windows, Checkit Pro's Windows option makes it easy to edit your Windows SYSTEM.INI and WIN.INI files.

Some of the testing performed by Checkit Pro is uncommon for diagnostic utility packages (for example, its capability to test modem/fax modem settings). Still, Checkit Pro lacks important features such as an easy-to-use listing of available DMA channels, which is crucial if you are trying to install a sound card and other hardware devices.

Micro-Scope

Micro-Scope by Micro 2000 is a full-featured general purpose diagnostics program for IBM-compatible systems. It has many features and capabilities that can be very helpful in troubleshooting or diagnosing hardware problems.

The Micro-Scope package is one of only a few diagnostics packages that are truly PS/2 aware. Micro-Scope not only helps you troubleshoot PS/2 systems, but also does some things that even IBM Advanced Diagnostics cannot do; for example, it can format industry-standard ESDI hard disk drives attached to the IBM PS/2 ESDI controller. When you attach an ESDI drive to the IBM ESDI controller, the BIOS on the controller queries the drive for its capacity and defect map information. IBM apparently chose a proprietary format for this information on its drives; if the controller cannot read the information, you cannot set up the drive or format it by using the PS/2 Reference Disk.

Although IBM used an ESDI controller in its PS/2 system, you could not get just any ESDI drive to work on that system. Some drive manufacturers produced special PS/2 versions of their drives that had this information on them. Another way around the problem was to use an aftermarket ESDI controller in place of the IBM controller so that you could use the IBM ESDI drive as well as any other industry-standard ESDI drive. With this method, however, you could not use the Reference Disk format program anymore because it works only with IBM's controller. Micro-Scope solves many of these problems because it can format an industry-standard ESDI drive attached to the IBM ESDI controller and save you from having to purchase an aftermarket controller or a special drive when you add drives to these systems.

Micro-Scope has also a hardware interrupt and I/O port address check feature that is more accurate than the same feature in most other software. It enables you to accurately identify the interrupt or I/O port address a certain adapter or hardware device in your

system is using—a valuable capability in solving conflicts between adapters. Some user-level diagnostics programs have this feature, but the information they report can be grossly inaccurate, and they often miss items installed in the system. Micro-Scope goes around DOS and the BIOS; because the program has its own operating system and its tests bypass the ROM BIOS when necessary, it can eliminate the masking that occurs with these elements in the way. For this reason, the program also is useful for technicians who support PCs that run under non-DOS environments such as UNIX or on Novell file servers. For convenience, you can install Micro-Scope on a hard disk and run it under regular DOS.

Finally, Micro 2000 offers excellent telephone technical support. Its operators do much more than explain how to operate the software—they help you with real troubleshooting problems. This information is augmented by good documentation and on-line help built in to the software so that, in many cases, you don't have to refer to the manual.

Norton Diagnostics

When you consider that Norton Diagnostics (NDIAGS) comes with the Norton Utilities version 8.0, and that Norton Utilities is already an essential collection of system data safeguarding, troubleshooting, testing, and repairing utilities, NDIAGS probably is one of the best values in diagnostic programs.

If you already have a version of Norton Utilities earlier than 8.0, get the upgrade. If you don't already have Norton Utilities, you'll want to strongly consider this package, not only for NDIAGS, but also for enhancements to other utilities such as the Stacker 4.0-ready Speedisk, Disk Doctor, and Calibrate. These three hard drive utilities basically represent the state of the art in hard drive diagnostics and software-level repair. SYSINFO still handles benchmarking for the Norton Utilities, and it does as good a job as any other package on the market.

NDIAGS adds diagnostic capabilities that previously were not provided by the Norton Utilities, including comprehensive information about the overall hardware configuration of your system—the CPU, system BIOS, math coprocessor, video adapter, keyboard and mouse type, hard and floppy drive types, amount of installed memory (including extended and expanded), bus type (ISA, EISA, or MCA), and the number of serial and parallel ports. Unlike some other programs, loopback plugs do not come in the box for NDIAGS, but a coupon is included that enables you to get loopback plugs free. Note that this program uses wrap plugs that are wired slightly different than what has been commonly used by others. The different wiring allows you to run some additional tests. Fortunately, the documentation includes a diagram for these plugs, allowing you to make your own if you desire.

