Service Information Manual

HP 9000 Series 300 Computers
Models 330/350

HP Part Number 98562-90030



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December 1986...Edition 1

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- WARNINGS contain information which, if not observed, could result in injury to personnel or loss of life.
- CAUTIONS contain information which if not observed, could result in damage to or destruction of equipment.
- Notes contain information that will assist you in accomplishing the job.

WARNING

The power supply is hazardous to personnel. Extreme care must be taken when connecting voltmeter probes to the test points. Turn off the unit and remove the power cord before connecting or removing test probes.

CAUTION

Integrated circuits on PC boards are susceptible to damage by electrostatic discharge. Extreme care must be taken when handling printed circuit boards. Use an Anti-static Workstation.

Note

Hewlett-Packard supports field repair of these products only to the board or assembly level. Component level information and repair is not within the scope of this manual, nor available.

Information Locator

Finding Service Information

On the next page is a Service Information Locator. It shows where to find a variety of subjects dealing with servicing these products. To use this table, first find the type of information you need to reference in the left-hand column. Next, move to the right in that row to a referenced chapter number. Last, move up the column with the information's referenced chapter to the top. Across the top are manual titles and part numbers that have the information documented.

Chapter identifiers in the Locator use the following codes:

Chapter Number:	Numbers, such as 2. Inclusive chapters, such as 4-6.
Appendices:	Letters, such as A for Appendix A.
Entire Manual:	All
Varies:	* (Check Table of Contents or Index.)

In some cases, two or more references will be shown for a given information type. You should check all references to be sure you get the specific information you need.

For example, suppose you need to find out what the Repair Philosophy is for the Model 318M Workstation's SPU. Locating "Repair Philosophy" in the left-hand column, and moving to the right in that row, you'll notice that this information is in "Chapter 1" of a manual. At the top of this column is the manual's abbreviated title. Chapter 7 in this manual lists manual titles and part numbers for service information.

Service Information Locator

Manuals identified in this locator are abbreviated by their initials:

SIM Service Information Manual
SHB Service Handbook
CRM Configuration Reference Manual
TTM Series 300 Test Tools Manual
SPM Site Preparation Manual
IRM Installation Reference Manual
PIN Product Installation Note
TDS Technical Data Sheet/Price List

Service Information Locator

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Product Information 1

Introduction

Workstations

Model 330 and 350 workstations provide state-of-the-art performance for the most demanding applications with a true 32-bit processor— the MC68020 operating at a full 25 MHz (Model 350) or 16 MHz (Model 330). A companion MC68881 floating point co-processor augments system performance, supporting both single and double-precision floating-point arithmetic and transcendental math functions. Complementing this hardware are the three popular Series 300 operating systems, HP-UX, BASIC, and Pascal.

Both workstations are well-suited for the advanced design requirements of design engineers in electrical, mechanical, and software engineering, including such computation-intensive tasks as logic simulation and printed-circuit board routing. Many research applications previously requiring the power of a mainframe computer now can be executed locally on these powerful workstations. The Model 350 is very suitable for high-end test and measurement applications, and supports a variety of office automation software.

Foundations of these workstations are the computers, or system processing units (SPU). Each uses a single Design Plus box that holds the four system boards that support all the functions required for most system configurations.

System Configurations

Several workstation systems are available with monitors, software and a variety of peripherals. You should refer to the current *Model 330/350 Pricing Information and Technical Data Sheet* to find out exactly what is currently offered.

Supported configurations of hardware and software are identified in the *Series 300 Configuration Reference Manual*, part number 98561-90020.

Model 330 and 350 computer bundled systems include:

- Standard color and monochrome systems.
- Color systems with 2½D accelerator.
- Graphics systems for 3D images and solid shaded models.
- Color and monochrome artificial intelligence development systems.

Typical system diagrams are shown in Figures 1-1 and 1-2.

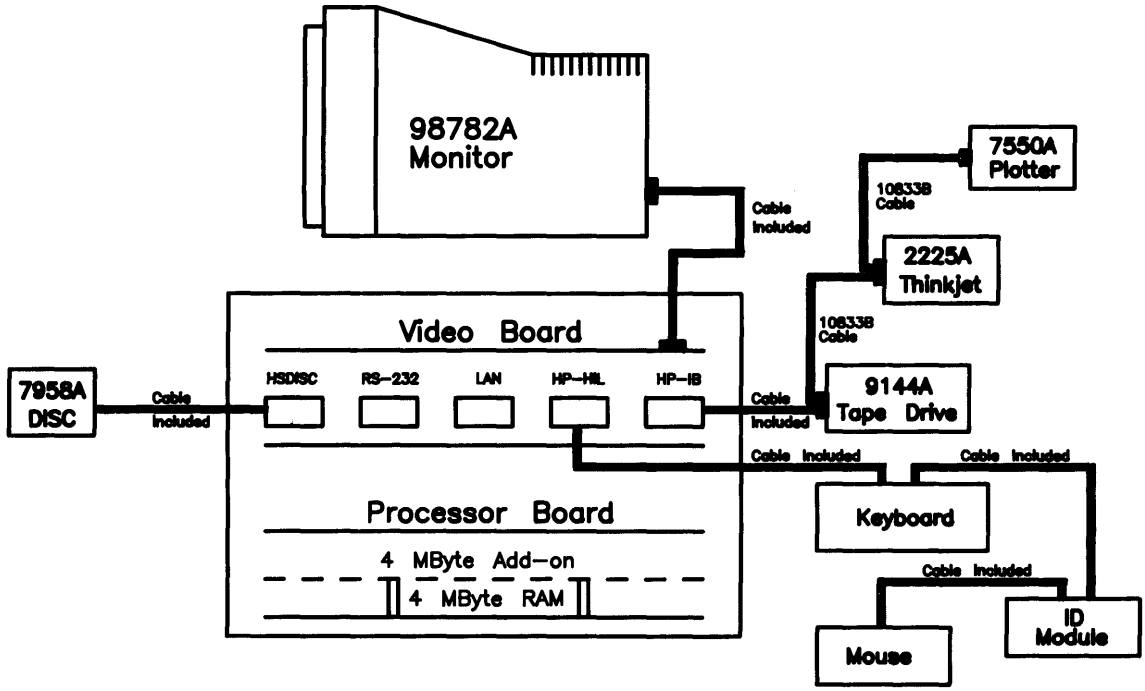


Figure 1-1. Model 350 Typical Workstation

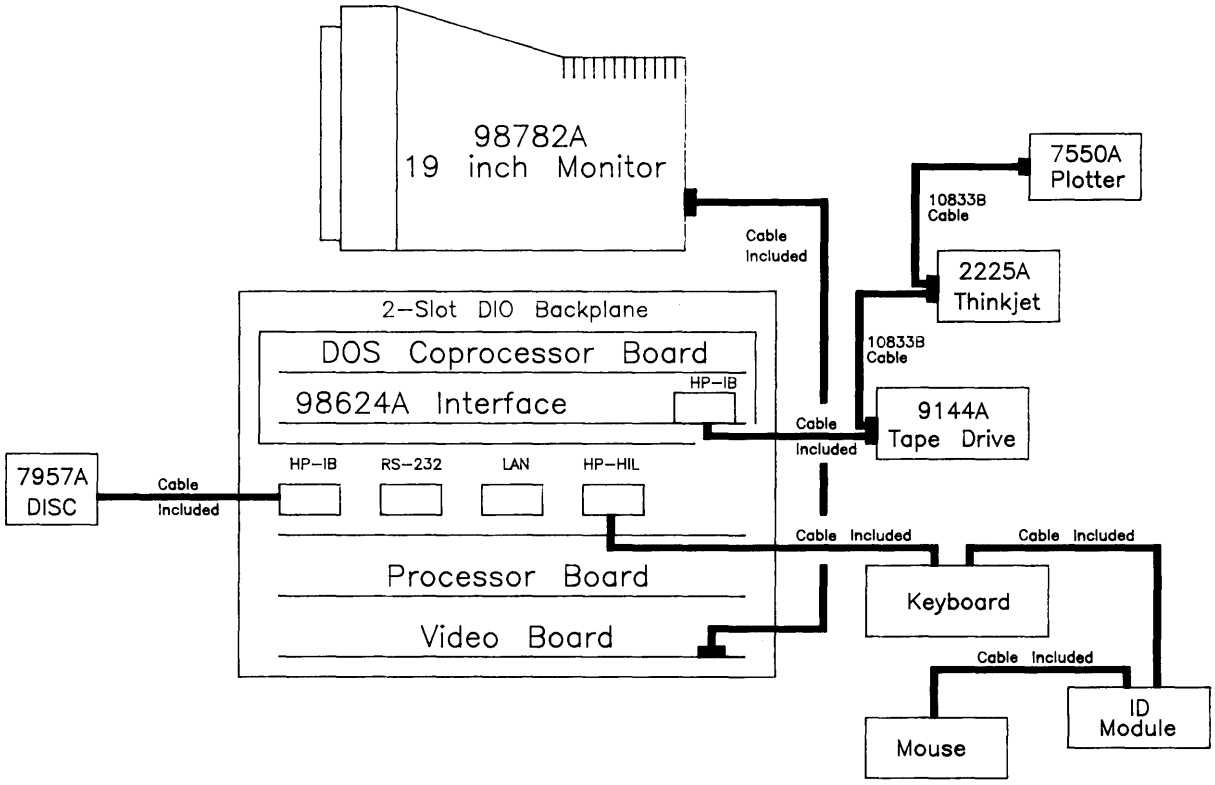


Figure 1-2. Model 330 Typical Workstation

Features

These computers have several useful features. Table 1-1 lists the main features.

Table 1-1. Model 330/350 Computer Features

Product/Option Number	Description
Model 330 (HP 98562A)	Model 330 system processing unit featuring: MC68020 CPU, 16.67 MHz MC68881 Floating Point Co-CPU, 16.67 MHz MC68851 Memory Management Unit, 16.67 MHz 4 Mbytes of Processor On-Board RAM 4 Mbytes RAM Standard, Maximum 8 Mbytes
Model 350 (HP 98562B)	Model 350 system processing unit featuring: MC68020 CPU, 25 MHz MC68881 Floating Point Co-CPU, 20 MHz HP Custom Memory Management Unit 8 Mbytes RAM Standard, Maximum 32 Mbytes 32-bit High-Speed System Bus
Common Features	4 Gbytes Virtual Memory address space 32-bit DIO-II I/O Bus IEEE-488 HP-IB Interface RS-232C Serial Interface IEEE 802.3/Ethernet LAN Interface with ThinMAU and "T" Connector High-speed IEEE 488 Disc Interface (optional on Model 330) Two channel DMA Controller HP-IB, HP-HIL, and RS-232 adapter cables.
Direct-Connect I/O Expanders	HP 98568A Opt. 132, 8 DIO Card Slots HP 98570A 2 DIO-II System Board Slots 4 DIO Card Slots
Backplane Upgrades	HP 98242A 4-slot DIO backplane. Can be added to 98562B or to 98570A. HP 98242B 2-slot DIO backplane. Can be added to 98562B or to 98570A. HP 98570A Opt. 004 provides 2 DIO slots and 3 system slots.
Memory Boards	HP 98258A 4 Mbyte RAM Board Optional Model 350 Memory: HP 98258B 4 Mbyte RAM Add-on HP 98258C 12 Mbyte RAM Add-on

Performance

The Model 350 computer provides 3-5 MIPS computational performance and offer high-performance graphics display to match the CPU. They are typically used as group resource workstations (shared by several designers) and as group computational and shared peripheral resources when networked to lower performance workstations belonging to individual engineers.

These workstations must be able to run UNIX-based applications for:

- Advanced design tasks (ME, EE, and others)
- Expert Systems Development
- PC Board Routing
- Circuit Simulation

High-end workstations must be networked via industry-standard LAN, preferably have AT&T System V UNIX[2] operating system compatibility, high-resolution monochrome or color displays, and very large RAM capacities.

Performance of Model 350 workstations is about **four times that of a VAX 11/780*** minicomputer doing integer computation. Now, applications once limited to large mainframes can be executed locally. New applications of artificial intelligence, coupled with design software, can now be developed and significantly increase the productivity of the design professional.

Full potential of the MC68020 processor is realized by the use of a 32 Kbyte cache with 32-bit wide entries operating at a 120 nsec cycle time (zero processor wait states). This large, high-performance cache buffers the 25 MHz processor from the main memory operating at an average 180 nsec cycle time over a 32-bit wide system bus. Hewlett-Packard's custom Memory Management Unit (MMU) translates virtual memory addresses into physical memory addresses in parallel with cache-miss detection (HP-UX only). This means that maximum system throughput is maintained for very large programs and multiple processes.

* Workstation vendors use the VAX 11/780 performance as the yardstick for system CPU performance (MIPS). Using this yardstick makes the Model 350 a 4 MIPS system.

[2] UNIX is a trademark of AT & T

Hardware

CPU - MC68020

Both models are an extension of the Series 300 family. Through use of the MC68020 at 16 MHZ (Model 330) and 25 MHz (Model 350), high-end performance of the Series 300 family is almost doubled and provides state-of-the-art technology.

Bus Architecture

A 16-bit I/O bus provides interfacing to most Series 200 and 300 accessory cards. This bus is called the DIO bus.

To increase speed, a new 32-bit I/O bus is used in this computer for even higher performance. This bus is called the DIO-II bus and provides 6 Mbyte/sec transfer rates, handling even the highest-performance peripherals independently of processor access to main memory. It is compatible with the 16-bit DIO bus of the Series 200 and the Model 310 and 320 computers, allowing access to most accessory and interface cards available for those systems.

Model 350 memory boards are accessed by a third, very-high speed 32-bit system bus. Connecting between the processor board and RAM boards, it allows faster read and write cycles than the I/O busses would permit.

Figure 1-3 is a diagram of the I/O architecture for the Model 330 and 350 computers.

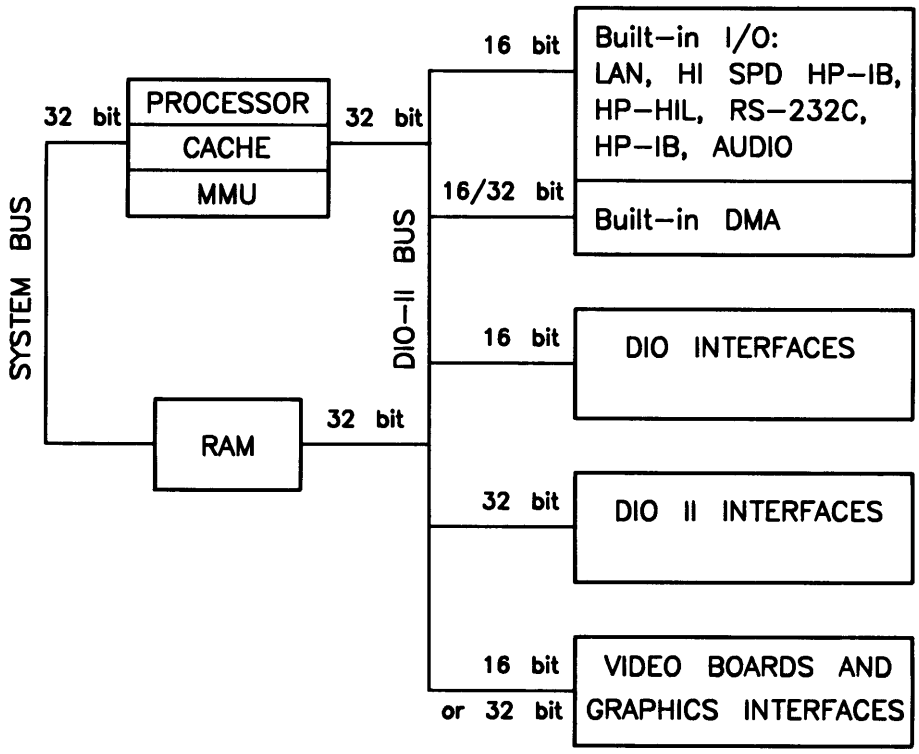


Figure 1-3. Model 330/350 Computer I/O Architecture

Motherboard/Backplane

As Figure 1-4 shows, three motherboard system-slot connectors are used by the system processor board, system interface board, and RAM board. One system slot is available for the video board, display system interface board, or 2-slot DIO backplane.

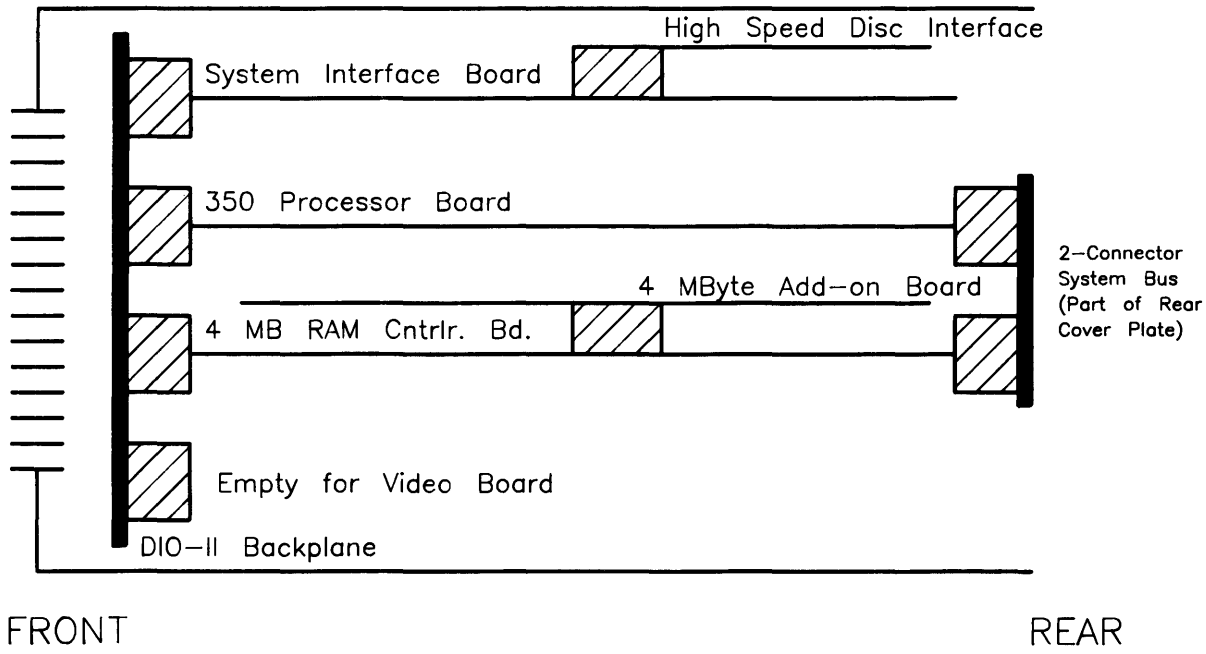


Figure 1-4. Model 350 System Slot Diagram

Keyboards

Two keyboards are compatible with the Model 330 and 350 HP-HIL interface:

HP 46021A

Standard keyboard is the Integrated Terminal Format (ITF) Keyboard. It connects to the HP-HIL connector on the system interface board.

HP 98203C

An optional keyboard with the same keys and rotary control knob as used with several Series 200 and 300 computers. It is used on the HP-HIL interface.

HP 9000 Hardware Compatibility

Model 330 and 350 hardware compatibility ensures use and/or support of the same:

- Series 200/300 interface/accessory cards (except 256 Kbyte and 1 Mbyte RAM cards).
- Series 300 graphics subsystems
- Peripherals supported on other Series 300 systems.

These workstations are fully compatible with the wide range of disc and tape drives, printers and plotters, and HP-HIL devices.

Either of the two optional Direct-Connect I/O Expanders can be added to the Model 330 or 350, allowing system expansion as application needs increase.

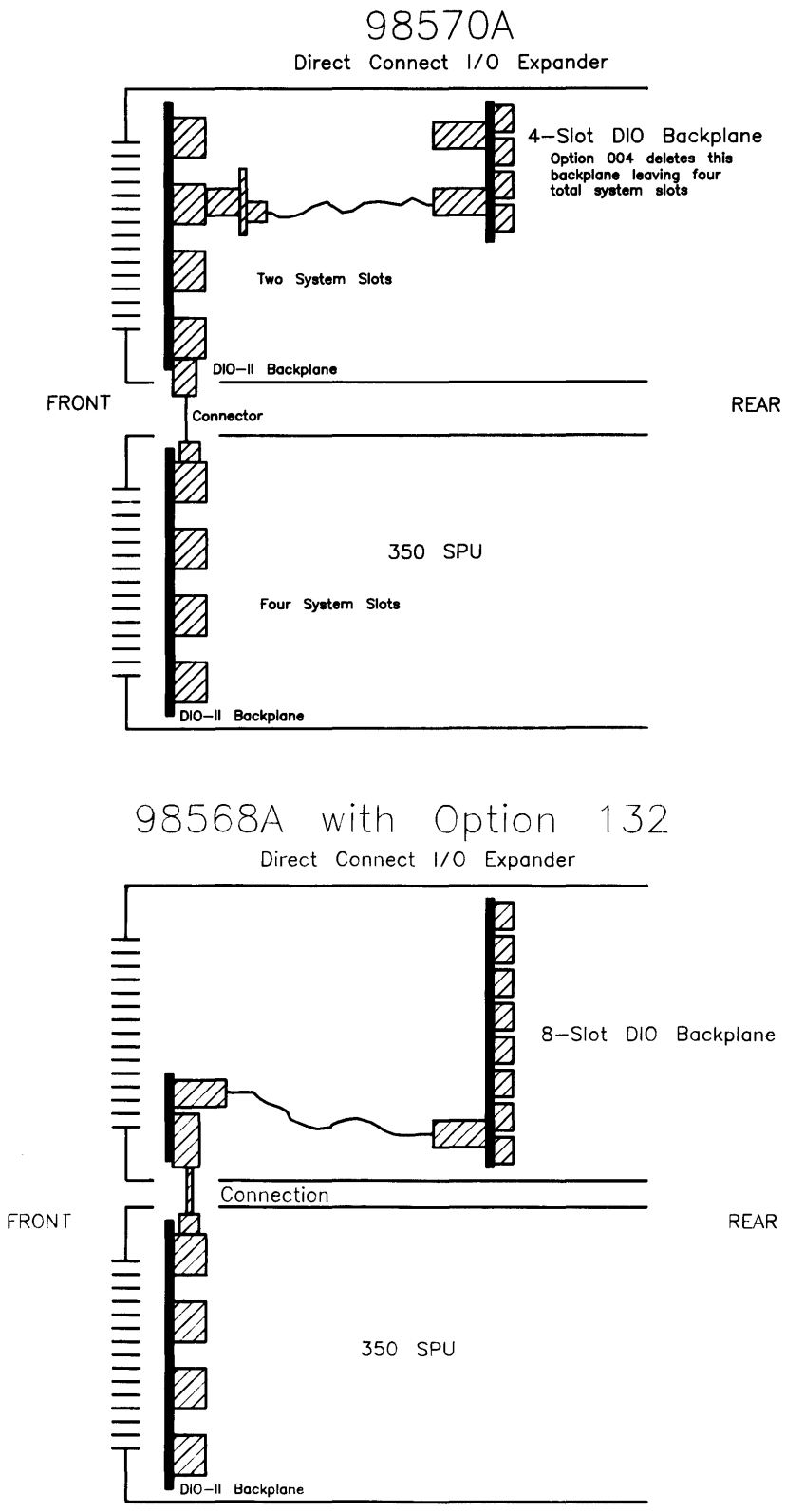


Figure 1-5. Direct Connect Expanders Diagram

Operating Systems

HP-UX 5.2

Series 300 HP-UX 5.2 adds support for both computers while maintaining object code compatibility with earlier releases. Programs will continue to run without recompiling. The 5.2 release supercedes all previous Series 300 releases.

Additional commands have been added so that the computer has a command set identical to the Model 840. All commands that are not hardware dependent are on the Series 300 systems, except job control.

The Application Execution Environment (AXE) is now available in both a single-user version and a new multi-user version. Single-user limitations have been removed. No additional commands or utilities are included. It is intended for use with run-only multi-user applications. Additional administration may be necessary for a multi-user system. The multi-user Programming Environment now requires the multi-user AXE as a prerequisite.

All of these computer's HP-UX systems feature a built-in LAN, allowing them to function as departmental resource servers for sharing space on large local discs and for sharing attached high-quality printers and plotters. Because the LAN is an industry standard, the Model 350 workstations can also be connected to other vendors' systems to access data and to utilize the other computing resources available to the department.

BASIC 5.0

BASIC 5.0 (HP 98613C) is a revision of the Series 200/300 BASIC 4.0, Revision 4.03. BASIC 5.0 provides upward compatibility with BASIC 3.0 and 4.0. New for BASIC 5.0 is a Hierarchical File System (HFS) Binary. Model 350 users now have access to the HP-UX file system directory, with or without HP-UX. HFS is compatible with LIF and SRM and provides easy switching between BASIC and HP-UX via soft re-boot.

BASIC 5.0 is sold either as a standalone language system or bundled with Series 200/300 systems, including the Model 330 or 350.

Pascal 3.2

Pascal 3.2 provides selective file back-up and is **object code compatible** with Pascal 3.1. An HFS Binary also provides access to the HP-UX file system directory with or without HP-UX.

Software Compatibility

For software, these computers:

- Use the same Series 300 Application Software Object Code.
- Are source code compatible with HP Precision Architecture.

Product Identification

Several terms in this manual are used to describe and identify the various parts of the computer and bus expander. This section explains the terms used to improve your understanding of service information.

Product Identification Terms

Each product has its set of included hardware similar to that in Table 1-1. Product numbering conventions used with this computer are explained here to clarify the following information:

- Systems Ordered by Customers.
- Products Ordered by HP Field Offices.
- Products Manufactured by HP Ft. Collins Systems Division

Systems Ordered by Customers.

When these computer systems are ordered by customers, a suffix is added to the Model number, such as Model 350AIM that identifies the computer system ordered by customers. Refer to the Model 350 Hardware Price List for a current listing of all bundled systems.

Products Ordered by HP Field Offices.

A five-digit product number is used by HP field offices to order the computers. This number is strictly for ordering purposes and not for formal product identification. HP 9000 Series 300 Model 330 and 350 Computer is Product Number HP 98562A and 98562B, respectively. A complete explanation of these names and numbers is shown later in this chapter. Configuration and other product information is also covered.

Products Manufactured by HP Technical Workstations Operations

At the manufacturing division, the computer's are built and configured using the numbering conventions explained above. Note that these numbers relate only to the computer or bus expander and do not include peripherals, such as disc drives, some monitors, and some accessories. Other HP divisions provide the rest of the products bundled with the computer system.

Serial Numbers

Serial numbers are affixed to each computer and bus expander for identification purposes. A decal on each product has the serial number. An example serial number is explained below:

Serial No. 2623A01234

Location: Behind the power supply access cover on the inside bottom of the chassis.

Description:

5-digit unique identifying number.

Country of Origin Code.

Product Code, decoded as:
First 2 digits + 60 = Last 2 digits of year product was introduced or significantly changed.
Last 2 digits = number of week in year product was introduced or significantly changed.

Hardware Terminology

Hardware is used to define physical elements of these products. Different parts and locations of hardware items are explained below.

Product Terms/Conventions

The following terms are used to describe products and their main parts and areas:

- **Computer** - A product containing the central processing unit (CPU) and other assemblies such as RAM, interface, and video boards, and other accessory cards. Sometimes the computer is referred to as the System Processing Unit (SPU).
- **DIO Slots** - The narrow slots for accessories in the back of the computer or expander. Two or four slots are available as options for the computer and expander. Distinction between these slots are:
    - The top slot is an **accessory card slot**.
    - The second slot down is an **I/O card slot**.
- **System Slots** - The wide slots in the computer or expander are for the processor, RAM, video, or system interface boards.
- **Internal (circuit)** - A circuit, such as an interface, that is part of the processor board. Internal does not mean 'inside the computer's case parts'.
- **External (circuit)** - A circuit that is located on an assembly other than the processor board. External does not mean 'outside the computer's case parts'.
- **Peripheral** - A device external to the computer, such as a keyboard, monitor, disc drive, plotter, printer, bus expander, etc.
- **I/O Expander** - A device external to the computer that connects to the computer's DIO-II bus. This device provides power to its installed accessory cards and permits more of these cards to be used in the computer system. Sometimes they are called bus extenders. For the Model 350 computer systems, the product name is Direct-Connect System Slot I/O Expander.
- **System** - One or more computers with one or more peripherals connected together to run an application for a desired end result.

PC Boards

PC boards in the computer and bus expander are made of several component parts. Identifying terms used in this manual are:

- **Cards** - Boards installed in the DIO card cage slots.
    - **I/O Card** - A card that outputs to and inputs from a peripheral device. They are installed in DIO slots. For example, an RS-232 I/O card.
    - **Accessory Card** - A card that only operates on the DIO bus and does not talk. to a peripheral device. They are installed in either I/O or accessory card slots.
- **Boards** - Assemblies installed in the wide system slots or inside the product. Boards are not usually removed or installed by users.

Two-board assemblies are those consisting of one board connecting to the motherboard and an "add-on" board attached to the bottom board. 8 and 16 Mbyte two-board assemblies are examples.

- **Backplane** - The board in the card cage with connectors for DIO cards to plug into.

Software Terminology

As used in this manual, software refers to information stored in, or on a device. Typically, this information can be changed and can be transferred to another location in the computer system. Types of software are:

- **Firmware** - The data or instructions in Read-Only-Memory (ROM) chips.
- **Operating Systems** - Computer languages, such as BASIC, Pascal, and HP-UX. They have various commands, statements, and keywords that when executed by the CPU in a particular sequence, cause computer to manipulate data to some desired end result.
- **Application Program** - A series of operating system program lines in a specific sequence to cause specific actions, such as accounting, electro-mechanical design, data sampling and output, etc. This information is sometimes referred to as software as it is information that is stored in or on a medium and can be transferred.

Hardware Support Documentation

The purpose of these computers and expanders Hardware Documentation is to support the installation and maintenance of these products. Hardware Support Documentation consists of six manuals for the HP 9000 Series 300 Models 330 and 350 Computers and HP 98568A Opt. 132 and HP 98570A Expanders:

- Service Information Manual
- Service Handbook
- Service Notes
- Test Tools Manual
- Self-Paced Hardware Training Guide.
- HP 9000 Series 200/300/500 Site Preparation Manual
- Series 300 Computer System Configuration Reference

The following manuals also relate to hardware:

- Various Installation Notes
- Series 300 Installation Reference
- Series 200/300 Peripheral Installation Guide

A complete listing of titles and part numbers is in Chapter 7 of this manual and the Model 330/350 Service Handbook, Chapter 10.

Service Information Manual

This manual (the one you're reading now) contains tutorial information on the computer's and bus expander's main features, functional descriptions of each assembly, and how to replace these assemblies.

Its purpose is to serve as a learning tool in training environments wherein the service person learns how the computer and bus expander works and its parts are replaced. Most of the information in the Service Information Manual is not found in the Service Handbook.

Organization of the Service Information Manual is as follows:

Chapter No. and Title	Contents
Front Matter	Has legal notices, safety situations explained, plus a Service Information Locator to help you find service information.
Chapter 1: Product Information	Introduces the computer/bus expander, covers features, specifications, options, accessories, operating systems, repair philosophy, and a general description of the Model 350 Computers and HP 98570 Bus Expanders. Has an overview of how the Hardware Documentation is organized.
Chapter 2: Assembly Replacement	In this chapter, disassembly and reassembly of all field replaceable parts for the computer and bus expander are covered. Reference to the Service Handbook and Chapter 6 is made for part number information.
Chapter 3: Functional Description	Each assemblies functional description is covered to block diagram level.
Chapter 4: Boot ROM Functions	The sequence of events for power-up, self-tests, and booting an operating system are explained. Turn-on displays are shown.
Chapter 5: Troubleshooting	This chapter contains tutorial information for troubleshooting the computer and bus expander. Self-test errors for the computer and expander are explained.
Chapter 6: Parts Lists	Has parts ordering information, as well as part numbers and descriptions of field replaceable parts.
Chapter 7: Reference	Contains hardware/software manual titles, and other helpful information.

Service Handbook

This manual is intended to be used on site during service situations. It contains information useful to configuring, troubleshooting, and replacing parts. It is organized as follows:

Chapter No. and Title	Contents
Chapter 1, Product Information Has a brief description of the product,	Has a brief description of the product, along with configuration and similar information. Product specifications are also listed.
Chapter 2, Environmental, Installation, and PM	Gives power requirements, fuse and power cord data, and installation information. If preventive maintenance is required, it is shown in this chapter.
Chapter 3, Configuration	Lists various product configurations and explains what each one is.
Chapter 4, Troubleshooting	Lists tools required, including Test Tools, and explains several troubleshooting procedures. Flow charts are frequently used.
Chapter 5, Tests	Lists tests to run to check out the computer, some peripherals, and some accessories and interfaces.
Chapter 6, Adjustments	There's no adjustments for the computer.
Chapter 7, Systems	Refers to the Model 330/350 Pricing Information and Technical Data sheet for current bundled system configurations.
Chapter 8, Replacement Parts	Lists part numbers for all field-replaceable parts and e1plains how they may be obtained.
Chapter 9, Diagrams	Block diagrams of the products are shown here.
Chapter 10, Reference	Other documentation related to these products are listed here with their part numbers.
Chapter 11, Service Notes	When you receive Service Notes for these products, they should be inserted here.

Test Tools Manual

Series 200/300 Test Tools Manual supports a software package for verifying the integrity of Model 330/350 computer system installations. The Test Tools manual and its associated discs or tape permit troubleshooting computer systems in failure analysis. Part numbers for the complete Test Tools packages are:

- 09800-12300 for 3.5-inch disk drives.
- 09800-12700 for 5.25-inch disk drives.

Contents of the four parts of the Test Tools Manual are

Part No. and Title	Contents
Part I, Introduction and Built-In Tests	Introduces the Test Tools package and overviews the computer self-tests and explains what the different tests do.
Part II, Computer Tests	Covers loading and running of Series 200 and 300 Computer Tests. Each test is explained as to what it does. Error messages are listed and explained.
Part III, System Functional Tests	Tells how various computer-peripheral tests are loaded and run. Tests are explained, error messages shown and defined. Examples of some tests are given. Includes tests for HP-HIL devices.
Part IV, CS/80 Exercisers	Explains how tests for CS/80 disc drives are loaded, ran, and results are interpreted. Error messages are shown as well as several examples of running the tests.

Service Notes

When a situation occurs that effects servicing of the computer or bus expander that is not covered in existing documentation, a Service Note is written to explain it. Service Notes are distributed through a Subscription Service to HP Customer Engineers and to customers on the Cooperative Support Program for these products. Being half-page in size, they are intended to be placed in Chapter 11 of the Model 350 Service Handbook.

Installation Notes

Each separately available accessory or upgrade has an Installation Note packaged with it. These Notes have instructions for configuring and installing the hardware.

Series 300 Configuration Reference Manual

All supported configurations of Series 300 Computer Systems are explained in this manual.

Section No. and Title	Contents
Section 1. Configuration Overview	Has configuration worksheets to assist in planning the application.
Section 2. Operating Systems and Application Software	Covers supported languages and media options.
Section 3. System Packaging	Lists the Model 350 features and options available.
Section 4. Interface and Peripheral Selection	Explains Interfacing, networking, mass storage, monitors, printers, and other output peripherals.
Section 5. Support Services	Overviews Customer Training, installation and support services, and consulting.
Appendix A. Detailed Product Reference	Gives detail information about computers, accessories, and peripherals.

Site Preparation Manual

Explains site preparation and how to prepare the computer site for hardware installation. Covers physical, environmental and electrical requirements. Its organization is shown below.

Chapter No. and Title	Contents
Chapter 1, Introduction	Explains the purpose and contents of the Site Preparation Manual.
Chapter 2, Responsibilities	Identifies customer and HP responsibilities for preparing the HP 9000 Computer System site. Includes a time frame for setting up the computer system, and identifies people who can provide assistance.
Chapter 3, Preparing the Electrical Environment	Includes power specifications, dealing with electrical interference, connecting cables, and data communication configurations.
Chapter 4, Preparing the Physical Environment	Explains heat and humidity considerations, airborne contaminants, and shipping weights and dimensions for movement and storage.
Chapter 5, Providing Other Necessities	Covers media storage, equipment and record protection, computer supplies, and nearby telephones for assistance which are an integral part of preparing for and sustaining the operation of a computer system.
Chapter 6, Equipment Arrangement and Space Planning	Provides information and guidelines for planning the location of the computer system equipment at your site.

Chapter 7, When Your Computer Arrives	Discusses the final preparation for system arrival, coordinated deliveries, arrival dates, how to check for damage in shipment, unpacking the cartons, and scheduling the installation of HP 9000 Computer Systems.
Appendix A	Lists product specifications for electrical requirements, heat generation, temperature and humidity requirements, and shipping dimensions.
Appendix B	Contains forms to use for preparing the site, such as Pre-Installation Worksheet, Shipment Scheduling Form, and a Site Completion Checklist.

Installation Reference

The computer and expander each have step-by-step procedures for installing them. An Installation Card is a pictorial set of instructions to show the installer how to unpack, connect, and power up the computer, disc drive, and monitor. More detailed information is contained in the Installation Reference. To install the operating system and/or application program, the documents supplied with these software products should be referred to.

Organization of the Installation Reference is:

Chapter No. and Title	Contents
Chapter 1: Introduction	Covers how the guide is organized and explains some computer fundamentals.
Chapter 2: Installing Your Computer	Includes procedures on positioning the computer, checking voltage settings, connecting power cords, and turning on the computer.
Chapter 3: Installing Accessories	This chapter covers accessory configuration and installation, such as memory or interface cards.
Chapter 4: Installing Your Keyboard and Monitor	This chapter covers keyboard and monitor installation.
Chapter 5: Installing HP-IB Peripherals	Standard HP-IB peripheral configuration and connection procedures.
Chapter 6: Installing Non-HP-IB Peripherals	Peripheral configuration and connection procedures other than HP-IB.
Chapter 7: Reading the Self-Test	Covers procedures performed by self-test and how to interpret the results of the self-tests. Error messages are explained and help is provided should the user get into trouble at this point.
Reference	This chapter has information regarding internal configuration switches, running extended tests, Boot ROM error messages and tutorial information on data communications and interfacing.
Glossary	Provides explanations of computerese terms and phrases.

Specifications

Electrical

Line voltage/Frequency	120 Vac @ 48-66 Hz 240 Vac @ 48-66 Hz
Fuse	8AF 250V
Backplane Power Available	
Model 330/350 Computer, HP 98568A Opt. 132 Expander, and HP 98570A Expander	Total Power Available from motherboard: 95 Watts @ +5 Vdc 40 Watts @ +12 Vdc 12 Watts @ −12 Vdc Each system slot: 23 Watts @ +5 Vdc 10 Watts @ +12 Vdc 3 Watts @ −12 Vdc
Line transient spike immunity (1 nsec rise, 800 nsec duration)	1 KVdc
Power Consumption	250 Watts maximum
Current Requirements	5.0 A @ 120 Vac 3.0 A @ 240 Vac
Maximum Heat Dissipation	853 BTU/hr 250 Kcal/hr
Battery Back-up	Real-Time Clock on System Interface Board

Environmental

Operating temperature	0 - 55° C
Operating humidity	5 - 95% relative
Operating altitude	4 572 metres (15 000 feet)

Electromagnetic Interference

Standards met	FCC Class A VCCI Class 2 VDE Class B, VDE 1046/84

Regulatory Requirements

Standards met	UL 478, 5th Edition CSA 154M-1983 IEC 380, 3rd Edition; 435, 2nd Edition

Physical

Dimensions (Computer or Expander)	
Height	130 mm (5.12 inches)
Width	325 mm (12.8 inches)
Length	376 mm (14.8 inches)
Weight	11.8 kg (26 pounds) maximum
Vibration Standard	Meets Class B requirements

Shipping Information

The shipping container for each computer includes the Localization Kit, which includes power cords, fuse, keyboard cable, HP-HIL cable, Installation Reference, and Installation Picture Card.

Models 330 or 350 Computer

Shipping Weight	15.9 kg (35 pounds)
Container Dimensions	Width - 502 mm (19.75 inches) Length - 559 mm (22 inches) Depth - 267 mm (10.5 inches Cube - 0.07 m^3 (2.65 $feet^3$)

HP 98568A Opt. 132 or 98570A Expander

Shipping Weight	12 kg (26.4 pounds)
Container Dimensions	Width - 502 mm (19.75 inches) Length - 502 mm (19.75 inches) Depth - 241 mm (9.5 inches) Cube - 0.06 m^3 (2.03 $feet^3$)

Model 350 Processor Board

CPU	MC68020 at 25 MHz
Floating Point Co-Processor	MC68881 at 20 MHz
Memory Management:	
Type	HP Custom MMU
Virtual Memory	4 Gbytes per process
Contexts	84 default, user settable
Page size	4 Kbytes/page
Cache Memory	
Type	Write through, instruction, data (external to MC68020 instruction cache)
RAM	16 Kbytes, 8K words of 32-bit entries
Cycle time	120 nsec
Partitioning	Four 32-bit words each; 2K partitions
Timers	
Match interrupt	Match on time of day 0.00 - 86 400.00 seconds
Delay interrupt	10 msec - 1.94 days
Cyclical interrupt	10 msec - 1.94 days
System Timer	4μsec resolution, accurate to 25 ppm
Beeper	Three independent tone generators controllable over 30 db.
Frequency range	81.46 Hz - 8.33 KHz
Resolution	Capable of approximate tone scale over 5 octaves
Duration	0.01 sec to 2.55 sec per tone

Model 330 Processor Board

CPU	
Type	Motorola MC68020
Clock Frequency	16.67 Mhz
Internal Architecture	32-bit data and address registers
Address range	4 Gbytes virtual mapped to 4 Gbytes physical
Data bus	32-bit synchronous to: 4 Mbytes On-board RAM
Co-processors	
Floating point	
Type	Motorola MC68881
Clock Frequency	16.67 Mhz
MMU	
Type	Motorola MC68851
Clock Frequency	16.67 Mhz
On-Board memory	
Size	4 Mbytes
Type	Byte parity error-checking
Average cycle time	300 nsec

Memory

Memory Boards	
Type	Byte parity error-checking
System bus width	32 bits address; 32 bits data
Bandwidth	22.2 Mbyte/sec read; 14.3 Mbyte/sec write
Average cycle time	180 nsec
Memory Sizes	
Model 330 Standard RAM	4 Mbytes on processor board
Model 330 Maximum RAM	8 Mbytes (4 Mbytes on processor plus one 4 Mbyte RAM controller board)
Model 350 Standard RAM	8 Mbytes: 4 Mbyte controller board plus 4 Mbyte add-on board
Model 350 Maximum RAM	32 Mbytes (2 boards of 16 Mbytes each)

DIO-II I/O Bus

Width	32 bits address; 32 bits data
Bus bandwidth	6 Mb/sec

System Interface Board

LAN Interface	
Media	ThinLAN coax cable (RG 58U)
Protocols	IEEE 802.3, Ethernet
Data Rate	10 Mbits /sec
Disc Interface	
Type	IEEE 488
Data Rate	1 Mbyte/sec
Number of connected drives	8 per interface supported (Additional disc interfaces are available as optional accessories)
Parallel Interface	
Type	IEEE 488
Data Rate	350 Kbyte/sec
Number of connected devices	15 per interface devices supported
Serial Interface	
Type	RS-232C standard
Connector	DB9 with cable; adapter to DB25
Battery-backed Real-Time Clock	
Resolution	10 milliseconds
Accuracy	±5 seconds/day
Battery type	Lithium; 1 year expected life
Keyboard requirements	HP 46021A (ITF type) with HP-HIL interface, 107-key low profile with numeric keypad, 8 special-function keys HP 98203C with HP-HIL interface, 106-key with rotary control knob, including 10 special-function keys.

HP-HIL and Video Accessories

Listed below are HP-HIL and video accessories compatible with the Model 350 workstations. For a complete list, consult the *HP 9000 Series 300 Model 350 Hardware Price List*, Part Number 5954-7061D.

