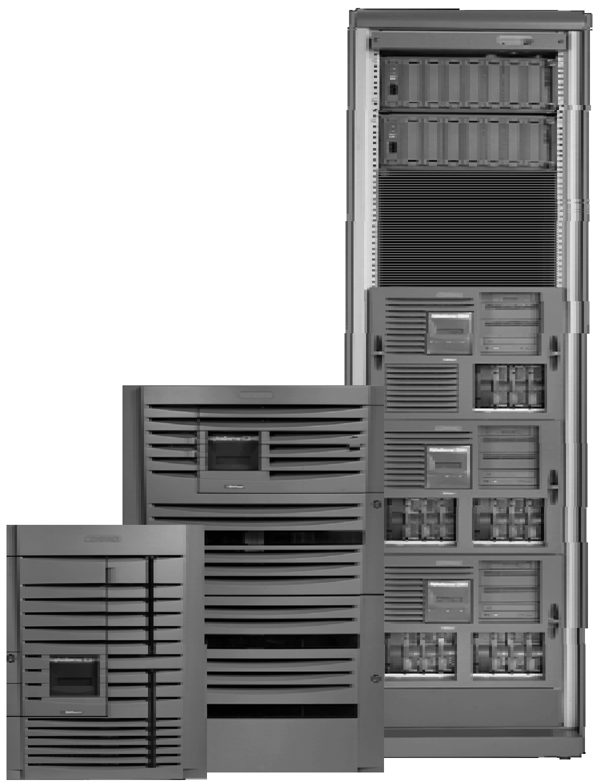
COMPAQ

Compaq AlphaServer ES40 Systems

Technical Summary



Contents

Compaq AlphaServer ES40 Systems

The *Compaq AlphaServer* ES40 system is a high performance, scalable enterprise server for business, technical, and scientific applications. With its flexible design, it can go in an office environment or computer room. It performs as a high-capacity database server, high-performance application server, Network File System (NFS) server, or Internet server.

***Compaq AlphaServer* products use the 64-bit Alpha RISC architecture that supports multiple operating systems: *Tru64 UNIX, OpenVMS,* and Linux operating systems. The *AlphaServer* ES40 system integrates into your current operating environment and anticipates future needs with upgrade capabilities.**

For more information on *Compaq AlphaServer* ES40 systems, see: http://www.compaq.com/alphaserver/servers.html.

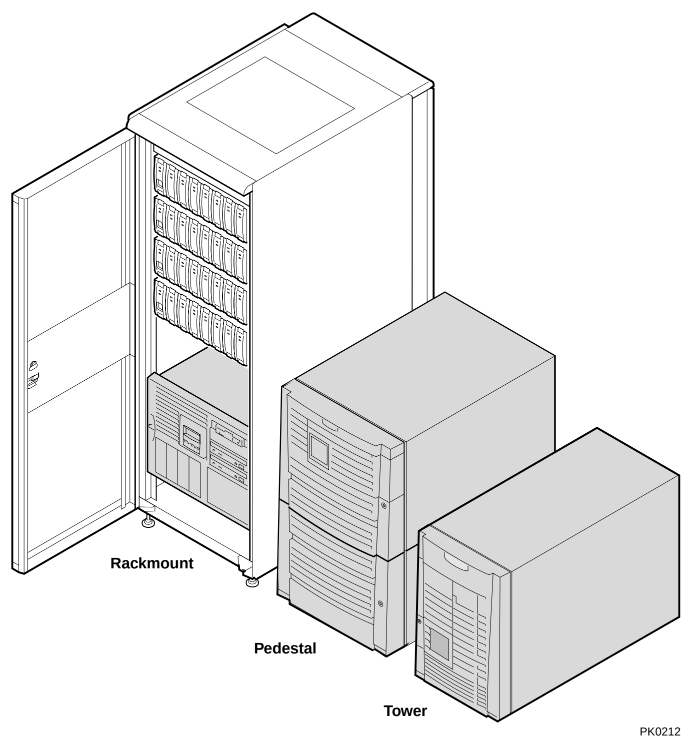
System Overview

The *Compaq AlphaServer* ES40 uses the third-generation Alpha 21264 processor. Two speeds are available, the EV67 chip, which runs at 667 MHz and the EV68 chip, which runs at 833 MHz. The switch-based system interconnect exploits the full potential of the 21264 chip.

The system is available in three packages: a standalone tower, a pedestal system with expanded storage capacity, and a rack-mount system. Two models are available: an entry-level system that supports 16 DIMMs (16 GB) and 6 PCI slots or a system that supports 32 DIMMs (32 GB) and 10 PCI slots. Each system variant is available with up to four processors.

The chassis used in the tower is rotated 90 degrees and installed in a pedestal enclosure or in a cabinet. Each chassis provides space for up to twelve 1-inch Ultra3 disks. Up to three BA36R StorageWorks shelves, or up to two Ultra3 Universal StorageWorks shelves can be installed in the pedestal system; and up to six BA36R StorageWorks shelves, or up to eight Ultra3 Universal StorageWorks shelves (single-bus or split-bus) can be installed in a cabinet.

Systems can be purchased with *Tru64 UNIX* or *OpenVMS* operating systems installed. Or they can be purchased without any operating system, allowing customers to install Linux.



Features and Benefits

- **Leadership 64-Bit Architecture**

The Alpha 64-bit architecture was introduced with the Alpha 21064 chip in 1992 and now the 21264, builds upon that proven architecture.

- **Performance**

The Alpha 21264 chip, the world's fastest microprocessor, is offered with a switch-based interconnect that supports four processors. This switch-based system provides a memory bandwidth of up to 5.2 Gbytes/sec (peak) using two 256-bit memory buses running at 83 MHz.

- **Scalability**

An entry-level system (Model 1) offers one processor, 512 MB memory, and 6 PCI slots. Model 2, can have 32 GB memory, and 10 I/O slots. The pedestal system provides space for another 21 disks using BA36R StorageWorks shelves, or 28 disks using Universal StorageWorks shelves. beyond the 12 in the chassis. The cabinet can house up to four systems and/or additional disks. All variants support up to four processors.

- **Reliability and Availability**

The *AlphaServer* ES40 uses the latest technologies to achieve redundancy, error correction, and fault management. The system has redundant fans and power supplies; fans, power supplies, and disks can be hot plugged. The remote management console (RMC) monitors, sends alerts, and records possible error conditions. The RMC can be accessed even if the system is completely down.

- **ES40 Workstation**

The system is also offered as a workstation and is called the *AlphaStation* ES40.

Third-Generation Alpha Chip

The third generation of the Alpha microprocessor, the Alpha 21264, is a superscalar superpipelined implementation of the Alpha architecture. The first offering of this chip was known as EV6. These systems are offered with the EV67 chip (.28 micron) and the EV68 chip (.18 micron). Each chip has over 15.2 million transistors. In our discussion here, the Alpha 21264 designation applies to all variants of the chip.