NDIAGS thoroughly tests the major system components and enables you to check minor details such as the NumLock, CapsLock, and ScrollLock LEDs on your keyboard. NDIAGS also provides an on-screen grid you can use to center the image on your monitor and test for various kinds of distortion that may indicate a faulty monitor. The Norton Utilities 8.0, as mentioned previously, is available for registered users of a previous version and can be purchased for $100 or less.

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PC Technician

PC Technician by Windsor Technologies is one of the longest running PC diagnostics products on the market. As such, it has been highly refined and continuously updated to reflect the changing PC market.

PC Technician is a full-featured, comprehensive hardware diagnostics and troubleshooting tool that tests all major areas of a system. Like several of the other high-end programs, PC Technician has its own operating system which isolates it from problems caused by software conflicts. The program is written in assembly language and has direct access to the hardware in the system for testing. This program also includes all of the wrap plugs needed for testing serial and parallel ports.

PC Technician has long been a favorite with field service companies, who equip their technicians with the product for troubleshooting. This program was designed for the professional service technician; however, it is easy to use for the amateur as well.

QAPlus/FE

QAPlus/FE by Diagsoft is one of the most advanced and comprehensive sets of diagnostics you can buy for 386, 486, or Pentium-based computers, including PS/2s. Its testing is extremely thorough, and its menu-based interface makes it downright easy to use, even for someone who is not particularly well-versed in diagnosing problems with personal computers. QAPlus/FE also includes some of the most accurate system benchmarks you can get, which can be used to find out if that new system you are thinking of buying is really all that much faster than the one you already have. More importantly, QAPlus/FE comes on bootable 3 1/2- and 5 1/4-inch disks that (regardless of whether your operating system is DOS, OS/2, or UNIX) can be used to start your system when problems are so severe that your system hardware cannot even find the hard drive. You also can install QAPlus/FE on your hard drive if you are using DOS 3.2 or later.

Many of you may already have a less comprehensive version of this program oriented towards end users called QAPlus. The basic QAPlus version is often included with systems sold by a number of different PC system vendors. Although the simple QAPlus program is OK, I much prefer the full-blown QAPlus/FE version for serious troubleshooting.

QAPlus/FE can be used to test your motherboard, system RAM (conventional, extended, and expanded), video adapter, hard drive, floppy drives, CD-ROM drive, mouse, keyboard, printer, and parallel and serial ports (the QAPlus/FE package includes loopback plugs for full testing of these ports). It also provides exhaustive information on your system configuration, including the hardware installed on your system, its CPU, and the total amount of RAM installed on your system. It provides full interrupt mapping—crucial when installing new adapter boards and other hardware devices—and gives you a full picture of the device drivers and memory resident programs loaded in CONFIG.SYS and AUTOEXEC.BAT, as well as other information about DOS and system memory use.

QAPlus/FE also includes various other utilities which are more likely to appeal to the serious PC troubleshooter than to the average PC user. These special capabilities include

a CMOS editor that can be used to change system date and time, as well as the hard drive type; installed memory size and other CMOS information; a COM port debugger; a hard drive test and low-level formatting utility; a floppy drive test utility; and a configuration file editor that can be used to edit AUTOEXEC.BAT, CONFIG.SYS, a remote system communication host program that enables service people with the full remote package to operate your computer via modem, as well as other text files.

Unlike some diagnostics programs, QAPlus/FE has a system *burn-in* capability, meaning it can be used to run your system non-stop under a full load of computations and hardware activity for the purpose of determining whether any system component is likely to fail in real life use. Many people use a burn-in utility when they receive a new system, and then again just before the warranty runs out. A true system burn-in usually lasts 48 to 72 hours, or even longer. The amount of time QAPlus/FE can burn-in a system is user-configurable by setting the number of times the selected tests are to be run.

Service Diagnostics
The Service Diagnostics program by Landmark also has several features that distinguish it from other packages. This section describes these features.