Table 1-2. HP-HIL Devices

Product Number	Product Name/Description
46021A	ITF keyboard
46060A	2-button Mouse
46083A	HP-HIL Knob
46084A	ID Module
46085A	Control Dial Module
46086A	32-button Control Box
46087A	ANSI A/ISO A4-size digitizer
46088A	ANSI A/ISO A3-size digitizer
46089A	4-button cursor for 46087A and 46088A
46094A	Quadrature port
46095A	3-button mouse for 46094A
98203C	Large Keyboard with Knob

Table 1-3. Video Accessories

Bus and Type	Product Number	Product Name/Description
DIO Video Card	HP 98546A	Display Compatibility Interface
DIO-II System Boards	HP 98287A	HP 98700A Interface
	HP 98542A	Medium Resolution Monochrome Video Board
	HP 98543A	Medium Resolution Color Video Board
	HP 98544B	High Resolution Monochrome Video Board
	HP 98547A	6-plane High-performance Color Video Board

Hewlett-Packard Support

Support services and policies mentioned in this section are subject to change. Please consult your local Hewlett-Packard Sales and Service Office for the current support policies.

Repair Philosophy

Field Repair Philosophy for the Model 330/350 Computers and the HP 98568A Opt. 132 and 98570A Expander is assembly, or board level. This means that when a failure occurs, the problem is diagnosed to the assembly having the failed part. That assembly is then replaced. Replacement assemblies are available through local HP Sales and Service Offices.

Some assemblies may be exchanged for rebuilt ones. Other assemblies are only available as new ones. Refer to Chapter 6, or the Service Handbook, Chapter 8, for information on replacement parts.

Schematics

In support of the repair philosophy, this manual contains information to the assembly level. Schematics are not available for these products.

Supported Configurations

Only computer systems with Hewlett-Packard approved parts, accessories, peripherals, operating systems and application programs are supported by Hewlett-Packard. Any computer system with other than HP approved hardware or software connected or installed must have the non-HP approved hardware and software removed by the customer before On-Site or Service Center repair is accomplished.

Repair Services

Hewlett-Packard provides repair services in three ways:

- On-Site Repair.
- Service Center Repair.
- Customer Repair.

On-Site Repair

For On-Site Repair, an HP Customer Engineer goes to the customers site, troubleshoots, and repairs the hardware to the assembly level. The defective assembly is replaced with a new or rebuilt assembly. This service is available through a service contract or a time-and-materials basis.

Hewlett-Packard Service Center Repair

The customer returns the defective product to the nearest HP Repair Center. An HP Customer Engineer repairs the product to the assembly level in the same manner as On-Site Repair. Upon being repaired, the product is returned to the customer. Contact your nearest HP Sales and Service Office for the location of the HP Repair Center, typical turn-around times, and shipping instructions.

Customer Repair

Customers have the option of repairing their own HP computer products. Contact your nearest HP Sales and Service Office for information concerning service training, special tools and test equipment, and spare parts.

Hewlett-Packard offers a Customer Cooperative Support Program to assist customers in maintaining their HP computer products. A variety of technical services and information are available. Your local HP Sales and Service can provide you with information about the Cooperative Support Program.

Hardware Support Services

There are many hardware support options available, from utilizing on-site maintenance groups to buying full support from the local sales office. Please contact your local Hewlett-Packard Sales and Service Office for these services.

Operating Systems Support

Primary Support

There are numerous operating system support options:

- Account Management Support (AMS) provides a local SE, on-site assistance, one Response Center caller and one alternate for telephone assistance, and a Software Materials Subscription.
- Response Center Support (RCS) provides one Response Center caller and one alternate for telephone assistance, and Software Materials Subscription.
- Software Materials Subscription (SMS) provides software and manual updates, Software Status Bulletins, and HP communicator magazine. Updates to ROM-based systems are not provided.

Support For An Additional System

The following options support an additional system:

- Additional System Coverage extends AMS or RCS coverage on the operating system to one additional system under the same system manager. All support is delivered through the central system.
- Extended Materials Support extends SMS by providing the right to make one copy of all central system materials for use on one additional system.
- Additional Response Center Caller provides one additional caller and one alternate for access to the HP Response Center
- Manual Update Service (MUS) provides one copy of updates to software reference manuals.
- Software Notification Service (SNS) provides issues of the HP Communicator and Software Status Bulletin.

Assembly Replacement 2

Introduction

Replacing parts in either the computer and expander require almost identical procedures. With the exception of a few parts unique to each unit, the access and replacement procedures are the same.

When the process is the same for both the computer and expander, they are referred to as the "unit". If different procedures are used for the computer or expander, the name of the unit is used.

Tools Required

CAUTION

The computer and bus expander use metric screws requiring the use of Pozidriv® screwdrivers. Do not use other cross-tip screwdrivers, such as Phillips or Reed-Prince. They will eventually damage the Pozidriv® screw head recess making screws hard to remove.

All field replaceable parts can be accessed with these tools:

- Static-free Workstation, HP Part Number 9300-0794
- #1 Pozidriv® screwdriver, 4-inch (100 mm) blade.

  Used for all screws except the power supply ground tab screw and expander to computer attaching screws.
- #2 Pozidriv® screwdriver, 4-inch (100 mm) blade.

  Used for the power supply ground tab screw and expander to computer attaching screws.
- Flat-tip screwdriver, 0.125-inch (3 mm) wide tip, 4-inch (100 mm) blade.
- Anti-Static Bags

Access Flow Chart

Figure 2-1 is an Assembly Access Flow Chart showing the access process to replace parts. To use this chart, identify the part to be replaced at the bottom of the chart. Then start at the top of the chart and work through the blocked steps toward the part to replace. This flow chart can also be used as a guide to install assemblies by starting at the bottom and working toward the top.

If you are learning how to replace parts in the computer and bus expander, you may want to start at the left side of the flow chart and remove each part in sequence. Procedures in this chapter are also organized in the same manner. Referencing the Model 330/350 Service Handbook, Chapter 8, Replaceable Parts, as you remove each assembly/part for the first time will help associate the part numbers with their respective assemblies

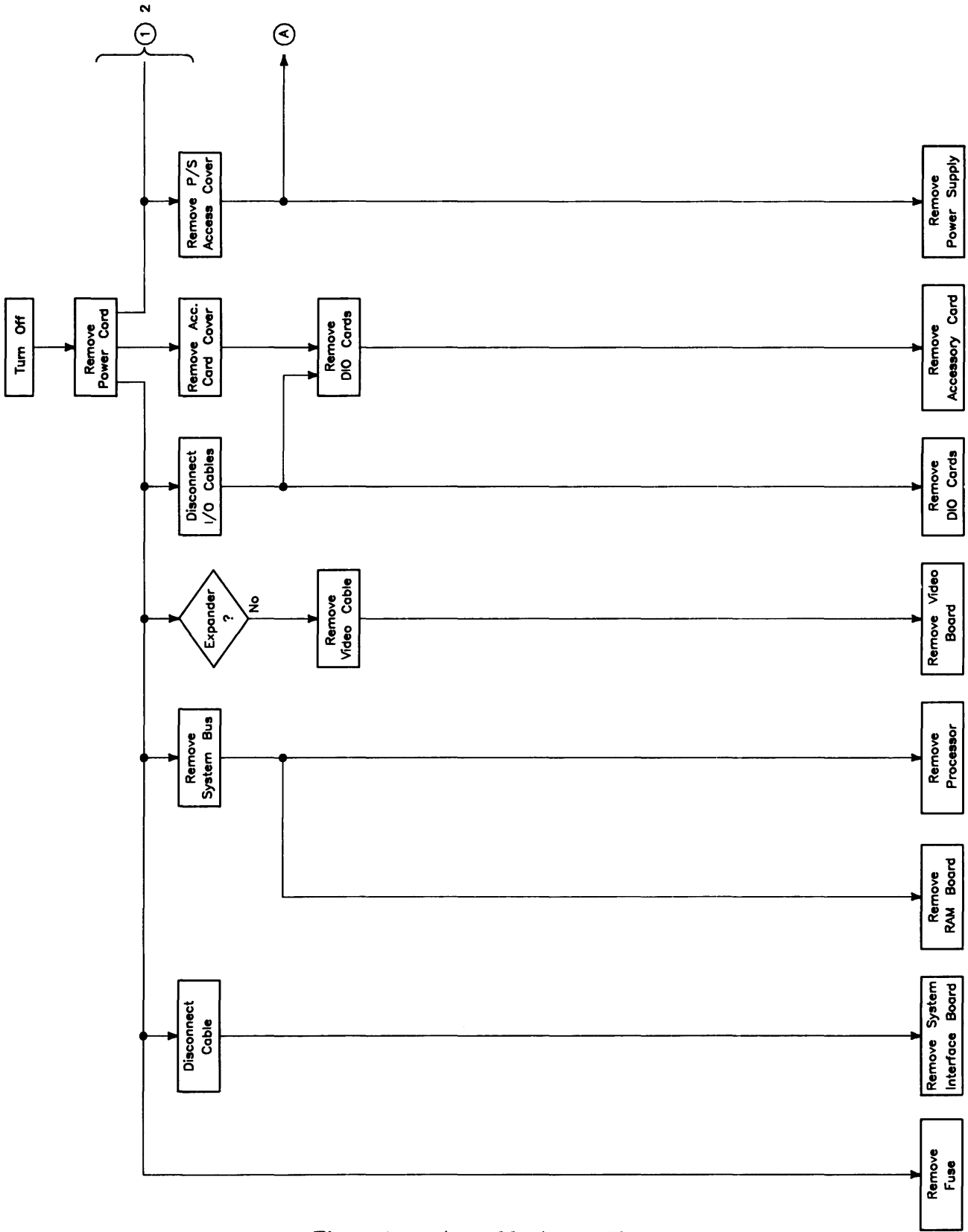


Figure 2-1a. Assembly Access Flow Chart

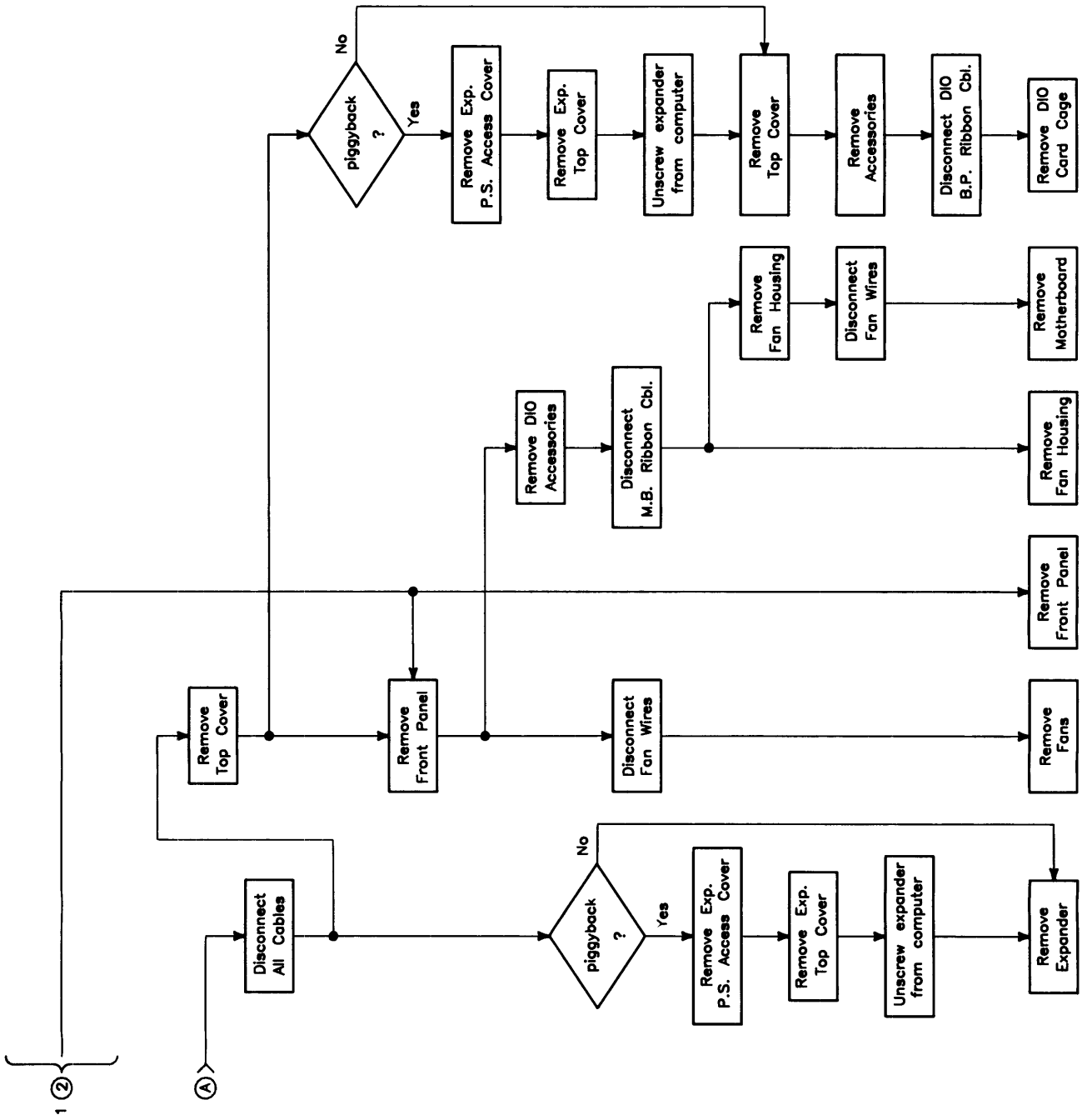


Figure 2-1b. Assembly Access Flow Chart

Parts Diagrams

Figure 2-2 and 2-3 show exploded views of the computer and expander. These diagrams should help you determine how the parts are installed or replaced.

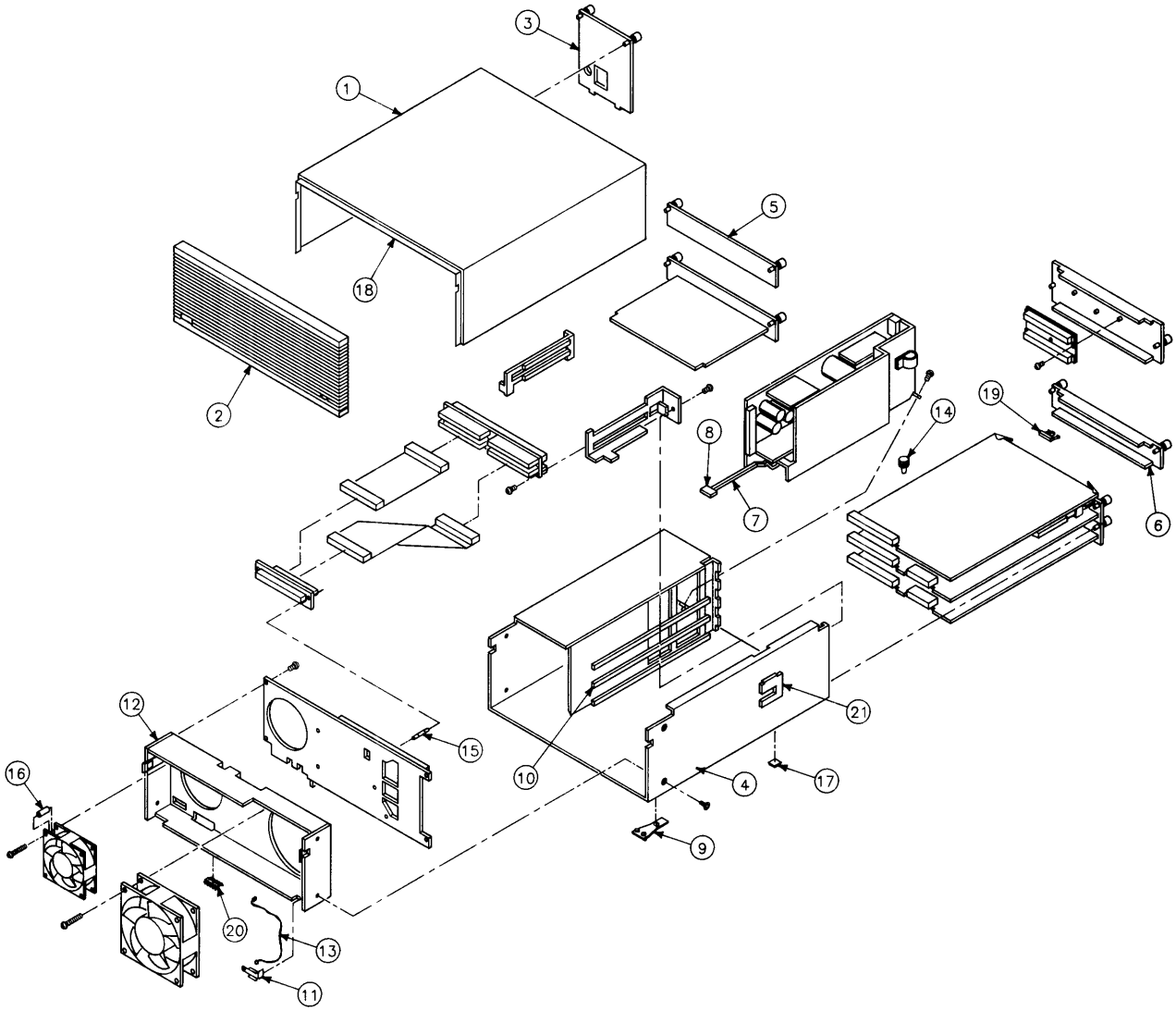


Figure 2-2. Computer Exploded Diagram

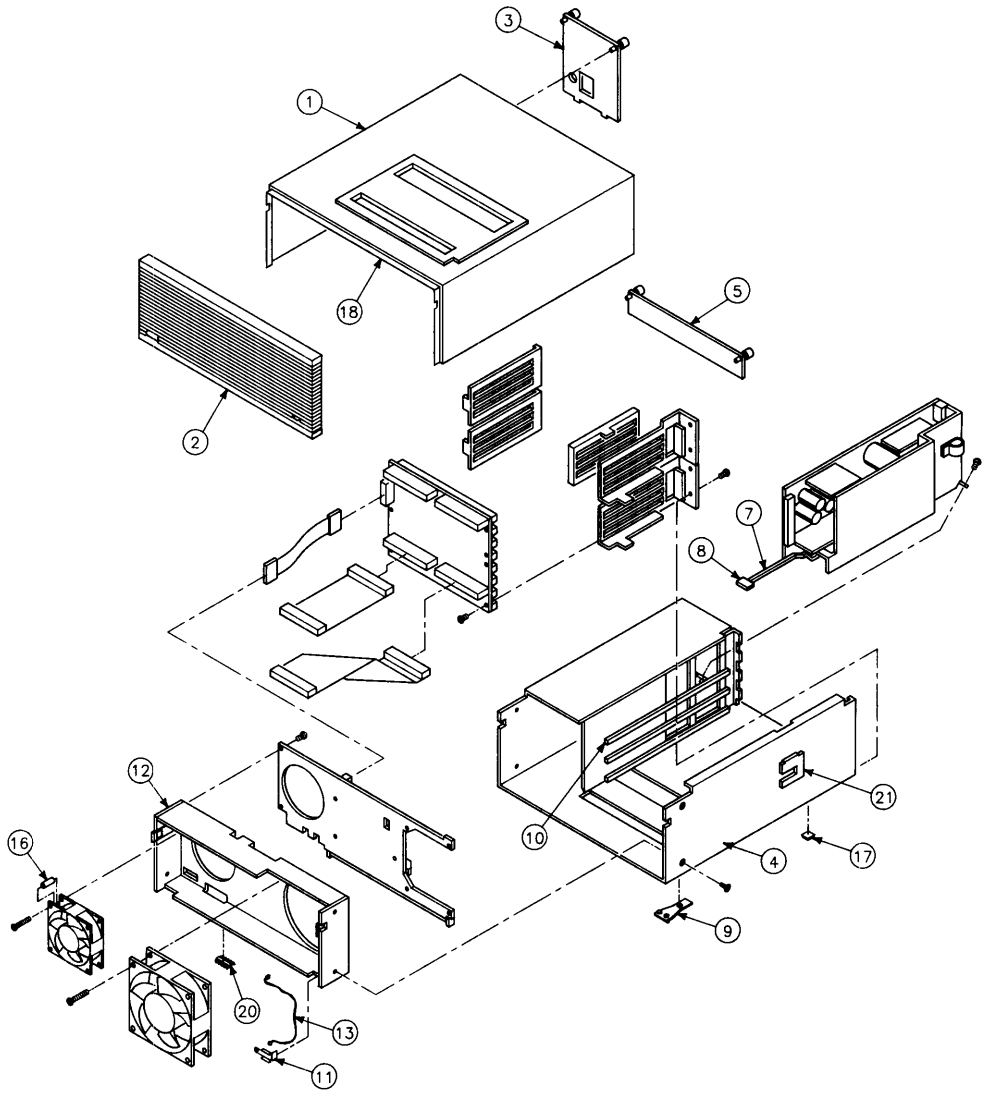


Figure 2-3. Expanders Exploded Diagram

Safety Precautions

Electrical Precautions

As with any electrical/electronic product, certain safety precautions must be practiced. These safety precautions, when followed protect both you and the equipment from injury and possible permanent damage.

WARNING

Always turn off the unit and remove the power cord before opening the unit to remove or replace an assembly. If maintenance activity requires power to be applied while the protective covers are removed, proceed only with extreme caution using safe, live-unit maintenance procedures. Do not touch energized components or parts with your fingers. Heed and follow all "WARNING-HAZARDOUS VOLTAGE" labels. Failure to follow these safety precautions may result in serious injury, or worse.

System Board Installation

CAUTION

Do not use excessive force to seat system boards in the system slot connectors.

If excessive force seems to be needed to install a board, remove the board, and inspect the motherboard's connector for bent pins. Straighten any pins that appear to be bent.

Remove the top cover and all boards above the one that is difficult to seat.

Re-insert the board to the motherboard's connectors and adjust the position of the board's connector to mate correctly with the motherboard's connector. Carefully seat the board. Reinstall the other boards in the same manner, then replace the top cover.

Electro-Static Discharge Precautions

Integrated circuit components in these products can be damaged by electro-static discharge. It doesn't make any difference whether the IC's are installed on a printed circuit board or laying on a table. Static charges can build up in people to a potential of several thousand volts by simply walking across a room.

These circuits in the computer, bus expander, accessories and peripherals can be protected by using a static free workstation and wearing clothes that do not hold static charges before handling any of the unit's PC boards.

When you need to remove or install a part, remove power from the product first. With the static free workstation in place, touch sheet metal with your fingers before touching the printed circuit assembly. If the assembly is not going to be re-installed, place the assembly in an anti-static bag and set it aside.

Following these precautions will extend the life of the computer products you maintain.

Assembly Replacement Procedures

Overview

In this section, procedures are listed for removing and installing each assembly. For each assembly, a list of Preliminary Requirements is listed. To perform these Preliminary Requirements, follow the steps shown in each Preliminary Item's replacement procedure.

Instructions are based on the following orientation of the hardware:

- The right side is the side on your right as you face the front of the unit. For example, the Power-On LED is on the unit's right side.
- The left side is the side on your left as you face the front of the unit. For example, the power supply is on the unit's left side.
- The front is the end toward you as you face the front panel. For example, the power switch is on the unit's front end.
- The back is the end away from you as you face the front panel. For example, the fuse is on the unit's back end.
- The top and bottom are relative to their normal positions.

These references are used in the procedures and should be followed regardless of how you are facing the unit. Figure 2-4 shows the hardware orientation.

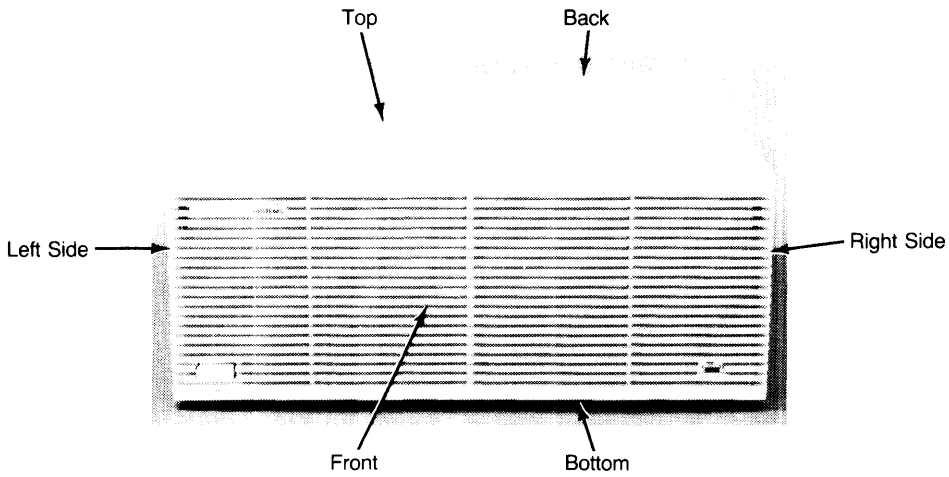


Figure 2-4. Hardware Orientation

Fuse

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Using a flat-tip screwdriver, press in on the fuse cap and rotate it counter-clockwise about ¼ turn. The fuse should pop out a little.
2. Pull out the fuse cap containing the fuse.
3. Remove the fuse from the fuse cap and replace it.
4. Reverse steps 1 through 3 to install the fuse.

HP-HIL Devices

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Disconnect the HP-HIL cable from the system interface board.
2. Remove the HP-HIL device from the other end of the HP-HIL cable.
3. To install an HP-HIL device, reverse steps 1 and 2.

System Bus

Preliminary Requirements

1. Turn the computer off.
2. Remove the power cord.

Procedure

1. Loosen the two (or more) captive thumbscrews holding the system bus to the rear panel, until the thumbscrews pop up.
2. Pull the system bus straight out by its handle, removing the system bus from the processor and RAM boards.
3. To install the system bus, reverse Steps 1 and 2.

Processor Board

Preliminary Requirements

Turn the computer off and remove these assemblies:

1. Power cord.
2. System bus (if present).

Procedures

1. Leverage the processor board out with its board ejectors.
2. Remove the processor board.
3. To install the processor board, reverse steps 1, 2 and 3.

Video Boards

Large video boards are usually in the top system slot. DIO video cards are in the DIO slots.

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Disconnect the video cables from the video board.
2. Using a #1 pozidriv or your finger tips, unscrew the two captive screws holding the video board in its system slot.
3. Remove the video board.
4. To install the video board, reverse steps 1, 2, and 3.

Interface Cards

These procedures apply to graphics display station or system interface boards in a system slot and I/O cards in a DIO slot.

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Disconnect the cables from the interface, except for the system interface board with high-speed disc add-on and HP-IB cable attached.
2. Unscrew the two captive thumbscrews holding the interface in the slot.

CAUTION

Some accessories consist of two assemblies connected together by ribbon cables. Do not completely remove these accessories with the panel on it until the cable has been disconnected. When reassembling these assemblies, sets, insert the top assembly first, then insert the lower one before connecting them together.

3. Remove the interface board/card from it's slot.

Note

Before installing interface boards or cards, ensure they are correctly configured for the application and/or peripherals.

4. For the high-speed disc add-on board, slide and rotate the HP-IB cable retaining plate counter-clockwise, then carefully remove the cable connector.

CAUTION

When installing the high-speed disc add-on board to the system interface board, use extreme caution when connecting the HP-IB cable to the add-on board. Improper connection will damage and bend pins on the add-on board connector. Connect the pins first, then the cable.

5. To install the interface, reverse steps 1, 2, 3, and 4.

Add-On Boards

This procedure tells how to remove the following assemblies:

- 98258-66521 4 Mbyte RAM Add-On.
- 98258-55622 12 Mbyte RAM Add-On.
- 98562-66531 High-Speed Disc Interface Add-On

Preliminary Requirements

Turn the computer off. Remove the power cord and the following assemblies:

1. System bus before removing RAM add-on boards.
2. The board with the add-on attached.
   - For RAM add-on, remove the 4 Mbyte RAM Controller Board.
   - For high-speed disc add-on, remove the system interface board.

Procedures

1. If the disc interface add-on is to be removed, slide and rotate the HP-IB cable retaining plate counterclockwise, then remove the cable connector from the side of the high-speed disc interface add-on board.
2. Remove the four screws holding the add-on board to its main assembly.
3. Pull the add-on board straight up and away from its main assembly.
4. To install an add-on board, reverse steps 1, 2, and 3.

Note

If the amount of RAM in the computer is changed, RAM must be reconfigured. Refer to the RAM configuration section in Chapter 3 of this manual, the RAM Board Installation Note, or Chapter 3 in the Service Handbook.

DIO Accessory Cards

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. If the card is behind a slot cover, remove the slot cover.
2. If the card is above and behind another card's rear panel, disconnect the cables from the card's panel, then remove the card.
3. Raise the card's ejector levers with your finger tips and unseat the card from the unit's DIO backplane connector.
4. Remove the card.

Note

Before installing DIO accessory cards, ensure they are correctly configured for the application and/or peripherals. Refer to the DIO accessory's Installation Note for the correct configuration.

---

5. To install the DIO accessory card, reverse steps 1, 2, 3, and 4.

Power Supply

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Unscrew the two captive thumbscrews holding the power supply access cover in place. Refer to Figure 2-5.

WARNING

A shock hazard exists on the power supply until about one minute after the unit is turned off. Use caution in handling the power supply.

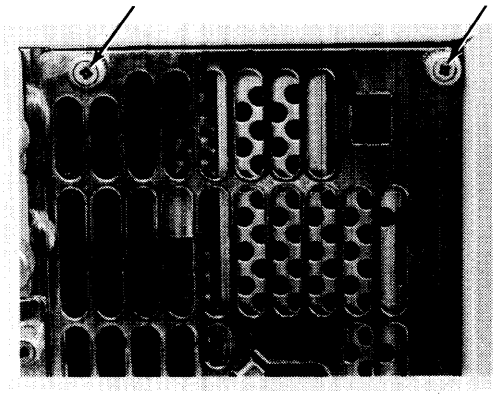


Figure 2-5. Power Supply Access Cover Screws

2. Remove the power supply access cover.
3. Remove the power supply grounding tab screw. Refer to Figure 2-6.

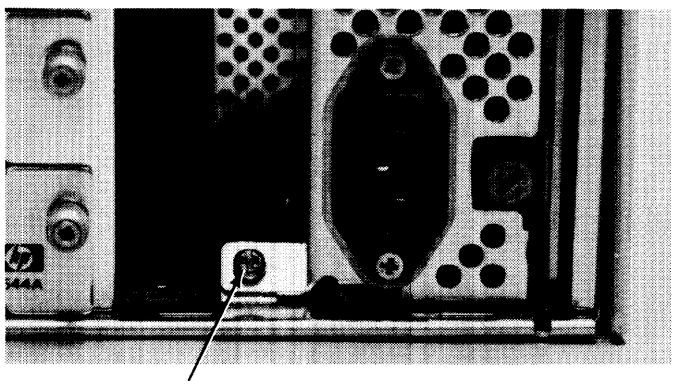


Figure 2-6. Power Supply Grounding Tab Screw

Caution

The ON-OFF button on the front of the computer is connected to the power supply by a long shaft . When removing the power supply, slide the power supply out carefully so you don't damage the ON-OFF switch shaft.

4. Remove the power supply.

Note

Replacement power supplies do not have the switch shaft connected. Install the switch shaft from the failed power supply on the replacement power supply.

5. Remove the switch shaft guide by pinching the tab shown in Figure 2-7 and removing the guide.

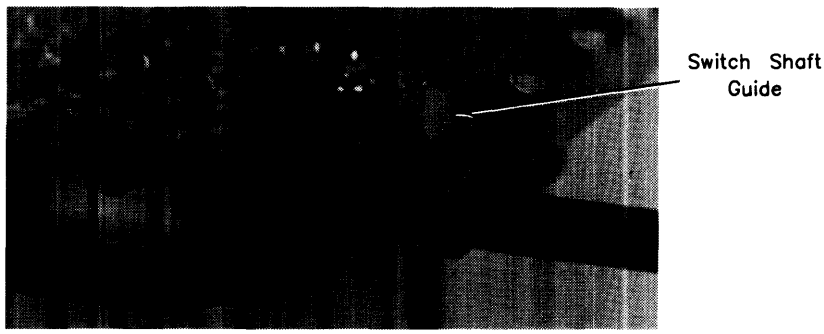


Figure 2-7. ON-OFF Switch Shaft Guide Removal

6. Remove the switch shaft from the ON-OFF switch by gently pulling the switch shaft off the switch. Refer to Figure 2-8.

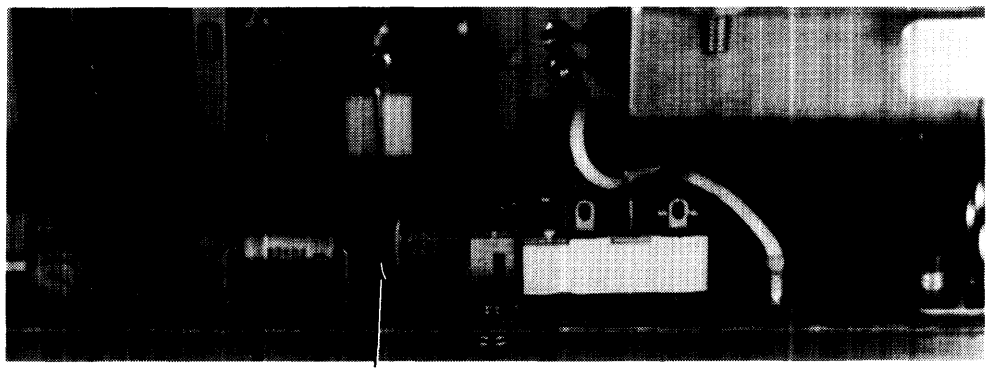


Figure 2-8. ON-OFF Switch Shaft Connection.

7. To install the power supply, reverse steps 1 through 6. Be sure to replace the power supply grounding screw.

Top Cover

Preliminary Requirements

Turn the unit(s) off. Remove the power cord(s) and these assemblies:

1. All cables from the installed accessory cards.
2. Power supply access cover.
3. Expander top cover, if the computer's top cover needs to be removed.

Expander Top Cover

When an expander is mounted on top of the computer, its original top cover is placed on the computer and the computer's top cover is placed on the expander. Keep this in mind if top covers need replaced. Chapter 8 in the Service Handbook lists top cover part numbers with their original unit.

1. Slide the expander's top cover to the rear and lift up on the back of the cover to remove it.
2. To install the top cover, place the top cover on the chassis, ensuring the RF shield plates are outside the sides of the chassis.

Assembly Note

When installing the top cover, ensure the lip on the back edge of the top cover catches the tab on the chassis when the top cover is fully seated in place.

---

3. Slide the top cover forward and fit the front of the top cover inside the front cover edges and engage the lip on both sides at the rear of the cover in the tabs on the chassis.

Computer Top Cover

When an computer is used with an expander, its original top cover is placed on the expander and the expander's top cover is placed on the computer. Keep this in mind if top covers need replaced. Chapter 8 in the Service Handbook lists top cover part numbers with their original unit.

1. If an expander is installed:
    a. Remove the expander's attaching screws shown in Figure 2-9.

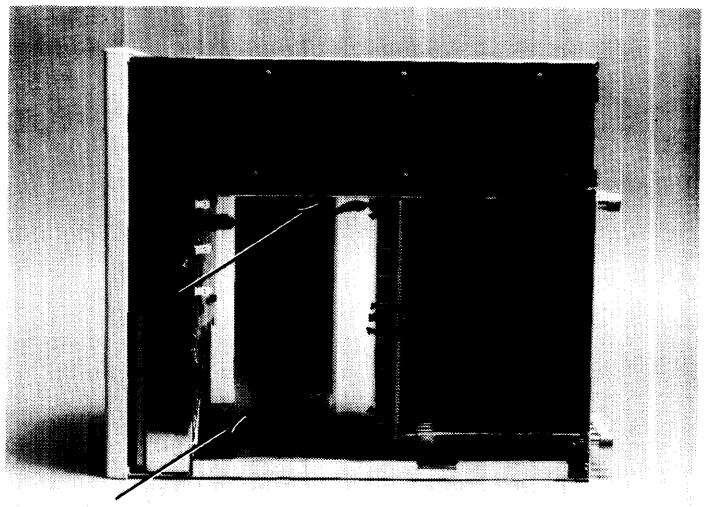


Figure 2-9. Expander to Computer Attaching Screws

b. Remove the expander from the computer and install the connector's protective sleeve or set the expander on its side.

c. Remove the flat-head screw that holds the computer's top cover to the motherboard connector.

2. Slide the computer's top cover to the rear and lift up on the back of the cover to remove it.

3. To install the top cover, place the top cover on the chassis, ensuring the RF shield plates are outside the sides of the chassis.

Assembly Note

When installing the top cover, ensure the lip on the back edge of the top cover catches the tab on the chassis when the top cover is fully seated in place.

---

4. Slide the top cover forward and fit the front of the top cover inside the front cover edges and engage the lip on both sides at the rear of the cover in the tabs on the chassis.

5. If an expander is to be installed:

a. Replace the top cover screw.

b. Install the expander.

c. Replace the two expander attaching screws.

d. Replace the expander top cover.

Front Panel

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.

Procedures

1. Using a thin blade flat-tip screwdriver, release the front panel catches on the right and left sides by pressing them inward as shown in Figure 2-10.

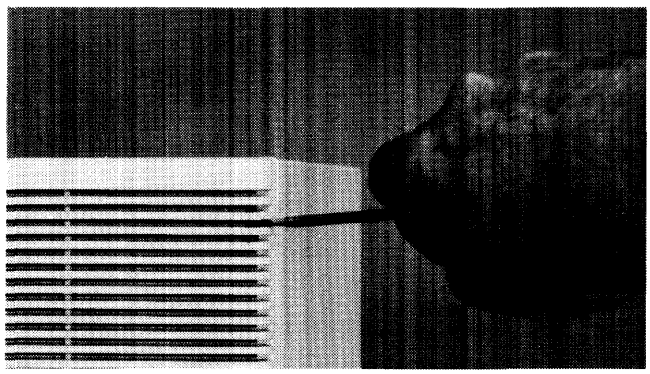


Figure 2-10. Releasing the Front Panel Catches

2. Carefully tilt the front panel forward to a 45° angle.
3. The front panel can be removed and set aside.

Note

When installing the front panel, ensure the lip at the bottom of the front panel fits over the sheet metal on the bottom of the fan housing.

---

4. To install the front panel, reverse steps 1 through 4.

Fans

Preliminary Requirements

1. Turn the unit off.
2. Remove the power cord.
3. Remove the front panel.

Procedures

1. Using needlenose pliers, disconnect the fan wire connector from its pins on the motherboard. Refer to Figure 2-11.

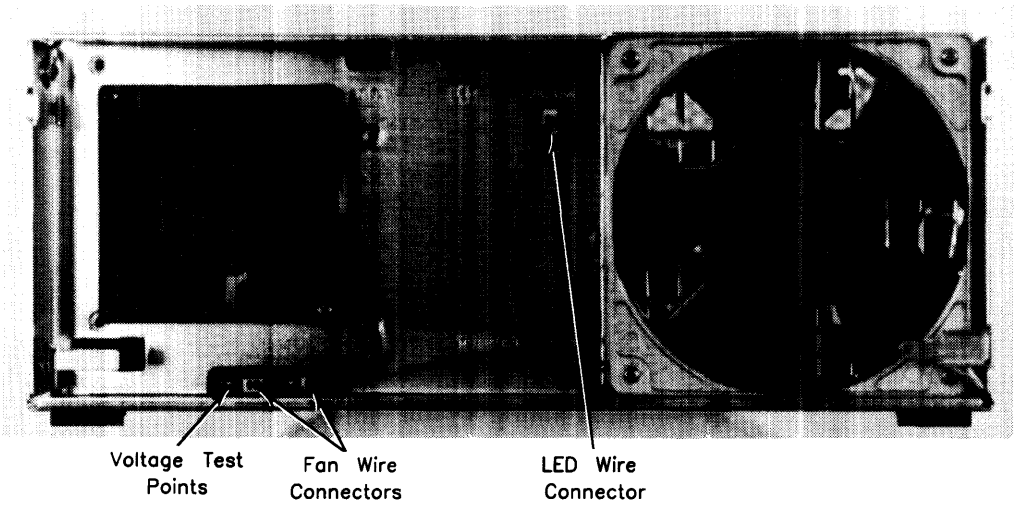


Figure 2-11. Fan Wire Connectors

2. For the large fan, slide the power-on LED/bracket toward the front and bend the wires aside.
3. Remove one of mounting screws from the fan to be replaced. Refer to Figure 2-12.

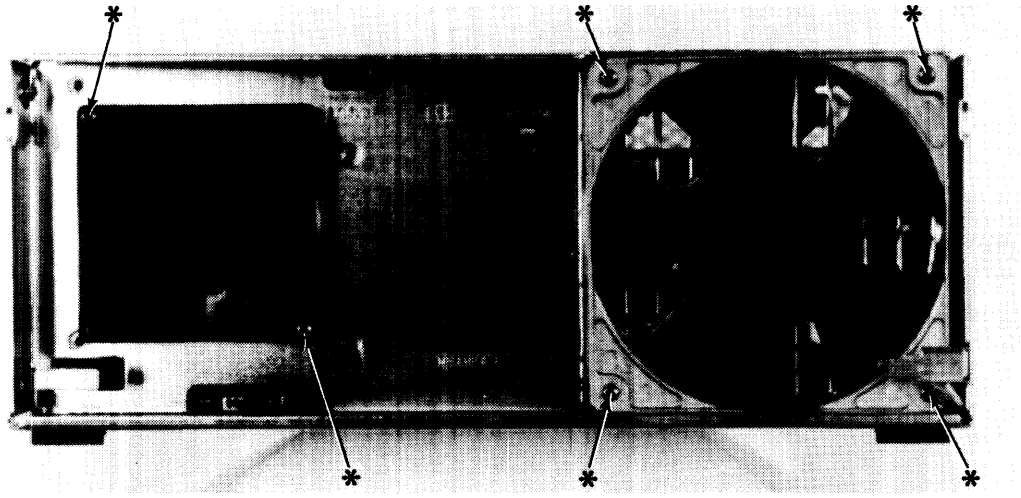


Figure 2-12. Fan Mounting Screws

4. While holding the fan in place with one hand, remove the other mounting screw from the fan.
4. Remove the fan.
5. To install the fan, reverse steps 1 through 3.

DIO Card Cages

DIO card cages come in 2- and 4- slot versions for the computer or HP 98570A expander. For the HP 98568A Opt. 132 expander, only two 4-slot card cages are used. Replacement procedures are given for each type.

Preliminary Requirements

Turn the unit off. Remove the power cord and these items:

1. All cables from DIO cards in the slots.
2. DIO slot cover if installed.
3. Power supply access cover.
4. Remove the expander from the computer if the computer's 2- or 4-slot DIO card cage is to be removed.
5. Top cover.

Procedure

1. Disconnect the DIO ribbon cables from the motherboard.
2. Remove the screw holding the right side of the DIO card cage to the card cage bracket. Refer to Figure 2-13.
    a. If a 2-slot DIO expander is installed, the card cage bracket is a separate metal piece that slips into the slot on the right side of the computer.

b. If a 4-slot DIO expander is installed, the card cage bracket is a tab that is part of the sheet-metal chassis on the right side of the computer.