Designed for performance, the 21264 achieves this goal by carefully studied and simulated architectural and circuit analysis. The 21264 memory system also enables the high performance levels. On-chip and off-chip caches provide for very low latency data access, which allows for very high bandwidth data access. (In ES40 systems the size of the off-chip cache is 8 MB running at 222 MHz (dual data rate cache) for EV67 and 8 MB running at 277 MHz DDR for EV68.)

Internal to each chip is a 64-Kbyte instruction cache (I-cache) and a 64-Kbyte data cache (D-cache).

- **I-cache.** 64 Kbytes, two-way set-associative, virtually addressed cache with 64-byte blocks
- **D-cache.** 64 Kbytes, two-way set-associative, virtually indexed, physically tagged, writeback cache with 64-byte blocks

Chip Operation

Several key design choices were made in the chip architecture to maximize performance: Four instructions are fetched each cycle, and then how those instructions are handled boosts the speed of execution. Register renaming assigns a unique storage location with each write reference to a register, avoiding register dependencies that can be a potential bottleneck to processor performance.

Another design feature, out-of-order execution, permits instructions to execute in an order different from the order that the instructions are fetched. In effect, instructions execute as quickly as possible. This allows for faster execution, since critical path computations are started and completed as soon as possible.

In addition, the Alpha 21264 employs speculative execution to maximize performance. It speculatively fetches and executes instructions even though it may not know immediately whether the instruction will be on the final execution path. This is particularly useful, for instance, when the 21264 predicts branch directions and speculatively executes down the predicted path. The sophisticated branch prediction in the 21264 coupled with the speculative and dynamic execution extracts maximum instruction parallelism from applications.

For more information about the chip, see: http://www.compaq.com/alphaserver/download/ev6chip.pdf.

Alpha 21264 Features

- Out-of-order instruction execution
- Large (64 Kbyte) on-chip data and instruction caches
- Improved branch prediction through intuitive execution
- Register renaming
- Increased bandwidth for high-speed access to second-level cache and system memory
- Motion video instructions
- Square root and divide instructions
- All instructions are 32 bits long and have a regular instruction format
- Floating-point unit, supports DIGITAL and IEEE floating-point data types
- 80 integer registers, 64 bits wide
- 72 floating-point registers, 64 bits wide

Model Variants

AlphaServer ES40 systems are offered in two models. The entry-level model provides connectors for four DIMMs on each of the memory motherboards (MMBs) and connectors for six PCI options on the PCI backplane.

Model 1	Model 2
1–4 CPUs	1–4 CPUs
Up to 16 GB memory	Up to 32 GB memory
6 PCI slots	10 PCI slots

To upgrade from Model 1, you replace the PCI backplane and the four memory motherboards. A Model 2 system has eight DIMMs on each MMB (32 total) and 10 PCI slots.

CPU Upgrades

Upgrading from the 500 to 667 or 883 MHz processors requires that the system board (54-25385-01) be a minimum revision of E05.

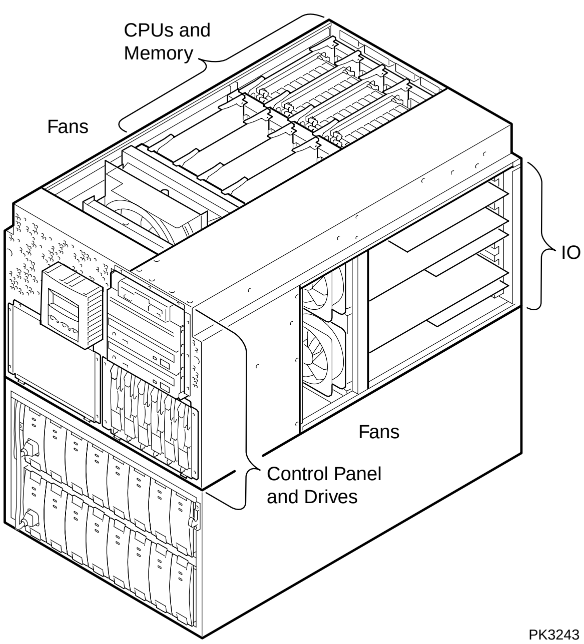
System Packaging

All system variants use the same chassis, with space for two disk cages in the front. Each cage holds up to six 1-inch Ultra3 SCSI disks.

The chassis has a compartment for the CPUs and memory and another one for the PCI I/O cards. The control panel, CD-ROM and floppy drives, and two additional removable media bays are in the front, along with space for up to two disk cages. The power supplies are in the rear.

Chassis, Pedestal View

Additional storage is available in the pedestal enclosure. The chassis is mounted over a box that can house up to three BA36R StorageWorks shelves (two in the front and one in the rear), or up to two Ultra3 Universal (single-bus or split-bus) StorageWorks shelves.



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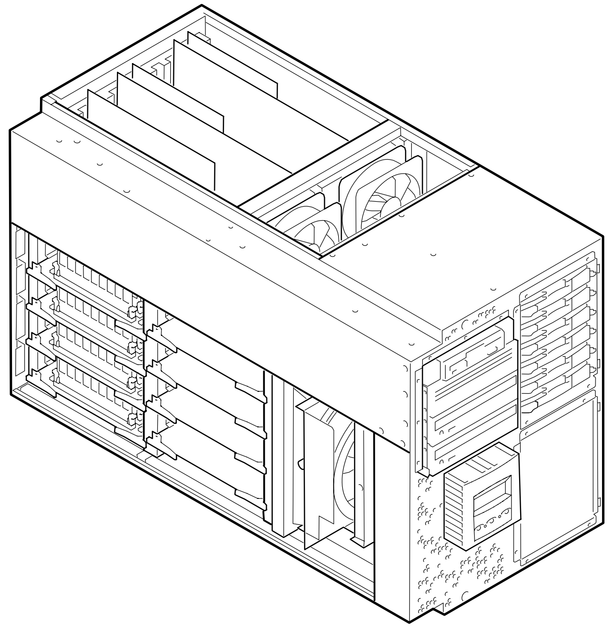
Chassis, Tower View

In the tower enclosure, the chassis is rotated 90 degrees, with the control panel and removable media bays keeping their same horizontal position as in the pedestal/rack system.



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Rackmount Chassis

When installed in a cabinet, the chassis has the same orientation as that used in the pedestal. The chassis can be mounted in the 67-inch or 79-inch M-series cabinet, which is a 19-inch wide RETMA cabinet. Each system requires 14 inches (8U) of vertical space. With the maximum number of systems in a cabinet (four), there can be two StorageWorks shelves. When the maximum number of disks is desired (six shelves), there can be three systems. (These numbers are for the H9A15 79-inch cabinet.)

Architecture

This system is designed to maximize the potential of the Alpha 21264 chip. The traditional bus interconnect has been replaced by a switch-based interconnect system. With a bus design, the processors, memory, and I/O modules share the bus. As the number of bus users increases, the transactions interfere with one another, increasing latency and decreasing aggregate bandwidth. However, with a switch-based system there is no degradation in performance as the number of CPUs, memory, and I/O users increase. Although the users increase, the speed is maintained.