The Service Diagnostics program is an excellent, all-around, comprehensive diagnostics package. The program has been around for awhile and has evolved to include nearly any test a troubleshooter could want. Service Diagnostics is known for its excellent memory tests, which are extremely thorough and accurate; it also gives you much control over the type of test to run. For example, you can optionally turn parity checking on or off during the tests, a feature not found in other programs. All memory errors are reported to the individual-bit level.

The Service Diagnostics program also has specific test routines for each different microprocessor that might be in a PC-compatible system. In other words, it detects the type of processor in your system and tests it by using specific routines designed for the processor. You can override the processor detection and specify the processor you have. The program can recognize and test specific Intel-based systems using 8088, 8086, 286, 386, 486, and Pentium CPUs. Also, Service Diagnostics specifically recognizes and tests Harris 80C88 and AMD 386 chips, as well as Intel, Cyrix, and IIT math coprocessors. The program also tests for several known bugs in 386 and 486 systems that have been known to cause problems in some systems.

Another Service Diagnostics feature is its floppy disk alignment diagnostics, which enable you to check the alignment of both 3 1/2- and 5 1/4-inch drives through the use of an included Digital Diagnostics Disk (DDD). These disks are accurate to a resolution of 500µ inches (micro-inches = millionths of an inch)—accurate enough for checking alignment, but not accurate enough for use in aligning a drive. For performing drive alignment, the program has a menu of analog alignment aids, designed to be used in conjunction with a more accurate Analog Alignment Disk (AAD) and an oscilloscope.

The Service Diagnostics program has an excellent hard disk, low-level format program for ST-506/412 drives. You can specify not only the interleave, but also the skew factor.

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Skew is the offset of sectors from one track to the next to allow for head-switching time. This process is possible because the low-level format routines in the Service Diagnostics work at the controller register level; the program bypasses DOS and the BIOS and interacts directly with the controller hardware. The program formats most ESDI drives, but cannot be used on SCSI or IDE drives.

A printer-test feature in the Service Diagnostics program enables test patterns to be sent to different printers. You can quickly verify the functionality of the port, cable, and printer in one simple operation.

I recommend diagnostics programs that accommodate the special features of IBM's PS/2 systems; Service Diagnostics meets this test. It has a separate stand-alone PS/2 version of the software designed specifically for PS/2 systems. This version recognizes PS/2 hardware differences and works correctly with the unique PS/2 CMOS RAM for adapter setup and configuration. The Service Diagnostics package includes excellent documentation that describes not only how to operate the software, but also how the software routines work. Landmark offers good technical support for its products.

Service Diagnostics packages also offer a special hardware-based diagnostics tool—diagnostics in ROM chips that can be plugged into the BIOS-chip sockets on a PC, XT, AT, or IBM-compatible motherboard. Such ROM-based diagnostics are useful in limited situations, particularly when you need to test a system that otherwise does not function. Note that these BIOS diagnostics do not function on all systems, but they can be useful on an IBM PC, XT, or AT, or a fully compatible system.

The Service Diagnostics program is available in three primary kits: the PC, XT, AT Kit with ROM POST modules, the PS/2 Complete Kit, and a Super Kit that includes everything. You also can buy special lower cost software-only modules for each specific type of system.

Disk Diagnostics

All of the general purpose diagnostics programs will test both floppy and hard disk drives. However, since these programs are general-purpose in nature, the drive tests are not always as complete as one would like. For this reason there are a number of specific programs designed expressly for performing diagnostics and servicing on disk drives. The following section discusses some of the best disk diagnostics and testing programs on the market and what they can do for you.