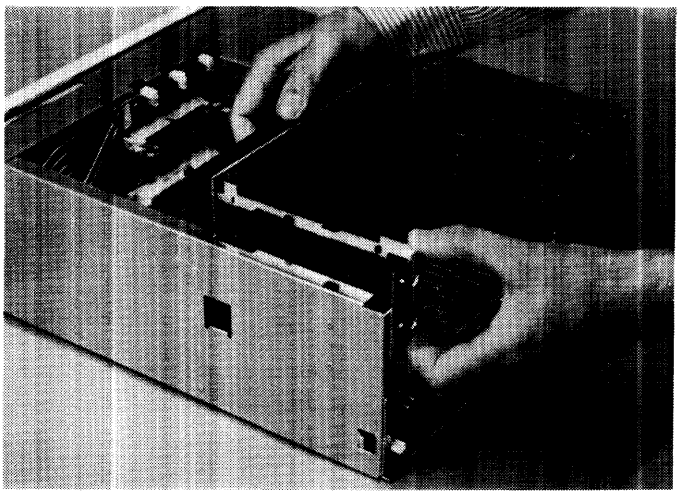


Figure 2-13. DIO Card Cage Bracket

3. Remove the screws holding the card cage to the chassis. Refer to Figure 2-14.

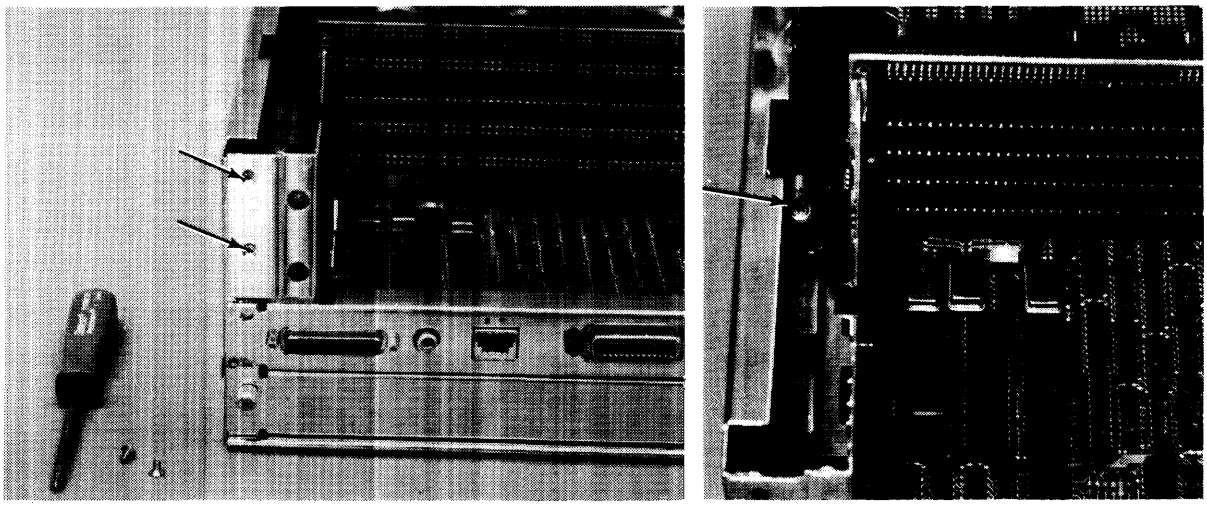


Figure 2-14. DIO Card Cage Screws

3. Slide the card cage out of position by rotating it to the right until the tabs on its left side clear their mounting slots and remove the card cage.

Assembly Note

Note that the left side of the card cage fits outside the chassis and the right side fits inside the chassis.

---

4. To install the card cage, reverse steps 1, 2, and 3.

DIO Backplane

Each 2- and 4-slot DIO adaptor has a backplane for cards to connect to. When this backplane needs to be replaced, here's what you need to do.

Remove these parts first.

1. Power cord after turning the unit off.
2. Power supply access cover.
3. Top cover.
4. DIO adaptor.

Procedures

CAUTION

Note the motherboard DIO-II and backplane DIO connectors each ribbon cable is attached to. Mark the ribbon cables, if necessary to help you remember.

When replacing the backplane, these ribbon cables must be reconnected correctly. Otherwise, smoke, fire, and brimstone may surely emit from this marvelous Hewlett-Packard product. So, please watch out and put it back together right.

---

1. Note what ribbon cable is attached to the motherboard and backplane connectors, then remove the ribbon cables from the backplane.
2. Remove the screws holding the backplane PC board to the card guides. The number of screws will differ depending on the specific backplane.

Note

If the DIO backplane is installed with the ribbon cables hooked up to the backplane's top two connectors and a DIO card is installed, the card won't work. There are no power traces from the top backplane connectors to the DIO card slots. **Ribbon cables must connect only to the bottom backplane connectors.**

---

3. To install a backplane, reverse these steps.

Fan Housing

Preliminary Requirements

Turn the unit off. Remove the power cord plus these assemblies:

1. All assemblies from the DIO and/or system slots.
2. Front panel.
3. Power supply access cover.
4. Power supply.
5. Top cover

Procedures

1. Disconnect any attached ribbon cables from the motherboard.
2. Disconnect both fan connectors from the motherboard.
3. Remove the four screws holding the fan housing in place. Refer to Figure 2-15.

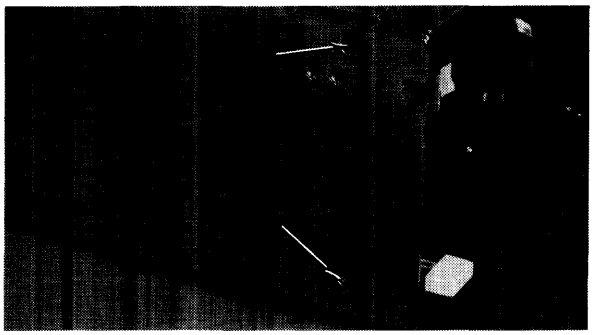


Figure 2-15. Fan Housing Screws

4. Pull the fan housing forward and remove it.
5. To install the fan housing, reverse steps 1 through 4.

Motherboard

Depending on the unit and its upgrades, different motherboards will be encountered. These procedures apply in all cases. Differences are shown relating to specific motherboards.

Preliminary Requirements

Turn the unit off and remove the power cord. Then remove these assemblies:

1. All boards from the system slots.
2. Power supply.
3. Top cover
4. Front panel.
5. Ribbon cables to motherboard.
6. Fan housing.

Procedure

1. Remove the LED and both fan wire connectors from the motherboard.
2. Remove the screws holding the motherboard to the fan housing, and remove it. Refer to Figure 2-16a, -16b, or -16c, depending on the unit.
3. To install the motherboard, reverse steps 1 and 2.

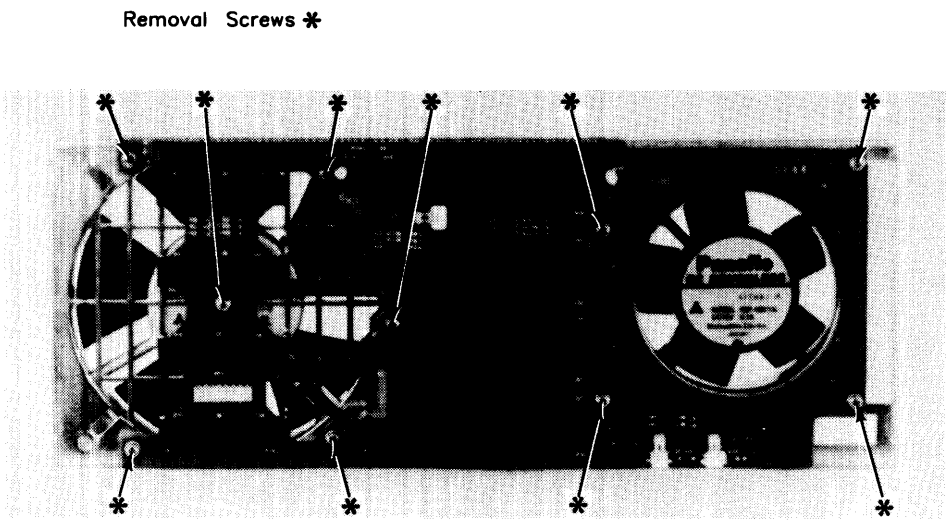


Figure 2-16a. Computer Motherboard Screws

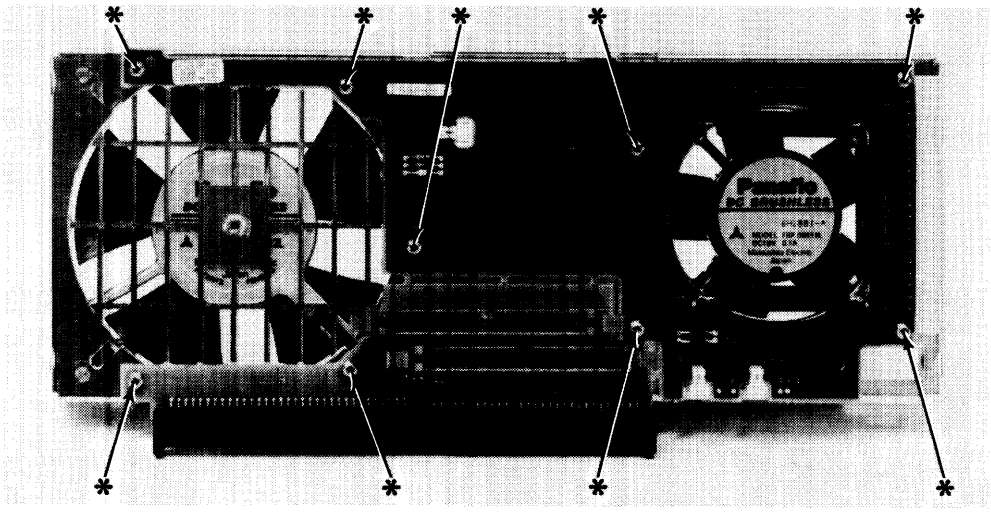


Figure 2-16b. HP 98568A Opt. 132 Expander Motherboard Screws

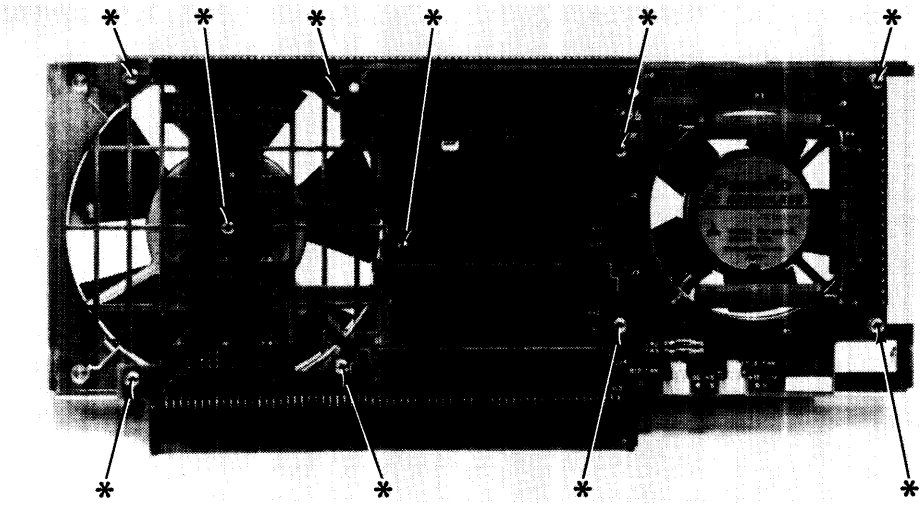


Figure 2-16c. HP 98570A Expander Motherboard Screws

Card Guides

Card guides on the left-hand side (power supply side) of the cage just snap into place. They may be removed by carefully unsnapping them.

Be sure they are replaced correctly, with the correct end toward the front and back of the unit.

Functional Description 3

Introduction

Computer Overview

Models 330 and 350 are improved versions of the Model 310 and 320. They were redesigned for higher performance to meet the compute-intensive requirements for design automation, as well as scientific analysis, and general purpose computation. Both are more tightly integrated than their predecessors with fewer physical pieces. They are similar in construction and uses the same power supply.

For the computers, most noticeable is the different board and card slots. Depending on the version, there are:

- Four DIO-II system board slots in the standard computer.
- Three system and two standard DIO slots in a computer that's had the 2-slot DIO backplane added.
- Two system and four standard DIO slots in a computer that's had the 4-slot DIO backplane added.

Expander Overview

Two direct-connect expanders permit additional accessory boards and cards to be used in the computer system. Each attaches directly to the computer through a solid connector between their motherboards. The HP 98568A Opt. 132 is an improved version of the earlier DIO expander used with Model 310/320 computers. A new expander, the HP 98570A, adds the larger system board slots to computer systems.

In the expanders, the board and card slots are identified below. Depending on the version, there are:

- Two system and four standard DIO slots in a standard HP 98570A expander.
- Four system slots in an HP 98570A expander with a delete option for the four DIO slots.
- Eight DIO slots in an HP98568A Opt. 132 expander.

Computer Architecture

Here's an overview of the architecture used in the Model 330/350 computers. You'll note that these computer's provide the peak performance potential of the Motorola architecture and maintain Series 300 compatibility.

Model 350 Cache-Based Design

The Model 350 employs a cache-based design. It has a large cache to accomodate the 25 MHz clock rate of the CPU and is 32 Kbytes in size. In addition, the Model 350 provides fast access times to high-speed RAM over a synchronous bus, the system bus. The system bus is connected between the processor board and RAM assemblies via a special system slot cover plate.

Figure 3-1 is a block diagram of the Model 330/350 architecture.

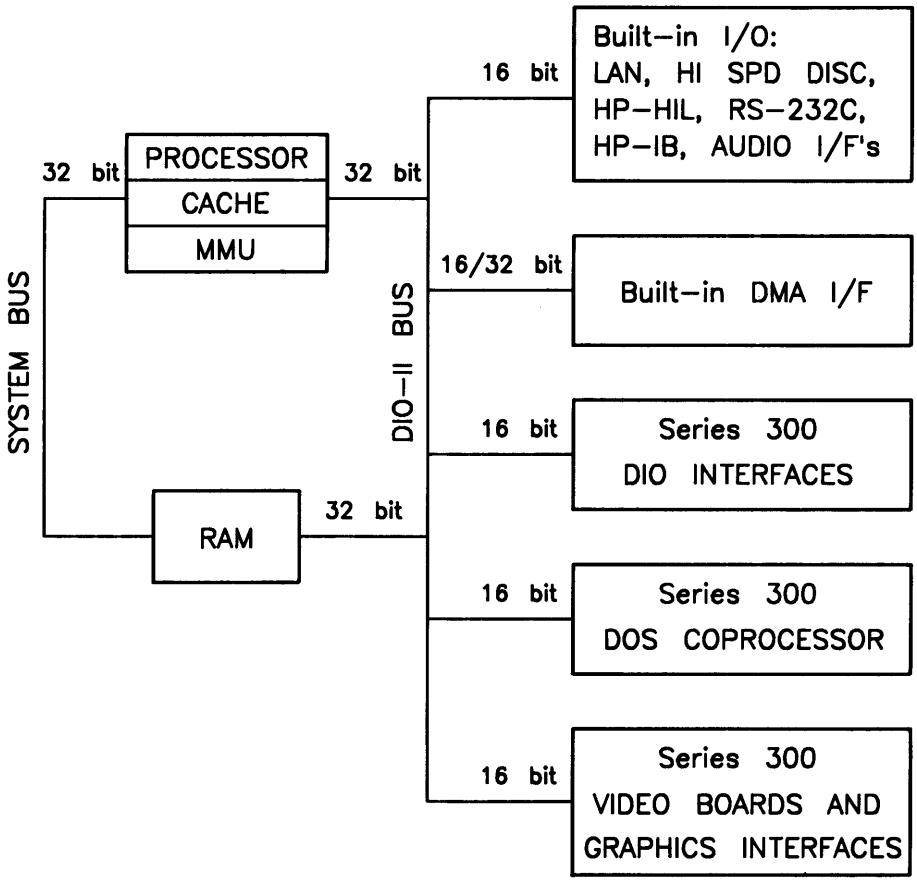


Figure 3-1. Model 330/350 Architecture Diagram

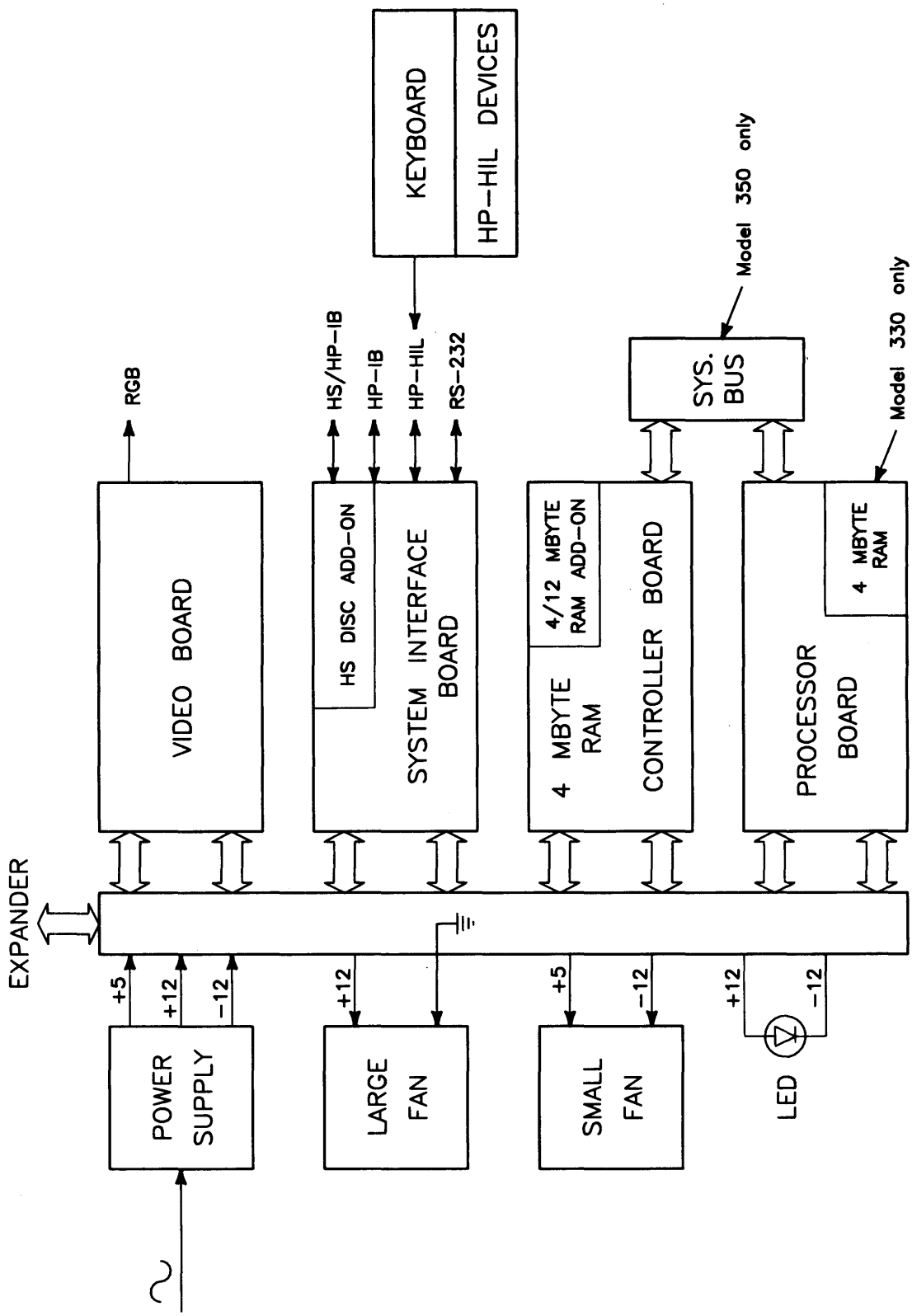


Figure 3-2. Model 330/350 Block Diagram

RAM is 32 bits wide. The cache fills at 22 Mbytes per second. The architecture comprises separate system bus (memory) and I/O busses. RAM is a dual-port design so the CPU and the I/O subsystem access RAM very nearly simultaneously, without contending for bus control. System performance is enhanced by the MC68020 executing program code with minimal conflict from I/O traffic to and from the disc drive.

Board size for the processor, RAM and system interface board is the "System Board" size of the Model 320. RAM boards provide up to 16 Mbytes per system slot. Two slots are available for a total supported physical RAM capacity of 32 Mbytes on the Model 350.

Computer Packaging

Each is packaged in a Series 300 chassis like the Models 310 and 320. For most applications, an expander is not necessary due to higher integration of components.

The computer has four system slots for the processor, RAM board, system interface board, and video board. Each system slot is part of the new DIO-II 32-bit backplane. DIO-II is made up of a two-connector system. The first is identical to the Series 200/300 DIO connector. A second, or DIO-II connector adds eight address lines, sixteen data lines and more control lines. When used with the signals on the DIO connector, they allow 32-bit address and data transfers. DIO-II is designed to be compatible with DIO in two ways:

- DIO bus masters, like the DOS Co-processor, can talk to DIO-II boards.
- DIO-II bus masters like the processor and DMA on the system interface board, can talk to DIO accessory and video cards.

System Implementation

Figure 3-3 is a diagram of a typical configuration.

Processor Board

- **Model 330** – 16 MHz MC68020, 16 MHz MC68881 coprocessor, MC68851 PMMU, 4 Mbytes RAM.
- **Model 350** – 25 MHz MC68020, 20 MHz MC68881 coprocessor, custom 25 MHz MMU, 32- KByte cache.

RAM Boards

The following RAM boards are supported **ONLY** in the computer:

- HP 98258A 4 Mbyte RAM Controller Board (Model 330 or 350).
- HP 98258B 4 Mbyte RAM Add-On Board (installed on the 4 Mbyte RAM controller board in a Model 350 only).
- HP 98258C 12 Mbyte RAM Add-On Board (installed on the 4 Mbyte RAM controller board in a Model 350 only).

- **Model 350** – Includes one 2-board 8 Mbyte assembly: one 4 Mbyte RAM Controller Board with a 4 Mbyte Add-On.

Options convert the 8 MBytes to 16 MBytes by replacing the 4 Mbyte add-on with a 12 Mbyte add-on. Additional RAM is available to extend total RAM up to 32 MBytes.

- **Model 330** – Includes 4 MBytes on processor board.

  One 4 Mbyte RAM controller board may be added for 8 Mbytes total.

System Interface Board

A Single-board I/O system includes HP-HIL, HP-IB, RS232, ThinLAN, beeper, DMA, and may have the optional high-speed HP-IB disc interface add-on. It may be located in the HP 98570A expander.

Video Boards

These computers support the same monitors as Models 310 and 320. These bit-mapped Video boards include both medium and high resolution color and monochrome versions.

Model 330/350 computers support the following video boards:

- HP 98542A Medium-resolution Monochrome Video Board
- HP 98543A Medium-resolution Color Video Board
- HP 98544A High-resolution Monochrome Video Board
- HP 98545A High-resolution Color Video Board
- HP 98546A Display Compatibility Interface Card (requires DIO card cage)
- HP 98547A High-resolution Color Video Board
- HP 98287A Interface to the HP 98700A Graphics Display Station (Requires DIO card cage)

Refer to the Series 300 Configuration Reference Manual for the current list of supported video boards.

Direct-Connect DIO or System Slot Expanders

An extension of the DIO and/or DIO-II interface bus using identical power supplies as the computer. Different slot sizes and quantities are available, depending on the expander and options.

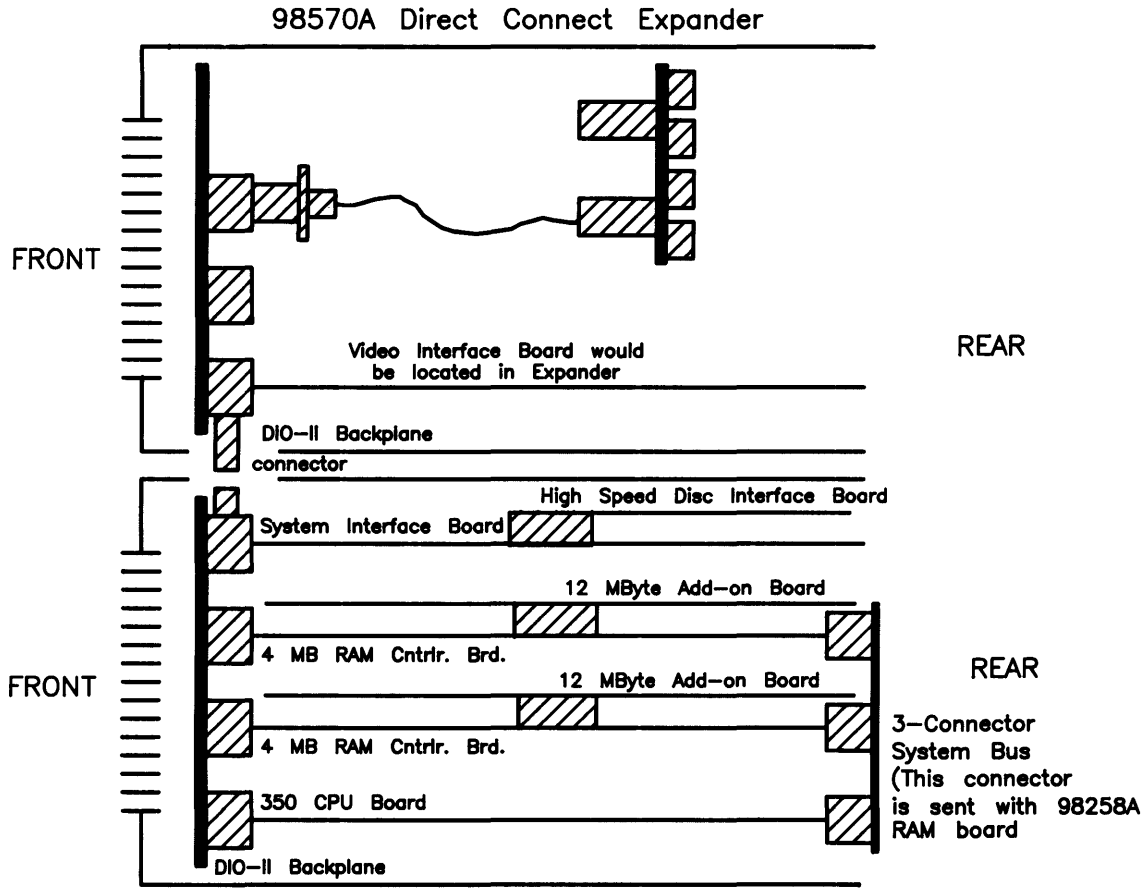


Figure 3-3. Model 330/350 SPU Configuration

Unsupported Accessories

The following accessories are not supported in Models 330/350 computer systems:

- HP 98254A 64 Kbyte RAM Card.
- HP 98256A 256 Kbyte RAM Card.
- HP 98257A 1 Mbyte RAM Card.
- HP 98603A ROM BASIC 4.0.
- HP 98603C ROM BASIC 5.0.
- HP 98620A Two-Channel DMA Interface.
- HP 98635A Floating-Point Math Card.
- 98561-66531 Human Interface Card.

Model 350 Processor Board

A new high-performance processor board is used in the Model 350. This board uses the 25 MHz MC68020 processor and the 20 MHz MC68881 floating point co-processor. It also contains a 32 Kbyte high-speed instruction/data cache, a memory management unit, a MC6840 timer, and two Boot ROMs.

Model 330 Processor Board

On this processor board, the MC68020 CPU and MC68881 co-CPU are clocked at 16 MHz. Although no cache is used, the MC68851 memory management unit is. On-board RAM of 4 Mbytes makes the Model 330 processor board powerful in its own right. RAM control and byte parity is similar to the 4 Mbyte RAM Controller Board.

Timer, Boot ROMs, and self-test LEDs are the same as the Model 350, as well as the same DIO-II and DIO bus capability. A system bus cannot used on the Model 330, therefore memory cycles will be slower than the Model 350.

Model 350 System Bus

On the Model 350 back panel, you will notice the cover plate over the processor and memory boards has a connector board mounted inside. This connector provides a high-speed memory bus between the Model 350 processor board and one or two RAM controller boards. This "connectorized" cover plate is called the system bus.

Model 350 RAM is tightly coupled to the Model 350 processor through the system bus. This allows much faster memory cycles and larger memory boards. It supports both 32-bit address and data. It also supports 16 byte cache line sustained read cycles at over 22 Mbytes/second. Single write-cycle sustained transfer rate on the system bus is 14.3 Mbytes/second.

Memory Boards

Each 4 Mbyte RAM Controller Board, and optional 4 or 12 Mbyte add-on board, uses one system slot. With this arrangement, 4, 8, or 16 Mbyte RAM assemblies are provided. The maximum amount of RAM in the system is limited to 32 Mbytes in a Model 350 and 8 Mbytes in the Model 330. Configuration is set by switches on the RAM controller board and Model 330 processor board.

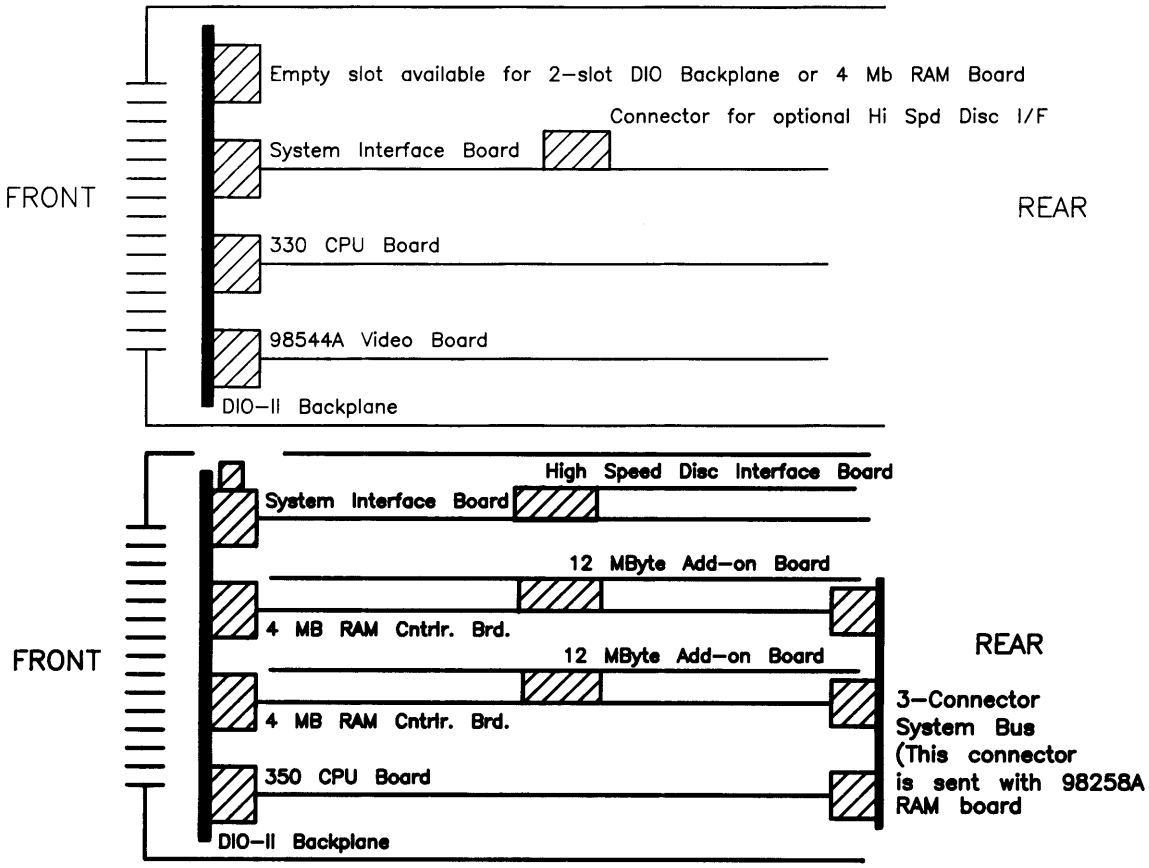


Figure 3-4. Model 330/350 RAM Configurations

System Interface Board

Human Interfaces

The system interface board is designed to meet most, if not all of the computer's human interface needs in a single system slot. It integrates RS-232, HP-IB, Audio, HP-HIL, Battery backed real time clock, LAN, DMA, and an optional high-speed disc HP-IB interface.

To maintain software compatibility, the designs of other interface cards are used. These cards are the HP 98625B, 98643, 98620B, and the original DIO size Series 300 human interface card. Each of these four sections of the board operates independently.

The LAN portion of the system interface board is software compatible with the current Series 200/300 DIO card (HP 98643A). Because of space constraints on the backplate, the ThinLAN implementation of the LAN was chosen. The MAU is built into the card and, with the BNC "T" connector, connects directly to the thin coax.

DMA is implemented on the system board with a new semi-custom CMOS standard cell. The chip is features an HP proprietary 1.5 micron CMOS process and is a compatible superset of the HP 98620B DMA interface card.

High-Speed Disc Add-On

An optional high-speed disc add-on is identical to the HP 98625B. It allows HP-IB word-wide transfers during DMA cycles and is fully supported by software. Because of limited space, the high speed disc is implemented on an add-on board and is connected similar to the RAM add-on boards. This configuration does not require any additional DIO or DIO-II slots.

A special HP-IB cable is used with this add-on and connects directly to the edge of the add-on board using a special connector.

Monitor Compatibility

Both models support the current Series 300 video boards and display systems.

- 512 by 400 monochrome and 4 plane color.
- 1024 by 768 monochrome and 6 plane color.
- HP 98720 1280 by 1024 Solid Rendering Display System.
- HP 98720H 1024 by 768 Graphics Display Station.
- Series 200 Display Compatibility Card Set.

Direct-Connect Expanders

Two expanders are available for these computers. Each connects to the computer through a rigid connection to the motherboard. Only one can be used at a time.

HP 98568A Expander, Opt.132

Option #132 modifies the existing HP 98568A to support the 32-bit DIO-II backplane. It adds eight DIO slots to the system in the same way that the HP 98568A without the option adds DIO slots for the Models 310/320, but with a different physical connection.

Support for DIO cards follows the same rules as for Models 310/320: interface cards may only be located in every other slot. Accessory cards may be installed in any slot. And since the smaller DIO-RAM (256K and 1 Mbyte) boards and DMA accessories don't work, for all practical purposes this 8-slot expander is really a 4-slot DIO interface expander.

HP 98570A Expander

Here's a new expander that adds two DIO-II system slots and four DIO slots. An available option deletes the 4-slot DIO backplane and converts the 98570A to 4 system slots.

HP 9888A Expander

For 16 slots, the HP 9888A is plugged into any available DIO slot in the computer. Up to two HP 9888A expanders are supported and provide 16 functional DIO slots (a total of 32 DIO slots) for interface cards.

Accessory cards using DMA are not supported in the HP 9888A Expander.

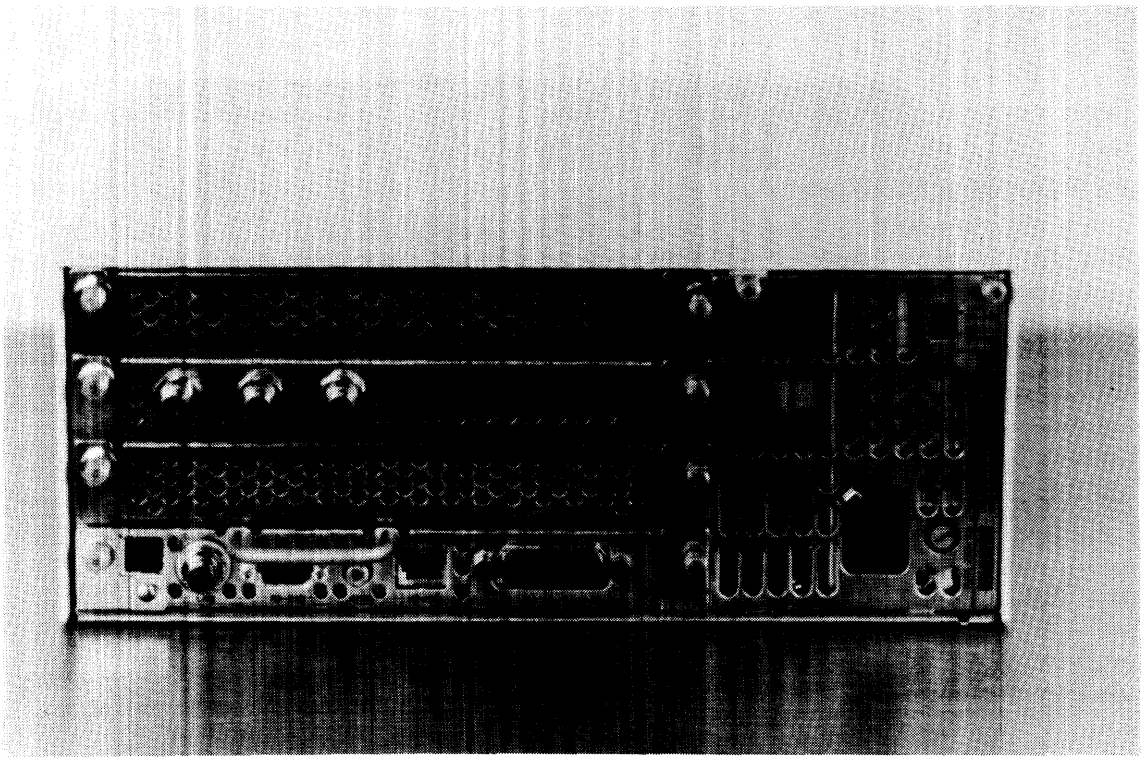


Figure 3-5. Computer and Expander Back Panels

DIO Adapters

Upgrades are available to convert the larger system board slots to smaller DIO card slots in the computer or the HP 98570A expander. Only one upgrade may be located in the computer.

HP 98242A 4-Slot DIO Adapter

This adapter converts two system slots to four DIO slots. The HP 98242A is standard in the HP 98570A Expander, but may be deleted using Option 004. For customers who delete it when they purchase the expander, but later wish to add it, the adapter is also available separately.

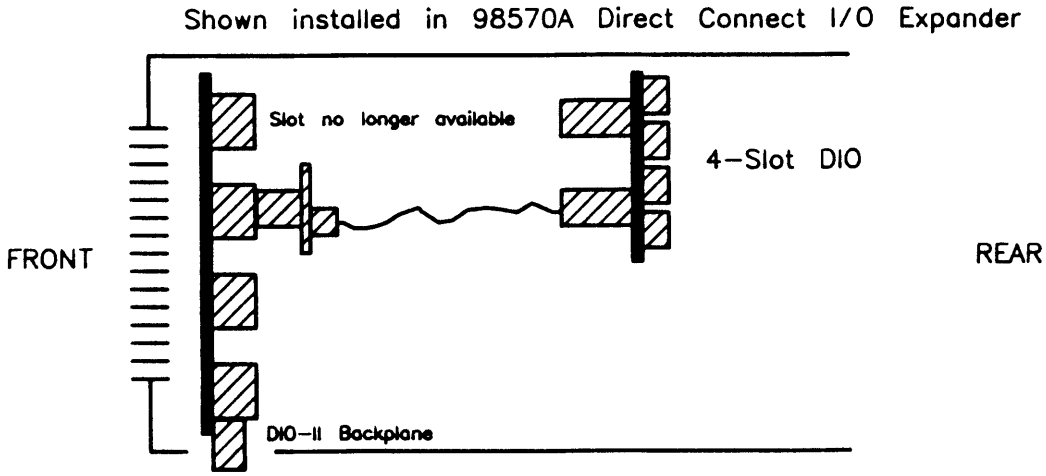


Figure 3-6. HP 98242A 4-Slot Adaptor Diagram

HP 98242B 2-Slot DIO Adaptor

The second adapter converts one system slot to two DIO slots. Use it with Model 350 when no bit-mapped video board is used, such as terminal-based multi-user systems . Some bundled systems will have it installed to accomodate the HP 98700A's DIO interface card.

DIO interface cards may only be located in every other slot. HP 98256/7 RAM cards are not supported. Thus, the 4-slot DIO upgrade is essentially a 2-slot upgrade, and the 2-slot upgrade is essentially a single slot upgrade.

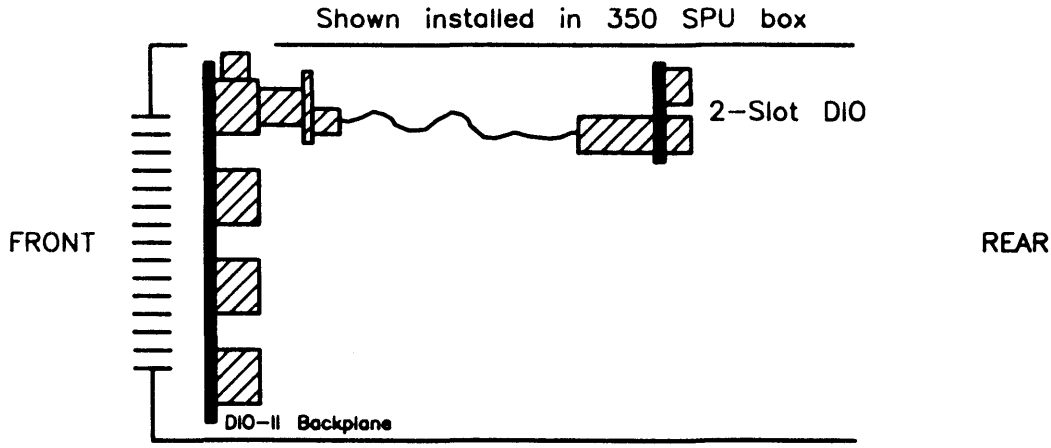


Figure 3-7. HP 98242B 2-Slot Adaptor Diagram

Power Supply

Introduction

Both computers and expanders use this power supply. The power supply provides all power to the assemblies installed in the unit. It is a non-adjustable switching supply that is an exchange assembly.

Power Supply Characteristics

Power supply characteristics are

- Operates on 120 or 240 VAC, 50-60 Hz.
- Outputs these voltages:
  - +5 Vdc
  - +12 Vdc
  - −12 Vdc
- Power-Up RESET signal sent to processor board to initialize CPU.

Maximum power consumed by the computer or expander is 250 watts. For the computer, power consumption by the power supply and assemblies in the system slots is included in the 250 watts. The remaining 147 watts is available for assemblies in the units system or DIO slots. In the expander, most of the power is available for system boards or DIO cards.

The following table shows the power available to all combined motherboard, DIO, and system slots for Model 330/350 computers and HP 98568A Opt. 132 and HP 98570A expanders.

Voltage	Power Available	Current Available
+5 Vdc	95 Watts	19 Amps
+12 Vdc	40 Watts	3.3 Amps
−12 Vdc	12 Watts	1 Amp

CAUTION

When boards are installed in the unit, they use power and the amount left over is less than shown in the table above.

Before installing boards or cards in the unit, ensure the total maximum power consumed by all cards and boards for each voltage in the unit does not exceed the power available at that voltage. If the board or card to be installed require more power than is available, damage to the accessory or computer/expander may result. Refer to the Service Handbook, Chapter 3.

Figure 3-9 is a block diagram of the power supply used in the computer and expander.