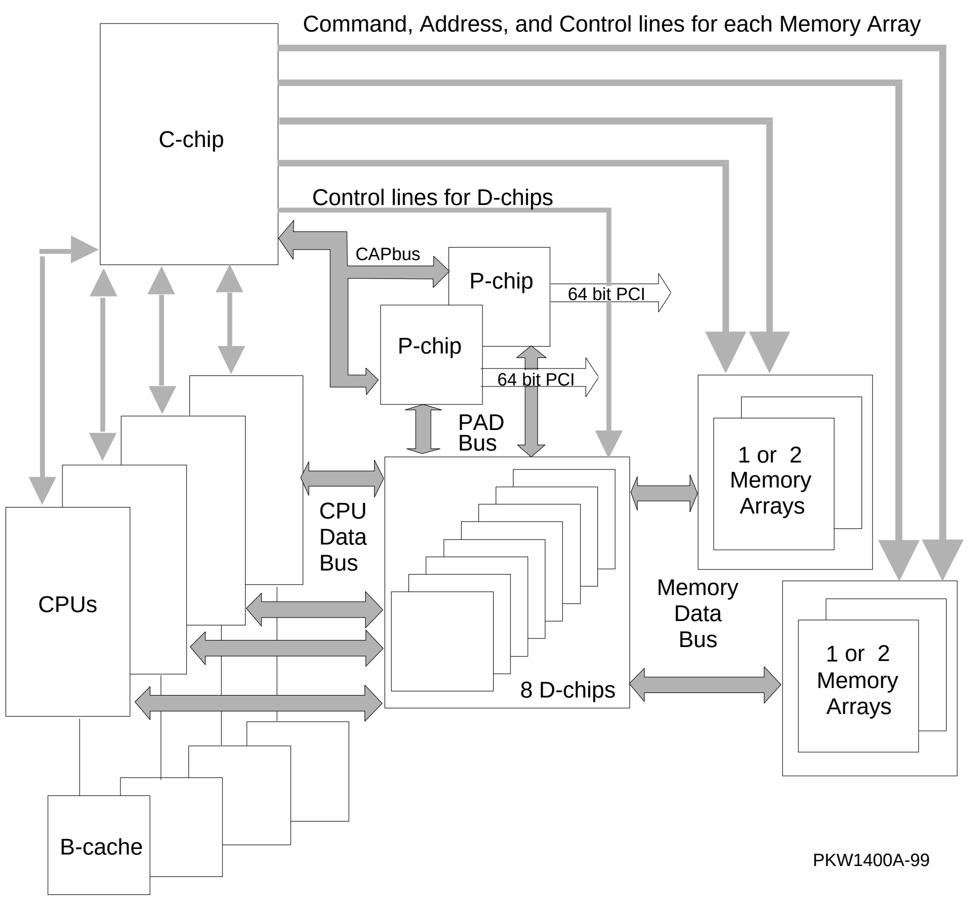
With a switch-based, or point-to-point interconnect, the performance remains constant, even though the number of transactions multiplies. The switched system interconnect uses a set of complex chips that route the traffic over multiple paths. The chipset consists of one C-chip, two P-chips, and eight D-chips.

- **C-chip.** Provides the command interface from the CPUs and main memory. Although there is only one C-chip in the system, it allows each CPU to do transactions simultaneously.
- **D-chips.** Provide the data path for the CPUs, main memory, and I/O.
- **P-chips.** Provide the interface to two independent 64-bit 33 MHz PCI buses.

This chipset is similar to that used in the *AlphaServer* DS20 system; however, this chipset supports up to four CPUs and up to 32 Gbytes memory. Interleaving occurs when at least two memory arrays are used.

Two 256-bit memory buses support four memory arrays, yielding a 5.2 Gbytes/sec system bandwidth. Transactions are ECC protected. Upon the receipt of data, the receiver checks for data integrity and corrects any errors.

System Block Diagram



System Board

The interconnect switch is implemented on the system board by the chipset consisting of one C-chip, two P-chips, and eight D-chips. This complex chipset provides the data and address path between the CPUs, memory, and the I/O subsystem.

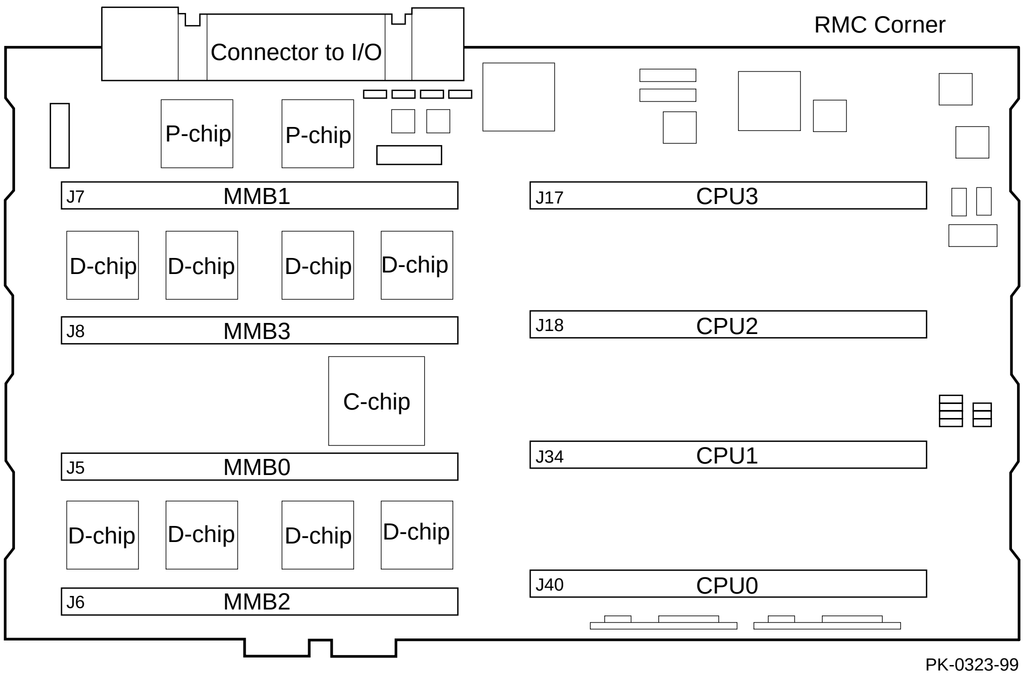
A flash ROM holds the console code and the NVRAM data.

Connectors are provided for four CPU modules and four memory motherboards.

One corner of the board holds logic for the remote management console (RMC).