Drive Probe

Many programs on the market evaluate the condition of floppy disk drives by using a disk created or formatted on the same drive. A program that uses this technique cannot make a proper evaluation of a disk drive's alignment. A specially created disk produced by a tested and calibrated machine is required. This type of disk can be used as a reference standard by which to judge a drive. Accurite, the primary manufacturer of such reference standard floppy disks, helps specify floppy disk industry standards. Accurite

produces the following three main types of reference standard disks used for testing drive function and alignment:

- Digital Diagnostic Diskette (DDD)
- High-Resolution Diagnostic Diskette (HRD)
- Analog Alignment Diskette (AAD)

The DDD disk, introduced in 1982, enables you to test drive alignment by using only software; no oscilloscope or special tools are needed. This disk is accurate to only 500μ-inches (millionths of an inch)—good enough for a rough *test* of drive alignment, but not nearly enough to use for *aligning* a drive.

The HRD disk, introduced in 1989, represents a breakthrough in floppy disk drive testing and alignment. The disk is accurate to within 50μ-inches (millionths of an inch)—accurate enough to use not only for precise testing of floppy drives, but also for aligning drives. With software that uses this HRD disk, you can align a floppy drive by using no special tools or oscilloscope. Other than the program and the HRD disk, you need only an IBM-compatible system to which to connect the drive. This product has lowered the cost of aligning a drive significantly and has eliminated much hassling with special test equipment.

The AAD disk has been the standard for drive alignment for many years. The disks, accurate to within 50μ inches (millionths of an inch), require that you use special test gear, such as an oscilloscope, to read the disk. These disks have no computer-readable data, only precisely placed analog tracks. Until HRD disks became available, using an AAD was the only way to align drives properly.

The Accurite program Drive Probe is designed to work with the HRD disks (also from Accurite). Drive Probe is *the* most accurate and capable floppy disk testing program on the market, thanks to the use of HRD disks. Until other programs utilize the HRD disks for testing, Drive Probe is my software of choice for floppy disk testing. Because the Drive Probe software also acts as a disk exerciser, for use with AAD disks and an oscilloscope, you can move the heads to specific tracks for controlled testing.

Disk Manager

Disk Manager by Ontrack stands today as the most comprehensive and capable hard disk test and format utility available. This program works with practically every hard disk and controller on the market, including the newer SCSI and IDE types.

The Disk Manager program allows testing of the controller as well as the drive. Read-only testing may be performed as well as read/write tests. One of the best features is the comprehensive low-level formatting capability, which allows a user to set not only interleave but skew factors as well. The low-level format portion is also capable of truly formatting most IDE drives, a feature that few other programs have.

If you do any testing and formatting of hard disks, this program should be in your utility library. I included more information about Disk Manager in Chapter 14, "Hard Disk Drives and Controllers."

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Data Recovery Utilities

There are several programs designed for data recovery rather than just hardware trouble-shooting and repair. These data recovery programs can troubleshoot and repair disk formatting structures (Boot Sectors, File Allocation Tables, and Directories) as well as files and file structures (database files, spreadsheet files, and so on).

Norton Utilities

The Norton Utilities by Symantec stands as perhaps the premier data recovery package on the market today. This package is very comprehensive and will automatically repair most types of disk problems.

What really makes this package stand out for me is the fantastic Disk Editor program. Currently there simply is no other program that is as comprehensive or as capable of editing disks at the sector level. For the professional PC troubleshooter or repair person, the Disk Editor included with the Norton Utilities can give you the ability to work directly with any sector on the disk. Unfortunately, this does require extensive knowledge of sector formats and disk structures. The documentation with the package is excellent and can be very helpful if you are learning data recovery on your own.

I find that data recovery is a lucrative service that the more advanced technician can provide. People are willing to pay much more to get their data back than to simply replace a hard drive. For more information on this subject, I have written a book called *Que's Guide to Data Recovery*, which is available from Que directly (see Appendix B).

For more automatic recovery that anybody can perform, Norton Utilities has several other useful modules. Disk Doctor and Calibrate are two of the modules included with the Norton Utilities version 8.0. Together, these two utilities provide exhaustive testing of the data structures and sectors of a hard drive. Disk Doctor works with both hard disks and floppies and tests the capability of the drive to work with the system in which it is installed, including the drive's boot sector, file allocation tables (FAT), file structure, and data areas. Calibrate, which is used for the most intensive testing of the data area of a drive, also tests the hard drive controller electronics.