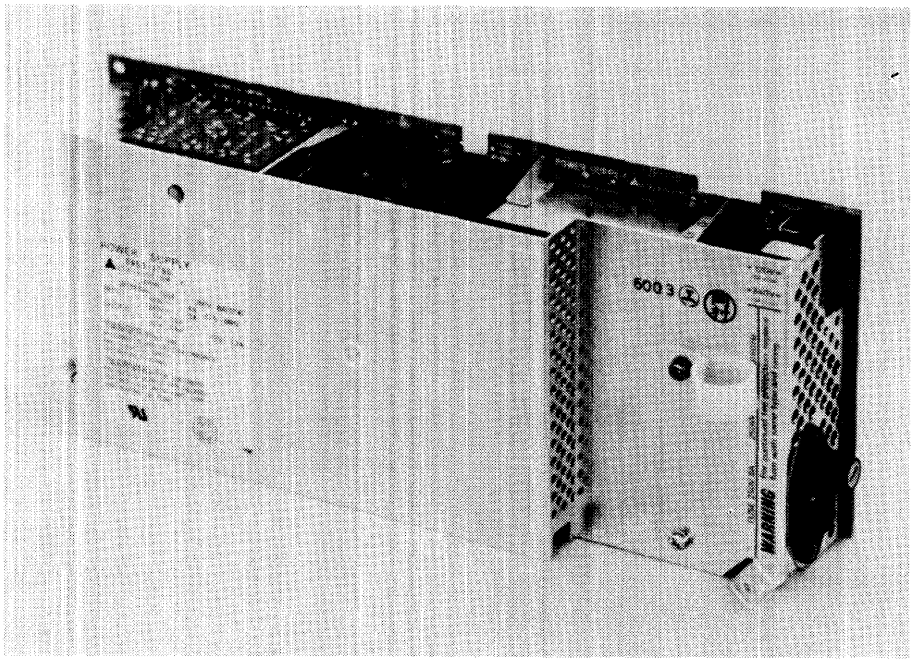


Figure 3-8. Computer/Expander Power Supply

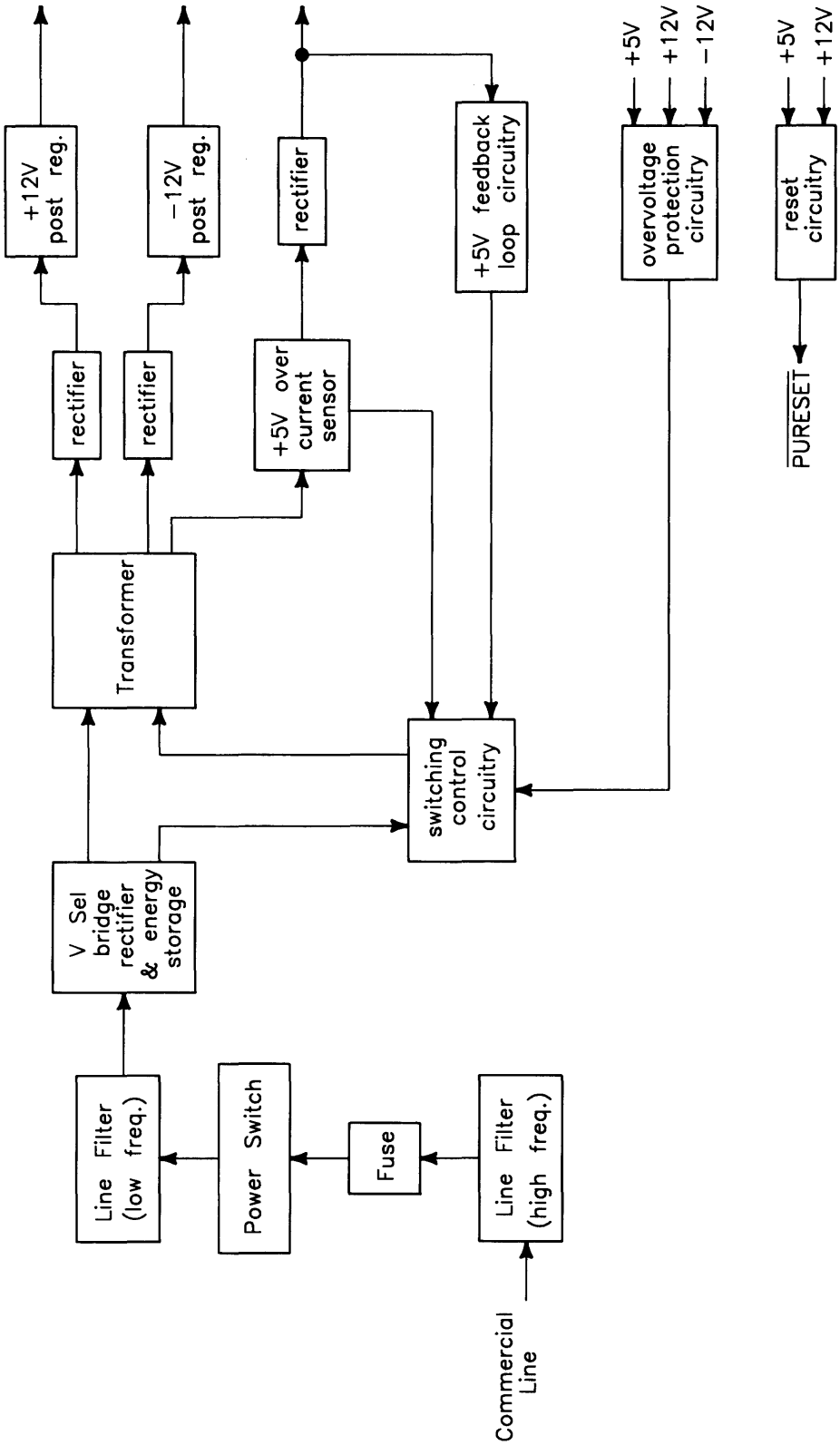


Figure 3-9. Power Supply Block Diagram

Input Section

Ac line voltage is supplied to the input section through the power cord. Functions of the input section are:

- High Frequency Filtering.
- Fusing.
- On-Off Switching.
- Input Voltage Selection.
- Low Frequency Filtering.

High Frequency Filtering

Line input voltage through the power cord is applied to a high-frequency line filter. This filter traps high frequency noise from both entering or leaving the power supply. It enables the output voltages to be virtually free from voltage spikes that may appear at the input. The filtered output is sent to the fuse and power switch.

Fuse

For both line voltage ranges, the same size fuse protects the power supply. Voltage selection and fuse size are shown in Table 3-1.

Table 3-1. Voltage Ranges and Fusing

Voltage Setting	Tolerance	Fuse Rating
120 Vac	+10%, −25%	8AF 250 Volt
240 Vac	+4%, −19%	8AF 250 Volt

The fuse rating 8AF means an 8 ampere fuse with a type F delay before blowing. In both cases, the line frequency is 48-66 Hz.

Low Frequency Filtering

When the power switch is turned on, voltage is applied to the Low Frequency Filtering circuits. These circuits trap low frequencies entering or leaving the power supply. They also reduce ripple in the output voltages. After filtering, the line voltage is sent to the Bridge Rectifier Section.

On-Off Switching

This operator-controlled switch connects power to the Low Frequency Line Filter. Located on the computer (or expander) front panel, it is mechanically connected to the power supply by a switch extension. When turned to the ON position, a green LED on the front panel is lit. The LED is connected to the voltage outputs and indicates that all power supplies are operating.

Input Voltage Selection

A voltage select switch is set to either the 120 Vac or 240 Vac position, depending on the line voltage. Voltage selection changes the input voltage to the bridge rectifier to make the bridge output the same for either line voltage.

Rectification and Switching Control Circuits

Functions of the Rectification and Switching Control circuits are:

- Full-Wave Bridge Rectifier.
- Switching Control Circuit.
- Power Transformer.

Full-Wave Bridge Rectifier

Part of the input ac voltage is applied across a full-wave bridge network that outputs a DC voltage. Large storage capacitors charge up to this voltage and provide a constant energy supply to the individual power supply circuits.

Switching Control Circuit

Voltage from the rectifier feeds a Switching Control Circuit that controls the amount of power going to each of the output voltage regulators. +5 Vdc feedback is applied to the Switching Control Circuit to regulate the +5 Vdc output. Overvoltage protection signals also input the Switching Control Circuit that will cause the power supply to shut down if voltage in the output supplies goes too high. A +5 Vdc over-current sensor input is another input to the Switching Control Circuit.

Power Transformer

Input ac voltage is also applied to the primary windings of a power transformer. Three sets of secondary windings each feed a voltage regulator for the output voltages. A voltage select switch is set to the line voltage range and causes the power transformer to have the same voltage output for both line voltage ranges.

Power Supply Regulators

Functions of the Power Supply Regulators are:

- +5 Vdc Power Supply.
- +12 Vdc Power Supply.
- −12 Vdc Power Supply.

+5 Vdc

Voltage from the power transformer feeds through a +5 Vdc current sensor than goes to the +5 Vdc rectifier. Output from the +5 Vdc rectifier is nominally 5.07 Vdc ±0.18 Vdc. The +5 Vdc output is also fed to the +5 Vdc Feedback Loop Circuit for regulation. It also is fed to the Overvoltage Protection Circuit and Reset Circuit. If the +5 Vdc fails, the Power-On LED on the front panel will go out as the +5 Vdc is part of the controlling voltage for the Switching Control Circuit.

+12 Vdc

Voltage from the power transformer feeds through a rectifier then to a +12 Vdc Post Regulator. The output from the Post Regulator is nominally +12.29 Vdc ±0.43 Vdc. In addition to being distributed in the computer (or expander), the +12 Vdc output is also fed to the Overvoltage Protection Circuit and Reset Circuit. External to the power supply, the +12 Vdc is connected to one side of the Power-On LED on the front panel.

−12 Vdc

Voltage from the power transformer feeds directly to a −12 Vdc Post Regulator. The output from the Post Regulator is nominally −12.29 Vdc ±0.43 Vdc. In addition to being distributed in the computer (or expander), the +12 Vdc output is also fed to the Overvoltage Protection Circuit and Reset Circuit. External to the power supply, the −12 Vdc is connected to the other side of the Power-On LED on the front panel.

Protection and Reset Circuits

Functions of the Protection and Reset Circuits are:

- Overvoltage Protection.
- Reset Signal Generation.

Overvoltage Protection Circuit

All output voltages are inputs to the Overvoltage Protection Circuit. If the voltage goes high, the circuit will shut down the power supply, protecting its components as well as components in other areas of the computer (or expander). The output of the Overvoltage Protection Circuit feeds the Switching Control Circuit.

Reset Circuit

When ac line voltage is applied, the power supplies start building up their output voltages. The +5 and +12 Vdc supplies input the Reset Circuit. As these inputs reach their operating voltages, the processor board circuits are also being powered up. When normal operating levels are reached, a Power-Up RESET (PURESET) signal is sent to the CPU to initialize it and start the Boot ROM sequence.

Power Distribution

Power Distribution routes power to the assemblies installed in the unit. Figures 3-10 and 3-11 shows how power is distributed in the computer and expander.

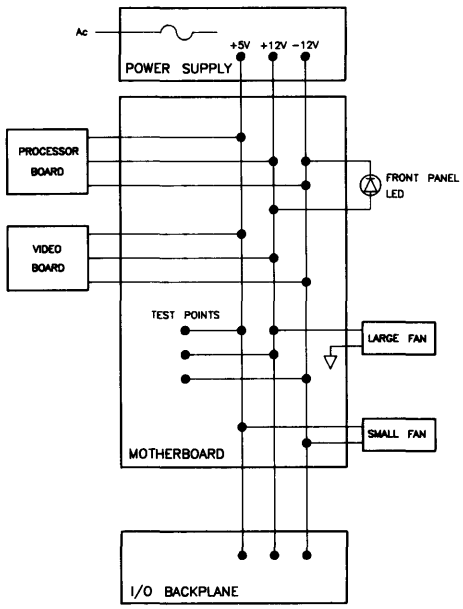


Figure 3-10. Computer Power Distribution

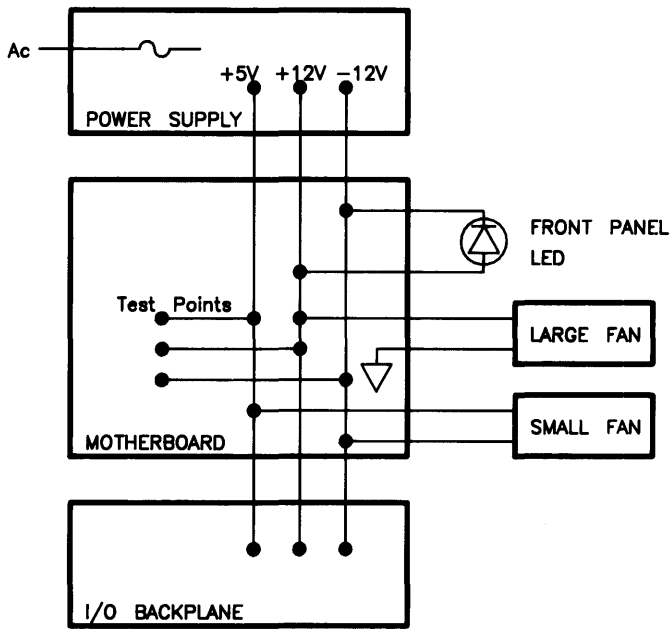


Figure 3-11. Expander Power Distribution

Power supply outputs are distributed through the motherboard. Test points are located on the motherboard and are accessible behind the front panel.

CAUTION

When custom designed accessory cards are being used in the DIO or DIO-II slots, their power consumption must be added to all cards and boards used in the unit. Information regarding the design of custom accessory cards is contained in the HP 9000 Series 300 Model 330/350 Accessory Development Guide, part number 98562-90010.

When the DIO adaptors are installed, power is distributed through the ribbon cables from the motherboard to these DIO backplanes connectors:

- Bottom connector on 2-slot DIO adaptors.
- Bottom and next to top connector on 4-slot DIO adaptors.

None of the other ribbon cable connectors have traces connecting power from the ribbon cable to the DIO slots. DIO interface accessories will get power only when connected in the bottom of each pair of DIO slots. Only data and control traces connect the top of each pair of DIO slots to the bottom one.

Motherboard

Introduction

Each unit has a different motherboard. This is necessary for the different connectors and shapes used for the computer and the two expanders. Refer to Figure 3-12 for the differences.

Virtually all assemblies connect directly or indirectly to the motherboard. It has connectors for other assemblies to interface with each other. Test points for power supply voltages are marked on the board.

Functions

Power is connected from the motherboard to the optional DIO backplane via a ribbon cable. In the computer, boards in the system slots are powered directly from the motherboard through two system slot connectors. Voltage test points are on the back of the motherboard and are accessible from behind the front panel.

Two fans are connected to motherboard power connections. The large fan is tied to the +12 and ground. The small fan is tied between +5 and −12 Vdc. Wires from the front-panel LED are connected to the +12 and −12 Vdc voltages on the motherboard.

The top of the motherboard is a large connector to interface with expanders. Data, control, and status signals are ported through this connector. There are no active components on the motherboard. Both the computer's and expander's motherboard have the same part number.

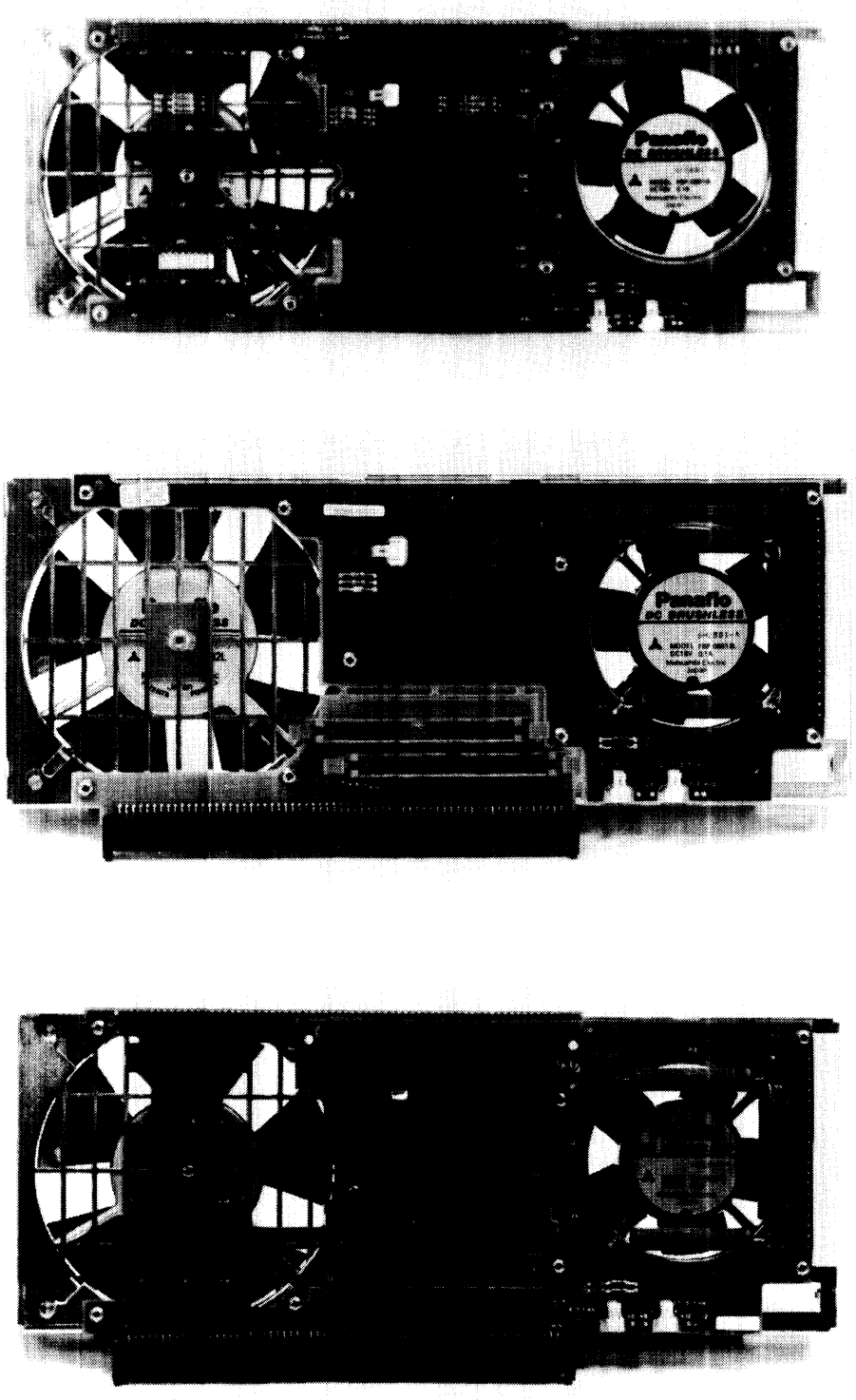


Figure 3-12. Computer and Expanders Motherboards.

HP 98242 DIO Backplane Board

Introduction

DIO backplanes are used as an option for the computer and standard in expanders.

Two versions are used:

- 2-Slot, used as an option to the computer and HP 98570A expander.
- 4-Slot, used as an option to the computer and HP 98570A expander. Two of these are used in the HP 98568A Opt. 132 expander for eight DIO slots.

Functions

Each expands a single motherboard DIO bus connector to either two or four slots for use with Series 200 or 300 accessory or interface cards. Function wise, they're no more than an extension of the DIO connector on the motherboard.

There are no active components on the DIO backplane boards or their associated ribbon cables.

Model 350 Processor Board

Introduction

This high-performance processor board for the Model 350 computer has:

- 25 MHz MC68020 CPU.
- 20 MHz MC68881 Floating Point Co-processor.
- 32 Kbyte direct mapped instruction/data cache.
- Memory Management Unit.
- MC6840 Timer.
- Boot ROM.
- Self-Test LEDs.

Figure 3-14 is a block diagram of the Model 350 processor board. Refer to this diagram for functional descriptions.

Central Processing Unit

A Motorola MC68020 CPU functions as the CPU on this board. Its asynchronous data bus is 32-bits wide for both addresses and data registers. The MC68020 CPU can address 32 Mbytes of RAM Operating at 25 MHz, it is significantly faster than other workstation CPUs.

The CPU has 57 instruction types and handles 7 major data types. It also has 18 addressing modes, 6 maskable and 1 non-maskable interrupt levels. Six stack frames exist in the MC68020.

Coprocessor

A floating-point coprocessor is used to increase system performance when certain floating-point math routines are part of the application. An MC68881 chip performs these functions. It implements the required IEEE standard capabilities. Performance is significantly greater than the HP 98635A Floating-Point Card.

Floating-point instructions become part of the language of the CPU in its operation.

Memory Management Unit

The MMU translates CPU logical addresses into physical addresses and handles access rights. Translation information is contained in tables resident in main memory. MMU halts the processor and performs bus cycles to access these tables. Translations are stored in a Translation Lookaside Buffer (TLB) so the tables do not need to be accessed for every CPU cycle. The CPU can run at the same speed with the MMU on or off.

Both the logical and physical address spaces are divided up into 4 Kbyte pages. The MMU provides the capability to map any logical page into any physical page. Write protection is provided by the MMU at the page and segment level. The table structure is the same as the Model 320 computer's MMU; this similarity allows software compatibility.

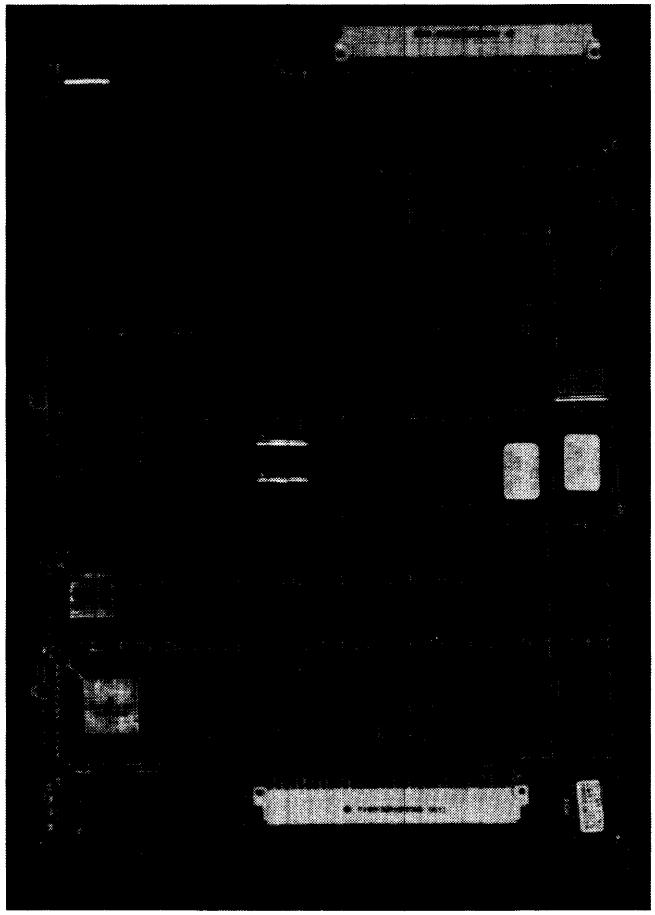


Figure 3-13. Model 350 Processor Board

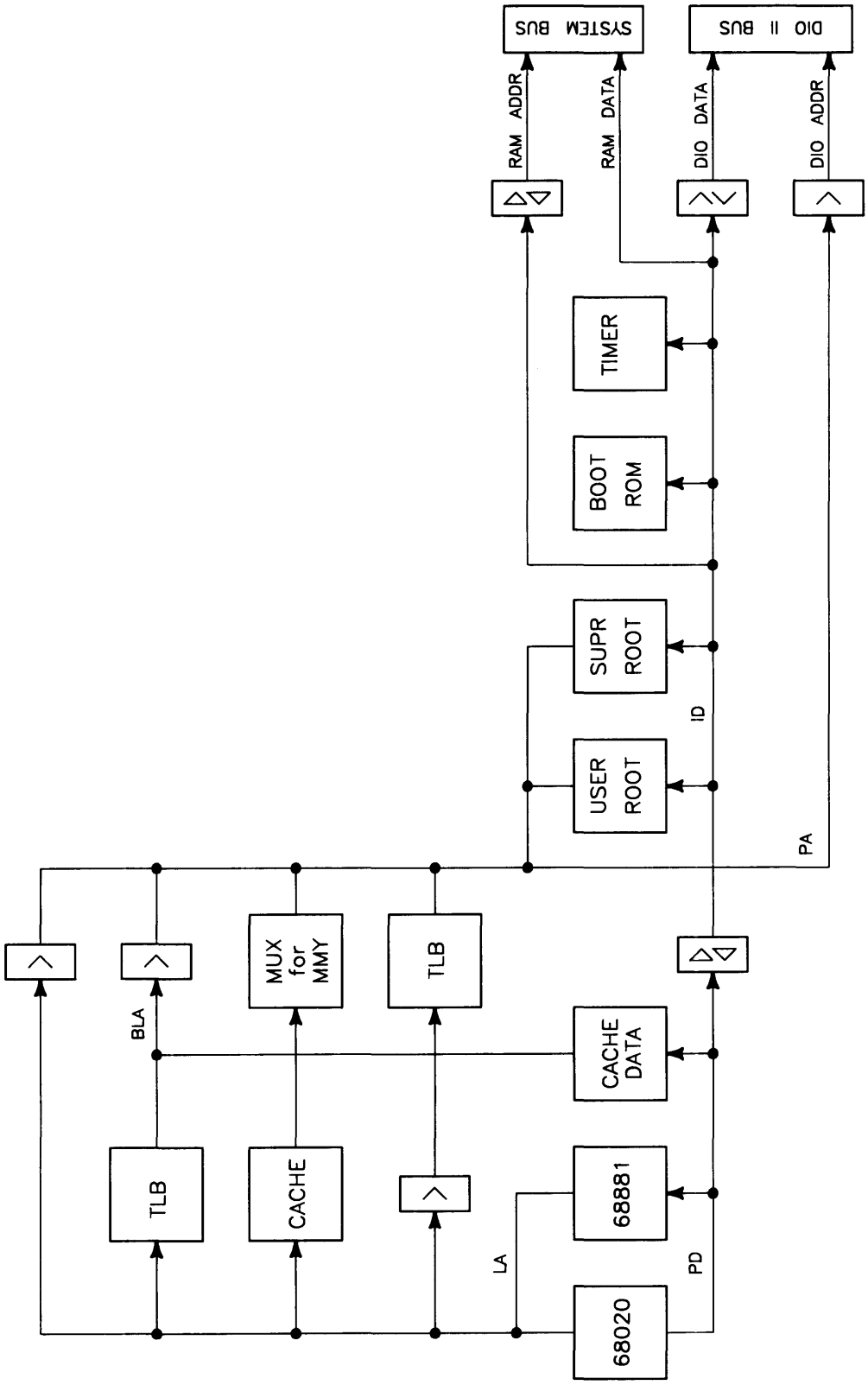


Figure 3-14. Model 350 Processor Board Block Diagram

Translation Tables

When the CPU attempts an access to a logical address whose translation is not resident in the TLB, an address translation cycle must be executed. This is called a table walk. The table algorithms used for address translation use segment and page tables, and user/supervisor root pointers.

Two levels of tables exist. The second layer is the Page table, which contains the physical addresses, called translations. The first layer is the Segment table, which mainly contains addresses of page tables. 32-bit logical address are divided into three offsets. Separate tables can exist for user and supervisor accesses.

Root pointers are hardware registers that contain the upper 20 bits of the starting address of the segment table. One pointer is used for supervisor mode, and one for user. The segment table offset is concatenated with selected root pointer, creating the address of the segment table entry. The MMU performs a memory cycle and reads from that address. Page table offset is concatenated to the bottom of the data from the segment table, which create the address of the page table entry. The MMU reads this address from memory. Information returned is the address of the physical page. This is the translation, and it is stored in the TLB for future reference.

Translation Lookaside Buffer

The TLB is a cache for address translations. When a translation has been completed, it is stored in the TLB so that a complete translation doesn't always need to be done when that logical address is accessed again. The organization of the TLB is a direct mapped set associative cache. The depth of the TLB is 2K entries, with 1K for user and 1K for supervisor.

Because the TLB stores data from main memory, any changes in the translation tables must be followed with either a complete or selective purge of the TLB. The TLB must also be purged whenever the root pointers are changed. The Model 350 processor board automatically purges the entire TLB whenever either of the root pointers are written.

Cache

On the processor, a 32 Kbyte virtual cache is used for data and instructions. It is a static memory array that is fast enough to allow the CPU to read data in three clock states, or 120 ns. This cache is set-associative with a set size of one. When data is coming into the cache, there is exactly one place where it can be stored. Cache is organized as 2048 lines of 16 bytes each. Hit rate of this cache is about 79% because of this larger line size.

Two banks of RAMs are used. The larger group is the cache data RAMs, where the actual data is stored. A smaller group is the cache key, where the upper bits of the address are saved. A cache entry consists of 16 bytes of data, along with 18 bits of key data and one valid bit.

During a CPU read cycle, the address is compared to the address in the key in the one location where that data could be stored. If the address matches, and the MMU is satisfied or shut off, the cache data memories drive the data directly to the CPU. If the cache misses, the associated hardware will start a bus cycle to read four long words, and fill one line of the cache.

With MMU Off

When the MMU is turned off, the cache key alone determines whether any given processor read cycle can hit the cache or must go to main memory. The bottom 512 Mbytes of address space is not cached. The remaining 3.5 Gbytes of space are cached.

With MMU On

When the MMU is on, the TLB and the cache key are accessed in parallel. If the TLB has a match, then the cache may continue; otherwise, the MMU performs a table walk to find the translation. On the next try, the TLB tag and cache key are checked again; obviously the tag will have a hit, and if the cache has a hit it can supply data to the CPU. Otherwise the hardware will perform a cache fill cycle.

Only the bottom 16 Mbytes of address space cannot be cached. The remaining 4080 Mbytes can be cached if desired. It is controlled by the Cache Inhibit bit in the page table entry. Note: the CI bit only inhibits reading data into the cache; it does not inhibit hits on data that is already stored there.

Virtual Cache

The cache is virtual, so it requires purging after translation table changes or after DMA to memory. Translation table changes cause virtual addresses to no longer represent their former constituent system lines. Because of the virtual cache, monitoring of DMA accesses to automatically invalidate cache data would require prohibitively long reverse address translation. Therefore the operating systems are responsible for clearing the cache after every DMA, or else DMAing only to cache-inhibited pages. The cache has separate user and supervisor valid bits. Any particular cache line could contain invalid data, valid supervisor data, or valid user data. Each half is automatically selectively cleared on a write to the corresponding root pointer. This allows software selective purging of the user and supervisor portions of the cache.

More information can be referenced in these manuals:

- MC68020 Users Manual (09826-90073).
- MC68881 Users Manual.
- HP 9000 Series 300 Model 330/350 Accessory Designer's Guide (98562-90010).

Boot ROM and Self-Test LEDs

A Boot ROM (actually two chips) whose instructions are executed by the CPU shortly after power up is used on this processor board.

Test LEDs are visible through the front cover slots. Different patterns of onn and off (1s and 0s) correspond to binary or hexadecimal error codes. These codes help you find out what's working and what is not.

Chapter 4 provides an in-depth explanation of the Boot ROM functions. Chapter 5 explains the error codes and other troubleshooting processes.

Model 330 Processor Board

Introduction

The Model 330 processor board has the following major parts:

- 16.17 MHz MC68020 CPU.
- 16.67 MHZ MC68881 Floating-Point Coprocessor.
- 16.67 MHz MC68851 Memory Management Unit
- 6840 Timer.
- Boot ROMs.
- Self-Test LEDs.
- 4 Mbytes of RAM.

A comparison between both processor block diagrams shows other differences which are the Paged Memory Management Unit and 4 Mbytes of RAM. Refer to Figure 3-16 for the following descriptions.

Central Processing Unit

An MC68020 CPU is also used on the Model 330 processor board. It is clocked at 16 MHz.

Memory Management Unit

The Model 330 processor board uses the MC68851 MMU for its memory management. No cache is used on the Model 330 processor board.

MMU connections to the CPU are through the coprocessor interface. All accesses to registers within the PMMU are done by use of coprocessor instructions rather than memory mapped registers. Page size is 4 Kbytes or larger. The TLB is a 64-entry CAM containing the most recently used translations. When a miss in the TLB occurs the MMU requests the bus from the MC68020 and conducts its own table walks. When the translation is retrieved the bus is returned to the MC68020 which re-runs the cycle with the correct translation contained within the PMMU. The PMMU can address the 8 Mbytes of physical address space supported on Model 330 computers.

For more information on tables within the PMMU consult the MC68851 Users Guide.

On-Board RAM

Memory on the Model 330 processor board is similar to the 4 Mbyte RAM controller board. It's like the RAM controller board, but simpler in operation. A comparison between the RAM section of Figure 3-16 and the RAM controller diagram in Figure 3-19 shows the difference.

RAM Control

The DIO-II bus handles all data and address transfers. It also supports DIO bus masters. The system bus is not used on the Model 330 processor; there is no connector on the processor board for it.

RAM Configuration

Configuration of the Model 330 processor's 4 Mbytes of RAM is set by 10 dip switches. These switches allow the RAM controller to adjust to the CPU as well as configure in the optional 4 Mbyte and 12 Mbyte add-on board sizes. Processor board on-board RAM top address is set by these switches.

Switches are set to one of the 4M address boundaries starting at the top of RAM, address FFFFFFFF. Only the three most significant digits (MSD) of hexadecimal addressess are affected. As the first eight switches (S31, S30 ... S24) represent the two MSDs, the last two switches (S23, S22) can only change the third hexadecimal MSD by 4M addresses; the lower two binary positions of the third hexadecimal digit are implied as 1.

Two configurations are possible for Model 330 computers. They are shown in the next section under RAM Configuration.

Optimizing Model 330 System Performance

Each of the Series 300 operating systems (BASIC, Pascal, and HP-UX) are booted into different memory address ranges. Application programs are loaded into other memory address ranges. Depending on the operating system and application program used, frequently accessed memory addresses may or may not be in processor on-board RAM. If optimum performance is desired for a given application, this may be possible by readdressing processor on-board RAM to the addresses frequently accessed by the application.

Cycle time for processor board RAM is less than for HP 98258A/B/C RAM assemblies. This is due to the longer read/write cycles on the DIO-II bus to the optional 4 Mbyte RAM controller board. You may configure the Model 330 computer's memory so the application program spends the maximum amount of time executing in the processor's on-board RAM.

If a Model 330 computer system has the maximum of 8 Mbytes of RAM, one of the two configurations shown in Table 3-5 will optimize that system's performance. Here's what to do to determine which configuration works best:

1. Select a frequently-used program or routine as a benchmark.
2. Run and time the benchmark program enough to determine that it consistently executes in the same length of time.

   Note: in this example, memory is now addressed as shown in Table 3-5, Example 1.

3. Turn the computer off and change the processor and 4 Mbyte RAM controller board's switches to the configuration that had the fastest time.

   Doing this relocates the processor board RAM to the second 4 Mbyte block (FFB) whose top address is 1111 1111 10 as shown in Table 3-5, Example 2. The 4 Mbyte block of RAM previously occupying these addresses moves up to the top of RAM, 1111 1111 11 (FFF).

Note

Should an error be made in configuring memory, error messages may be displayed during power-up. Check the configuration switches on all RAM assemblies and the Model 330 processor board carefully.

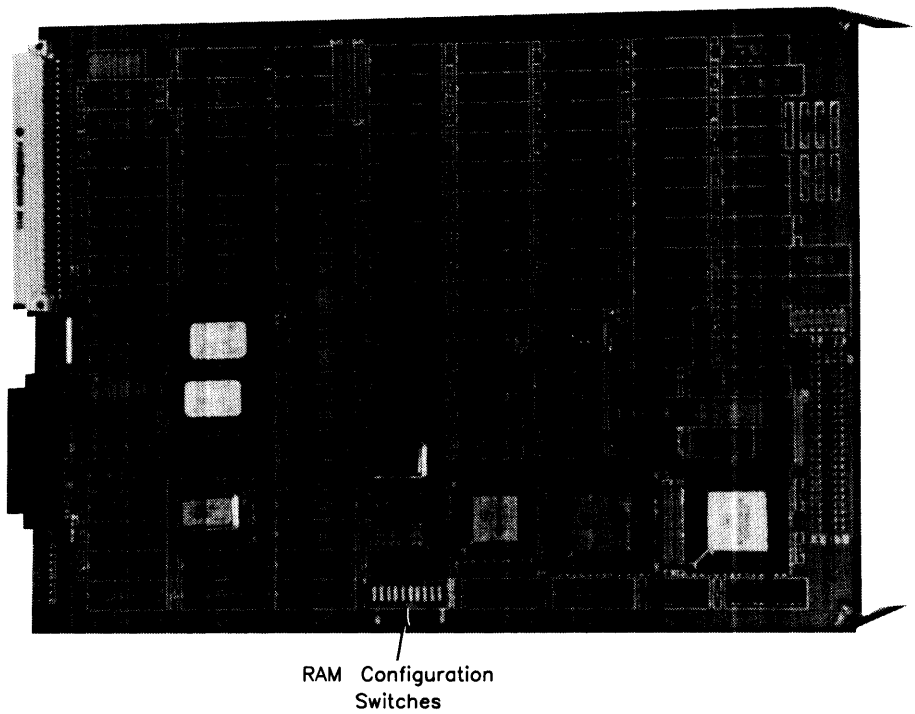


Figure 3-15. Model 330 Processor Board

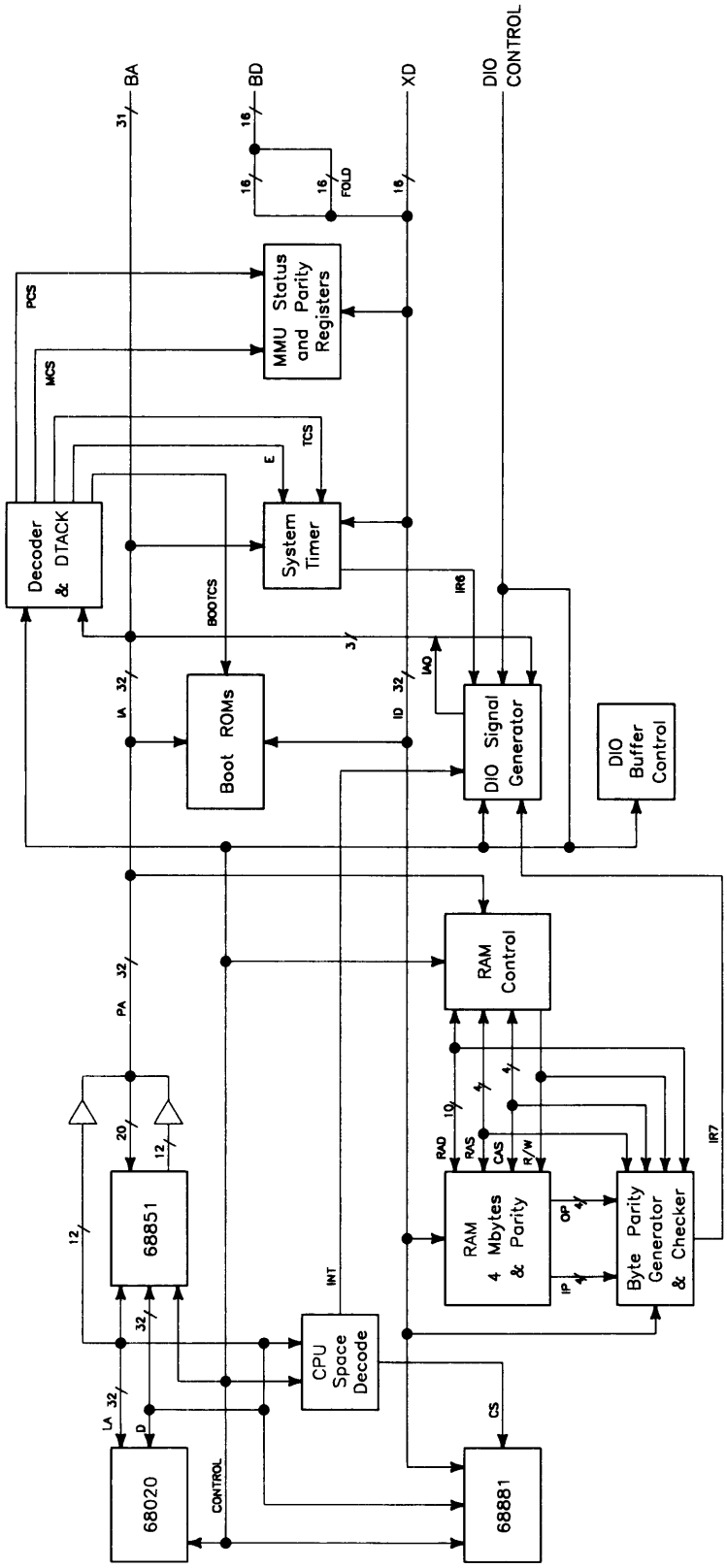


Figure 3-16. Model 330 Processor Board Block Diagram

Bus Architecture

Introduction

Two or three bus systems are used between the processor boards and memory or accessories and interfaces:

- System Bus – for fast RAM read/write cycles, Model 350 only.
- DIO Bus – for I/O operations with earlier Series 200/300 accessory cards.
- DIO-II Bus – for better I/O operations with the newer Model 330/350 interface and video boards.

Model 350 System Bus

Memory boards are tightly coupled to the Model 350 processor through a high-speed system bus. This allows much faster memory cycles and more RAM on memory boards. The system bus supports 32-bit addresses and data increasing maximum possible memory address space to 4 Gbytes. Synchronous to the processor clock, it supports a write cycle, a read cycle, and a quad-read cycle.

A 2-slot system bus connects the Model 350 processor to one RAM controller board and support up to 16 Mbytes of RAM. When the second RAM controller board is added for more than 16 Mbytes of RAM, the 3-slot system bus connects the processor board to both 4 Mbyte RAM controller boards.

Model 330 computers do not use the system bus. Memory cycles in the Model 330 will be slower than the Model 350.

DIO and DIO-II Bus

The standard 16-bit DIO (also used in the Model 310 and 320 computers) is used: all existing Series 300 I/O cards will function normally. In addition, new I/O boards are supported on DIO-II. DIO-II extends additional signal lines to some system slots, which allow 32-bit address and data transfer.

DIO-II supports standard Series 300 system size boards, as well as the newer 32-bit system boards. It is an extension of the DIO bus used on Model 310/320 computers. In the system slots, a second connector has been added that carries eight additional address lines, 16 additional data lines, and several new control signals. The processor drives the lower 23 address bits on DIO address lines, and drives the upper eight bits on the new address lines. The most significant sixteen bits of data are transferred on DIO lines, and the least significant 16 bits are transferred on DIO-II lines.

When the Model 350 processor is not performing I/O cycles, it does not need the DIO/DIO-II bus at all. Another bus master could obtain control of the bus while the processor continues running, using the system bus. This parallelism should allow very high throughput with DMA. However, memory circuits on the Model 350 processor board are connected to the system bus and not the DIO bus. Since the processor uses this bus to access the RAM, they are not available to external bus masters. In other words, only the CPU can access the Boot ROMs, MC6840 timer, self-test LED's, and MMU control registers.

DIO and DIO II are both asynchronous busses, with DIO II being a superset of DIO. The timing of DIO II has been changed from that of DIO. The master initiates a bus cycle by asserting the address and the appropriate address strobe(s) and data strobe(s). The slave then responds by taking the data off the bus during a WRITE cycle or by putting data on the bus during a READ cycle. The slave then completes the cycle by asserting one of the DTACK* (Data Transfer ACKnowledge) signals.

In DIO-II there are four distinct types of bus cycles:

- Address only.
- Single data transfer.
- Block data transfer.
- Read modify write (RMW).

DIO upgrades are available for the computer and expander to convert DIO-II system slots to 2- or 4-slots for use with standard DIO accessory cards. The earlier HP 98256A 256 Kbyte and HP 98257 1 Mbyte RAM cards are not supported in this configuration, due to bus timing and addressing differences.

RAM Boards

Introduction

Model 330/350 RAM boards consists of one controller board and two add-on boards listed in Table 3-2.

Table 3-2. Model 330/350 RAM Boards

Product No.	Product Name
HP 98258A	4 Mbyte RAM Controller Board
HP 98258B	4 Mbyte RAM Add-On Board
HP 98258C	12 Mbyte RAM Add-On Board

Either a 4 or 12 Mbyte Add-On board can be added to the 4 Mbyte RAM Board. With this arrangement, 4, 8 or 16 Mbytes of RAM in each system slot is possible. Maximum RAM in the system (inside the computer) is 32 Mbytes (two 16 Mbyte 2-board assemblies) for a Model 350. For Model 330 computers, 8 Mbytes of RAM is supported; 4 Mbytes on the processor board and one 4 Mbyte RAM controller board.

HP 98256A 256 Kbyte and HP 98257A 1 Mbyte RAM Cards are not supported on these computers; they won't function correctly.

Refer to Figure 3-19 for the RAM board block diagram.

RAM Architecture

Each RAM controller is a 4 Mbyte with parity RAM board for the Model 330/350 computers. The 4 Mbyte or 12 Mbyte add-on boards provide an additional 4 or 12 Mbytes of memory when installed on the controller board. When a 4 Mbyte add-on is attached to a 4 Mbyte RAM controller board, an 8 Mbyte RAM 2-board assembly is formed. In the same manner, if the 4 Mbyte add-on is used, a 16 Mbyte 2-board RAM assembly is formed.

The RAM controller board contains the control and interface circuits used for its memory and any add-on RAM board. In Model 350 computers, the board uses two busses, the DIO-II (the 32-bit extension to the DIO bus), and the system bus (a high speed memory bus between the RAM and Model 350 processor board). When running with a Model 350 processor, most data transfers will take place over the system bus. When the system bus is not used, as with the Model 330, transfers will take place on the DIO-II bus. In addition, all DMA transfers take place on the DIO-II bus.