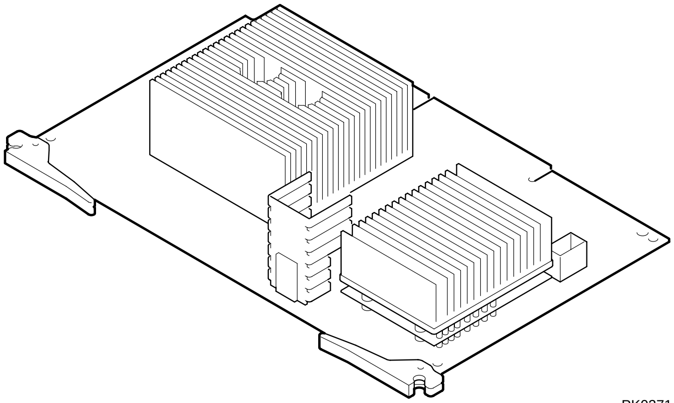
On the back side of the module are connectors for the power supplies. The I/O connector provides both signals and power to the PCI backplane.

Component and Connector Locations



Processor Module

An *AlphaServer* ES40 can have up to four CPU modules. In addition to the Alpha chip, the CPU module has an 8-Mbyte second-level cache and a DC-to-DC converter with heatsink that provides the required voltage to the Alpha chip. Power-up diagnostics are stored in a flash ROM on the module.



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Processor Configuration Rules

- The first CPU module is installed in CPU slot 0.
- Additional CPUs are installed in the next available slot.
- CPUs must be identical in speed and cache size.

Memory

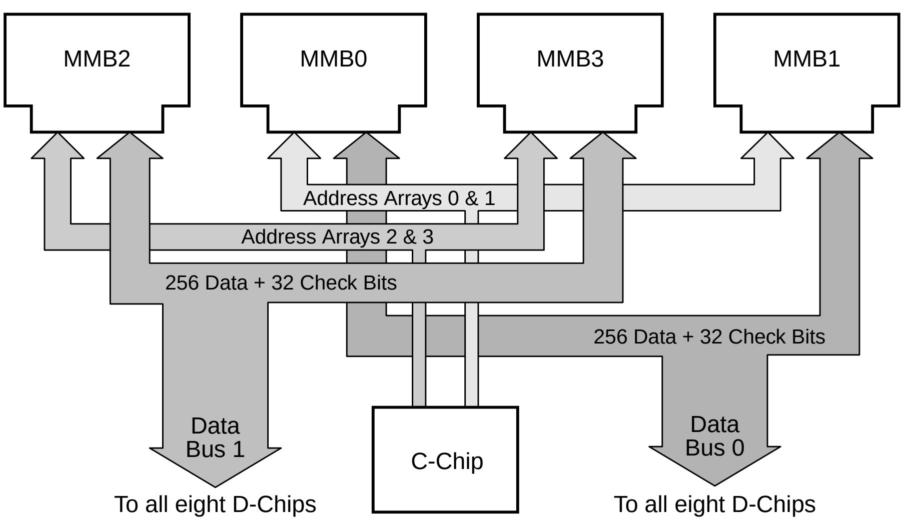
Memory throughput in this system is maximized by the following features:

- Two 256-bit wide memory data buses
- Very low memory latency (120 ns) and high bandwidth with 12 ns clock
- ECC memory

The switch interconnect can move a large amount of data over two independent memory data buses. Each data bus is 256 bits wide (32 bytes). The memory bus speed is 83 MHz. This yields 2.67 GB/sec bandwidth per bus (32 x 83 MHz = 2.67 GB/sec). The maximum bandwidth is 5.2 GB/sec (2.67 x 2).

The design challenge was to maximize the capabilities of the two wide data buses. Distributing the 256 data bits equally over two memory motherboards (MMBs) was one solution: simultaneously, in a read operation, 128 bits come from one MMB and the other 128 bits come from another MMB, to make one 256-bit read. Another 256-bit read operation can occur at the same time on the other independent data bus.

In addition, two address buses per MMB (one for each array) allow overlapping/pipelined accesses to maximize use of each data bus. When all arrays are identical (same size and speed), the memory is interleaved; that is, sequential blocks of memory are distributed across all four arrays.



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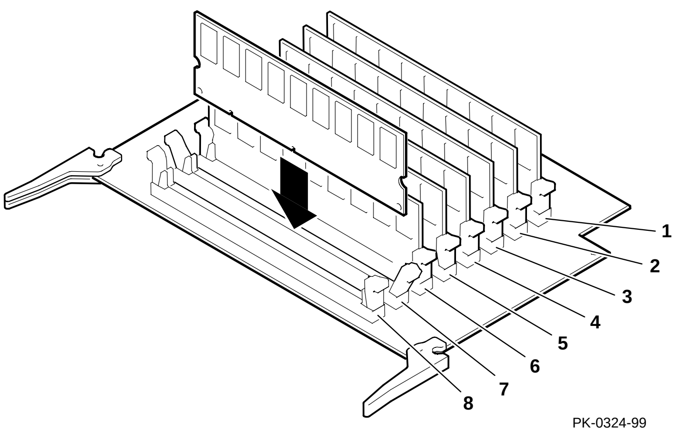
Memory Options

Each memory option consists of four 200-pin industry-standard DIMMs. The DIMMs are synchronous DRAMs. The Model 1 system supports up to four memory options (16 DIMMs), and the Model 2 system supports up to eight options (32 DIMMs). Memory options are available in the following sizes:

- 512 Mbytes (128 MB DIMMs)
- 1 Gbyte (256 MB DIMMs)
- 2 Gbytes (512 MB DIMMs)
- 4 Gbytes (1 GB DIMMs)

With the 4 GB option, Model 1 supports 16 GB memory and Model 2 supports 32 GB memory.

Memory Motherboard



Memory Configuration

A memory option (or set) consists of four DIMMs, and all four DIMMs must be the same size.

- Fill sets in numerical order. Populate all 4 slots in Set 0, then populate Set 1, and so on.
- An array is one set for systems that support 16 DIMMs and two sets for systems that support 32 DIMMs.
- DIMMs in an array must be the same size and type. For example, suppose you have populated Sets 0, 1, 2, and 3. When you populate Set 4, the DIMMs must be the same size and type as those installed in Set 0. Similarly, Set 5 must be populated with the same size and type of DIMMs as are in Set 1, and so on, as indicated in the following table.