Calibrate also can be used to perform deep-pattern testing of IDE, SCSI, and ST-506/412-interface drives—writing literally millions of bytes of data to every sector of the drive to see whether it can properly retain data, moving data if the sector where it is stored is flawed, and marking the sector as bad in the FAT.

Calibrate can perform a nondestructive low-level format of ST-506/412 drives, which means that the data stored on the drive is not destroyed as it is when you use the controller BIOS to perform a low-level format on these drives. Often, in performing deep-pattern testing and low-level formatting of ST-506/412 drives, Calibrate can refresh, or remagnetize, bad sectors and return them to service so that they can be safely used again for data storage. Calibrate also can be used to test for the optimal interleave on ST-506/412 drives and nondestructively change the format if system performance would benefit.

Due to the excellent Disk Editor, anybody serious about data recovery needs a copy of Norton Utilities. The many other modules that are included are excellent as well, and the latest versions now include NDIAGS, which is a comprehensive PC hardware diagnostic.

Others

Several other good data recovery packages are on the market. Some offer general purpose data recovery such as PC-Tools by Central Point Software. Others are designed to recover specific types of files, and due to their narrow focus, are much better than general purpose programs for this task. I highly recommend the dSALVAGE Professional by Comtech Publishing for recovering the database files used by most popular database programs.

Configuration Utilities

Many utilities that are on the market today specialize not only in hardware diagnostics, but also in hardware configuration. These programs are designed to tell you what type of hardware you have and how it is configured. I find this type of program to be one of the most useful, because most PC problems result from improper system configuration.

MSD (Microsoft Diagnostics)

Since the introduction of Windows 3.1 and now with DOS 6.0 and higher, Microsoft has included a little-known program called MSD (MicroSoft Diagnostics). MSD is not really a full-blown diagnostics program but is more of a system configuration utility. MSD provides quick answers to system configuration problems such as interrupt request line (IRQ) conflicts and memory address problems.

In addition, MSD provides basic information about the system it is running on, including the BIOS, processor type, video adapter, network (if any), the mouse, disk drives (including CD-ROM drives), parallel and serial ports, and the DOS version. Also provided is extensive information on any device drivers and memory resident programs loaded into memory. This information can be very useful in locating conflicts between two programs or especially when trying to fit different programs into different areas of memory. MSD can present in a visual manner the locations in memory each module occupies; this can be much more helpful than the text listings provided by the DOS MEM command.

MSD is provided free with Windows 3.1 and higher and with MS-DOS 6.0 and higher. This means that if you are not using Windows and are using other OEM versions of DOS such as IBM's PC-DOS, then you may not have MSD installed on your system. In that case, you can still get the program for free by downloading it from the Microsoft BBS (see Appendix B for the number). Microsoft has decided to treat MSD as a public domain program, and it can be downloaded for free by anyone with access to a modem. Although it may not be the greatest system configuration utility available, it certainly does a very good job, especially on memory, and the price is right!

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InfoSpotter

One of my favorite configuration utilities is InfoSpotter by Renasonce. This program displays a great deal of information about a system, and is especially known for the intuitive way this information is formatted on-screen. I have used this program in my training seminars because the display makes the information easier to understand. In addition to configuration reports, InfoSpotter also includes some limited hardware diagnostics tests, which make it more useful than some of the others.

SysChk

SysChk by APS (Advanced Personal Systems) is also a favorite of mine. This program is distributed through the shareware concept, which makes it easy to try before you buy it. This program goes way beyond what simpler programs like MSD will do, and is much less expensive than some of the other commercial programs. You can get SysChk through CompuServe or virtually any other source of shareware software. SysChk also has a very intuitive user interface that displays the system configuration and hardware details in an easy to understand fashion.

Windows Diagnostic Software

With the startling success of Windows 3.0 and 3.1, software utility manufacturers have raced to fill what was perceived as a shortage of diagnostic programs that run under Windows. The results have been mixed. But some good utility packages have emerged.