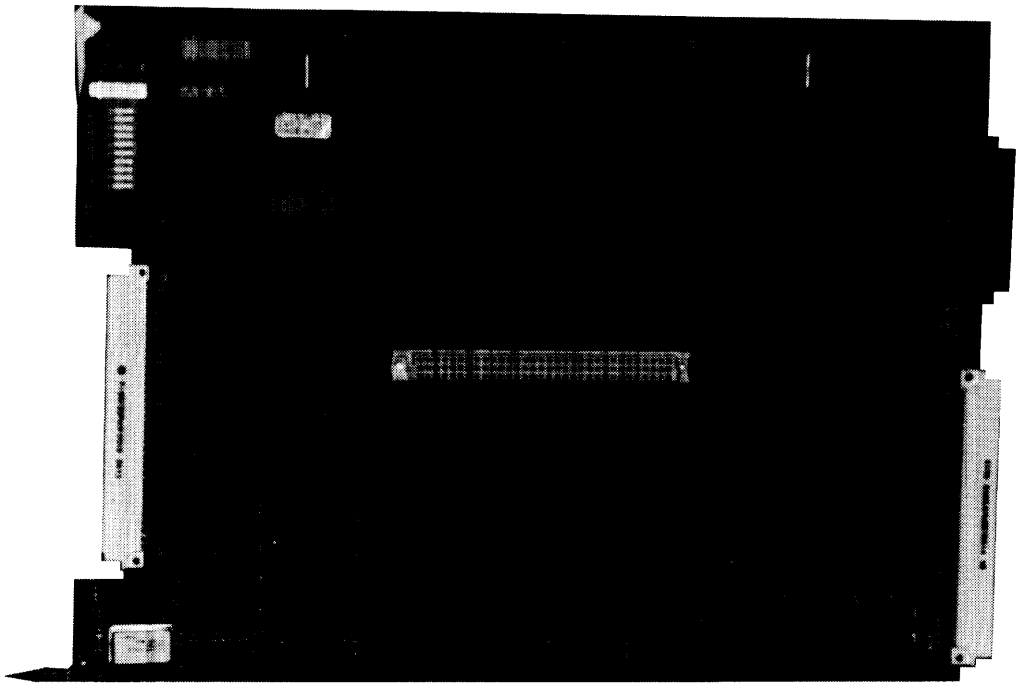


Figure 3-17. HP 98258A 4 Mbyte RAM Controller Board

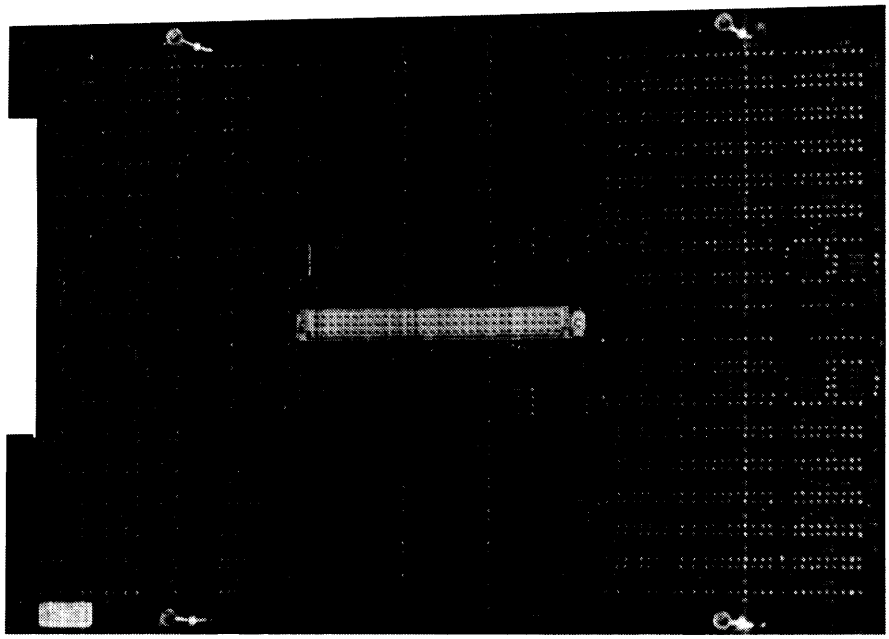


Figure 3-18. HP 98258B/C 4/12 Mbyte RAM Add-On Board

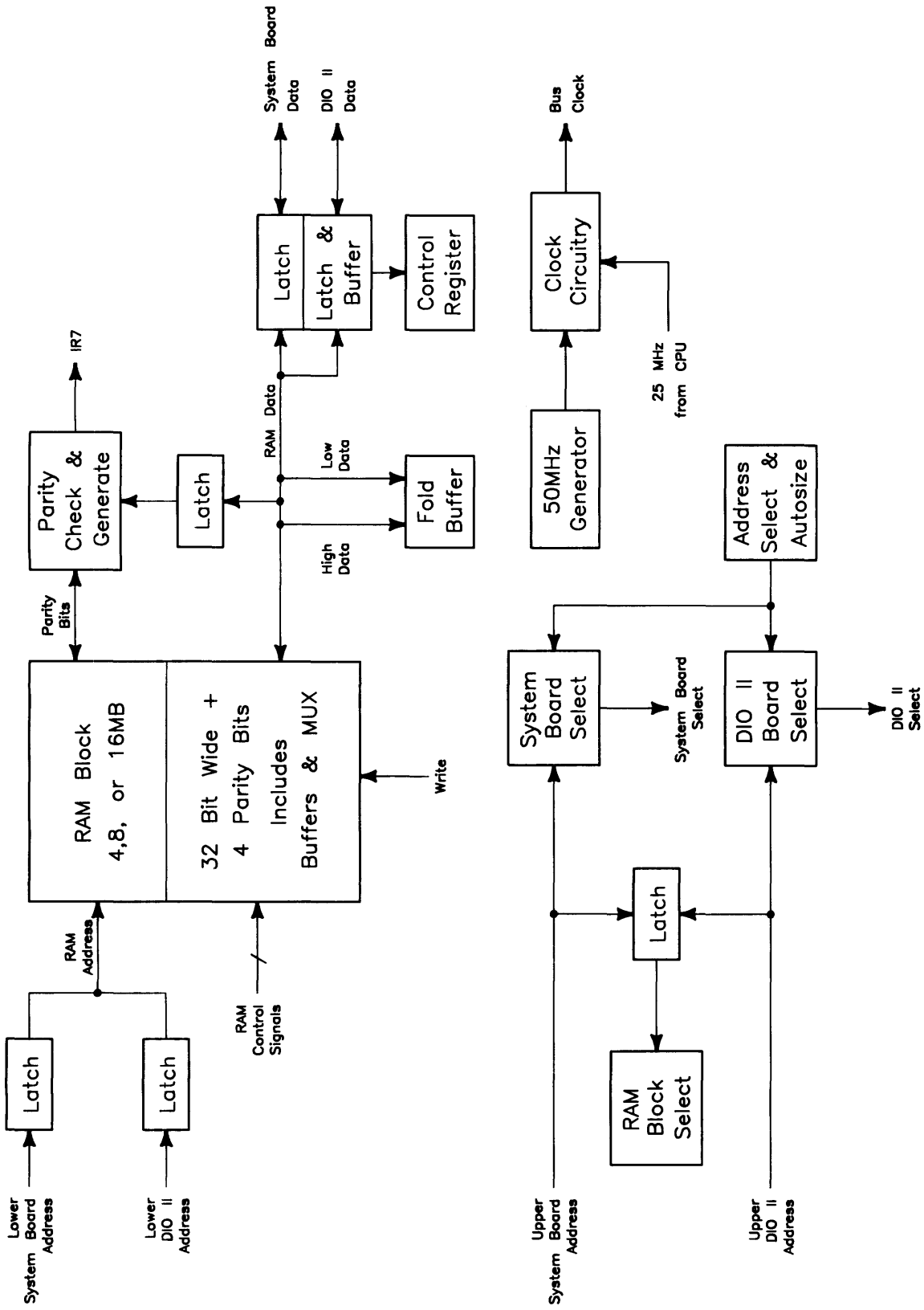


Figure 3-19. HP 98258A/B/C RAM Assembly Block Diagram

RAM Address and Size

The address select and autosize block contains ten switches to configure the 4 Mbyte RAM controller board and add-on board, if attached. Set the switches to locate the top address for the block. If an add-on board is added, the switches won't change because the autosize circuit locates the add-on RAM below the 4 Mbyte block on the RAM controller board. 4 Mbyte RAM controller boards used in the Model 330 must be configured next to the 4 Mbyte block on the Model 330 processor board, which also has RAM configuration switches.

RAM Clock

The 4 Mbyte RAM controller board is clocked by 25 MHz from the Model 350 through the system bus and the on-board 25 MHz clock is disabled. In Model 330 computers, the 25 MHz is generated from a 50 MHz crystal on the RAM controller board.

Board Select

A board select circuit will determine when the board is being accessed and will issue either system bus select or DIO-II bus select. The RAM block select circuit will determine which 4 Mbyte block is being accessed.

Write Cycle

For a write cycle, after select is issued, the lower address lines will be latched. Then the data lines are latched, and parity will be generated. Finally, both the data and the parity will be written to the appropriate RAM chips.

Read Cycles

Normal Read Cycle

For a normal read cycle, after select is issued, the lower address lines will be latched. Then the appropriate RAM chips will be read and parity will be checked providing parity is enabled. If there is a parity error, it is indicated to the CPU and data will be latched. If there is no parity error, the data will be latched to the data bus.

Quad Read Cycle

A cache fill read runs the same as a standard read, except 4 long reads are performed.

Fold Buffer

A fold buffer is used to 'fold' data from the upper 16 data bits to the lower 16 data bits, or the other way around. This is used when a 16 bit device, such as the DOS or high-speed disc interface board, accesses data that is stored in 32-bit format.

Control Register

The control register is used to turn on and off parity and to determine if interrupt was caused by a parity error.

Model 350 System Bus Data Transfers

The dual-ported 4 Mbyte RAM controller board supports a high-speed 32-bit synchronous system bus port and a 32-bit asynchronous DIO-II port. The DIO-II port also supports DIO bus masters allowing it to be used with either processor board as well as the HP 98286A DOS Coprocessor System.

RAM Configuration

Memory configuration and addressing is set by ten address switches on the HP 98258A 4 Mbyte RAM board. These switches determine the top address of a 4, 8, or 16 Mbyte block of RAM. When the Model 330 is configured, remember the 4 Mbytes of processor on-board RAM that must be contiguous with the 4 Mbyte RAM controller board if it's installed.

One or two 4 Mbyte RAM controller boards are supported on Model 350 computers. Only one is supported on Model 330s.

Setting Address Switches

RAM assemblies (either one of the three combinations of HP 98258A/B/C RAM boards must be configured on address boundaries equal to the RAM on the assemblies, In other words, 4 Mbyte assemblies can only be addressed to every 4M addresses starting from the top of RAM; 8 Mbyte 2-board assemblies at every 8M address; 16 Mbyte 2-board assemblies at every 16M address.

Ten RAM configuration switches (S31 (MSB) through S22 (LSB)) are used on the HP 98258A RAM Controller Board. They determine the addresses used on the assembly and are set to the top address in the block of RAM the assembly will respond to.

Switches are set to one of the 4 Mbyte RAM blocks starting at the top of RAM, address FFFFFFFF. Only the three most significant digits (MSD) of hexadecimal addresses are affected. As the first eight switches (S31 through S24) represent the two MSDs, the last two switches (S23, S22) can only change the third hexadecimal MSD by 4M addresses; the lower two binary positions of the third hexadecimal digit are implied as 1. Therefore, RAM is addressed in 4 Mbyte blocks.

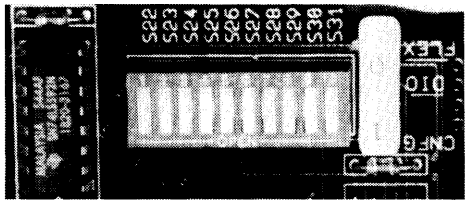
Table 3-3 lists all possible configuration switch settings for a Model 350 computer. As the Model 330 is limited to 8 Mbytes of RAM, only the top two switch settings are possible.

Table 3-3. HP 98258A/B/C RAM Configuration

Decimal Address	3 Hex MSDs	Switch Settings
4 294 967 295	FFF	1111 1111 11
4 290 772 991	FFB	1111 1111 10
4 286 578 687	FF7	1111 1111 01
4 282 384 383	FF3	1111 1111 00
4 278 190 079	FEF	1111 1110 11
4 273 995 775	FEB	1111 1110 10
4 269 801 471	FE7	1111 1110 01
4 265 607 167	FE3	1111 1110 00

Several Model 350 configurations exist, depending on what RAM assemblies are used. Table 3-4 shows three examples. RAM assemblies in examples include those with the 4 or 12 Mbyte add-on boards for the 8 and 16 Mbyte sizes. Arrows in the table indicate the 4 Mbyte address block(s) used by the Add-On RAM Boards.

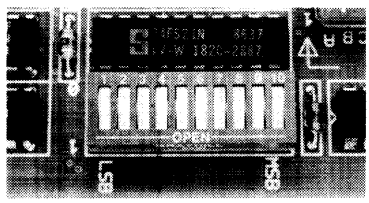
Table 3-4. Example Model 350 RAM Configurations



Block Top Address	Example 1, 32 Mbyte Total RAM Assy./Config. Sw.	Example 2, 16 Mbyte Total RAM Assy./Config. Sw.	Example 3, 20 Mbyte Total RAM Assy./Config. Sw.
FFF	16 Mbyte 1111 1111 11	8 Mbyte 1111 1111 11	4 Mbyte 1111 1111 11
FFB	↓	↓	16 Mbyte 1111 1111 10
FF7	↓	8 Mbyte 1111 1111 01	↓
FF3	↓	↓	↓
FEF	16 Mbyte 1111 1110 11		↓
FEB	↓		
FE7	↓		
FE3	↓		

As 8 Mbytes is the limit for Model 330 computers, two configurations are possible. Refer to Table 3-5.

Table 3-5. Example Model 330 RAM Configurations



Block Top Address	Example 1, 8 Mbyte Total RAM Assy./Config. Sw.	Example 2, 8 Mbyte Total RAM Assy./Config. Sw.
FFF	Proc. Bd. 1111 1111 11	4 Mbyte 1111 1111 11
FFB	4 Mbyte 1111 1111 10	Proc. Bd. 1111 1111 10

Video Boards

Introduction

Video boards allow the computer to send bit-mapped display information to medium or high resolution monitors. The user may upgrade his computer system from medium to high resolution by installing a different board. Upgrading is accomplished through an exchange program. It may be performed by the user with common tools without CE support.

One monochromatic and two color video boards are available for the HP Series 300 computer systems. The color boards provide four-plane color display capability allowing the user to display 16 colors from a palette of over 16 million colors. A description of these boards follows:

- HP 98542A Medium-Resolution Monochromatic Video Board. This version displays 512 by 400 pixels and drives the low resolution monochromatic monitors.
- HP 98543A Medium-Resolution Color Video Board. This version displays 512 by 400 pixel pairs and drives the low-resolution color monitors.
- HP 98544B High-Resolution Monochromatic Video Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.
- HP 98547A High-Resolution Color Video Output Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.

These boards make extensive use of large scale integrated (LSI) circuits. Up to six (depending on the board) NMOS III Display Controller chips provide an integrated bit mapped display with window-move hardware and frame buffer support. Color mapping is entirely handled by another NMOS III chip called the Frame Buffer Controller. This chip performs color mapping and D to A conversion. Video memory consists of uses nibble-wide (4-bit) Display RAM (DRAM). The major difference between these assemblies is the amount of DRAM each has.

Video boards perform the similar functions, which are:

- Establish display clock frequency in the computer system.
- Initialize according to the specific monitor used.
- Identifies itself and set character shape by ID/FONT ROM.
- Respond to interrupts on DIO/DIO-II bus to change color map data.
- Control the display RAM maps.
- Color boards output Red-Green/Sync-Blue Video to the color monitor.
- Monochromatic boards output Video/Sync to the monochromatic monitor.

Each of these is explained in the following functional description. Refer to Figure 3-21.

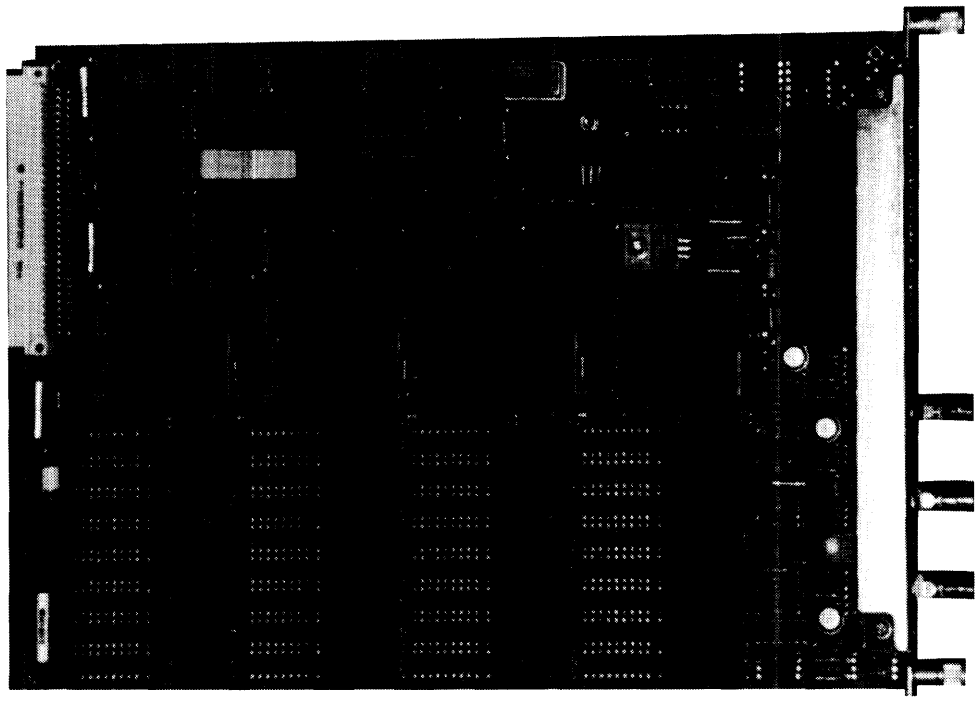


Figure 3-20. Typical Video Board

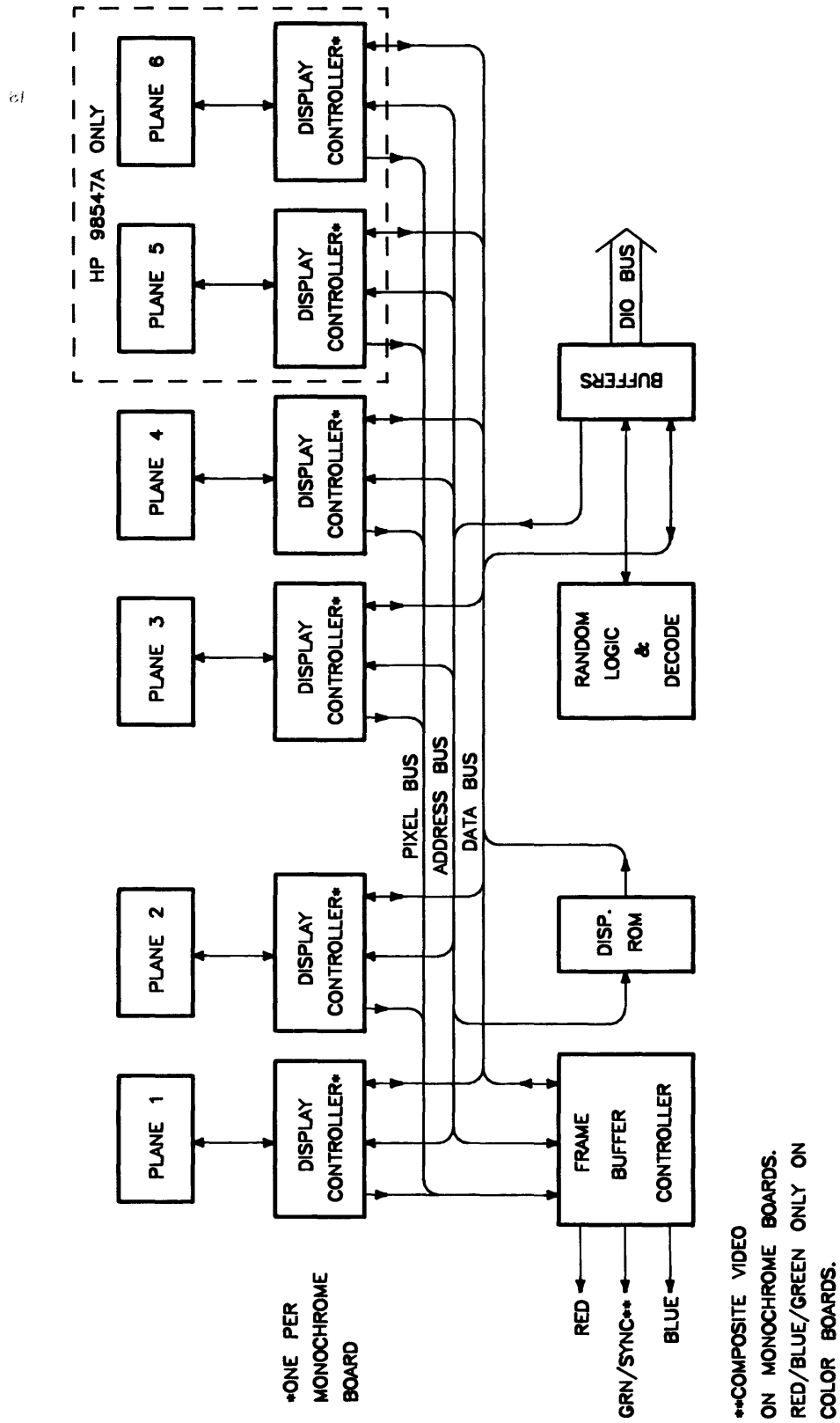


Figure 3-21. Typical Video Board Block Diagram

Video RAM

Both high- and medium-resolution color video boards have four or six planes of memory. The medium-resolution board uses eight memory chips per plane. This is enough to display 512 doubled pixels by 400 scan lines. High-resolution boards requires more memory chips per plane. Resolution is 1024 by 768 single pixels.

Table 3-6 shows how the display RAM is organized for the desired resolution for each board.

Table 3-6. Video Board RAM and Resolution

Video Board	RAM chips	Total RAM	Resolution
HP 98542 Med-Res Monochrome	8	64 Kbytes	512 by 400
HP 98543 Med-Res Color	32	256 Kbytes	512 by 400
HP 98544 High-Res Monochrome	16	128 Kbytes	1024 by 768
HP 98547 High-Res Color	64	512 Kbytes	1024 by 768

Color Mapping

Color boards have four or six plane color mapping. Mapping is entirely under control of the Frame Buffer Controller. The high-resolution board has more RAM than the medium-resolution board.

Display Controller

The Display Controllers are the heart of these video boards. They provide complete video control and bit-mapped alpha support for one graphics plane. Interfacing directly with the computer CPU, it integrates and manages most display functions. The functions of the Display Controllers are:

- Provide horizontal and vertical timing signals to the sweep section of the video board.
- Provide refresh data to the frame buffer.
- Generate the blinking underline cursor.
- Enable window move operations.
- Output video and sync signals to the frame buffers.

Architecture provides for either color or grey-scale monochromatic display use. The display is organized with one memory byte for each display pixel. This corresponds to a maximum capability of eight planes with one byte per pixel per plane. Each bit in the byte goes to a separate frame buffer memory plane. Pixel data is transferred 32 bits (or pixels) at a time by read and write operations with display RAM by the video board. Logic internal to this chip enables software to perform byte-per-pixel access.

Frame Buffer Controller

The Frame Buffer Controller resides on two busses; the computer's DIO bus, and the frame buffer data bus. It performs the following functions:

- Receives frame buffer data for DRAM refresh.
- Maps 4 bits per pixel into 256 colors out of more than 16 million possibilities.
- Generates graphics video outputs.
- Allows the CPU to read and write the color map.

Communication on the CPU bus consists of register reads and writes in byte format under control of the CPU. On the memory bus, communication consists of frame buffer word loads under control of the Color Display Controller.

Video Output

Video output is compatible with several HP monitors. Standard Red, Green (with sync), and Blue outputs are available through BNC connectors on the color boards. For monochromatic boards, composite video with sync is output through a single BNC connector. In

For color boards, a data merging circuit in the Frame Buffer Controller combines color and blanking data from the display memory into a 24-bit data stream. Three digital to analog converters change this data stream into a current source for each of the three color outputs. These outputs connect through cables to the video amplifiers in the color monitor.

Display RAM Control

Frame buffer and the Frame Buffer Controller register set are fixed in internal address space. Frame Buffer Controller registers and the processor board's Frame Buffer Controller both use the same addresses.

Interrupt Structure

The interrupt structure is similar to DIO interrupts. On receiving an interrupt and verifying the interrupt is coming from the video board, the CPU must then poll the video boards to determine the interrupting device.

Identification and Font ROM

Each video board has an ID/FONT ROM. This is a 16 Kbyte wide ROM that supplies the CPU with information about the video board type. Initialization and dot clock frequency information is also provided.

Alpha character font is the size and shape of the dot matrix used to create letters, numbers, and other keyboard symbols. The system monitor will display the font defined in the ID/FONT ROM during computer power-up and self test. If another font is required for the application, the operating system or application software can specify another available font to be used. Standard FONT, or pixel display matrix for the video boards is shown below:

Video Board	Character Matrix	Character Cell
Medium-Resolution	9 by 12	10 by 15
High-Resolution	6 by 10	8 by 16

Clocks and Timing

The display clock frequency is different for each video board. At power-up, the CPU executes instructions from the Boot ROM to determine the presence of and type of the video board. Data in the ID/FONT ROM is placed in a Display Controller register to set the display clock frequency.

System Interface Board

Introduction

The HP 98247A System Interface Board meets most, if not all, I/O needs of the Design Automation marketplace. Functions possible with this board card includes:

- RS-232.
- HP-IB.
- Audio Jack.
- HP-HIL.
- LAN.
- DMA.
- Optional High-Speed Disc HP-IB Interface Add-On.

The system interface board allows this wide range of interfaces at the minimum cost. The LAN and optional high-speed disc interface add-on allows users to choose the interfaces that are necessary for their application.

To maintain software compatibility, the designs of several existing interface cards used in the Models 310/320 were integrated together. Cards emulated on the system interface board are:

- HP 98625B High-Speed Disc Interface.
- HP 98643 Local Area Network (LAN)/300 Link.
- HP 98620B DMA Controller.
- 98561-66532 Human Interface Card.

Each of these sections of the board operates independently from one another. Interfaces are identical to the earlier 98561-66532 Human Interface Card. Software compatibility is assured.

Figure 3-23 is a block diagram of the system interface board. Refer to this diagram for functional descriptions.

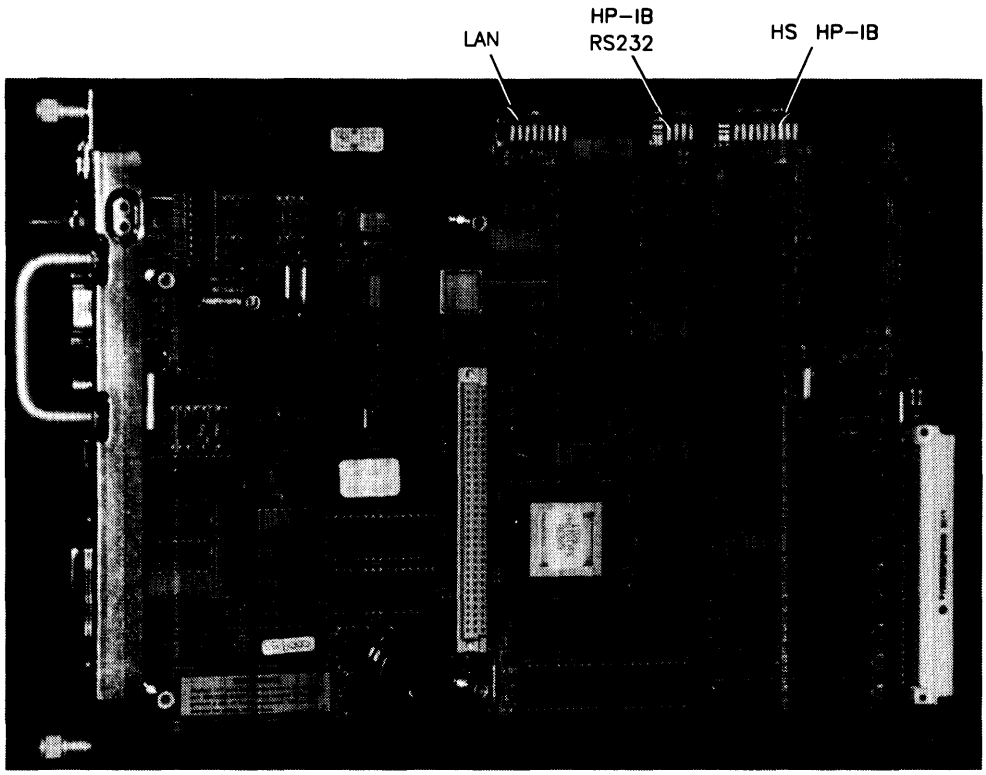


Figure 3-22. System Interface Board

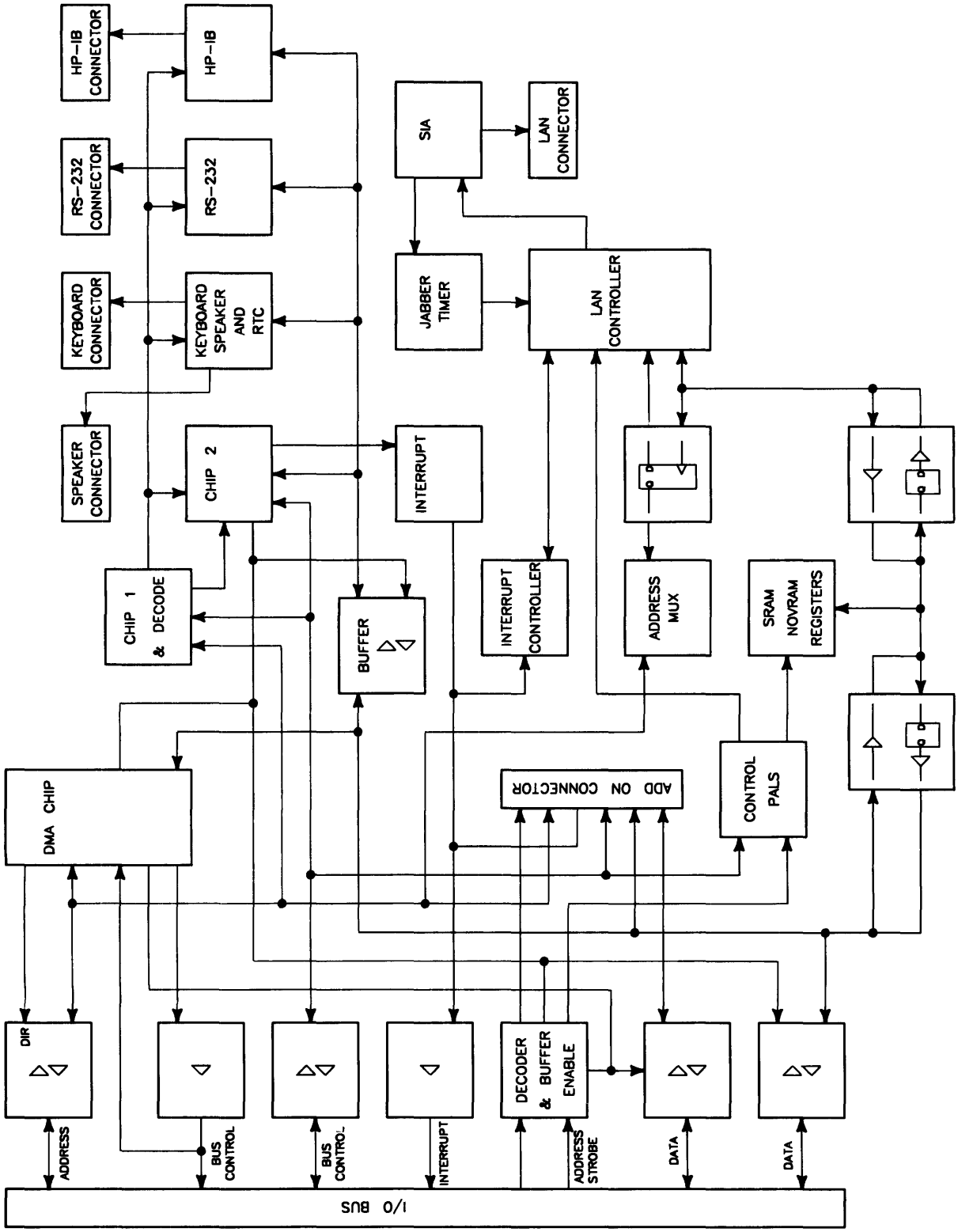


Figure 3-23. System Interface Board Block Diagram

Direct Memory Addressing

DMA chip architecture is a compatible superset of the HP 98620B DMA Controller which is used with HP 9000 series 200 and 300 computers. The chip is a Standard-Cell design implemented in a CMOS process.

Refer to Table 3-7 for DMA specifications.

Table 3-7. DMA Specifications

Feature	Specification
Input Clock	10 MHz
Channels	2
Channel Priority	Programmable, high or low, each channel
Channel Arbitration	Round-robin
Bus Arbitration	DIO daisy chain
Transfer Types	8-bit (byte) 16-bit (word) 32-bit (long word)
Max Transfers	4G transfers per arming
Bus Bandwidth Use Limits	Programmable: 100%, 50%, 25%, 12.5%
Min Cycle Time	300 ns
Max Theoretical Transfer Rate	13.3 Mbytes/sec
Typical Burst Transfer Rate	2.8 Mbytes/sec (word transfers to RAM controller boards
Interrupt levels	Programmable: 7, 6, 5, 4, 3
Address range	FFFFFFFF - 00000000

LAN Interface

Local Area Network (LAN) functions are divided into three areas:

- Backplane interface to the DIO-II bus.
- Shared memory area.
- Frontplane interface to the network.

Interface with the DIO-II bus includes select code decoding, interrupt control, data bus buffers and latches, and address multiplexers. A 16-bit wide data bus is used.

The shared memory area has the memory controller circuits, 16 Kbytes of RAM, 64 nybbles of nonvolatile storage of the node address, and standard DIO control, status, and ID registers. Multiplexing of DIO-II information and the LAN chip set is also part of the controller circuit.

Frontplane circuits include the LAN chip set, timer, and the transceiver chip. The LAN chip set serves the dual function of a DMA controller and an Ethernet/EEEE 802.3 controller. Encoded data from the SIA is transmitter by the transceiver chip. Data from the network is sent by the transceiver chip to the SIA.

The LAN portion of the board is software compatible with the HP 98643 LAN/300 Link Card.

Eight DIP switches on the system interface board control the following LAN functions:

- Select Code, 0 through 31.
- Interrupt Level, 3 through 6.
- Local/Remote.

Switches for LAN interface configuration are explained Table 3-8. Refer to the picture of the system interface board, Figure 3-22 for its location.

RS-232 Interface

An RS-232 Interface section is part of the system interface board's electronics. Using an INS8250 UART, it's almost identical to the HP 98644A RS-232 Serial Interface Card. It differs from the HP 98644A Interface Card in that it:

- Allows interrupts at level 5 only. There are no switches to change the interrupt level is the same as the HP 98644 Card.
- Permanently sets the select code to 9. The HP 98644 card has switches which allow this address to be changed.
- Does not allow reconfiguration to change the RS-232's ID to that of the HP 98626 card.

Three switches on the system interface board are associated with RS-232. Located on the HPIB/RS232 configuration switch, they perform the following functions:

- **REM** – Controls the local/remote bit in the ID register.
- **MEN** – Sets the handshake input lines to their default condition, all ones.
- **DIS** – Disables the RS-232 at select code 9 so it won't be found. all ones.

In addition to the registers built into the INS8250 UART, two external register have also been implemented. Both sets of registers are multi-mapped within a 64 Kbyte region of memory associated with I/O select code 9.

HP-IB Interface

Hewlett-Packard Interface Bus (HP-IB) is HP's version of the IEEE 488 interface standard. HP-IB on this board is much like HP-IB implementations on other HP 9000 Series 200/300 computers. It uses a TMS9914 HP-IB controller which allows data transfer rates up to 450 Kbytes/second. The TMS9914 is a memory-mapped I/O device which is multiple-mapped within a 64 Kbyte internal I/O device.

Two registers control hardware which can generate an interrupt as a result of a HP-IB device responding to a parallel poll. It has the ability to generate an interrupt from a parallel poll response. For this feature, two registers external to the TMS9914 are used. These registers are in addition to the two external registers that exist for internal HP-IB interfaces in other Series 200 computers.

All registers associated with the HP-IB are multiple mapped within a 64 Kbyte block of memory in the internal I/O address range.

One configuration switch for HP-IB system controller is on the system interface board. Located on the HPIB/RS-232 configuration switch block, the SC switch is set to 1 if the computer is the system controller or 0 if not.

Information on the TMA9914A and its registers can be found in the 'TMS9914A General Purpose Interface Bus (GPIB) Controller' Data Manual.

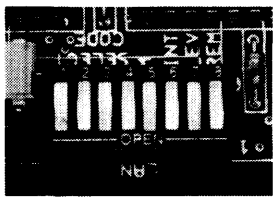
Configuration Switches

Three DIP switch blocks on the system interface board configure interfaces for:

- Local Area Network (Table 3-8).
- HP-IB and RS-232 (Table 3-9).
- High-Speed Disc Add-On (Table 3-10).

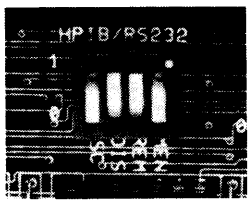
Refer to the picture of the system interface board, Figure 3-22 for its location.

Table 3-8. Eight LAN Configuration Switches



Switch Label	Function/How It's Used
$\overline{\text{SELECT}}$ (1 - 5)	Select Code: 1 (L) is LSB, 5 (M) is MSB. (Shipped with 10100, SC-20)
INT (6) LEV (7)	Interrupt Level: LEV (7) is MSB 7 6 - - 0 0 = Level 3 0 1 = Level 4 1 0 = Level 5 (Shipped setting) 1 1 = Level 6
REM (8)	Local/Remote 0 = Local (Shipped setting) 1 = Remote

Table 3-9. HP-IB and RS-232 Configuration Switches



Switch Label	Function/How It's Used
MEN	Modem Enable 1 = Modem lines enabled (Shipped setting) 0 = Modem lines disabled
REM	Remote Terminal Enable 1 = Remote Mode 0 = Local Mode (Shipped setting)
DIS	RS-232 Disable 0 = Enabled(Shipped setting) 1 = Disabled
SC	Internal HP-IB System Controller 1 = System Controller (Shipped setting) 0 = Not System Controller

High-Speed Disc Add-On

Refer to Figure 3-25 for this description

The high-speed disc interface add-on is identical to the HP 98625B card. It allows word wide transfers during DMA cycles and is fully supported by software. Because of limited space, the High Speed Disk card is implemented on a separate board. This board configuration has the benefit of allowing users to order the HP 98262A High-Speed Disc Add-On to upgrade their system interface board.

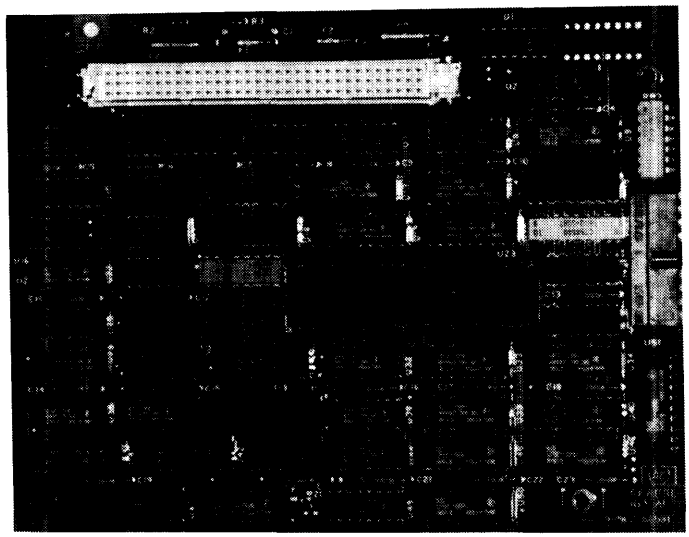


Figure 3-24. High-Speed Disc Add-On Board

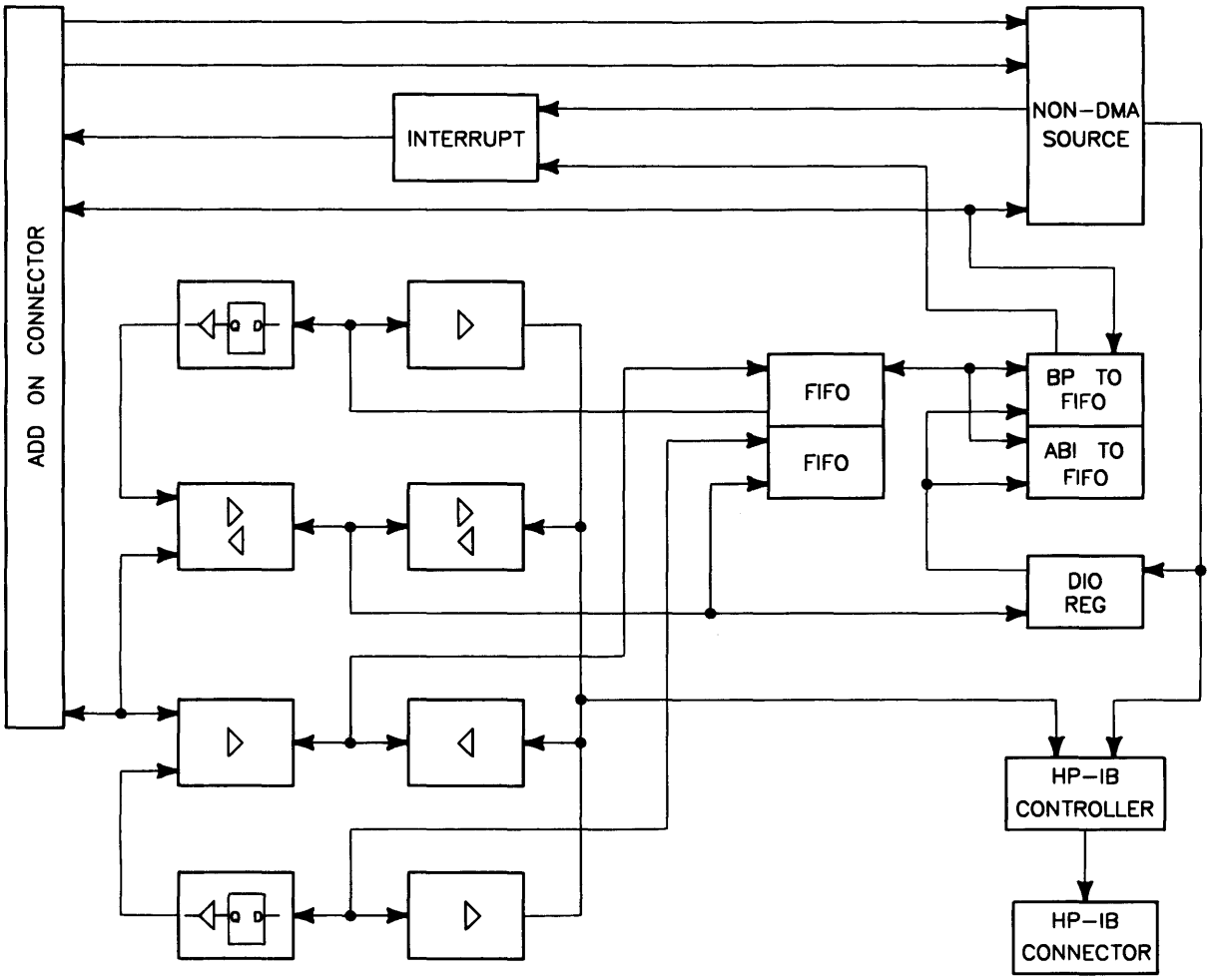


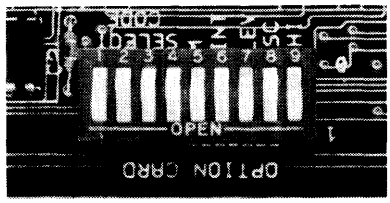
Figure 3-25. High-Speed Disc Add-On Board Diagram

The optional high-speed disc interface configuration switches control:

- Select Code, 0 through 31.
- Interrupt Level, 3 through 6.
- System Controller.
- Low/High Speed.

Switches on the system interface board for high-speed disc interface configuration are shown in Table 3-10. Refer to Figure 3-22 to locate these switches.