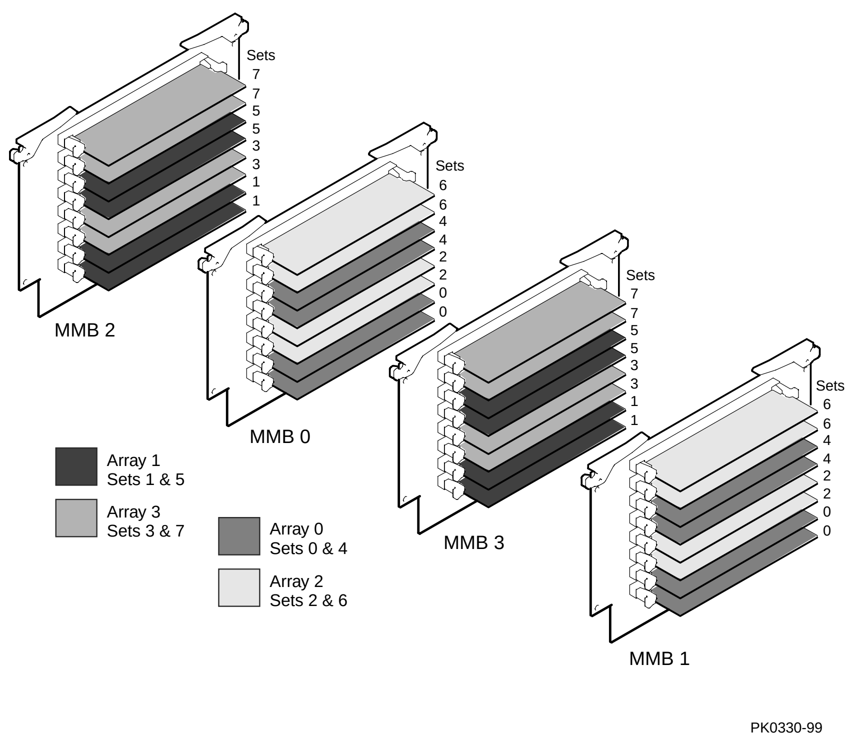
Array	Model 1 System	Model 2 System
0	Set 0	Set 0 and Set 4
1	Set 1	Set 1 and Set 5
2	Set 2	Set 2 and Set 6
3	Set 3	Set 3 and Set 7

- Systems that require full redundant power (three power supplies) are restricted to a maximum of 24 Gbytes memory.

Memory Performance Considerations

With one memory option (4 DIMMs) installed in either Model 1 or Model 2, memory operation interleaving will not occur. With two memory options (8 DIMMs), memory read-write operations are two-way interleaved. Interleaved operations reduce the average latency and increase the memory throughput over noninterleaved operations. With four memory options (16 DIMMs) installed, memory read-write operations are four-way interleaved, maximizing memory throughput.

Memory Arrays and Sets on Memory Motherboards



System I/O

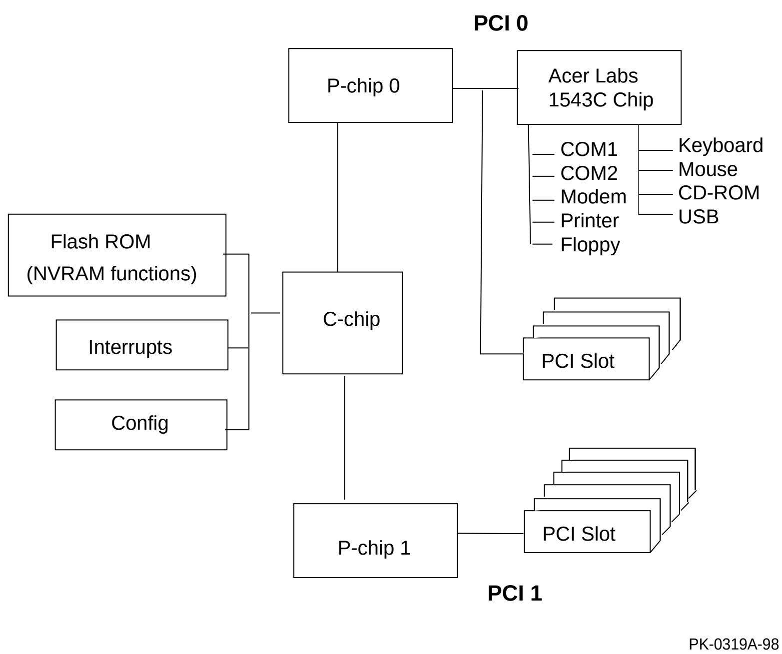
Two industry-standard PCI I/O buses allow you to use inexpensive, widely available I/O options. Both 32-bit and 64-bit PCI options can be used; 3.3V and 5V options are supported.

The industry-standard PCI bus is the number one choice for high-performance I/O options, such as disk storage and high-performance video applications.

The PCI bus implementation has the following characteristics:

- Fully compliant with the PCI Version 2.1 Specification
- Operates at 33 MHz, delivering a peak bandwidth of 500 MB/sec; over 250 Mbytes/sec for each PCI bus
- 6 option slots (Model 1) or 10 option slots (Model 2)
- Supports three address spaces: PCI I/O, PCI memory, and PCI configuration space
- Supports byte/word, tri-byte, and longword operations
- Exists in noncached address space only

Block Diagram of I/O Control



I/O Implementation

In a Model 2 system that has 10 I/O slots, PCI 0 has 4 slots, and PCI 1 has 6 slots. In a Model 1 system with 6 slots, each PCI has 3 slots.

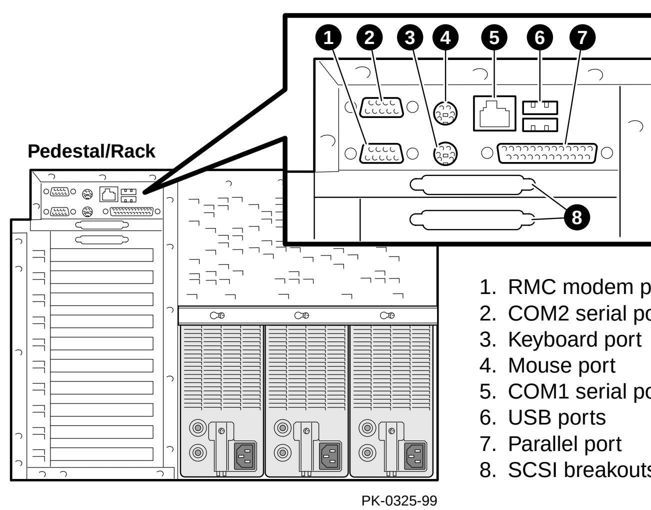
The Acer Labs 1543C chip provides the bridge from PCI 0 to ISA. The C-chip controls accesses to memory on behalf of both P-chips.

I/O Configuration Rules

A VGA controller, if present, must be installed in PCI 0.

I/O Ports

At the rear of the system are connectors offering access to two serial communications ports, one modem port for the remote management console, one parallel port, ports for the keyboard and mouse, and two USB ports. Two SCSI breakouts are also on the back panel.



1. RMC modem port
2. COM2 serial port
3. Keyboard port
4. Mouse port
5. COM1 serial port
6. USB ports
7. Parallel port
8. SCSI breakouts

System Control

Close monitoring and control of the system environment and hardware is done by the remote management console (RMC). This logic also allows the system operator to monitor the system from a remote location. The RMC logic is implemented using a PIC17C44 microprocessor on the system board. The RCM firmware code resides on the microprocessor and in flash memory. The RMC is powered by an auxiliary 5V supply, so even when the system is powered off at the control panel the RMC can be accessed—so long as the system is plugged in.