For example, the Norton Desktop for Windows, which many users think of first as a replacement for Program Manager, includes SYSINFO, an excellent system hardware information program that offers details on your drives, available IRQs, memory, video adapter, printer, and other system information. SYSINFO also offers a benchmark that measures your CPU performance.

Another excellent Windows diagnostic program is WinSleuth, which benchmarks your system and performs extremely thorough testing of your system hardware. It also details your drives, memory, video adapter, printer, and other system components.

But a real treasure is WinSleuth's capability to tell you the IRQs available when Windows is running, and also the available direct memory access (DMA) channels. Although numerous DOS-based utility packages provide this information, few do so in Windows. And WinSleuth Gold can save you literally hours of scratching your head while trying to configure a sound board or other adapter to run in Windows.

Winprobe by Landmark is one of the most comprehensive of the Windows diagnostic utilities. Besides displaying system information and memory usage, Winprobe also helps you optimize your Windows configuration files (.INI files) and offers literally hundreds of tips for improving Windows performance. Winprobe can optimize Windows memory usage on the fly, which can be very helpful if you run many programs simultaneously.

Shareware and Public-Domain Diagnostics

Many excellent public-domain diagnostic programs are available, including programs for diagnosing problems with memory, hard disks, floppy disks, monitors and video adapters, as well as virtually any other part of the system. These programs can be excellent for users who do not perform frequent troubleshooting or who are on a budget.

Many programs assumed to be "public domain" are really not. These are often called shareware or user-distributed software. These programs are not free like true public domain programs, but are in fact commercial software that is merely distributed for free. In most cases you are allowed to try the program for a period of time before registering and paying for the software. Be sure to register; this will allow the author to stay in business, providing excellent software through the shareware concept, and you will then be notified of any updates or improvements. In some cases registration entitles you to the next version of the program for free, and may include other incentives such as an enhanced version of the program with additional features.

Shareware is a set of commercial-quality programs distributed under a *try now, pay later* concept. The authors of shareware programs depend on honest users to pay for the shareware they use (generally only a few dollars). *Public domain* software has been released by the author to be used by anyone without the payment of a fee of any kind to the author.

Most often, you obtain shareware programs by downloading them from a BBS by using a modem. However, some companies distribute shareware on disk. One of these companies stands out: the Public Software Library. This organization, which began as an outgrowth of a Houston computer users' group, has acquired the single best collection of public-domain and user-supported software. What makes this company extraordinary is that all the software is tested before entering the library, which eliminates virus or Trojan-horse programs that can damage a system. Buggy programs also usually don't make it into the Public Software Library. All the programs are the latest available versions, and earlier versions are purged from the library. Many other shareware disk distribution companies don't think twice about sending you a disk full of old programs.

The programs in this library are not sold but distributed. The authors are aware of how these programs are distributed, and no excessive fees are charged for the disk and copying services. This truly legitimate company has the program authors' approval to distribute software in this manner. All disks are guaranteed, unlike many comparable organizations that seem bent on making as much money as they can.

Besides the Public Software Library, you can find many shareware and public-domain programs on local Bulletin Board Systems (BBSs). If you have access to CompuServe, one of the best places to look for this type of software is in the IBMHW forum.

VI

Troubleshooting

Summary

This chapter examined the diagnostic hardware and software utilities you can use as a valuable aid in diagnosing and troubleshooting a system. First, the chapter described the three levels of diagnostic software (POST, system, and advanced) and explained how you can get the most from the POST each time your system boots. This chapter also included detailed information about IBM error codes and a reference chart showing the meanings of some of these codes.

In addition, this chapter covered diagnostic and benchmarking utility packages, such as IBM's system diagnostics and advanced diagnostics, as well as many other aftermarket general and special purpose diagnostics. Each of these packages, although taking different approaches to troubleshooting a PC, provides specialized diagnostics for particular areas of the system, such as system memory, hard drives, floppy drives, COM ports, parallel ports, video adapters, keyboards, the mouse, and other components.

Finally, this chapter included a discussion of diagnostic utilities distributed as shareware or released into the public domain. Shareware and public-domain software are a rich source of utilities that are relatively inexpensive, or free for the downloading.