Table 3-10. High-Speed Disc Add-On Configuration Switches



Switch Label	Function/How It's Used
$\overline{\text{SELECT}}$ (1 - 5)	Select Code: 1 (L) is LSB, 5 (M) is MSB Shipped with SC-14
INT (6) LEV (7)	Interrupt Level: LEV (7) is MSB 7 6 - - 0 0 = Level 3 0 1 = Level 4 (Shipped setting) 1 0 = Level 5 1 1 = Level 6
SC (8)	System Controller 1 = System Controller (Shipped setting) 0 = Not System Controller
LOW (9)	Low/High Speed 0 = Low Speed 1 = High Speed (Shipped setting)

HP-HIL Devices

Introduction

Hewlett-Packard Human Interface Link (HP-HIL) is an HP standard for interfacing Series 300 computers and other workstations to human input devices. A list of HP-HIL devices is shown in Table 3-11.

Asynchronous serial communications protocol enables you to select a set of input devices, connect them to your computer, and work with any application program.

A link controller on the system interface board controls the HP-HIL. Each HP-HIL device has an circuit to interface information to and from the device. Limitations for the HP-HIL are:

- Up to seven devices can be on the link.
- Maximum distance between devices is 2.4 metres, total link maximum length is 16.8 metres. This does not include the 15 or 30 metre extensions.
- Series 300 Maximum link current is 1 A.

Link Controller

A block diagram of a typical link controller is shown in Figure 3-26.

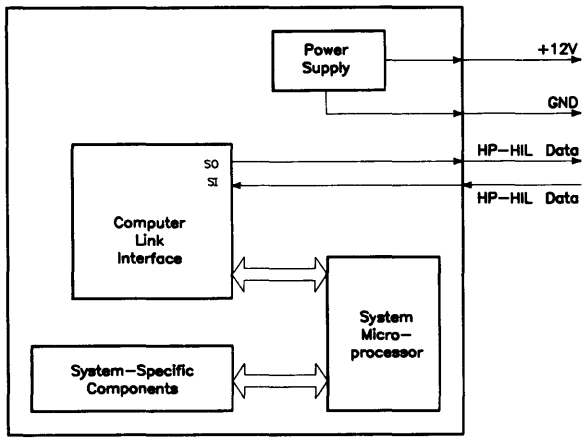


Figure 3-26. HP-HIL Link Controller Block Diagram

Power Supply

One voltage, +12 Vdc is taken from the host computer and output as a regulated power supply to external devices on the link. Up to 1 A can be supplied to devices. When configuring HP-HIL devices with Series 300 computers, care must be used to ensure the total power drawn by all devices does not exceed 1 A. In Table 3-11, devices are listed with their power requirements.

Table 3-11. HP-HIL Devices and Power Requirements

Product Number	Device Name	Milliamps	Watts
HP 35723A	Touchscreen Bezel	250	3.0
HP 46021A	ITF Keyboard	100	1.2
HP 46021A	ITF Keyboard	145	1.74
HP 46060A	HP Mouse	200	2.4
HP 46080A	Extension Module	25	0.3
HP 46081A	3 Metre Ext.	25	0.3
HP 46082A/B	15/30 Metre Extension[1]	50	0.6
HP 46083A	Rotary Control Knob	110	1.32
HP 46084A	ID Module	60	0.72
HP 46085A	Control Dials	350	4.2
HP 46086A	Button Box	80	0.96
HP 46087A[2]	"A"-Size Digitizer[2]	200	2.4
HP 46088A[2]	"B"-Size Digitizer[2]	200	2.4
HP 46094A	Quadrature Port Device[3]	80	1.2
HP 46095A	Three-Button Mouse	80	0.96
HP 92916A	Barcode Reader	100	1.2

Notes:
[1] Extension cables have two boxes, each draws 25 mA.
[2] Includes HP 46089A 4-Button Cursor.
[3] Port devices require 80 mA; devices attached cannot exceed 120 mA.

Computer-Link Interface

Model 350 computer DIO bus architecture is interfaced to the HP-HIL microprocessor in these circuits. They allow device input data to be used by the host computer.

Microprocessor

The HP-HIL microprocessor on the computer's assembly provides support for link protocol and is responsible for:

- Configuring the link.
- Processing input device data.
- Error recovery.
- Initiating commands onto the link through the Link Interface.

Link Interface

Data is exchanged between the device and the host computer through the link interface. It accepts commands from the microprocessor for transmitting and receiving messages in an HP-HIL frame format.

Each frame is a 150 μsec long, 15-bit fixed format. A frame is shown in Figure 3-27.

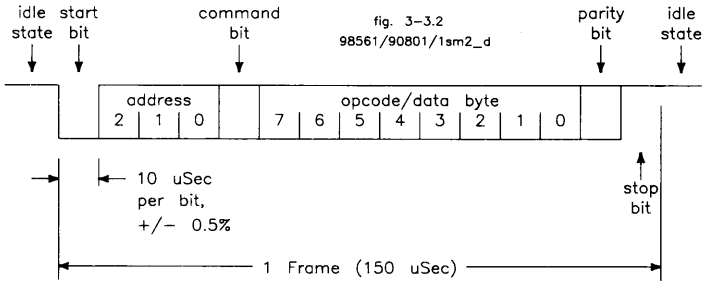


Figure 3-27. HP-HIL Frame Structure

Frames may be sent up to once each 154 sec allowing data transfer rates of up to 6500 bytes/second. HP-HIL protocol performs automatic configuration, identification, and polling of up to seven devices. Error recovery, device and system reset, and simple output commands provide a simple device integration.

When the computer is turned on, the link is polled for devices. Each device on the link has its own ID which is sent to the computer and stored in memory. The link is polled 60 times per second. Should a device have data to input to the computer, it sends its data frame to the computer for processing. As each device's frames has its own address in a 3-bit word, no more than 7 devices can be used on the link at one time.

HP-HIL Cables

A four-wire cable connects HP-HIL devices to each other and to the computer. AMP Shielded Data Link (SDL) connectors are used and are easily installed and removed from the computer or device. Keyboard cable connectors are keyed and are marked with dots to indicate where they are connected. Figure 3-28 shows the connector pinouts.

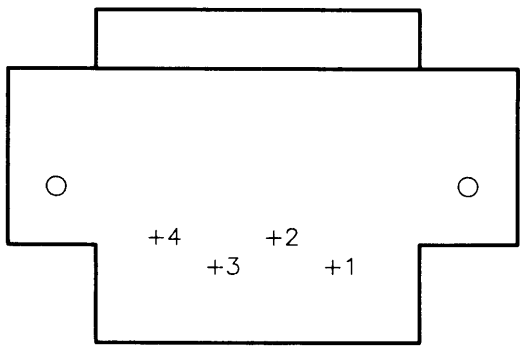


Figure 3-28. HP-HIL Cable Connector

Device Controller

A block diagram of a typical device controller is shown in Figure 3-29.

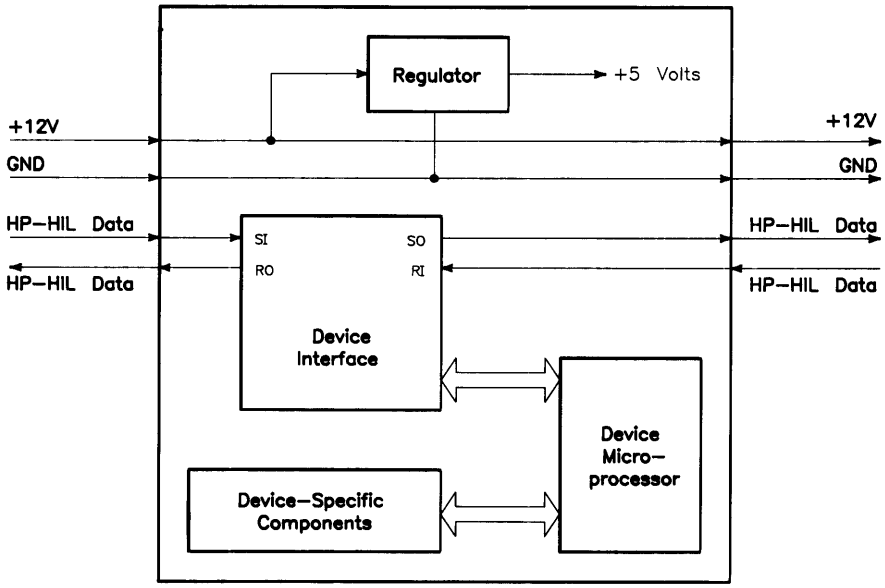


Figure 3-29. HP-HIL Device Controller Block Diagram

Regulator

From the HP-HIL cable, +12 Vdc is regulated down to +5Vdc for use by device components. The +12 Vdc input is also sent to components needing that supply.

Device Interface

The device interface serves as the communication link between the device and system HP-HIL microprocessor. In addition to transmitting and receiving data, it also interrupts the device microprocessor when a correctly addressed data frame or improper format is received. It also provides device hardware reset, lowers the NMI line at power-up and at device hard reset command.

Device Microprocessor

Tasks performed by the device microprocessor include maintaining the interface, data sending and receiving tasks. It also converts device information to data for the device microprocessor to send to the computer as human input information.

Device-Specific Components

Various components are used depending on the device. Digitizers, keyboards, knobs, and a host of other human input functions are converted to data for the device microprocessor. Each device will have its own specific components, depending on the input task details.

Display Compatibility Interface

Introduction

An HP 98546A Display Compatibility Interface enables bit-mapped video from the computer to be compatible with the HP 35721, HP 35731, and HP 35741 monitors when one of the following operating systems is used:

- HP Series 200 BASIC 2.0, 2.1, and 3.0.
- HP Series 200 Pascal 2.0, 2.1 and 3.0.

Two DIO cards are used and each may be individually replaced. These items are included in the package:

- Video Card.
- Graphics Card.
- Various video cables

Both cards are installed in adjacent DIO card slots. The video card must be in a DIO interface slot with the graphics card in the accessory slot directly above the video card.

This two-card set has the following functions:

- Bit-Mapped Video Input
- Katakana or Roman 8 Character font.
- 50 or 60 Hz Refresh Rate Selection
- Alpha and/or Graphics Video Output

Figures 3-31 and 3-33 are block diagrams of the cards. Refer to these diagrams for functional descriptions.

Video Card

Input Video

Bit-Mapped video from a video board is input to the video card through the BNC connector labeled **Video In**. The card contains a relay that selects either the externally supplied video signal (from another video board) or the on-board generated alpha/graphics video to be sent to the monitor.

Timing and Drivers

Timing clock signals and video driver circuits required to interface the graphics card are on the video card. Vertical sync circuits are controlled by the position of the 50/60 Hz monitor refresh rate switch. Both vertical and horizontal sync pulses are output to the video circuits to be part of the composite video output.

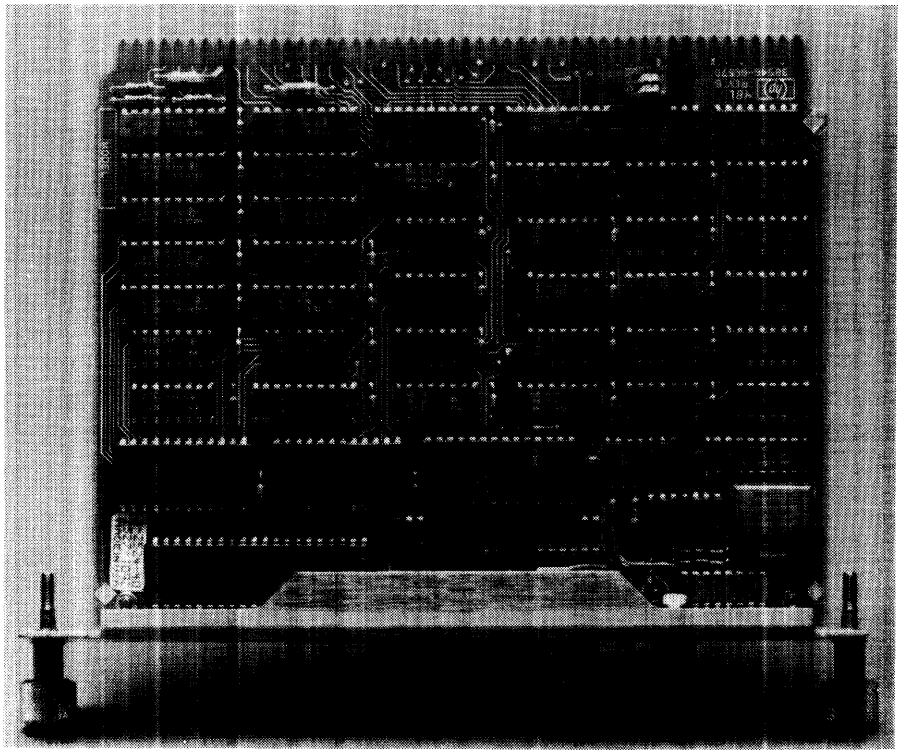


Figure 3-30. HP 98546A Display Compatibility Interface Video Card

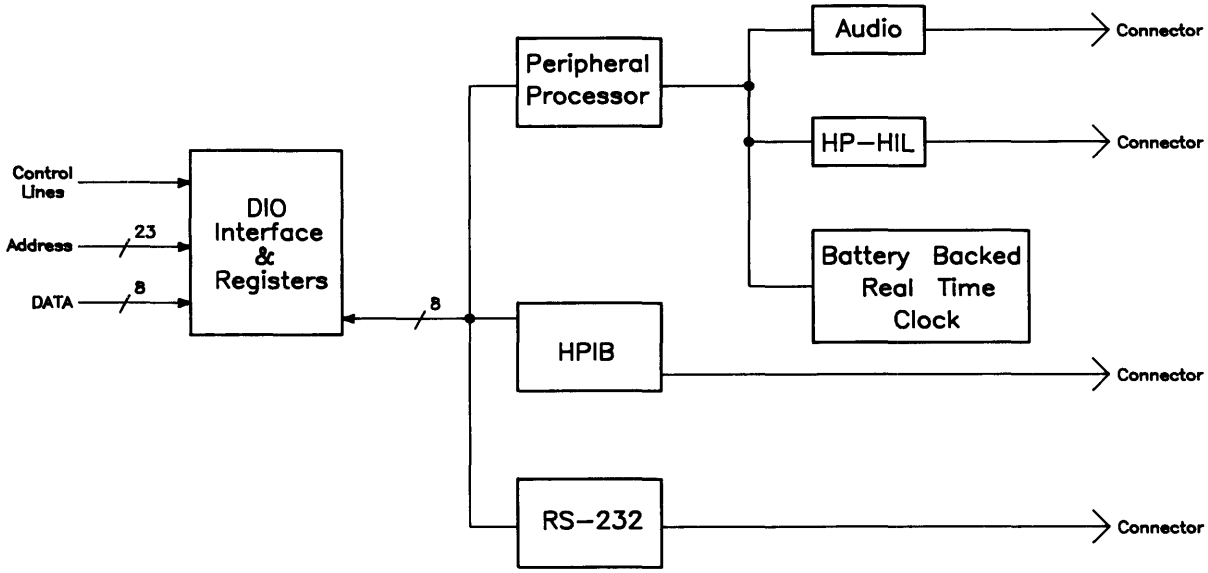


Figure 3-31. HP 98546A Display Compatibility Interface (Video) Block Diagram

Alpha Video

Alpha video is stored in on-board RAM and provides 25 lines of text with 80 characters per line. Provisions for inverse video and half-bright user-definable key labels in the bottom two display lines are enabled through software programming. Text is 8-bit ASCII modified for the monitors supported. A switch determines whether Katakana or Roman 8 character font will be used.

Configuration Switches

Two switches determine display refresh rate and alpha character font. Refresh rate is determined by the switch farthest from the edge connectors and should be set to the line voltage frequency. Otherwise, the monitor's display may flicker. A 50 Hz and 60 Hz position is available and the printed circuit board is labeled accordingly next to this switch.

The switch nearest the edge connectors determines the character font. When the computer system is used in Japan, or when BASIC or Pascal operating systems with revisions lower than 3.0 is used, this switch should be placed in the 0 position to enable the Katakana characters to be displayed. For all other countries, the switch should be placed in the 1 position to enable the Roman 8 style of characters. Labeling on the printed circuit board next to the switch with a 0 and 1 identifies the respective switch positions.

Video Output

Alpha and/or graphics Video is combined with sync pulses from the timing circuits as a composite video signal. Video is output from the **Monitor** BNC connector on the video card's rear panel.

When graphics mode is selected by software, graphics video from the graphics card is input to the video card and output from the BNC connector labeled **Monitor**. When alpha video is selected, alpha video is output from the same connector. This type of video is called separate alpha/graphics video.

For systems using a color monitor with this card set, the green video with sync is input from the color video circuits in the computer and is processed the same as composite monochrome video. The **Monitor** output, which in this case is green video with sync, is connected to the green input connector on the color monitor. Red and Blue outputs from the video board in the system slot are fed directly to the Red and Blue input connectors on the color monitor.

Graphics Card

Circuits required to control the graphics video are on the graphics card. This card is the same one used with the HP 98204 Composite Video Cards for Series 200 computers.

Graphics Video

Inputs from the video card through the ribbon cable are converted to a 390 by 512 graphics display and stored in on-board RAM. Graphics memory is organized such that the first 8 pixels displayed in the upper left-hand corner of the display correspond to the first byte of memory in graphics RAM. Each succeeding byte corresponds to the next 8 pixels to the right in the graphics display.

Graphics Video Output

Graphics video is sent back to the video card through the ribbon cable connector.

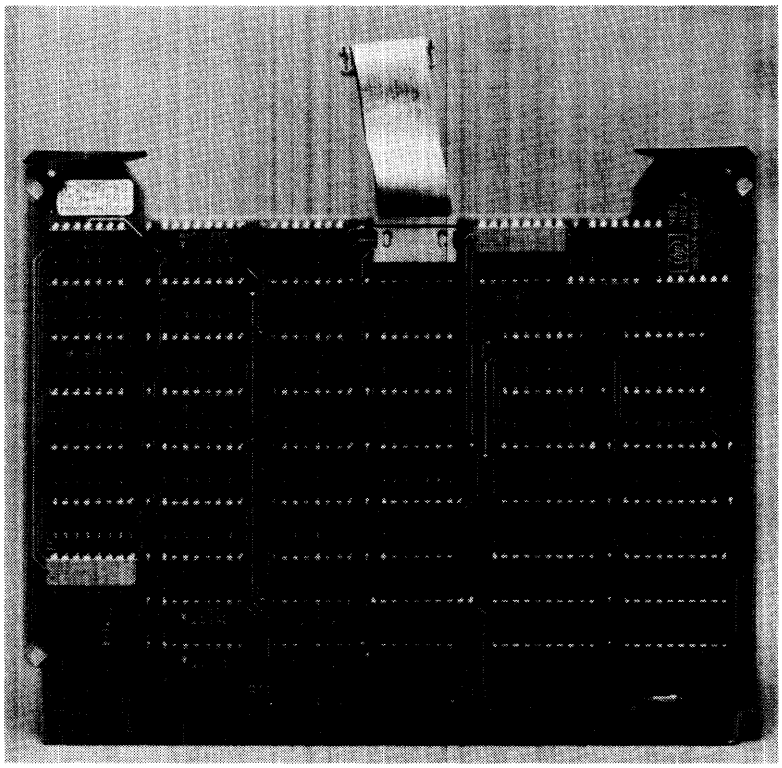


Figure 3-32. HP 98546A Display Compatibility Interface Graphics Card

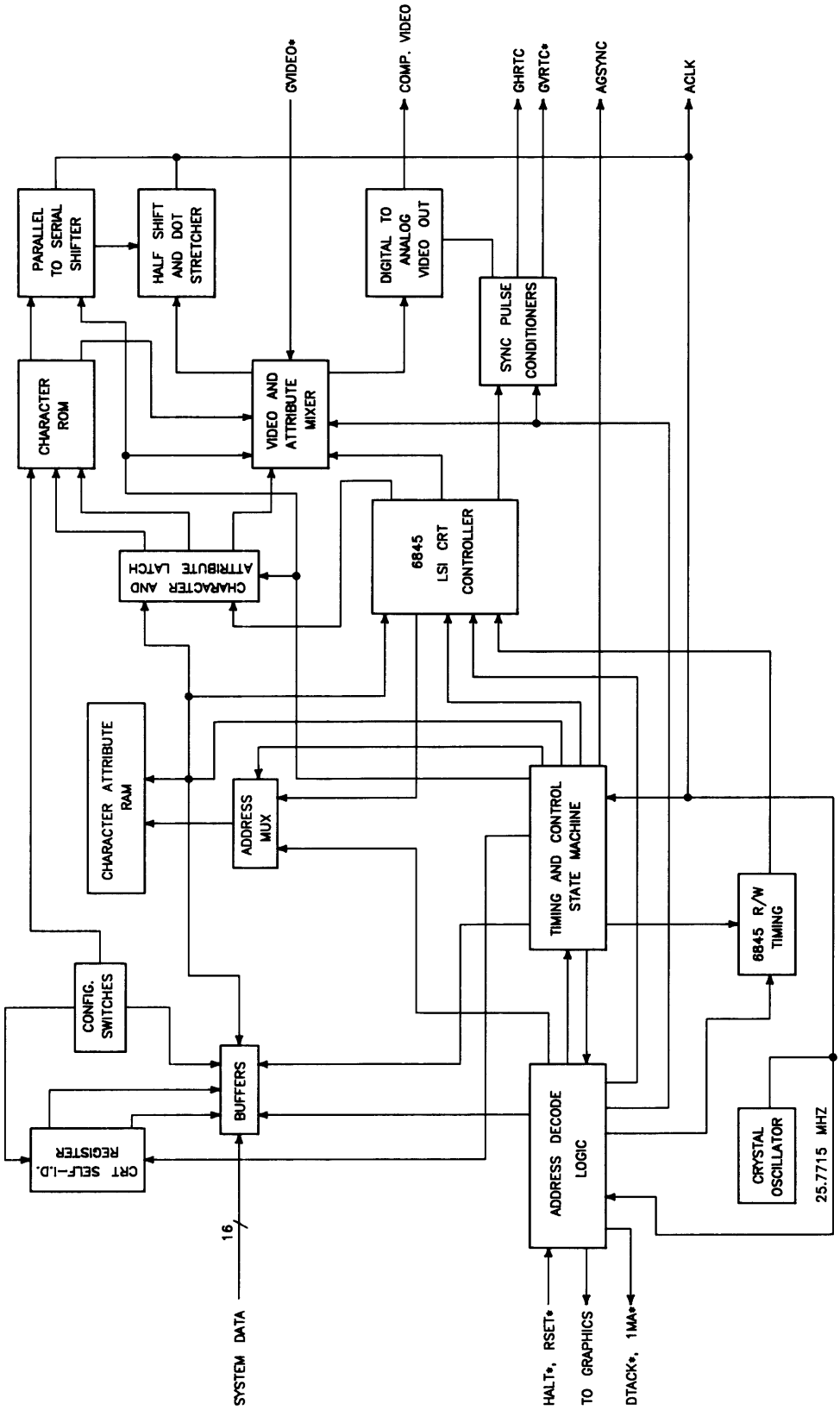


Figure 3-33. HP 98546A Display Compatibility Interface (Graphics) Block Diagram

Boot ROM Functions 4

Introduction

When the computer is turned on, three Boot ROM instruction sets are executed by the CPU. Other Series 300 computers have similar Boot ROM functions. Information on the following functions is in this chapter.

- Power-Up Sequence.
- Self-Tests.
- Booting Operating System.

Power-Up Sequence

Power-up Overview

These events happen when the computer is turned on and the Boot ROM code is executed by the CPU for the power-up sequence. Tests and initialization of devices are:

- Necessary for operation of Boot ROM code (CPU, Boot ROM, RAM).
- Used for interaction with user during power-up (display, keyboard, and some I/O) second.
- Used for booting (HP-IB, and SRM interface card).

Note

Exhaustive testing of computer hardware not used by the boot ROM should be done using the Series 300 Test Tools and/or by some other means. *The Boot ROM's self-test code is not a component level diagnostic tool.*

Table 4-1 shows the flow of events for the Power-Up Sequence. It shows everything that happens between power-up and the start of the boot scanner. This includes self-test and initialization. During the Power-Up Sequence, the LEDs and the monitor's display are used to tell what is happening. The section that follows discusses how the LEDs are used.

Pressing [Reset] will re-start the Power-Up Sequence. RESETs are locked-out or deferred during all mass storage operations to prevent leaving devices stranded in unknown states.

On power-up, the CPU is initialized and executes the Power-Up Sequence instructions in the Boot ROM. The Power-Up Sequence is shown in Table 4-2.

Table 4-1. Power-Up Flow Chart

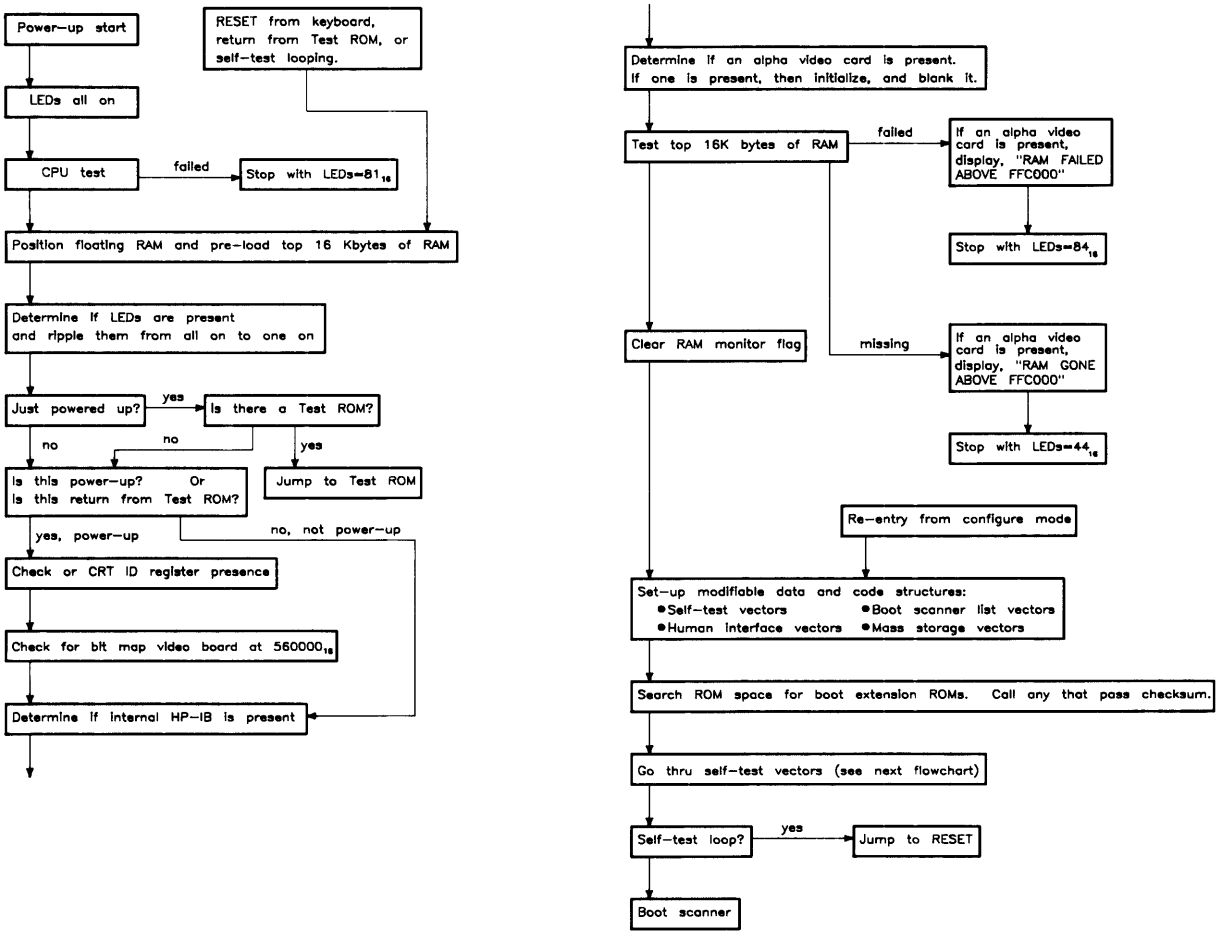


Table 4-1. Power-Up Flow Chart (Continued)

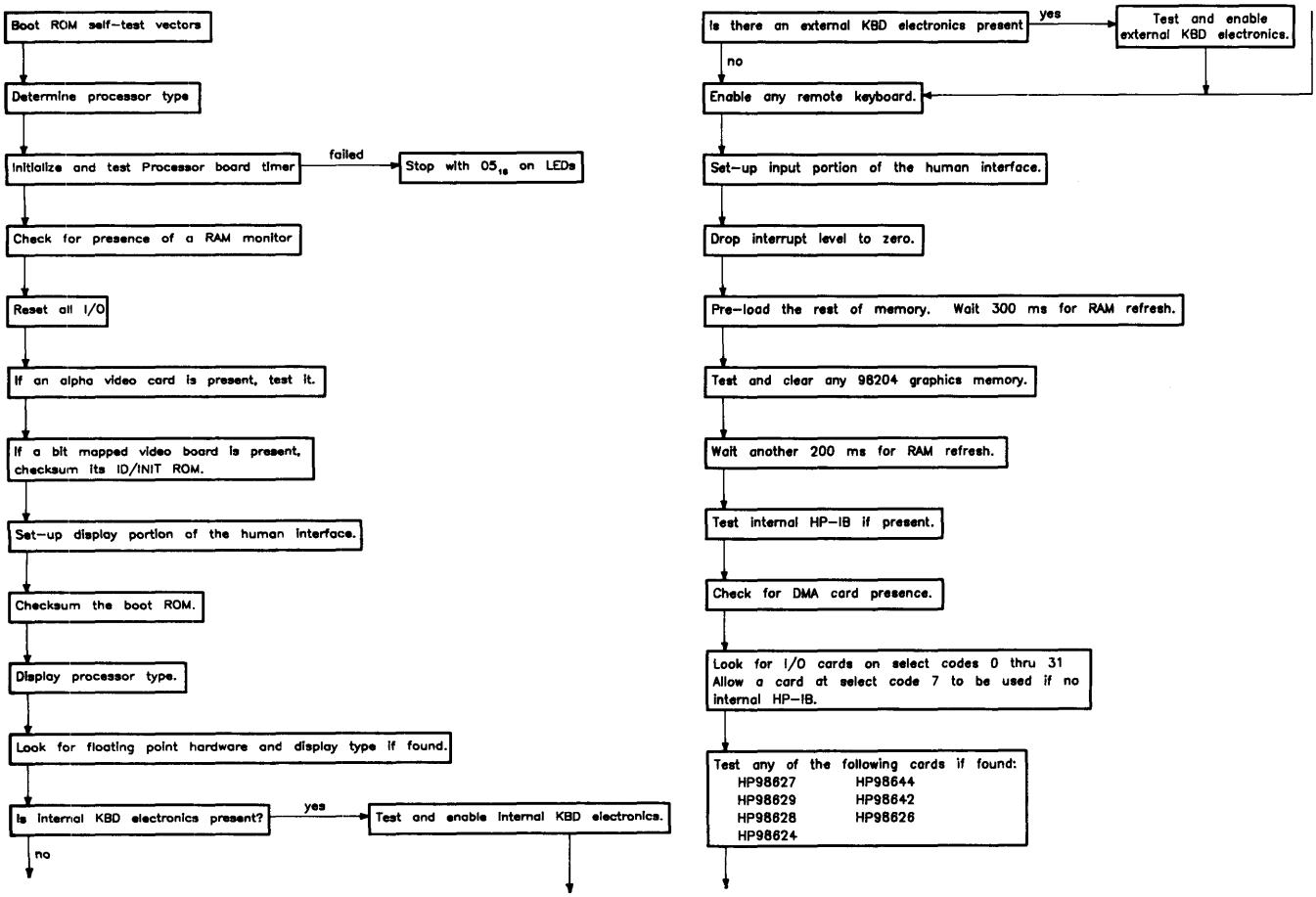
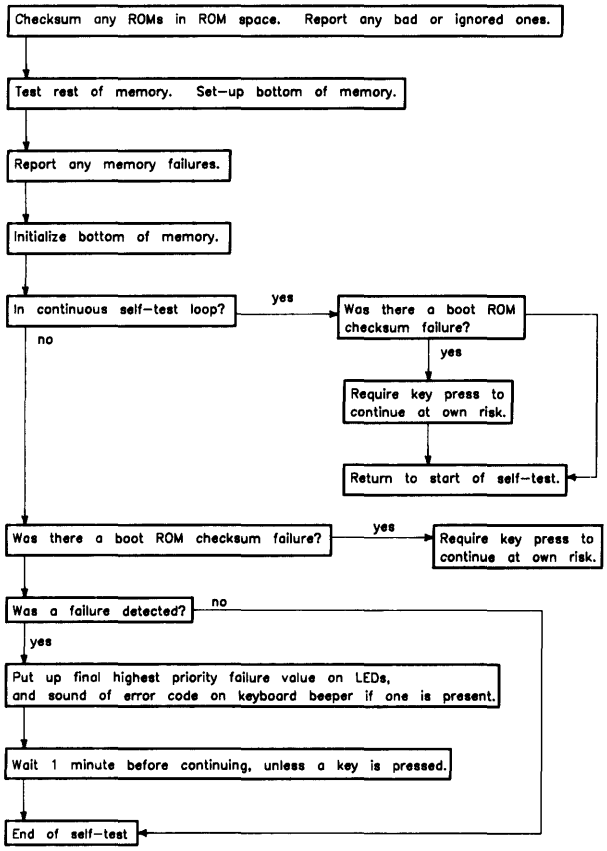


Table 4-2. Power-Up Sequence.



Power-Up Sequence Explained

1. Turn on test LEDs.
2. Test CPU.
3. Set up data structures.
4. Search for any Boot Extension ROMs and call any valid ones.
5. Determine CPU type (MC68010 or MC68020).
6. Initialize and test processor board timer.
7. Look for display RAM.
8. Reset all I/O.
9. Initialize the video board circuits.
10. Checksum the Boot ROM.
11. Display CPU chip type.
12. Initialize keyboard electronics.
13. Drop interrupt level.
14. If HP 98546A Compatibility Display Interface is found, initialize and clear graphics.
15. Test HP-IB on processor board, if present.
16. Find any Direct Memory Access (DMA).
17. Find accessory I/O cards. Report all found. Test the following:
    a. HP 98629 SRM Controller.
    b. HP 98527 Color Output Card.
    c. HP 98624 (TI9914 HP-IB).
    d. HP 98626 RS-232 Interface Card.
    e. HP 98644 RS-232 Interface Card.
    f. HP 98642 4-port Multiplexed RS-232 Card.

    The HP 98628 RS-232 Interface Card, if found, will be reported but not tested.
18. Checksum any ROMs in ROM address range and report any problems.
19. Test remaining RAM and set up bottom of memory.
20. Report any memory failures and the amount of memory found.
21. Initialize the bottom of memory (Boot ROM scratch pad).
22. Output final LED value.

Configure Mode Software Override

Configure Mode is a Boot ROM feature that allows the modification of some power-up defaults independent of which OS will eventually be booted. To enter Configure Mode, wait until one of the following keyboard messages is displayed:

Message	Location of Keyboard Electronics
`Console Keyboard at XX`	On card other than HP 98644A in I/O slot.
`98644 at XX`	On HP 98644A Card in I/O slot.

Note: `XX` is the select code of the interface card.

Then, before an operating system is booted, hold CTRL down and press C.

All mass storage operations lock-out and defer the response to the `CTRL-C` (just as they defer RESETs). This is to prevent leaving a mass storage device stranded in an abnormal state (e.g. disc spinning).

An example Configure Mode display is shown in Figure 4-1.

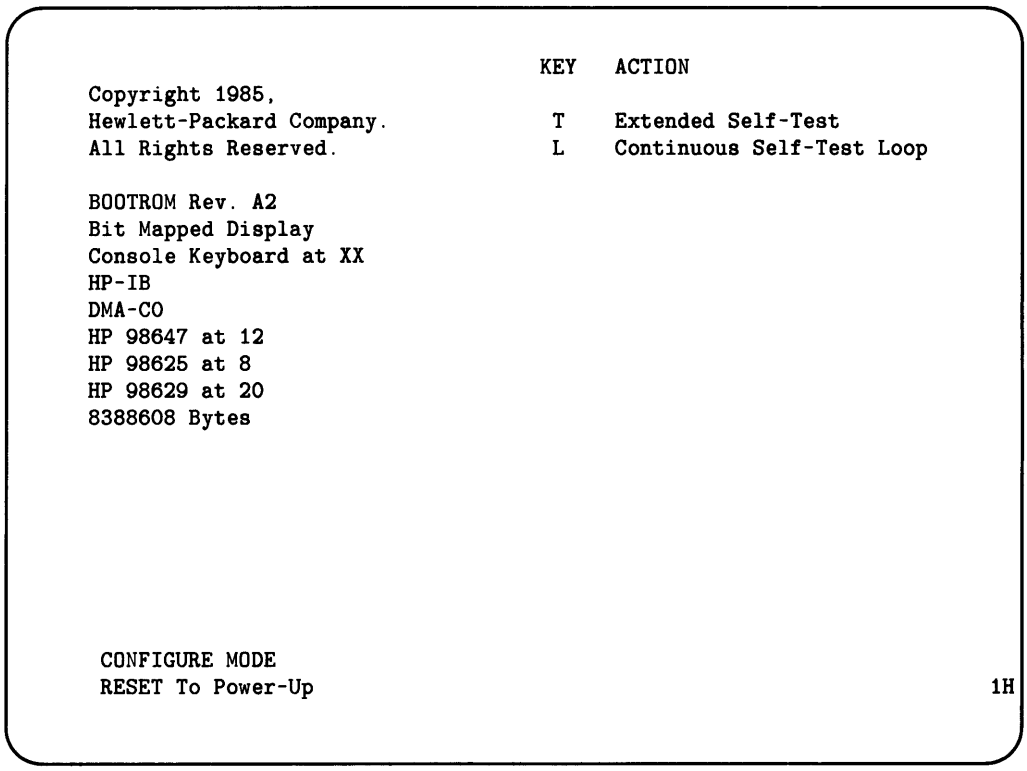


Figure 4-1. Example Configure Mode Display

Once in Configure Mode, several options are displayed. One of the option keys must be pressed within approximately 5 minutes of entering Configure Mode. Otherwise, the Boot ROM will time-out and start power-up over again. Available options are:

- Force Long Memory Test
- Continuous Self-Test
- 50 Hz CRT
- 60 Hz CRT

Regardless of the option chosen, most of the self-test will be repeated. If the memory test has already been completed and the extended self-test option is chosen, then the main memory test portion of the self-test will be repeated, otherwise it will not.

Force Long Memory Test

If the [T] key is pressed, the self-test will be started over and the long memory test will be executed. Long memory test is a marching/walking ones and zeros test taking about 5 seconds per 1 Mbyte of RAM.

Otherwise, the default short memory test will be executed. The short memory test is an address/address complement test taking about 1 second per 1 Mbyte of RAM.

Continuous Self-Test

Pressing [L] causes the Boot ROM to continuously repeat the self-test portion of its code. This is a toggle switch, so entering Configure Mode while already in Continuous Self-Test Mode, and choosing the "L" option, will stop the continuous self-test and cause the Boot ROM to continue normal operation.

While in Continuous Self-Test Mode, the Boot ROM will not wait, beep or stop for most failures, but will just continue looping through self-test. However, the following failures **will** stop self-test looping:

- **CPU register failure:**

  In this case the Boot ROM stops with the display blanked and the value

  81_{16} on the LEDs.

- **Memory failure in the top 16K bytes:**

  In this case the Boot ROM stops with the display blanked and the value 84_{16} on the LEDs. If a non-bit-mapped video board and monitor is connected, the message `NEED GOOD RAM ABOVE FFFFC000` will be displayed on that monitor.

- **Boot ROM checksum failure:**

  In this case the Boot ROM stops with the message `CONTINUE AT OWN RISK (Press RETURN To Continue)` on the display, the value 83_{16} and then beeps four low tones and two high tones. Pressing [Return] will cause the Boot ROM to continue self-test looping.

50 or 60 Hz CRT

Ac line voltage is either 50 Hz or 60 Hz. A monitor's vertical sweep frequency may cause display flicker if an incompatibility exists between the ac line frequency and the vertical sweep frequency. These options permits the user to set the video board for the local line voltage frequency.

The 50/60 Hertz CRT options are only available with non-bit-mapped video cards. With one of these cards installed, if [5] or [6] is pressed, a soft override of the power-up CRT frequency occurs. The power-up CRT frequency of the HP 98546 Display Compatibility Interface is determined by a switch on its video card. When this switch is set to 0, the power-up default is 60 Hz, when this switch is set to 1, the power-up default is 50 Hz. If [5] or [6] is pressed during configure mode when there is both an alpha/graphics video card set and a bit mapped video board present, then the key pressed will effect the alpha display (even though the '5' and '6' are not displayed). If no alpha/graphics video card set is present and [5] or [6] is pressed, the Boot ROM will re-enter self test, but the display will not be effected.

An example Configure Mode display with 50/60 Hz information is shown in Figure 4-2.

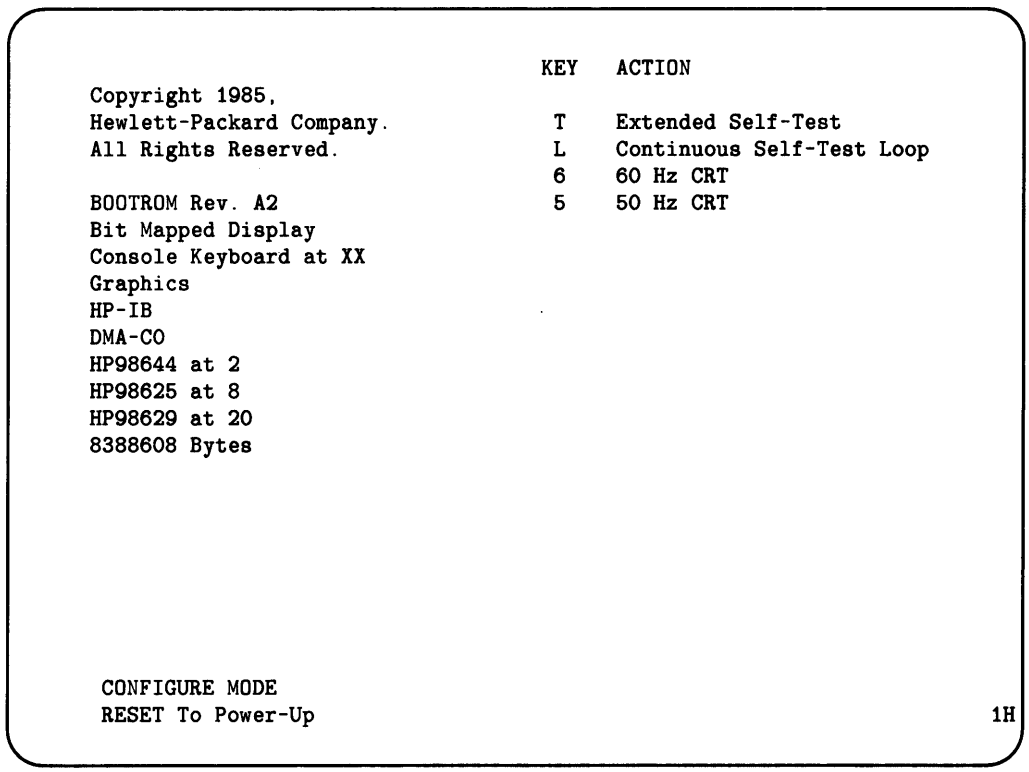


Figure 4-2. Configure Mode Screen Display with 50/60 Hz Information

The Human Interface

Several devices may act as the "console", or primary human, or system interface for the Boot ROM. These devices permit input and output functions between the person and the computer system. Possible console devices are:

Output Devices

Functional output devices are listed below.

- HP 98642 (4-port, multiplexed RS-232) card with the remote bit set (with a supported HP terminal).

  Supported HP terminals are defined as those terminals supported by HP on HP-UX for the Series 300 computers. See the section of this chapter describing Remote Human Interface for Boot ROM requirements.

- HP 98626 card with the remote bit set (with a supported HP terminal).
- HP 98644 card with the remote bit set (with a supported HP terminal).
- System Interface Board RS-232 controller (same as HP 98644 card) with the remote bit set (with a supported HP terminal).

  Only one output device at a time will be used as the console output device, however, the Boot ROM will initialize and clear all bit-mapped video circuits on the video boards or video cards in the accessory slots that it finds, even if that video circuit is not chosen as the output to the console device.