The RMC provides the following monitoring and control functions:

- Monitors thermal sensors on the CPUs, the PCI backplane, and the power supplies
- Monitors voltages, power supplies, and fans
- Handles hot swapping of power supplies and fans
- Controls the control panel display and writes status messages on the display
- Detects alert conditions such as excessive temperature, fan failure, and power supply failure and sends an alert
- Shuts down the system if any fatal conditions exist
- Records error log information in nonvolatile RAM on each failing device

Storage

Removable media in the chassis includes a CD-ROM drive, floppy diskette drive, and two 5.25 inch half-height bays, which can be combined for one 5.25 inch full-height bay.

A disk cage in the front of the chassis supports up to six Ultra3 SCSI Universal 1-inch disk drives (9.1, 18.2, or 36.4 GB). The drives are available at 10,000 or 15,000 RPM. Another disk cage can be added so that up to twelve disks can be installed. Each cage requires its own SCSI adapter.

Storage shelves can be either BA36R StorageWorks shelves or Ultra3 Universal StorageWorks shelves. The BA36R StorageWorks shelf supports seven disks per shelf; the Ultra3 Universal StorageWorks shelf supports 7 disks (single-bus) or 14 disks (split-bus) per shelf.

The pedestal system can include:

- Up to three BA36R StorageWorks shelves
- Up to two Ultra3 Universal StorageWorks shelves (single-bus or split-bus)

The rackmount cabinet can include:

- Up to six BA36R StorageWorks shelves
- Up to eight Ultra3 Universal StorageWorks shelves

Fibre Channel

Available on these *AlphaServer* systems is the next storage interface, Fibre Channel, which eliminates issues with today's SCSI interfaces such as distance, bandwidth, scalability, and reliability. Fibre Channel (FC) is the answer to not only server-to-storage connections but also to server-to-server networking, because multiple protocols are supported. SCSI, TCP/IP, video, or raw data can all take advantage of high-performance, reliable Fibre Channel technology.

With the KGPSA PCI Fibre Channel adapter, the ES40 systems provide a storage interconnect that is 2.5 times as fast as UltraSCSI: 100 vs 40 Mbytes/sec data throughput. The KGPSA adapter allows you to manage storage including the HSG80 RAID controller in a switched FC topology.

RAID (Redundant Array of Independent Disks)

The system can be configured with optional PCI RAID controllers to organize disk data cost-effectively, improve performance, and provide high levels of storage integrity. Today, RAID is only available with StorageWorks shelves.

The optional RAID controllers have the following features:

- Support for hot-swap drives
- Automatic rebuild after hot swap
- Console support for booting system from RAID
- RAID levels 0, 1, 0+1, 5
- Optional write cache
- Optional read cache
- Support for command queuing

Server Management

The *AlphaServer* products support important operational and platform management requirements.

Operational Management

Server/Network Management. Compaq Insight Manager is included with every system. This software tool allows you to monitor and control Alpha based servers. *Insight Manager* consists of two components: a Windows-based console application and server- or client-based management data collection agents. Management agents monitor over 1,000 management parameters. Key subsystems are instrumented to make health, configuration, and performance data available to the agent software. The agents act upon that data, by initiating alarms in the event of faults and by providing updated management information, such as network interface or storage subsystem performance statistics.

Remote Server Management. The integrated remote management console (RMC) lets the operator perform several tasks from a serial console: monitor the system power, temperature, and fans, and reset, halt, and power the system on or off. The monitoring can be done locally or remotely through a modem.

Platform Management

The *AlphaServer* ES40 systems support platform management tasks such as manipulating and monitoring hardware performance, configuration, and errors. For example, the operating systems provide a number of tools to characterize system performance and display errors logged in the system error log file.

In addition, system console firmware provides hardware configuration tools and diagnostics to facilitate quick hardware installation and troubleshooting. The system operator can use simple console commands to show the system configuration, devices, boot and operational flags, and recorded errors. Also, the console provides inventory support and configuration management by giving access to serial numbers and revisions of hardware and firmware.

Error Reporting

Compaq Analyze, a diagnostic service tool used to determine the cause of hardware failures, is installed with the operating systems. It provides automatic background analysis, as it constantly views and reads the error log file. It analyzes both single error/fault events and multiple events. When an error condition is detected, it collects the error information and sends it and an analysis to the user. The tool requires a graphics monitor for its output display.

Security

- Front doors can be locked to prevent access to the disk drives and the rest of the system.
- An interlock sensor switch shuts down power if the top cover to the CPU/memory area is removed while power is on.
- Password protection is offered by the SRM console and RMC.

Reliability and Availability Features

The *AlphaServer* ES40 system achieves an unparalleled level of reliability and availability through the careful application of technologies that balance redundancy, error correction, and fault management. Reliability and availability features are built into the CPU, memory, and I/O, and implemented at the system level.

Processor Features

- CPU data cache provides error correction code (ECC) protection.
- Parity protection on CPU cache tag store.
- Multi-tiered power-up diagnostics to verify the functionality of the hardware.

When you power up or reset the system, each CPU, in parallel, runs a set of diagnostic tests. If any tests fail, the failing CPU is configured out of the system. Responsibility for initializing memory and booting the console firmware is transferred to another CPU, and the boot process continues. This feature ensures that a system can still power up and boot the operating system in case of a CPU failure. Messages on the operator control panel power-up/diagnostic display indicate the test status and component failure information.

Memory Features

- The memory ECC scheme is designed to provide maximum protection for user data. The memory scheme corrects single-bit errors and detects double-bit errors and total DRAM failure.
- Memory failover. The power-up diagnostics are designed to provide the largest amount of usable memory, configuring around errors.

I/O Features

- ECC protection on the switch interconnect and parity protection on the PCI and SCSI buses.
- Extensive error correction built into disk drives.
- Optional internal RAID improves reliability and data security.
- Disk hot swap.

System Features

Auto reboot. On systems running *Tru64 UNIX* or *OpenVMS*, a firmware environment variable lets you set the default action the system takes on power-up, reset, or after an operating system crash. For maximum system availability, the variable can be set to cause the system to automatically reboot the operating system after most system failures.

Software installation. The operating systems are factory installed. Factory installed software (FIS) allows you to boot and use your system in a shorter time than if you install the software from a distribution kit.

Diagnostics. During the power-up process, diagnostics are run to achieve several goals:

- Provide a robust hardware platform for the operating system by ensuring that any faulty hardware does not participate in the operating system session. This maximizes system uptime by reducing the risk of system failure.
- Enable efficient, timely repair.

Audible beep codes report the status of diagnostic testing.
The system has a firmware update utility (LFU) that provides update capability for console and PCI I/O adapter firmware.
A fail-safe loader provides a means of reloading the console in the event of corrupted firmware.

Thermal management. The air temperature and fan operation are monitored to protect against overheating and possible hardware destruction. Six fans provide front to back cooling, and the power supplies, in the rear, have their own fans. If the temperature rises, the system fans speed up; or if necessary to prevent damage, the system shuts down. If the main fan, which cools the system card cage, fails, a redundant fan takes over.