- A bit mapped video board at internal address 560000_{16}. This includes the HP 98700 and all of the video boards.

  The Boot ROM tries to talk to devices with a primary DIO ID of 25 and a secondary DIO ID of 1, and it expects these devices to have ID/FONT ROM information.

- An HP 98546 Compatibility Display Interface. This alpha/graphics video card set is similar to the HP 98204B card. Note that the Boot ROM will turn off video to this card set just before booting an OS. It is up to the operating system to restore video if this card set is to be used.
- HP 98627 Color Card

Input Devices

Functional input devices are listed below.

- Remote HP 98642 card with supported HP terminal.
- Remote HP 98626 card with supported HP terminal.
- Remote HP 98644 card with supported HP terminal.
- System Interface Board RS-232 controller (same as 98644 card) with the remote bit set (with a supported HP terminal).[1] HP-HIL, keyboard, and HP-IB electronics.
- I/O slot HP-HIL or keyboard electronics. The only version of this hardware is the keyboard electronics in the HP 98700 and 98720 Display Controller.

The Boot ROM chooses the output devices in the manner shown in Figure 4-3.

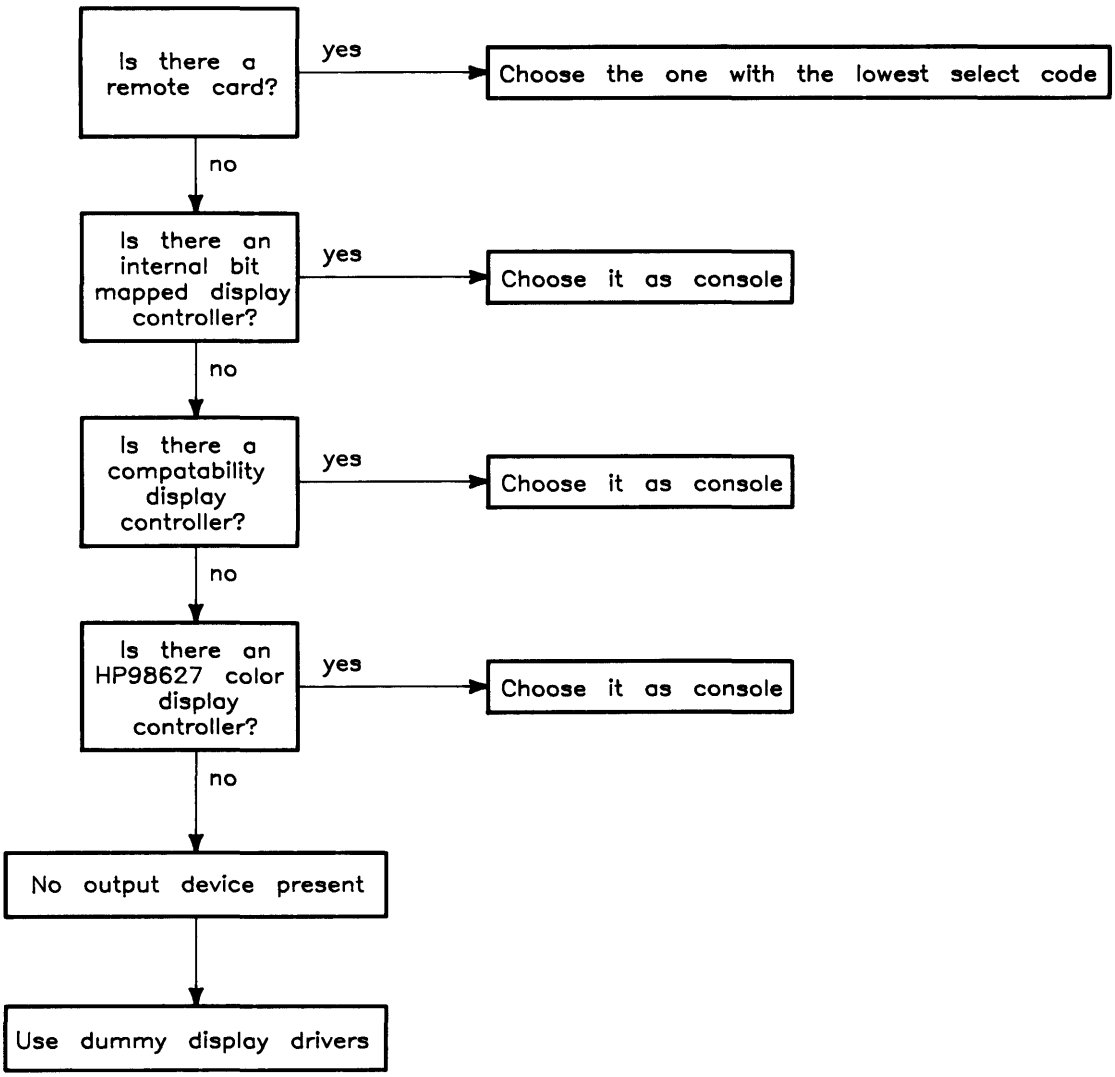


Figure 4-3 Boot ROM Output Device Selection Flow Chart

The Boot ROM chooses the input devices in the manner shown in Figure 4-4.

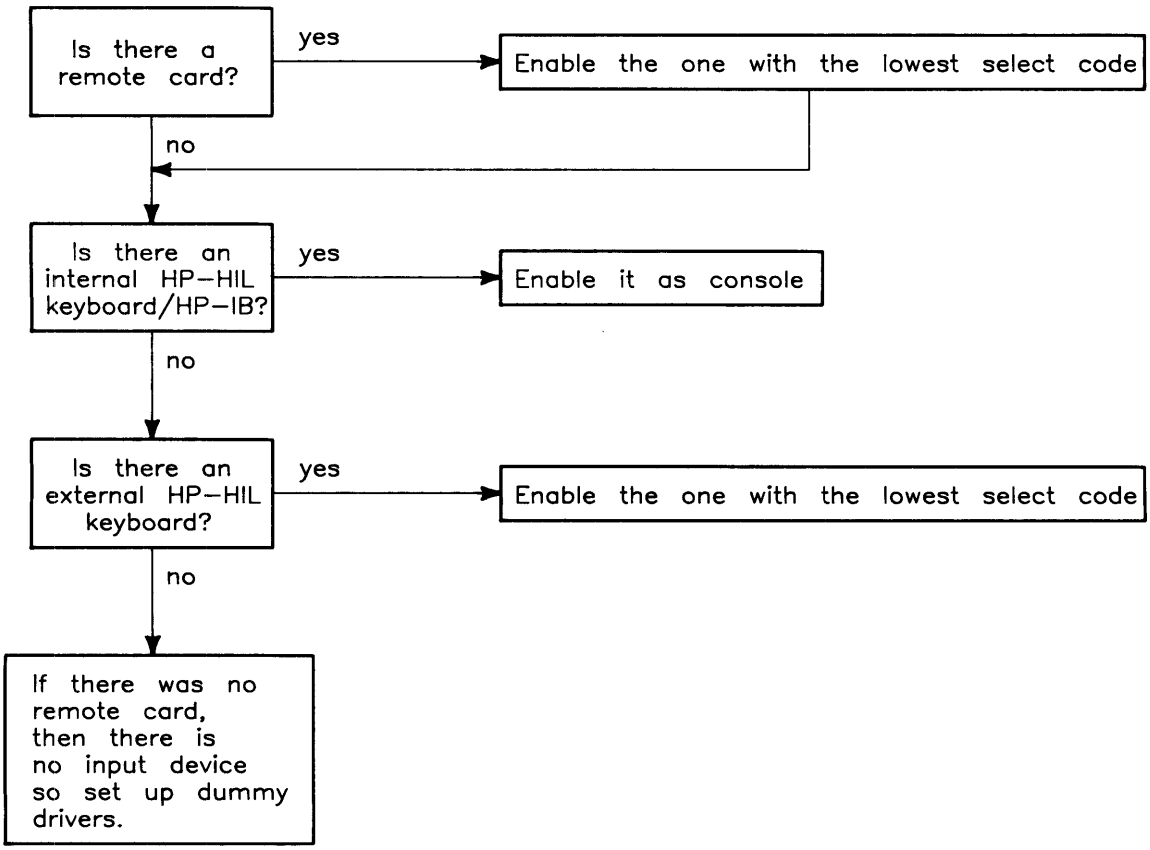


Figure 4-4. Boot ROM Input Device Selection Flow Chart

Note that if keyboard electronics and a remote terminal are both present in a system, they will both be enabled. Similarly, if accessory card keyboard electronics and a remote console are both present in a system, they will both be enabled, provided no other keyboard electronics are present.

When more than one set of accessory card keyboard electronics is present, then the one with the lowest select code is enabled. If several HP 98700s exist on a system, then it is the user's responsibility to ensure that the accessory card keyboard electronics associated with the HP 98700 display controller at the address 560000_{16} has the lowest select code of all accessory card keyboard electronics in the system. This must be done to ensure that the keyboard associated with HP 98700 "A" is not input console while the display of HP 98700 "B" is output console. The Boot ROM does not attempt to verify the display/keyboard relationship.

If no output device is present, but a keyboard is present, then that keyboard will still act as the console input device. Similarly, if no input device is present, but a video output is present, then that video output will still act as the console output device. If neither an input device nor an output device is present, the Boot ROM will go ahead and automatically Boot the default operating systems as long as no errors are discovered during self test. Refer to the section on Self-Test for more details.

Remote terminals as consoles are discussed in more detail in the next section.

Remote Human Interface

Very early in the Power-Up Sequence, a search is made for one of the following interfaces with its "remote" switch set:

- HP 98642 (4 port, multiplexed RS-232),
- HP 98626 RS-232 Interface Card
- HP 98644 RS-232 Interface Card

The search starts at select code 0 and ends at select code 31 or when one of these remote cards is found that passes self-test. If one is found, it becomes the Remote Human Interface. If the Remote Human Interface is an HP 98642 card, the the terminal on port 1 will be used as the console. All other ports are ignored by the Boot ROM.

Note

Note that the 98562-66530 System Interface Board with on-board RS-232 interface is treated as an HP 98644 RS-232 interface card by the Boot ROM.

To indicate that a remote human interface has been found (at, for example, select code 9), the first line of the internal display, if present, will display:

```
Remote Interface at 9
```

After this point the monitor's display will not change until a system is booted. Any internal or external keyboard, if present, will work just as it would if there were no remote console (see previous section for details).

To use the remote interface, an 80 wide terminal with at least 24 lines that accepts the following HP standard terminal escape sequences is required:

Terminal Escape Sequence	Display Activity
Escape H Escape J	Clear Screen and reset cursor
Escape &aDDY	Move Cursor to Row DD
Escape &aDDC	Move Cursor to Column DD

With the HP 98626 card, the Boot ROM will use the baud rate, pacing, and line characteristics specified by the card's configuration switches.

Note

HP 98626 cards are shipped with these switches at zero. When booted with ENQ/ACK enabled on the HP 98626 card and XON/XOFF enabled on the terminal, the Boot ROM sequence stops, waiting forever for a response.

Since the HP 98644 and HP 98642 cards do not have line characteristic switches, they will always be assigned the following characteristics when used as remote console by the Boot ROM:

- 8 bits/char.
- No parity.
- A single stop bit.
- 9600 baud.
- XON/XOFF handshaking.

The terminal's display will be the same as a monitor driven by video electronics on video board. Keyboard functions will be as driven by the system interface board, except that the [Break] key on the terminal is mapped to the [Reset] key on the local keyboard.

During the self-test of I/O cards, the card driving the remote interface will not be disturbed. It was tested earlier and passed. Otherwise, the interface could be disabled.

Self-Test

When the machine first powers up, the boot ROM gets control. Before transferring control to a system by booting it, the boot ROM has several responsibilities.

Hardware Initialization Support.

Some hardware must be initialized as soon as possible after power-up to prevent improper operation. Examples are display initialization and floating RAM positioning, neither of which can wait for an OS to be loaded.

Assembly Self-Test Support.

Self-Tests have about 95% confidence that a tested logic assembly is functioning properly. The reason for these tests is to tell the user that the computer is working properly. This consists of indicating all installed accessories in the computer (and expander, if connected) and reporting all detected failures.

Boot ROM self-test routines may not identify and indicate all hardware failures correctly. Several things contribute to this. They include hardware design and the fact that testing for 100% of all failure types is virtually impossible.

Tests Performed by the Boot ROM

Set-Up Code Segment

A series of tests and initialization routines which set up the computer so the rest of the Boot ROM code can function safely are the first section of Boot ROM code.

The first part of the unextendable code segment includes the following routines (note that, before each step, the LEDs are set to a new value which reflects that step):

1. Bus Error Handler:

   The BUS ERROR vector is set up to point to a routine which decides if the CPU stack registers are functional.

2. CPU Test:

   Three different values are passed, one at a time, through each of the CPU Registers. If an error occurs, the Boot ROM halts with a "CPU Failed" code on the LEDs.

3. Position Floating RAM and Pre-load the Top of Memory:

   The Boot ROM steps through the first 16K bytes of memory, until a bus error occurs and to initialize for the top memory test. If a bus error does not occur, the Boot ROM starts at the top of memory and reads every 64 Kbyte boundary until a bus error occurs or until just before the bottom RAM address is reached.

4. Cycle LEDs:

   The LEDs are rippled from all on to all off except one. There is a small delay for each ripple state which is used to cause a short delay between memory pre-load and the test to check for memory refresh failures.

5. Check for video electronics:

   A check is done for the ID register of a HP 98546A card set. A bit is set to indicate its presence. Then the Boot ROM looks for a bit mapped video boards by checking location 560000_{16} for a primary DIO ID of 25 and a secondary ID of 1. If the proper ID is found, then a bit is set to to indicate the presence of a bit-mapped video board.

6. Determine if Internal HP-IB is Present:

   Channel zero of the system interface board is armed.

7. Determine Which, if any, Alpha video card is Present:

   A register is set to the location of the top RAM test routine. Note that only video boards with an ID register are supported.

8. Initialize and Blank Alpha Display Controller, if present:

   If an HP 98546A card set is present, then it will be initialized and blanked.

9. Top RAM Test:

   A memory test is executed on just enough RAM to allow the rest of the Boot ROM code to operate. (A "fatal error" will occur when there is not enough RAM.) If there is a memory failure, 84_{16} will be displayed on the self-test LEDs. If memory is missing, 44_{16} will be displayed on the self-test LEDs. If an alpha display controller is present, the Boot ROM will also write one of these messages:

   ```
   RAM FAILED ABOVE FFFFC000

   RAM GONE ABOVE FFFFC000
   ```

   for memory failure and memory missing, respectively. These messages will not be displayed on a monitor through a bit-mapped video board.

NOTE

If high RAM fails or is missing, then the test LEDs and beeper will give the only notification on a system with a bit-mapped video board or remote console.

NOTE

The functions in the next section depend upon a working RAM stack. As in the previous steps, the LEDs are set to a new value before each step.

Test and Boot Code Segment

This section explains the sequence the CPU executes Boot ROM test list vectors and loops through self-test if continuous self-test is enabled.

The Test List (like the Boot List) is a temporary structure used by the Boot ROM to allow upgrades and extensions. Test and/or initialization code for a given devices does these things:

- Indicate on LEDs the device being tested.
- If the device is present THEN
- If the test initialization fails THEN indicate the failure
- ELSE indicate the presence of the device.

A step-by-step list of what happens in this Boot ROM code segment is explained. As before, each step is preceded by an indication of that step on the LEDs. The test list for the Boot ROM is as follows:

1. Which Processor:

   The stack is checked to determine the CPU is an MC68020.

2. Initialize Timer:

   The Boot ROM initializes and tests the timer on the processor. If a failure occurred, then the Boot ROM halts with 05_{16} on the LEDs.

3. Identify Display RAM:

   The Boot ROM determines if display RAM is present at 880000_{16}. If there is, then its presence is noted.

4. Reset I/O:

   A RESET instruction is executed to clear all I/O. The Boot ROM sets up the HP-HIL keyboard electronics to ensure that its timer does not lose time. Keyboard electronics on an accessory card are not set up.

5. Initialize and Test Video Circuits:

   The output human interface soft vectors are set up to to handle the video output circuits or dummy display drivers are set up if no video circuits are present. If alpha video output circuits are present, then a memory test of the alpha, and highlight memories is executed. If bit-map video output circuits are present, then its ID/FONT ROM is checksummed and the circuits are initialized and cleared. If a failure is discovered it is indicated on the LEDs. The message `SELF-TEST MODE` is shown on the bottom of the display. See the section on Human Interface for the console selection algorithms.

6. Display Copyright Notice:

   The Boot ROM displays a 1985 copyright message.

7. Boot ROM Checksum:

   If the Boot ROM checksums successfully, then the Boot ROM version (`BOOTROM Rev. A2`) is displayed, otherwise the message `BOOTROM Rev. A2 Failed` will be displayed. If there was a video circuit memory failure discovered in the alpha display initialization and test routine, then it will be shown on the display as:

   ```
   Memory Failed at <Hex-Address>
   (W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
   ```

8. Identify Floating Point Hardware.

   A search is made for the MC98881 Coprocessor. It is identified but not tested.

9. Initialize, and Test Keyboard Electronics:

   The keyboard human interface vectors are set up for the processor's keyboard electronics, if present, and their self-test value is checked. If the keyboard electronics failed self-test, then `Keyboard Failed` is displayed and the appropriate error code is sent to the LEDs and the beeper. If the processor's keyboard interface is present and passed self-test, then the message `Keyboard` is displayed.

   If no processor keyboard electronics are present, then the external I/O space is searched for accessory card keyboard electronics (for the HP 98700A). If found, it is treated the same as the processor keyboard electronics except that the message `Keyboard at 8` (where X is the select code of the accessory card keyboard electronics) is displayed if the keyboard passes self-test, and the message `Console Keyboard at XX Failed` is displayed if it fails self-test.

   NOTE

   Note that only the I/O card keyboard electronics chosen as console keyboard will be tested. Several seconds are required to identify the console keyboard. Other keyboard electronics in I/O slots will be identified, but not tested.

   ---

10. The message `RESET to Power-Up` appears on the last line of the display.

11. Drop Interrupt Level:

    The interrupt level is dropped to zero.

12. Pre-load Memory:

    The message `LOADING MEMORY` appears on the last line of the display while the end of memory is found by pre-loading the RAM not currently in use by the Boot ROM code. If a long test is to be done, the RAM is loaded with $EEEE1111_{16}$. If the fast test is to be done, each RAM location is loaded with its own address. When pre-loading is finished, the message `SELF-TEST MODE` is displayed on the last line of the display. Then, a 300 ms delay is executed to catch refresh failures.

13. Test and Initialize Graphics on Alpha/Graphics Card.

    If an HP 98546A is present, then it is tested with a byte-wide RAM test. If the graphics test is passed, then the message **Graphics** is displayed. If the graphics test is failed, then the message **Graphics Failed** is displayed and the appropriate value is sent to the LEDs. If there is a graphics memory failure, it is shown on the display as following two lines:

    ```
    Memory Failed at <Hex-Address>
    (W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
    ```

    Finally, graphics memory is cleared.

14. Test HP-IB:

    If the processor has HP-IB and it is the system controller then the Boot ROM will test it. If the HP-IB hardware fails the test, then the message **HP-IB Failed** is displayed and the appropriate value is sent to the LEDs. If the HP-IB hardware is present and had no failures, then **HP-IB** is displayed.

15. Check For DMA Presence:

    When the DMA chip on the system interface board is found, the message **DMA-C0** is displayed. C is the class and 0 is the revision. No testing of the DMA chip or circuits is done.

16. I/O Card Tests:

    Select codes 0 through 31 are scanned by the Boot ROM. For each select code the following steps are taken:

    a. The appropriate value is sent to the LEDs indicating which select code is being examined.

    b. If one of the following cards is found at the current select code, it will be tested by the Boot ROM:

        - HP 98629 SRM Controller card
        - HP 98627 Color Card
        - HP 98625A/B HP-IB Card
        - HP 98626 RS-232 Interface Card
        - HP 98644 RS-232 Interface Card, or
        - HP 98642 4-port Multiplexed RS-232 Interface Card

        If the card at the current select code has no failures, then the message **HP98XXX** is displayed for that card. If the card fails, then the message **HP98XXX Failed** is displayed for that card and the appropriate value is displayed on the LEDs. A memory failure on the HP 98627 Color Output Card is indicated by the message:

        ```
        Memory Failure at <Hex-Address>
        (W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
        ```

The following I/O cards are identified by the Boot ROM, but are not tested:

- HP 98622 GPIO
- HP 98623 (BCD)
- DIO bit-mapped video cards with a primary ID of 25 and secondary ID of 0 or 1
- HP 98638 RS-232 Card
- HP 98633 Multiprogrammer Interface
- HP 98640 (ACD)
- HP 98641 RJE Card
- HP 98643 LAN Card
- HP 98653 EPROM Programmer
- HP 98659 Bubble RAM Card
- HP 98691 RS-232 Card
- HP 98695 (3270 Emulator)

17. If the Boot ROM finds an external I/O card that it does not recognize, it will display the message

    ```
    IDXX at YY
    ```

    where XX is the combined value of the card's primary and secondary IDs, and YY is the card's select code.

18. Test RAM:

    The message `TESTING MEMORY` is displayed on the last line of the display, and the rest of memory is tested. Parity errors are displayed as they occur, such as:

    ```
    parity bit error at FFFF1234
    ```

19. Set Up Memory:

    The message `SELF-TEST MODE` is printed on the last line of the display. If a memory failure occurred, then the appropriate value is sent to the LEDs and following message is displayed:

    ```
    Memory Failed at <Hex-Address>
    (W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
    ```

    After a failure the Boot ROM drops back to the next 64K byte boundary, unless the failure was is in the top 64K, in which case the Boot ROM drops back to the next 2K boundary. The global Boot ROM variables are set up. Available RAM is displayed as a base ten number in bytes. The amount of RAM available should equal the amount of RAM installed minus 164 bytes.

    For example if one HP 98258A RAM board with an HP 98258C add-on board, the amount of RAM displayed would be about `16777052 Bytes`.

20. Allocate Memory:

    Temporary memory is set up for the Boot scanner and Booter routines.

21. Display Final LED value:

    If an error occurred during self-test, then the appropriate value will be sent to the LEDs and sounded off on the beeper. The lower seven bits of LED value are sounded off (MSB first) with ones represented by high frequency long notes and zeros represented by low frequency short notes. If a Boot ROM checksum error has occurred, then the Boot ROM will stop execution with the message **CONTINUE AT OWN RISK (RETURN To Continue)** on the bottom line of the display. The Boot ROM will continue if the [Return] key is pressed. If an error has occurred and continuous self-test looping is not enabled, and the error was not a Boot ROM checksum error, then the Boot ROM will wait one minute for the monitor to warm up before continuing, and will display the message **WAITING 1 MINUTE (RETURN To Abort Wait)**. Pressing the [Return] key will cause the Boot ROM to abort the one minute wait and continue.

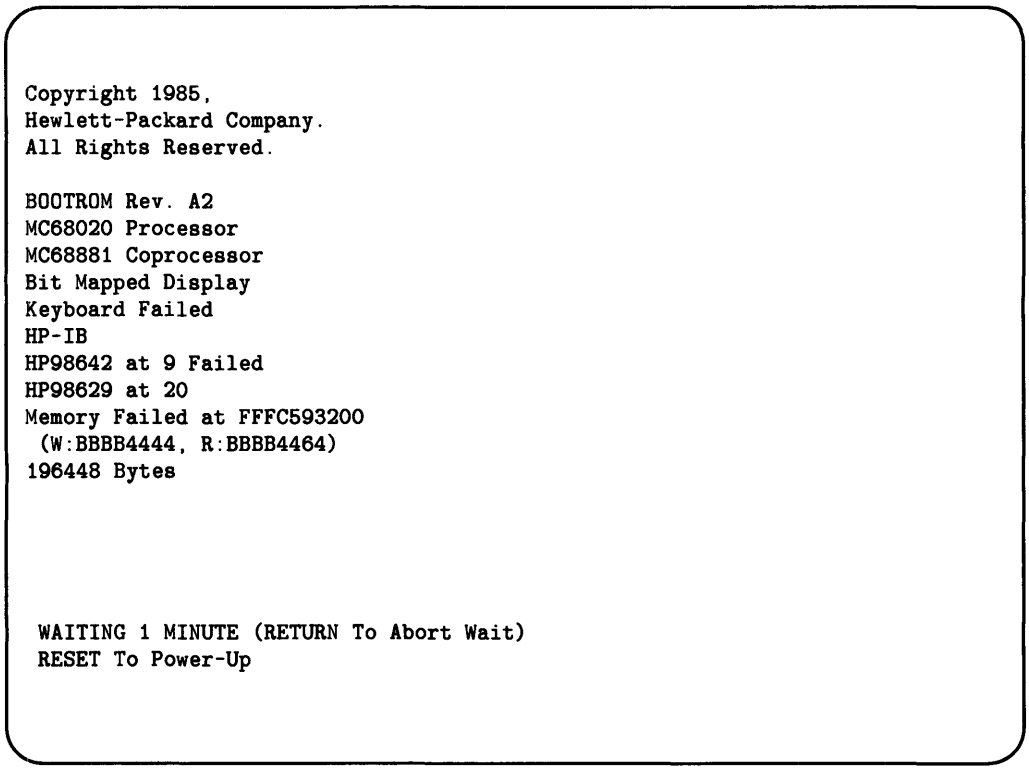


Figure 4-5. Example Self-Test Error Display

Memory Tests

Word Tests

Word (16 bit) wide tests are executed on main memory. There are two types of word wide tests used. Tests on the upper 16K bytes and all peripherals always use the slower, walking ones and zeros, test. The rest of main memory may use either the slow test, or a faster "address in memory" test.

Byte (8 bit) wide tests use the walking ones/zeros test. This test is used on any peripheral that has less than full word wide memory (e.g. alpha display controller memory, and some graphics memory).

These tests are faster than the same ones used with the Models 310 and 320. As the MC68020 ICACHE is enabled, there is a noticeable speed improvement.

The same messages are used for reporting all memory failures, but they are interpreted slightly differently for word and byte memory tests.

For word wide memory test errors, the following message is displayed:

```
Memory Failed at AAAAAAAA
(W:BBCCDDEE, R:FFGGHHII)
```

This error message can be decoded as shown:

W: BBCCDDEE is the write pattern.

R: FFGGHHII is the read pattern.

BB and FF are at address AAAAAAAA.

CC and GG are at address AAAAAAAA+1.

DD and EE are at address AAAAAAAA+2.

EE and II are at address AAAAAAAA+3.

For byte wide memory test errors, the following message is displayed:

```
Memory Failed at AAAAAAAA
(W:BBCCDDEE, R:FFGGHHII)
```

This error message can be decoded as:

W: BBCCDDEE is the write pattern.

R: FFGGHHII is the read pattern.

BB and FF are at address AAAAAAAA.

CC and GG are at address AAAAAAAA+2.

DD and EE are at address AAAAAAAA+4.

EE and II are at address AAAAAAAA+6.

Parity Tests

Parity checking is enabled during the memory test phase. Error messages are one of these two types:

- `pairity bit error at FFFF1234` – means a failure was detected at the address given by the parity checking circuits; a parity error was signaled when none should have been.
- `data parity error at FFFF4321` – a RAM failure was detected at the address given and the parity checking circuits signaled the error.

Addresses in the parity error messages is the address of the lowest of four consecutive addresses. The error could have occurred in any or all of those four addresses. Parity errors will be displayed during the TESTING MEMORY phase of the self-test and testing will continue.

End of Memory Test

At the end of the memory test, message like this example:

```
Memory Failed at FFFFABCD
```

will be displayed if either of the above conditions have occurred. If the error was a DATA failure, the bit pattern written and pattern read will also be displayed. If only parity errors were detected, then only this message will be displayed:

```
Memory Failed
```

Should either or both types of memory failures occur, the Boot ROM instructions will cause the CPU to wait one minute before finishing the self-tests and going on to boot an operating system.

Booting Operating Systems

Boot System Selection

The Boot ROM provides two modes of operation, attended and unattended. These two modes allow a user to either select from several operating systems on mass storage devices or to automatically boot an operating system (OS) with no user intervention.

Unattended Operation

In an Unattended situation, the first operating system found will be loaded and given control. To find an OS, the Boot ROM will search a boot list of prioritized devices. The first OS found on one of these devices will be booted. If none is found, the boot list will be searched again until a one is found. This allows discs not present at power-up to be found after their initialization is complete.

Once a device has been successfully accessed, it will never be accessed again until re-power-up or a reset. This minimizes wear on mass storage devices and limits the confusion of operating systems disappearing and re-appearing on shared resource management systems.

To force the boot of a particular system when the machine is unattended, the user has the following options:

- Make sure that the OS to be booted is the first to be found according to the boot list search. This is quite easy to do simply by changing device addresses, select codes, or OS names, or by moving OSses. The prioritized boot list is discussed in detail latter in this section.
- On an SRM with multiple OSses, make the first OS to be found one that looks at the host's SRM node address and uses the node address to decide what secondary OS to boot. (The Boot ROM can then be called to boot a particular OS.)

Attended Operation

To force the boot of an OS not chosen by the boot list, the user must enter Attended Operation Mode. This mode is entered by pressing the space bar, Return, or any letter or number during power-up after the input portion of the human interface (i.e., the keyboard or terminal) has been initialized but before a default OS is booted. A good way to do this is to hold down the space bar until the OS selection menu is seen. This will cause a boot selection menu to be displayed. A user can be sure that the input human interface has been initialized when one of the following (depending on the human interface provided) is displayed in the self-test list:

Keyboard Message	Keyboard Electronics Select Code
`Keyboard`	System interface board HP-HIL section
`Console Keyboard at XX`	Where XX is the lowest select code of keyboard electronics in an I/O slot.
`HP 986XX at X`	Where the Xs are the type and select code of the remote human interface.

The boot selection menu displays all accessible OSses as the Boot ROM locates them. An OS is selected by typing the one to three character string (a single letter or a 1 to 2-digit number followed by a single letter) listed in the menu. Note that the character used to enter Attended Operation Mode is considered part of this string.

As the keys are accepted they appear in the lower right hand corner of the display. An example menu screen is shown in Figure 4-6.

```
Copyright 1985,
Hewlett-Packard Company.                :REMOTE, 21, 0, 8
All Rights Reserved.                      2B  SYSTEM_BASIC
                                        :ROM
BOOTROM Rev. A2                           B  B
MC68020 Processor                         A  A
Bit Mapped Display                        H  H
Console Keyboard at XX                    F  F
HP-IB                                     Z  +
DMA-CO                                  :HP8290X, 706, 0
HP98644 at 2                              3B  SYSTEM_BAS
HP98642 at 8                            :HP7908, 803, 0
HP98626 at 9                              1H  SYSTEM_HP-UX
HP98625 at 14                           :REMOTE, 20, 0, 8
HP98629 at 20                             1F  SYSTEM_FORTRAN
HP98629 at 21                             2F  SYSTEM_FORTH
8388608 Bytes                             1Z  SYSTEM_4TH
                                          1P  SYSTEM_PASCAL
                                          1b  SYSburp



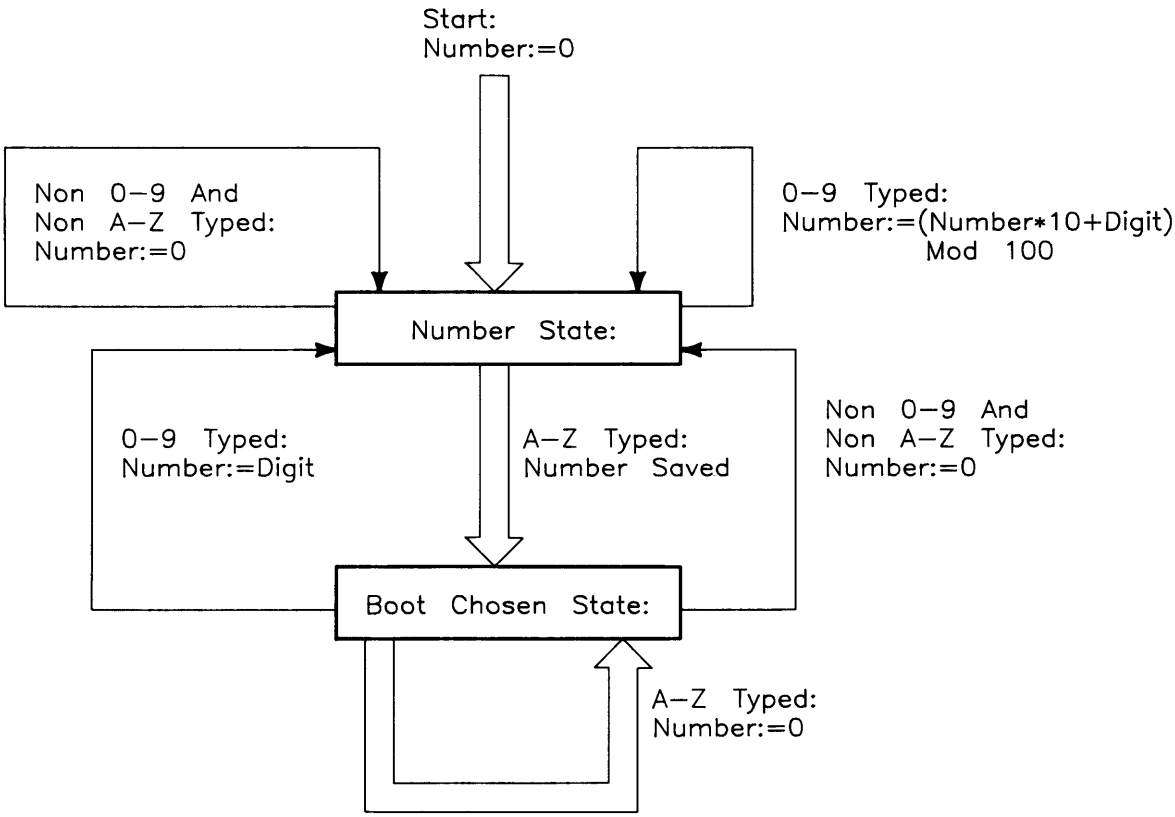
 SEARCHING FOR A SYSTEM (Press RETURN To Pause)
 RESET To Power-Up                                                  1H
```

Figure 4-6. Attended Operation Mode Display Example.

A ROM OS is selected by a number-letter entry. If the user knows that a particular choice is desired, such as "2F" or "31B", then the user can type that response as the computer powers up to make a selection. This simple human interface makes it possible to make a selection without waiting for the display to show what OSses are available.

A state diagram of how the Boot ROM interprets the key sequence for selecting an OS is shown in Table 4-4.

Table 4-4. Boot ROM Key Sequence Interpretation State Diagram



The state diagram shown in Table 4-4 is executed in the interrupt service routine for the human interface input device.

Note that only keys [A] through [Z], [a] through [z], and [0] through [9] are allowed to select an OS. Other keys are simply ignored. This makes the handling of all nationalized keyboards much simpler.

Because it is possible to find more OSses than there are lines on the display, the search scan can be paused and continued by toggling the [Return] key. The line next to the bottom of the screen indicates the current state with one of two messages:

```
SEARCHING FOR A SYSTEM (Press RETURN To Pause)
```

or

```
PAUSED (Press RETURN To Continue)"
```

The menu will wrap around to the top of the screen and overwrite itself whenever all available lines are used. When the Boot ROM is paused, all activity stops. Because the keyboard is polled, there may be a delay before a key press takes effect.

Boot System Priority Control

Devices are searched in priority order for OSses. This priority order is determined by the boot list. The boot list for the Boot ROM is:

1. Disc drives at select codes 0-31 on bus address 0, unit 0, volume 0
2. An SRM at node 0 at select code 21 on volume 8
3. HP 98259 Bubble Memory Card on select code 30
4. HP 98255 EPROM Card "disc", unit 0
5. Remaining disc drives at select codes 0-31, bus addresses 0-7, units 0-16, volumes 0-7
6. Remaining SRMs at select codes 0-31
7. Remaining HP 98259 Bubble Memory Cards on select codes 0 through 29 and 31
8. Remaining HP 98255 EPROM Card "disc" units

Each device is allowed to have multiple OSses. Again, if the machine is unattended, it will boot the first OS found. If the computer is attended (i.e. a key was struck after the input human interface was initialized), it will display all OSses found until one is selected and that one is found.

For each category in the boot list, there is also an order of search based on address location. In all cases, lower addresses are found first. This means a device at select code 0 will be found before a device at select code 7. If a device has multiple addresses to locate it, then searching is done at a local level first. For example, after looking at select code 7, bus address 1, unit 1, the Boot ROM will look at select code 7, bus address 1, unit 2 before going to select code 8.

The boot list permits change and control of which OS will be booted in the Unattended Mode. Priorities used to establish the boot list are:

- High priority addresses before low priority addresses
- Local OSses before remote OSses (Local refers to dedicated devices and remote refers to shared devices, i.e. an SRM)
- Flexible media before Hard media
- Small capacity devices before large capacity devices

Default Mass Storage Variable

The boot ROM is responsible for setting up the default mass storage variable, DEFAULT_MSUS. It is used by OSses for three purposes as the:

- Default MSUS for operating systems
- Device from which to load an AUTOSTART program, and
- Device from which to do a secondary load.

The DEFAULT_MSUS is set according to the following algorithm:

1. Same as the MSUS of the booted OS, or
    a. A non-ROM value passed in DEFAULT_MSUS to the booter routine (this is done only by OSses calling the booter, not by the Boot ROM itself), or
    b. The first device found with LIF, SDF, or UNIX formatted media present if ROM is specified in DEFAULT_MSUS, or
    c. The first device found present in the boot list if ROM is specified in DEFAULT_MSUS and no media can be found (i.e., an on-line disc drive with no media present), or
    d. A LIF media in an HP 8290XM drive at HP-IB 700 drive 0, if ROM is specified in DEFAULT_MSUS and no devices are present.

Supported Boot Configurations

Listed below are all hardware interfaces over which the Boot ROM can boot an OS on all 32 I/O Select Codes where applicable.

- Internal HP-IB (If not present, external select code 7 is available for any of the other interfaces.)
- HP 98624 HP-IB Interface Card
- HP 98629 SRM Card
- HP 98625A/B HP-IB Interface Card (Except not with HP 8290X.)
- System Interface Board DMA circuits (displayed as DMA-C0)
- HP 98255 EPROM Card
- HP 98259 Bubble Memory Card
- HP 98262A High-Speed Disc Add-On

Interface protocols that can be used to boot an OS with the Boot ROM are:

- CS/80
- SS/80
- Amigo
- SRM
- EPROM
- Bubble RAM

Media formats from which an OS may be booted using the Boot ROM are:

- LIF (8000_{16})
- SRM
- SDF HP 9000 Model 520; 0700_{16} (Mid-Range Format) (Boot Area)
- UNIX (3000_{16}) (Boot Area) (Note that this is different from HP-UX.)

The Boot ROM can boot OSses from the following boot devices:

- SRM via HP 98629 card, `/SYSTEMS` directory only
- AMIGO protocol HP-IB Discs (e.g. 8290XM, 9895, L-Codes and 7906/20/25)
- HP 98255 EPROM Card in "Disc" format.
- HP 98259 Bubble Memory Card
- CS/80 protocol HP-IB discs (e.g. HP 7908)
- SS/80 protocol HP-IB discs (e.g. HP 9122)
- CS/80 Tape

NOTE

Some of these devices, namely the HP 7906/20/25, may not meet EMI requirements when used with Series 300 computers, but their support in the drivers comes inexpensively with other discs that are supported.

For all devices there are seven generic error messages that can be displayed:

Message	Meaning
`No Device`	Communication was lost with the device.
`No Medium`	There was no media (e.g. floppy disc) present.
`Not Ready`	The device was not ready.
`Read Error`	An error occurred while reading from the device.
`Bad Hardware`	A hardware fault occurred.
`Bad State`	The device is in an unknown or unexpected error state.
`Bus Error`	A bus error occurred during a memory transfer

If the error terminates the actual load of an OS, it will appear in the next to the bottom line of the display followed by the device mass storage specifier (e.g. `:HP7908, 803, 0`). If the error occurs during scanning for OSses, it will not terminate the scan. In this case the error(s) will be listed on the left hand side of the display. Figure 4-7 is an example display with several errors.

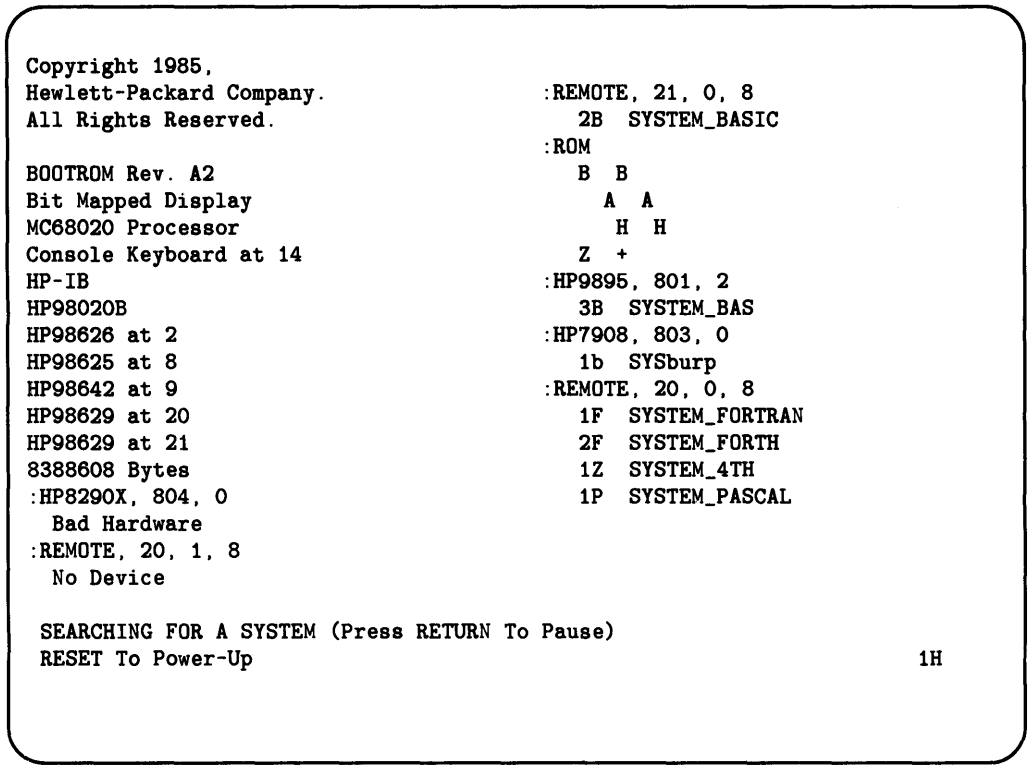


Figure 4-7. Boot Display with Errors

Chapter 5 explains troubleshooting the computer and bus expander using self-test errors displayed on the monitor or LEDs.

Booting From The SRM

Placing bootable OSses on sector oriented devices is fairly straight forward. On LIF devices an OS file must be created, and on SDF and HP-UX devices a boot area must be created. For the SRM, OSses to be booted must be placed in system files in the directory `/SYSTEMS`.

Because the SRM is a shared resource there are some unavoidable and peculiar behaviors that can be exhibited if the `/SYSTEMS` directory changes while the Boot ROM is scanning it. During the scanning or booting process, the order of the directory can be re-arranged, OS files can be deleted, or added. This means that the Boot ROM may show an OS that does not exist anymore, may not show an OS that does exist, or may never show an OS that has always been there.

If an OS that does not exist is chosen to be booted, the Boot ROM will stop with the error `NOT FOUND`. A reset is required to try again.

As long as the `/SYSTEMS` directory is stable, which is usually the case, everything will work as expected.

Troubleshooting 5

Introduction

Analytic Troubleshooting

Troubleshooting computers is the process of getting answers to these five questions:

- What exactly is wrong, or what are the bad symptoms?
- Where are the bad symptoms appearing?
- When do the bad symptoms occur?
- How bad is the problem or to what extent does it occur?
- What actually caused the problem in the first place?

Getting the answers to these questions usually makes the troubleshooting process much more effective and less costly. When a failure in a computer system occurs, remember these questions and get the answers to each of them.

After you have all answers possible, decide what's the most probable cause of the problem. Sometimes you'll arrive at several choices for a cause. For each choice, qualify it against the answers to the questions above. The most probable cause is the one that logically justifies the correct answers to these questions.