Error handling. Parity and other error conditions are detected on the PCI buses. The memory checking scheme corrects single-bit errors and detects double-bit errors. Multiple ECC corrections to single-bit errors detected by the operating systems help in determining where in the system the error originated. Errors are logged for analysis.

Disk hot swap. The hardware is designed to enable hot swap of disks. Hot swap is the removal of a disk while the rest of the system remains powered on and continues to operate. This feature contributes significantly to system availability. Since many disk problems can be fixed without shutting down the entire system, users lose access only to the disks that are removed.

N+1 power redundancy. A second or third power supply can be added to provide redundant power to the chassis. A second power supply is needed for more than two CPUs or if a second disk cage is installed. In this case the third supply provides redundancy. The third power supply provides full N+1 redundancy for configurations using up to 24 Gbytes memory. Power supplies are 720 watts (DC). Each has two LEDs to indicate the state of power to the system.

An external UPS can be purchased to support critical customer configurations. Because power is maintained for the entire system (CPU, memory, and I/O), power interruptions are completely transparent to users.

Installation and Maintenance

The systems are designed for easy hardware, software, and option installation. Options ordered with a system are pre-installed and tested at the factory. The operating systems are also installed at the factory.

Additional CPUs, memory, power supplies, and disks can be added to the tower and pedestal systems by anyone with appropriate technical training and experience. Installation of components in a rackmount system is reserved for service providers and self-maintenance customers.

Clustering

A cluster is a loosely coupled set of systems that behaves (is addressed and managed) like a single system, but provides high levels of availability through redundant CPUs, storage, and data paths. Clusters are also highly scalable; that is, CPU, I/O, storage, and application resources can be added incrementally to efficiently increase capacity. For customers, this translates to reliable access to system resources and data, and investment protection of both hardware and software.

Clustering allows multiple computer systems to communicate over a common interface, share disks, and spread the computing load across multiple CPUs. Clustering is implemented using our traditional interconnects and using the newest technology.

PCI to Memory Channel Interconnect

Under *Tru64 UNIX* and *OpenVMS*, you can build high-availability clusters using the PCI to Memory Channel interconnect. The Memory Channel interconnect is a high-bandwidth, low-latency PCI-based communications interconnect for up to eight *AlphaServer* systems. Data written to one computer's memory is shared by other computers on the Memory Channel bus.

The PCI adapter is the interface between a PCI and a Memory Channel bus. This bus is a memory-to-memory computer system interconnect that permits I/O space writes in one computing node to be replicated into the memories of all other nodes on the Memory Channel bus. A write performed by any CPU to its reflected address region results in automatic hardware updates to memory regions in other nodes. One node’s write is “reflected” to other nodes as a direct side effect of the local write. This provides a memory region with properties similar to a high-performance shared memory across a group of nodes.

Operating System Support

For clustered *Tru64 UNIX* systems, TruCluster Software solutions allow users access to network services and provide further failover recovery from server, network, or I/O failures. *Tru64 UNIX* cluster systems use the SCSI bus and/or PCI to Memory Channel interconnect bus between disks and systems.

OpenVMS cluster systems use the CI, SCSI, Ethernet, FDDI, and Memory Channel as the interconnect between disks and systems.

The primary means of clustering *AlphaServer* ES40 systems depends on the operating system.

- CI clusters, *OpenVMS* only
- Memory Channel, *Tru64 UNIX* and *OpenVMS*
- SCSI clusters, *Tru64 UNIX* and *OpenVMS*

Performance and Benchmarking

Compaq has an ongoing program of performance engineering, using industry-standard benchmarks that allow comparisons across major vendors' systems. These benchmarks against competitive systems are based on comparable CPU performance, coupled with comparable memory and disk expandability.

See Table 1 for the record-breaking performance numbers of the *AlphaServer* ES40 systems

System performance, however, is highly dependent upon application characteristics. Thus, benchmark information is one helpful "data point" to be used in conjunction with other purchase criteria such as features, service, and price.

Sources of Performance Information

Performance information is available on the Internet.
http://www.compaq.com/alphaserver/performance/index.html
http://www.ideasinternational.com/benchmark/spec/specfp_s2000.html

Information for Compaq Partners

If you are a Channel or Reseller Partner, you can find the tools, resources, and information you need to conduct Compaq business online on the secure Compaq Partner Network extranet site: http://CPN.compaq.com

Also see the Compaq Solutions Alliance site at http://csa.compaq.com

Service and Support

Compaq provides a comprehensive set of services that range from migration, consulting, and training, to direct support of Alpha systems, software, and applications. For information on Compaq Services, point your Web browser to http://www.compaq.com/services.

Hardware Warranty

The *AlphaServer* ES40 system and components, including CPU, memory, PCI controllers, and power supplies, have a 3-year on-site, 5-day per week, 9-hour per day hardware warranty with next-day response time.

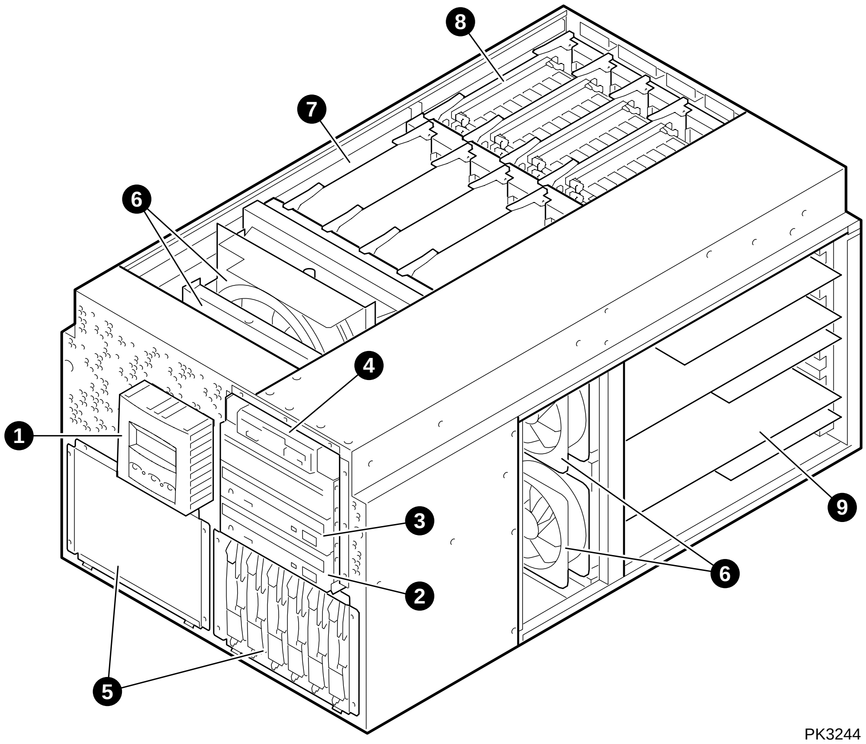
StorageWorks components contained in the pedestal or cabinet systems are supported by the comprehensive StorageWorks warranty: five years for disks, three years for controllers, two years for tape devices, and one year for other components. The first year includes on-site next-day response time. Network products in the pedestal or cabinet systems carry the network products warranty.