Materials Required

Several items are required to troubleshoot the computer or expander to the failed assembly:

- Model 330/350 Computer and HP 98568 Opt. 132/98570A Expander Service Handbook
- Series 200/300 Test Tools Package.
- Digital Voltmeter.
- Anti-Static Workstation.

Test LED Displays

Eight test LEDs are located behind the front panel and are visible from the front of the computer. In this manual, the LED's are shown in the following context:

LED On ●

LED Off ○

Troubleshooting Procedures

System Level

System level troubleshooting consists of finding out what part of a computer system is not working correctly. A system consists of the computer and its installed accessories, interfaces, peripherals, power source, *and the users.* Each of these system elements is subject to the environment which includes, physical, electrical, and human factors.

When part or all of the computer system fails, your initial activity should be finding the part of the system has the problem. One of the best things to do first is to talk to the users and ask them to give specific information on what they and the system were doing when the system, or part of it, failed. You may have to duplicate their activities in order to make the failure occur. If the failure is intermittent, this process may take some time.

Running tests on the system can also be helpful. A test is nothing more than a specific action with the system that should result in a specific response. Simple tests are nothing more than typing in simple instructions on the keyboard and executing them. A command to print or plot specific date is an example. Mass storage, graphics, or other functions can be checked in the same way. These type of tests are called Quick Checks.

After determining what part, or product, of the system is failing, the next step is to find out what part of the product is causing the problem. In this case, it is assumed that the computer or expander has the problem. The rest of this chapter covers troubleshooting the computer and expander.

Computer/Expander Troubleshooting

Both units may be analyzed alike, except for the processor in a computer's system slot. Each has the same power supply, motherboard, fans, and backplane system.

Three levels of troubleshooting these products are explained. For each level different portions of these products must be operational. A summary of these levels and what must be operational is shown in Table 5-1.

In order to choose the best approach to start with, obtain as much information as possible from the user. If the unit is not working at all, the Inoperative Unit Procedure is a good place to start. If the user indicates that most of the unit is operating properly, the Functional Unit Procedure may be a good place to start. If the users information is not conclusive, use the following procedure to determine the problem area:

1. Turn the unit on and check for fan and Self-Test LED operation.
2. If the fans or LED's aren't working, go to the Inoperative Unit Procedure. If they do work, go to the Functional Unit Procedure.

Table 5-1. Computer/Expander Troubleshooting Procedures

Procedure	What MUST Function
Inoperative Unit	Nothing
Live Unit	Power Supply Motherboard
Functional Unit	Computer: Power Supply Part of processor Part of motherboard Top 16K of RAM DIO-II Bus Some inputs from keyboard Output to operate monitor Bus Expander: Power Supply Part of motherboard One accessory card

Inoperative Unit Procedure

An Inoperative Unit is one which does not appear to function at all. No power-on or self-test LEDs, fan rotation, or response to keyboard inputs are typical symptoms. Nearly all inoperative units have one of these basic problems:

- Defective power supply.
- Voltage select switch in wrong position
- Improper line voltage/frequency or defective power cord.

Follow this procedure to isolate the problem. If an assembly is defective, this procedure indicates which assembly should be replaced to eliminate the problem.

WARNING

Hazardous voltages are present in the unit when it is plugged in. Turn the unit off and unplug the unit before placing test leads, checking fuses, or removing/installing assemblies.

1. Check that the voltage select switch is set correctly. Refer to Chapter 2 in the Service Handbook for the correct procedures.
2. Check that the fuse is good and of the correct size. If the fuse is defective, replace it. If the fuse is good, skip to Step 4.
3. Turn the unit on, then turn it off and recheck the fuse. If the fuse is defective skip to Step 5, otherwise go on to Step 4.
4. If one or both fans are not rotating, check the voltage across the inoperative fan's voltage terminals. If the voltage is correct, the fan is defective. If not, continue with the voltage check procedure. Fan voltage should be as shown below.
    a. Large fan voltage: +12 Vdc.
    b. Small fan voltage: +17 Vdc (+5 and −12 Vdc).
5. If the fuse is open, one of the installed assemblies is defective.
6. Remove all assemblies from the slots.
7. Replace the fuse. Install the power cord and turn the unit on, then turn it off and recheck the fuse. If the fuse is good, one of the removed assemblies is defective. If the fuse is open, the power supply, motherboard, or backplane is defective; go to Step 8.
8. Disconnect the card cage ribbon cables.. After installing a new fuse turn the unit on, then off, and check the fuse. If the fuse is good, the backplane is defective, If the fuse is blown, the power supply or motherboard is defective.
9. Repeat Step 8 but instead remove the motherboard. If the fuse is good, the motherboard is defective. Otherwise, the power supply is defective. After replacing the defective unit, you should now be able to perform Live Unit Troubleshooting Procedures.

Live Unit Procedure

A live unit is one which has a motherboard and properly functioning power supply but the unit will not function. One of the assemblies installed (other than the power supply) is usually defective. Live units often are very difficult to troubleshoot, since a problem anywhere on a bus in the computer or bus expander can shut the system down and prevent the execution of any instructions, even those from the self-test.

The Live Unit Procedure is a method for finding the defective assembly which is preventing the processor from executing instructions. It assumes that the power supply is operating properly, and the self-test tried to run, but didn't.

If the power supply is not operating properly, refer to the Dead Unit Procedure. If the turn-on self-test runs enough to either display a failure, stalls in a meaningless state, or passes, refer to the Functional Unit Procedure.

Live Unit Procedure is explained by first assuming either the computer or bus expander is defective but which one cannot be determined at this time. Depending on the application, several accessory cards may be installed in both units. Once the problem in the computer system has been isolated to the computer/bus expander units, it's sometimes best to start with a minimum configuration.

Minimum Configuration

A minimum configuration consists of just enough assemblies to function at a minimum level, but not necessarily correct. For this computer, a minimum functional level is that required to light the Self-Test LEDs. Minimum hardware to do this is:

- Power Supply.
- Motherboard.
- Processor Board.
- At least 4 Mbytes of RAM configured at the top of memory.

For the bus expander, the minimum functional configuration is:

- Power Supply.
- Motherboard.
- One functional board or card.

Computer Minimum Configuration

To get a minimum configuration in the computer, follow these steps after verifying the power supply functions correctly.

CAUTION

Remember to turn the unit off and unplug it before removing any assembly. Use ESD precautions and a static-free workstation.

1. Turn the unit off.
2. Separate the bus expander from the computer.
3. Remove all accessories. Leave enough RAM installed that's configured at the top of memory.
4. Leave the processor board in.
5. Remove the top cover and disconnect the ribbon cable from the backplane.
6. Plug the unit in and turn it on. The Self-Test LED's should ripple and change state several times.
7. If the LED's do not light or ripple, turn the computer off, unplug it, and relocate the processor to the other system slot.
8. Plug the computer in, turn it on, and watch the LEDs. If the LED's don't light or ripple, either the motherboard or processor is bad. Replace one or the other and retest until the LED's light and/or ripple.

Before you can proceed further, the minimum configuration must work. If this configuration works, then you can proceed to the next level, Functional Unit Troubleshooting.

Bus Expander Minimum Configuration

To get a minimum configuration in the bus expander, follow these steps after verifying the power supply functions correctly.

CAUTION

Remember to turn the unit off and unplug it before removing any assembly. Use ESD precautions and a static-free workstation.

1. Turn the unit off.
2. Remove all boards/cards except one that can be recognized by the self-test.
3. Plug the bus expander in and turn it on.
4. Turn the computer on.
5. Verify the self-test identifies and/or correctly tests the board/card in the bus expander.

   If the board or card does not pass self-test, turn both units off, and relocate the board or card to another slot.

6. Repeat steps 4 and 5 until the board or card passes self-test. If the assembly does not pass self-test, either it or the bus expander is defective. In this case, repeat steps 6 and 7 using another board or card.

Before you can proceed further, the minimum configuration must work. If this configuration works, then you can proceed to the next level, Functional Unit Troubleshooting.

Functional Unit Troubleshooting

A functional unit is one that passes the minimum configuration test. It doesn't have to function properly, but at least start the self-test and light the LEDs for the computer. For the bus expander, one accessory card must at least pass self-test.

For the computer to pass the minimum computer configuration functions correctly, the LED's should end up as:

O O O O O O O O

Once the computer minimum configuration self-test passes, you're ready to start testing with an Intermediate Configuration.

Intermediate Configuration

You may configure the computer several ways for intermediate level troubleshooting in Functional Unit procedures. A good place to start is by having memory configured to address at the top of RAM. This will verify that more of the processor board is working. The procedures are:

1. Turn off the computer, unplug it, and reconnect the ribbon cables to the backplane.
2. Install a memory board (without system bus on a Model 350) configured for the top of RAM.
3. Plug the computer in, turn it on and watch the LED's go through self-test.
4. If the LED pattern is correct, skip to Step 6.

   If the pattern is incorrect, either the backplane or the processor is bad. Power down and relocate the memory board in another system slot, then retest. If necessary, run the test with the memory board in each system slot.
5. If the LED pattern is correct, skip to Step 6. If the pattern is incorrect, either motherboard or processor is bad. Replace each one and retest until the correct LED pattern is achieved.
6. If you're testing a Model 330 computer, skip to Step 12. For a Model 350, power down and unplug the computer. Install a the system bus between the processor board and a memory controller board.
7. Turn on the computer. Watch the self-test display on the monitor.
8. The display should be correct and reflect the total memory in the computer,

If the self-test display is correct, skip to Step 12.

9. Power down and unplug the computer. Install a video board and connect it to a monitor. Turn on the monitor.
10. Turn on the computer. Watch the self-test display on the monitor.
11. The display should be correct and reflect the total memory in the computer,

    If the self-test display is correct, skip to Step 12.

    If the self-test display is incorrect, the monitor, processor or video board may be defective. Replace these and test as required to get the correct display.
12. Turn the computer off and install the system interface board, then install the keyboard.
13. Turn the computer on and observe the self-test display. Check the keyboard to see if the self-test sequence responds to the keyboard. If the response is correct, you now have a Minimum Functional System. If the response is incorrect, go on to Step 11.
14. If the response to the keyboard inputs in incorrect, the keyboard, its electronics, or cable could be defective. Replace each until keyboard response is correct.

To have a Minimum Functional System, the following hardware must perform the indicated functions as shown in Table 5-2.

Table 5-2. Minimum Functional System

Assembly	Minimum Functions Performed
Power Supply	All voltages normal and within specifications.
Processor Board	CPU chip executes self-test, cycles memory, most instructions executed OK, self-test LED light.
4 Mbytes of RAM	Addresses, read/writes, and refreshes.
Video Board	Processes and outputs video.
System interface board.	Inputs/Outputs data between processor and peripherals.
Monitor	Displays information.

Once this level of operation is achieved, a similar process can be used to install and check other accessories, interfaces, and peripherals in the complete system. This also may be a good point to load and run one of the tests in the Series 200/300 Test Tools Package. Refer to the Test Tools Manual for tests information such as:

- Minimum Hardware Configuration Required.
- Test Loading and Running.
- Interpreting Test Results.

Series 300 Model 330/350 Test Tools are explained in the next section.

Test Tools

Overview

Series 200/300 Test Tools is a software package for verifying the integrity of Model 330 and 350 computer system installations. While the tests do not provide totally comprehensive system diagnostics, they are a valuable tool for trained service personnel when installing, servicing, and troubleshooting these computer's workstations. The tests can also be used by less-experienced users and operators for determining whether or not professional assistance is needed to identify and fix a system malfunction.

The tests described in this manual are for testing and troubleshooting Series 300 systems that do not require formal verification of operation before use. Series 300 HP-UX systems have a more critical need for system verification tests, so these tests may be used as part of the standard HP-UX operating system (HP-UX System Functional Tests and CS/80 Exerciser programs are very similar to the equivalent tests described in this manual). The Series 300 Computer Tests described in Part II of this manual can be used for troubleshooting beyond the testing level provided by HP-UX test programs, provided the system being tested has an internal or external flexible disc drive for loading and running the test software.

Series 200/300 Test Tools provide the following test capabilities when combined with the computer's Boot ROM self-test.

Computer Tests

Series 300 Computer Tests for the Model 330 and 350 computers are supplied on one of two discs, the other is for for Series 200 computers. They test the processor board, RAM, video and interface electronics, and other functions.

System Functional Tests

Five discs contain these tests. The first disc contains the Pascal-based operating system environment and the main menu; the other discs contains the test programs. These tests are used to verify communication between the computer and supported peripherals. They do not add significantly to the confidence levels achieved by the Boot ROM self-test program, though they expand confidence in overall system integrity by providing visible proof that communication with selected peripherals is correct and that interfacing is connected and set up correctly. The tests do not provide any worst-case tests at maximum speed or similar margin-of-safety tests.

CS/80 Exercisers

CS/80 Exerciser Programs are supplied on a single disc and is used to verify that CS/80 disc drives are correctly connected to the computer, and that the computer can successfully write and retrieve data to and from the disc or tape. The Pascal-based program also provides access to CS/80 disc and tape error logs for analyzing drive and media performance. This information is useful for troubleshooting, and for planning preventive maintenance programs.

Package Contents

The combined Series 200/300Test Tools software package is provided on both 3.5-inch discs and 0.25-inch tape as shown below:

Description	Part Number
Series 200/300 Test Tools, one 0.25-inch tape	09800-12700
Series 200/300 Test Tools, eight 3.5-inch discs	09800-12300

Discs in the 3.5-inch disc package are listed below.

Contents	Part Number
Series 200/300 Test Tools Manual	09800-90001
Series 200 Computer Tests Disc Rev. 1.1	09800-10336
Series 300 Computer Tests Disc Rev. 2.0	98561-11334
Series 200/300 System Functional Tests Discs:	
SFT0 Disc Rev. 1.2	09800-11334
SFT1 Disc Rev. 1.2	09800-11335
SFT2 Disc Rev. 1.2	09800-11336
SFT3 Disc Rev. 1.2	09800-11337
SFT4 Disc Rev. 1.2	09800-11338
CS/80 Exerciser Disc Rev. 3.1	09800-11304

One tape and the manual are packaged with the tape version.

Self-Test

Use the self-test to troubleshoot a unit which can execute some instructions, but cannot accept, store or output data correctly. This means that the basic elements of the computer are functioning. The basic elements include the power supply, processor board, and at least the first 16k bytes of RAM. If any of these are not known to be functional, refer to the Initial Troubleshooting Procedure section.

The self-test checks most assemblies in the computer. Both pass and error displays in binary are shown by the LED display. LED's are located behind the front panel and are visible through the holes in the front panel.

For a functional description of the self-tests, refer to Chapter 4.

Failure Indications

As the self-test progresses, the LED's display the current state. At the end of the test, a power-up with no errors is indicated by all LEDs turned off and by immediate entry into the boot scanner.

Should a failure occur during the self-tests, it will be indicated on the LEDs at the end of the tests. If there was more than one failure, the highest priority failure will be indicated on the LEDs. All the LED values are shown in Table 5-3.

The highest priority failure is also output to the beeper, if present. The lower seven bits of the LED value are beeped in seven tones as follows:,

- Most significant bit first.
- One second beep per bit.
- A zero (LED off) is represented by a low tone.
- A one (LED on) is represented by a high tone.

If no failure occurs, the beeper will not sound off. If the failure was a Boot ROM checksum error, the following message will be displayed:

```
CONTINUE AT OWN RISK (Press RETURN To Continue)
```

Once this message has been printed, the [Return] key must be pressed to continue to the boot scanner. The probability is fairly low that the error will adversely affect the user, but if it does, it could be catastrophic.

For all other failures, the message:

```
WAITING 1 MINUTE (Press RETURN To Abort Wait)
```

will be displayed.

The Boot ROM will time out after approximately one minute and will then continue into the boot scanner. This allows time for the display to warm up and for the user to read the error messages. These failures are usually non-fatal so, in an Unattended Mode, the Boot ROM will still boot the first OS it finds. Pressing [Return] will terminate the beeping error code and abort the one minute wait. Pressing [Return] will also make the computer revert to the Attended Mode. This means that the Boot ROM will display all OSses found and will not boot one until one in chosen and entered by the user.

General Description of Failure Codes

Table 5-3 shows the general meaning of error codes. These codes are explained further in other tables. LED patterns are represented by a black dot for on and a white dot for off. Letter designators indicate the LED in that position is on or off, depending on the binary code used to represent the device or failure type.

Table 5-3. General Failure LED Indications

Upper 2 Bits Fail Indicator	LED Code and Failure Description
State Indication Only:	○○ SS SSSS Where SS SSSS Indicates State of Power-up
Required Device Missing or DTACK Failure:	○● DD DDDD Where DD DDDD Indicates Device
Failing Device:	●○ DD DDDD Where DD DDDD Indicates Device
Special Codes (Special Case Highest Priority Codes):	● ● ● ● ● ● ●● LEDs Never Accessed (or Unused Code) ○ ● ● ● ● ● ●● LEDs Failed to DTACK ○ ○ ○ ○ ○ ● ○● Timer on processor board has failed or is missing.

Lower 2 Bits State or Device Codes	LED Code and Failure Description
Miscellaneous (Highest Priority):	XX ○○ FFFF Where FFFF indicates Failure (Xs are don't-care bits)
Internal Peripheral Failure (Medium Priority):	XX ○● PPPP Where PPPP is Peripheral Number
I/O Card Failure (Lowest Priority):	XX ● S SSSS Where S SSSS is Select Code

State and Failure Codes

Table 5-4a is a list of all LED failure codes used in the computer Boot ROMs. Codes are listed here in numerical order for easy reference, and then again in order of occurrence and priority.

Table 5-4a. Model 330/350 Boot ROM LED State and Failure Codes

(In numerical order):

Explanation	LED Code
No failure	○ ○ ○ ○ ○ ○ ○○
LED ripple (all on, then off in sequence from MSB)	○ ○ ○ ○ ○ ○ ○●
Resetting I/O	○ ○ ○ ○ ○ ○ ●○
Checksumming Boot ROM (or LED ripple)	○ ○ ○ ○ ○ ○ ●●
Testing top RAM (or maybe the Boot ROM checksum failed)	○ ○ ○ ○ ○ ● ○○
Processor board timer failed or is missing	○ ○ ○ ○ ○ ● ○●
Searching for boot extension ROMs	○ ○ ○ ○ ○ ● ●○
starting test vector list (or LED ripple)	○ ○ ○ ○ ○ ● ●●
Preloading RAM	○ ○ ○ ○ ● ○ ○○
Testing RAM	○ ○ ○ ○ ● ○ ○●
Checksumming ROM systems	○ ○ ○ ○ ● ● ○●
LED ripple	○ ○ ○ ○ ● ● ●●
Testing internal keyboard (or an interrupt line is stuck)	○ ○ ○ ● ○ ○ ●○
Testing external keyboard	○ ○ ○ ● ○ ● ○○
Testing internal HP-IB	○ ○ ○ ● ○ ● ●○
Testing internal mass storage	○ ○ ○ ● ○ ● ●○
Testing DMA card	○ ○ ○ ● ● ○ ○○
Checksumming ID/INIT ROM on bit-mapped video board	○ ○ ○ ● ● ● ○●
Testing alpha video board	○ ○ ○ ● ● ● ●○
Testing graphics on alpha/graphics (or LED ripple)	○ ○ ○ ● ● ● ●●
Testing I/O card on select code 0	○ ○ ● ○ ○ ○ ○○
Testing I/O card on select code 1	○ ○ ● ○ ○ ○ ○●
through	through
Testing I/O card on select code 9	○ ○ ● ○ ● ○ ○●
through	through
Testing I/O card on select code 31 (and LED ripple)	○ ○ ● ● ● ● ●●

Continued on the next page.

Table 5-4b, Model 330/350 Boot ROM LED State and Failure Codes

Continued from previous page.

Explanation	LED Code
RAM gone above FFFFC000, no memory found	○ ● ○ ○ ○ ● ○○
LEDs Failed to acknowledge or LED ripple	○ ● ● ● ● ● ●●
CPU register test failure, or bad MC68020	● ○ ○ ○ ○ ○ ○●
Boot ROM checksum failure, or bad Boot ROM	● ○ ○ ○ ○ ○ ●●
RAM failure above FFFFC000, or memory is bad	● ○ ○ ○ ○ ● ○○
RAM failure, or part of memory is bad	● ○ ○ ○ ● ○ ○●
Insufficient RAM to self-test or boot system	● ○ ○ ○ ● ○ ●○
System Interface Board Keyboard Electronics Failure	● ○ ○ ● ○ ○ ●○
Bad keyboard circuit, not system interface board	● ○ ○ ● ○ ○ ●●
System interface board HP-IB failure	● ○ ○ ● ○ ● ○○
DMA failure on system interface board	● ○ ○ ● ● ○ ○○
Character font for video board missing or bad	● ○ ○ ● ● ● ○○
Video board failed	● ○ ○ ● ● ● ○●
Alpha video card failure	● ○ ○ ● ● ● ●○
Graphics failure on alpha/graphics board	● ○ ○ ● ● ● ●●
I/O card on select code 0 failure	● ○ ● ○ ○ ○ ○○
I/O card on select code 1 failure	● ○ ● ○ ○ ○ ○●
through	through
I/O card on select code 9 failure	● ○ ● ○ ● ○ ○●
through	through
I/O card on select code 31 failure	● ○ ● ● ● ● ●●
LEDs never accessed (or LED ripple)	● ● ● ● ● ● ●●

Table 5-5. Boot ROM Sequential State LED Codes

Explanation	LED Code
LED ripple (all on, then off in sequence from MSB)	○ ○ ○ ○ ○ ○ ○●
Testing top RAM	○ ○ ○ ○ ○ ● ○○
Searching for boot extension ROMs	○ ○ ○ ○ ○ ● ●○
Starting test vector list	○ ○ ○ ○ ○ ● ●●
Testing Processor Board Timer	○ ○ ○ ○ ○ ● ○●
Resetting I/O	○ ○ ○ ○ ○ ○ ●○
Testing Alpha Card	○ ○ ○ ● ● ● ●○
Testing system interface board keyboard electronics	○ ○ ○ ● ○ ○ ●●
Checksumming Boot ROM	○ ○ ○ ○ ○ ○ ●●
Preloading RAM	○ ○ ○ ○ ● ○ ○○
Testing graphics on alpha/graphics card	○ ○ ○ ● ● ● ●●
Testing system interface board HP-IB	○ ○ ○ ● ○ ● ○○
Testing system interface board DMA	○ ○ ○ ● ● ○ ○○
Testing I/O card on Select Code 0	○ ○ ● ○ ○ ○ ○○
Testing I/O card on Select Code 1	○ ○ ● ○ ○ ○ ○●
through	through
Te ing I/O Card on Select Code 9	○ ○ ● ○ ● ○ ○●
through	through
Testing I/O card on Select Code 31	○ ○ ● ● ● ● ●●
Testing RAM	○ ○ ○ ○ ● ○ ○●

Table 5-6. Boot ROM LED Failure Codes – Prioritized

Explanation	LED Code
LEDs never accessed	● ● ● ● ● ● ●●
LEDs failed to DTACK	○ ● ● ● ● ● ●●
CPU failure	● ○ ○ ○ ○ ○ ○●
Processor board timer failed	○ ○ ○ ○ ○ ● ○●
Boot ROM checksum failure	● ○ ○ ○ ○ ○ ●●
Top RAM test failure	● ○ ○ ○ ○ ● ○○
RAM failure	● ○ ○ ○ ● ○ ○●
Insufficient RAM	● ○ ○ ○ ● ○ ●○
System interface board keyboard electronics failure	● ○ ○ ● ○ ○ ●●
System interface board HP-IB failure	● ○ ○ ● ○ ● ○○
System interface board DMA failure	● ○ ○ ● ● ○ ○○
I/O card on select code 0 failure	● ○ ○ ● ○ ○ ○○
O card on select code 1 failure	● ○ ○ ● ○ ○ ○●
through	through
I/O card on select code 9 failure	● ○ ○ ● ● ○ ○●
through	through
O card on select code 31 failure	● ○ ● ● ● ● ●●
Alpha video card failure	● ○ ○ ● ● ● ●○
Font failure in processor board video circuit	● ○ ○ ● ● ● ○○
Graphics failure on alpha/graphics card.	● ○ ○ ● ● ● ●●
No Failure	○ ○ ○ ○ ○ ○ ○○

Parts Lists 6

Replacement Parts Information

Introduction

Field replaceable parts are listed in this chapter for the computers and expanders. Components, such as ICs, are not available for field repair.

Parts are available direct from:

Corporate Parts Center
333 Logue Avenue
Mountain View, California 94042 USA

Telephone: (415) 968-9200

Parts may be ordered through your local HP Sales and Service Office. To help get parts as soon as possible, please write the address and telephone number of your local HP Office in the spaces below.

Name: _____

Address: _____

City, State ZIP: _____

Telephone: _____

Cooperative Support Program

HP's Cooperative Support Program is available for customers that can provide technical assistance, manual updates, and other helpful information for hardware support. Your local HP Sales and Service Office can provide the information for this support service.

Exchange Parts

Exchange parts are available for some items at a reduced cost. When an exchange part is ordered, your account will be charged for a new part. Customers have 15 days to return the failed part to receive credit for the difference between a new and exchange part.

Please return failed exchange parts to your local HP Sales and Service Office as soon as possible. Place them in anti-static bags (see Parts List for part numbers) and package them securely in a sturdy container. It's a good idea to save the containers and static-free bags you receive parts in and use them to ship parts in.

Part Number Lists

The parts listed in this section apply to both Models 330/350 computers and the HP 98568A Opt. 32 and HP 98570A expander, unless noted otherwise. Various interfaces, accessories and HP-HIL devices are also listed.

Static-Free Bags

Part Number	Description	Comments
9222-0978	9-inch by 10-inch cushioned pouch, for DIO cards	
9222-0980	9-inch by 15-inch cushioned pouch, for system boards	

Labels

Part Number	Description	Comments
98562-84002	Identification Label	
5958-4325	UL Info Label	
7120-3428	CSA Label	
7121-4858	Service Warning Label	
7121-4733	Serial Label	
7124-2083	Voltage warning label	
98570-84002	FCC Label, Expander	
7121-4859	Fuse Rating Label	
98562-84005	Battery Warning Label	
5955-8036	Computer compliance label	
5955-8037	Peripheral compliance label	
9320-5673	Blank ID# label	

Computer Electrical Parts

Miscellaneous Electrical Parts

Part Number	Description	Comments
1250-0781	BNC coax adaptor	
5180-0410	Large fan	
5180-1303	Small fan	
5180-0407	LED cable assembly	
98561-61601	DIO Bus cable (short)	
98561-61602	DIO Bus cable (long)	
98561-61604	RS-232 cable	
98562-61600	Fast HP-IB cable	

Printed Circuit Boards

Exchange Part Number	New Part Number	Description	Comments
	0950-1760	Power supply (without switch shaft)	
	98561-66500	DIO-II backplane	
98562-69511	98562-66511	Model 330 Processor board	
98562-69516	98562-66516	Model 350 Processor board - 517	
98562-69520	98562-66520	4 Mbyte RAM controller board —	98258-66520
98562-69521	98562-66521	4 Mbyte RAM add-on board —	98258-66521
98562-69522	98562-66522	12 Mbyte RAM add-on board —	98258-66522
98562-69530	98562-66530	System interface board - 33	
98562-69531	98562-66531	High-speed disc add-on board	
	98562-66501	Motherboard	
	98562-66502	2-connector system bus	
	98562-66503	3-connector system bus	
	98562-66506	2-slot DIO backplane	
98542-69570	98542-66570	Med-res monochrome video board	
98543-69570	98543-66570	Med-res color video board	
98544-69570	98544-66570	Hi-res monochrome video board	
98545-69570	98545-66570	Hi-res color video board	
98546-69571	98546-66571	Display compatibility video card	
98547-69570	98547-66570	Hi-res color video board	
98204-69577	98204-66577	Display compatibility graphics card	

Computer Case Parts

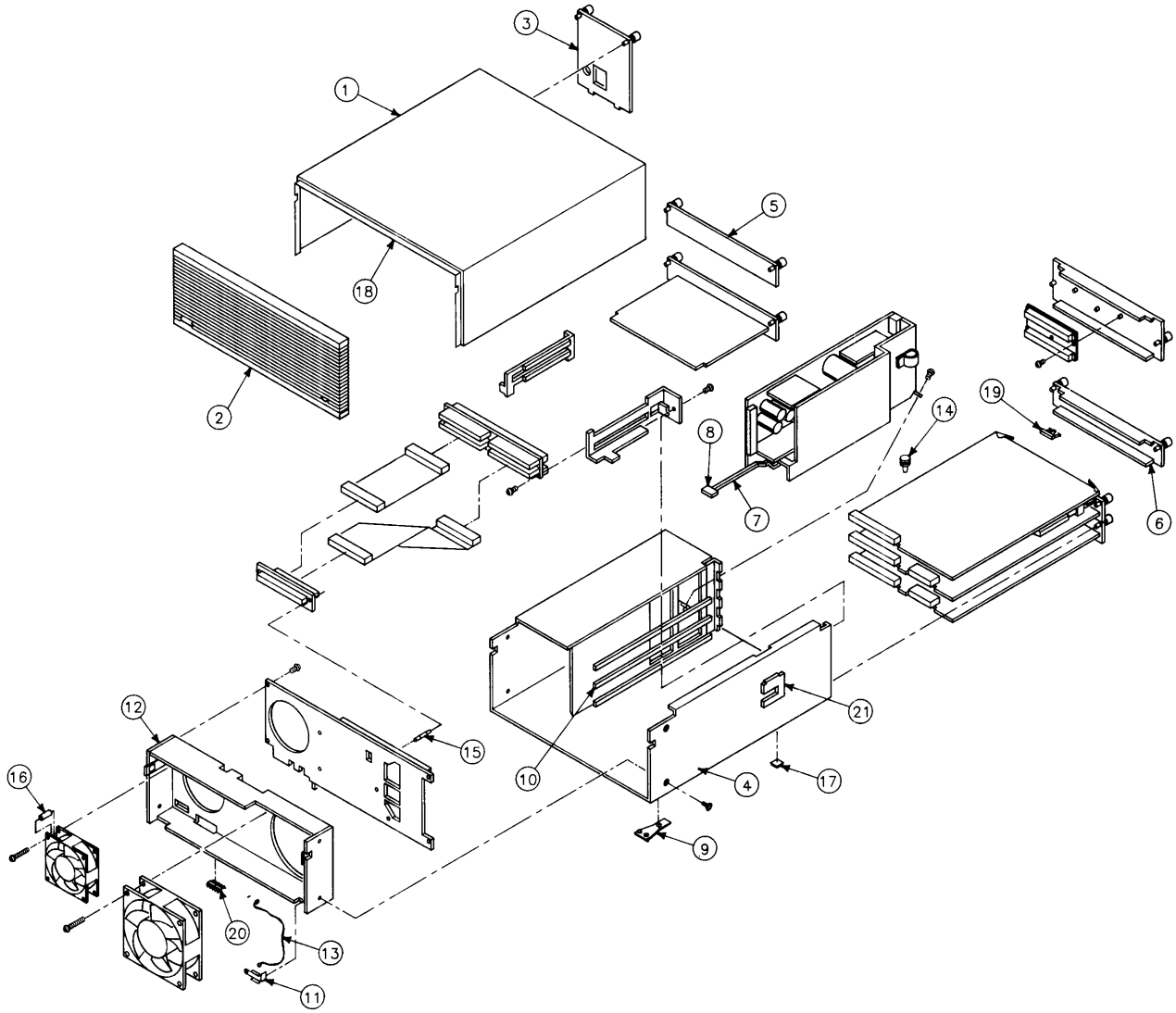


Figure 6-1. Model 330/350 Computer Case Parts.

Computer Case Parts List

Ref.	Part Number	Description	Comments
1	5001-9009	Top cover	
2	5041-2413	Front panel	
3	5001-3700	Power supply cover	
4	5001-3696	Chassis	
5	98561-04102	2-slot cover plate	
6	98561-04107	Cover plate	
7	5041-2412	Power switch shaft	
8	5041-1203	ON-OFF pushbutton	
9	09121-48303	Moulded foot	
10	0403-0379	PC board guide	
11	5001-9001	LED bracket	
12	5001-9011	Fan plate	
13	09817-47700	Light pipe	
14	0380-1655	Snap-in spacer	
15	0380-1901	Support post	
16	0380-0012	Round spacer, 0.875-in. long	
17	0403-0427	Mounting foot bumper	
18	5041-2420	Top cover insulator	
19	5180-0409	Spring clip	
20	8160-0389	Double RFI finger	
21	5001-3694	Card guide bracket	
	0515-0219	Screw M3 × 6, flat head	
	0515-0389	Screw M3.3 × 8, pan head, ext. lock washer	
	0515-0536	Screw M3 × 0.5, machine	
	0515-0990	Screw M3 × 3.5, pan head, ext. lock washer	
	0515-1146	Screw M3 × 6, pan head patch	

Expander Case Parts Diagram

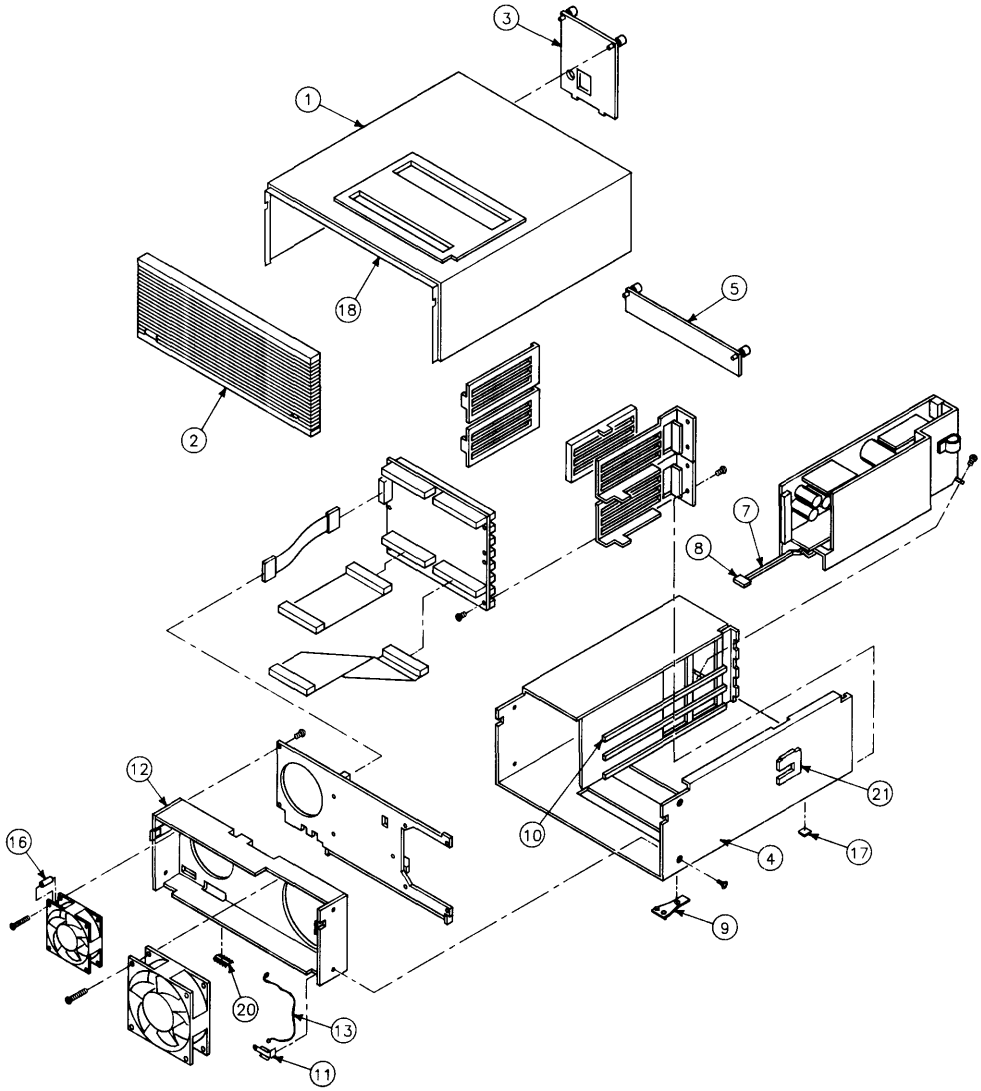


Figure 6-2. Expander Case Parts Diagram

HP 98570A and 98568A Opt. 132 Expander

Expander Case Parts List

Ref.	Part Number	Description	Comments
1	5001-9015	Top cover (with cable slots)	
2	5041-2413	Front panel	
3	5001-3700	Power supply cover	
4	5001-9014	Chassis	
5	98561-04102	2-slot cover plate	
6	5001-9016	System slot cover plate	
7	5041-2410	Power switch shaft	
8	5041-1203	ON-OFF pushbutton	
9	09121-48303	Moulded foot	
10	0403-0397	PC board guide	
11	5001-9001	LED bracket	
12	5001-9011	Fan plate	
13	09817-47700	Light pipe	
14	0380-1655	Snap-in spacer	
15	0380-1901	Support post	
16	0380-0012	Round spacer, 0.875-in. long	
17	0403-0427	Mounting foot bumper	
18	5041-2420	Top cover insulator	
19	5180-0409	Spring clip	
20	8160-0389	Double RFI finger	
21	5001-3694	Card guide bracket	
	5041-2414	Ganged card guide	
	5041-2418	Pin cover	
	5041-2419	Channel-lock	
18	5041-2420	Top cover insulator	
	98561-04107	Cover plate	
	0515-0219	Screw M3 × 6, flat head	
	0515-1146	Screw M3.5 × 8, pan head, ext. lock washer	
	0515-0898	Screw M4 × 7, 6mm long	
	0515-0913	Screw M4 × 7, 10mm long	
	0515-0990	Screw M3 × 3.5, pan head, ext. lock washer	

Printed Circuit Boards

Part Number	Description	Comments
0950-1760	Power supply (without switch shaft)	
98570-66501	HP 98570 Standard motherboard	
98562-66508	Adaptor Board/Cable	
98561-66501	4-slot DIO Backplane	
98568-66500	HP 98668 Opt. 132 8-slot backplane	

Miscellaneous Electrical Parts

Part Number	Description	Comments
5180-0410	Large fan	
5180-1303	Small fan	
5180-0407	LED cable assembly	
98561-61601	DIO Bus cable (short)	
98561-61602	DIO Bus cable (long)	

External Cables

Part Number	Description	Comments
8120-3616	Color Cable	
	Audio Cable, RCA-RCA	
09920-61602	Interface Cable	
8120-4483	Video Cable Adaptor, RCA-BNC Color Cable, High-resolution Cable, 4963-E-24	
5061-6533	Video Cable, RCA-RCA Audio Cable, RCA-earphone	

HP-HIL Devices

Exchange Part Number	New Part Number	Description	Comments
35723-69003	35723-66003	Touchscreen PC board	
	46021-60201	ASCII Keyboard	
	46020-60001	Keyboard Cable	
	HP 46060A	HP Mouse	
	46080-61601	Video Cable, 3-conductor	
	46081-61601	2.4-metre extension cable	
	46082-61601	Short audio cable	
	46082-61602	30-metre audio extension cable	
	46082-61603	30-metre video cable	
	46082-61604	15-metre remote cable	
	46082-61605	15-metre video cable	
	46083-61601	Short audio cable	
	46083-67901	Switch cap assembly	
	HP 46085A	Control dials	
	46085-85000	Overlay	
	0403-0430	Moulded foot	
	QEDS-7099	RPG Pot assembly	
	5041-2416	RPG knob	
	HP 46084A	ID module	
	HP 46086A	Button box	
	HP 46087A	"A" size digitizer	
	HP 46088A	"B" size digitizer	
	HP 46094A	Quadrature port device	
	HP 46095A	3-button mouse	
	HP 92916A	Bar code reader	

References 7

Introduction

Information in this chapter should help you in various situations. The references include part numbers of many hardware documents used with Model 330/350 computer systems.

Service Information Locator

In the front of this manual, and in the front of the Model 330/350 Service Handbook, is a Service Information Locator. It lists subjects and shows chapter numbers in other Hardware Support Document that has the information.

Localized System Identification

Model 330/350 computer systems have keyboards and display characters localized for the language spoken and written in several countries. When an HP field office orders a computer system, a letter suffix is added to the field office ordering number to ensure the correct keyboard and character font is bundled with the hardware. Table 7-1 identifies the letter suffixes to product numbers for these systems.

For example, a system ordered from an HP field office in Toronto, Canada, to be used by English speaking Canadians, the field would order 98562BL.

Table 7-1. Localized System Suffixes

Local Language	Localized System Suffix
U.S.A English	A
French Canadian	C
German	D
European Spanish	E
French	F
Dutch Canadian	H
Katakana (Japanese)	J
Intercontinental English	K
Canadian English	L
Latin Spanish	M
Norwegian	N
Swiss German	P
Swiss French	Q
Swedish	S
UK English	U
Belgium Dutch	W
Finnish	X
Danish	Y
Italian	Z

Related Hardware Documentation

Hardware Support Documentation

Table 7-2. Hardware Support Documentation

Printed Pages Part Number	Manual Title
09000-90041	HP 9000 Series 200/300/500 Site Preparation Manual
98561-90020	Series 300 Configuration Reference Manual
09800-90001	HP 9000 Series 200/300 Test Tools Manual
98562-90010	HP 9000 Series 300 Model 330/350 DIO-II Accessory Development Guide
98562-90030	HP 9000 Series 300 Model 330/350 Service Information Manual
98562-90039	HP 9000 Series 300 Model 330/350 Service Handbook
98562+49A-90101	HP 9000 Series 300 Model 330/350 Self-Paced Hardware Training Guide

Table 7-3. Document Binders

Binder Part Number	Description
9282-1077	1-inch, 3-ring, 8.5 by 11-inch page size, 300 pages
9282-1078	1.5-inch, 3-ring, 8.5 by 11-inch page size, 350 pages
9282-1079	2-inch, 3-ring, 8.5 by 11-inch page size, 600 pages
9282-1080	2.5-inch, 3-ring, 8.5 by 11-inch page size, 750 pages
9282-1081	1-inch, 3-ring, 7 by 8.5-inch page size, 300 pages
9282-1082	1.25-inch, 3-ring, 7 by 8.5-inch page size, 450 pages
9282-1080	1.5-inch, 3-ring, 7 by 8.5-inch page size, 600 pages

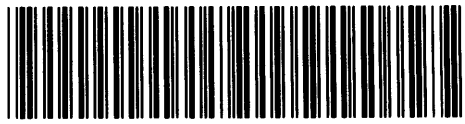
Installation Manuals/Notes

Table 7-4. Installation Manuals/Notes

Printed Pages Part Number	Manual Title
5958-4342	HP 98542/3/4/5A Video Board Installation Note
5958-4343	HP 98569A Rack-Mount Kit Installation Note
5958-4344	HP 98567A Rack-Mount Kit Installation Note
5958-4351	HP 98567B Rack-Mount Kit Installation Note
98242-90600	HP 98243A Upgrade Processor Installation Note
98242-90601	HP 98242B 2-Slot DIO Backplane Installation Note
98244-90601	HP 98244A Core Upgrade Installation Note
98246-9060?	HP 98246A Model 330 Processor Board Installation Note
98246-90601	HP 98246A Model 350 Processor Board Installation Note
98247-90601	HP 98247A System Interface Board Installation Note
98258-90601	HP 98258A 4 Mbyte RAM Controller Board Installation Note
98258-90601	HP 98258A 4 Mbyte RAM Add-On Board Installation Note
98262-90601	HP 98262A High-Speed Disc Add-On Board Installation Note
98546-90600	HP 98546A Display Compatibility Interface Installation Note
98560-90623	HP 98562B/98587B/98586B Installation Note
98568-90600	HP 98568A Eight-Slot Bus Expander Installation Note
98622-90000	HP 98622A GPIO Installation Manual
98623-90000	HP 98623A BCD Installation Note
98624-90000	HP 98624A HP-IB Installation Note
98625-90000	HP 98625A/B Disc Interface Installation Manual
98626-90000	HP 98626A RS-232 Installation Manual
98627-90000	HP 98627A Color Video Interface Installation Manual
98628-90001	HP 98628/98691 Datacomm Installation Manual
98630-90000	HP 98630A Breadboard Installation Manual



HP Part Number
98562-90030
Microfiche No. 98562-99030
Printed in U.S.A. 12/86



98562-90630
For Internal Use Only