Users can upgrade to higher levels of service through a variety of hardware supplemental services.

Software Warranty

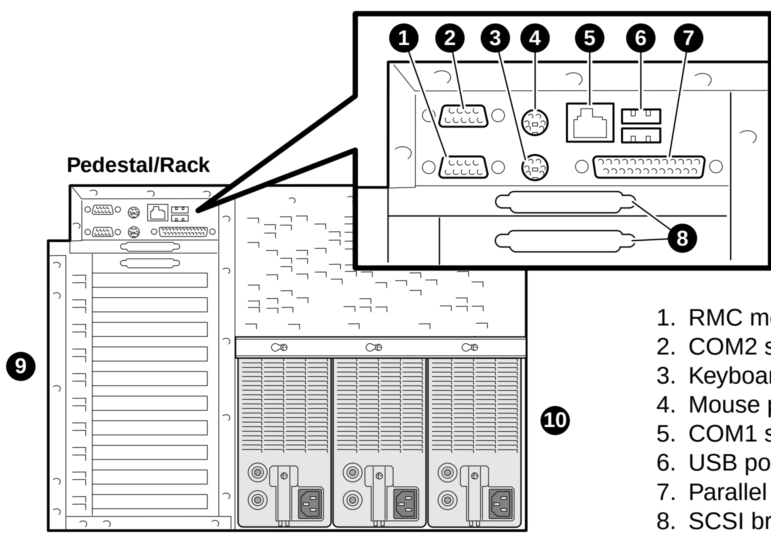
The warranty for *Tru64 UNIX* and *OpenVMS* is conformance to SPD with advisory telephone support for a period of 90 days. Users can upgrade to higher levels of service through a variety of software supplemental services.

Compaq AlphaServer ES40 System Diagrams



PK3244

1. Control panel
2. CD-ROM drive
3. Removable media bays
4. Floppy diskette drive
5. Storage drive bays
6. Fans
7. CPUs
8. Memory
9. PCI slots



PK-0327-99

1. RMC modem port
2. COM2 serial port
3. Keyboard port
4. Mouse port
5. COM1 serial port
6. USB ports
7. Parallel port
8. SCSI breakouts
9. PCI slots
10. Power supplies

System Features at a Glance

Table 1 provides a quick reference to features of the *Compaq AlphaServer* ES40 systems.

Table 1 *AlphaServer* ES40 Features

System Features		
CPU features	6/667	6/833
Symmetric multiprocessing	1–4 processors	1–4 processors
CPU clock speed	Alpha 21264A / 667 MHz	Alpha 21264A / 833 MHz
Cache size (on chip/on board)	64 KB I, 64 KB D / 8 MB ECC DDR	64 KB I, 64 KB D / 8 MB ECC DDR
Memory (maximum)	16 GB in Model 1 and 32 GB in Model 2 *	

	67/667			**68/833**		
Performance	**1 CPU**	**2 CPUs**	**4 CPUs**	**1 CPU**	**2 CPUs**	**4 CPUs**
SPECint2000			433			544
SPECfp2000			562			658
SPECint_rate2000	5.05	10.3	19.8	6.31	12.5	24.7
SPECfp_rate2000	6.50	12.2	21.9	7.63	14.0	25.5
SPECweb99			2,304			
SPECjvm98	71.9	83.5		100	104	
SPECjbb2000		23,787			15,152	28,032
SPECsfs97 .v3			14,157			
TPC-C			30,738 tpmC @ $29			

Standard Features	1.44 MB diskette drive, CD-ROM drive, 1 RMC dedicated serial port, 2 serial ports, 1 parallel port, keyboard and mouse, integrated remote system management console, operating system license and customer documentation, Internet software

Storage			
Removable media	CD-ROM, floppy diskette, two HH 5.25” removable media bay		
System chassis storage	12 disks (437 GB with 36.4 GB disks) Ultra3 SCSI		
Pedestal	**Disk Drive Cages PLUS**	**BA36R StorageWorks Shelves OR**	**Universal StorageWorks Split-Bus Shelves**
	12 disks (437 GB @ 36.4 GB)	21 disks (764 GB @ 36.4 GB)	28 disks (1 TB @ 36.4 GB)
		***Total capacity*: 1.2 TB**	***Total capacity*: 1.5 TB**
H9A10 cabinet	**Disk Drive Cages**	**BA36R StorageWorks Shelves**	**Universal StorageWorks Split-Bus Shelves**
	24 disks (874 GB @ 36.4 GB)	42 disks (1.5 TB @ 36.4 GB)	112 disks (4 TB @ 36.4 GB)
		***Total capacity:* 2.4 TB**	***Total capacity:* 4.9 TB**
H9A15 cabinet	**Disk Drive Cages**	**BA36R StorageWorks Shelves**	**Universal StorageWorks Split-Bus Shelves**
	36 disks (1.3 TB @ 36.4 GB)	42 disks (1.5 TB @36.4 GB)	112 disks (4 TB @ 36.4 GB)
		***Total capacity:* 2.8 TB**	***Total capacity*: 5.4 TB**

I/O System	
I/O slots	6 PCI slots in Model 1 or 10 PCI slots in Model 2
Maximum PCI throughput	Over 500 MB/sec with two 256 MB/sec buses
High Availability Features	
System	System auto reboot, thermal management, remote system management, RAID 0, 1, 0+1, 5, hot swap of disks, power supplies, and fans, memory failover, ECC memory, ECC cache, N+1 power supply,* SMP CPU failover, error logging, optional uninterruptible power supply
OpenVMS clusters	CI, Ethernet, SCSI, FDDI, PCI to Memory Channel Interconnect
Tru64 UNIX TruClusters Solutions	SCSI, PCI to Memory Channel Interconnect
Operating Systems	*Tru64 UNIX, OpenVMS*, Linux
Warranty	
Hardware	3-year, on-site, 5 day x 9 hour warranty with 24-hour response
Software	90-day telephone advisory support for *OpenVMS* and *Tru64 UNIX*

* Configurations requiring N+1 redundant power are restricted to a maximum of 24 Gbytes memory; if full redundancy is not required, 32 Gbytes memory is supported.

Physical Characteristics

Table 2 details basic physical characteristics of the system, and Table 3 gives the electrical characteristics.

Table 2 ***AlphaServer*** **ES40 Physical Characteristics**

Dimensions	Tower	Pedestal	Rackmount
Height	50.8 cm (20.0 in.)	78.2 cm (30.8 in.)	35.2 cm (13.87 in.)
Width	38.7 cm (15.25 in.)	50.8 cm (20.0 in.)	44.7 cm (17.6 in.)
Depth	78.7 cm (31.0 in.)	80.6 cm (31.75 in.)	76.5 cm (30.1 in.)
Weight	65 kg (143 lb) typical; 96 kg (211 lb) maximum	127 kg (280 lb) typical; 159 kg (350 lb) maximum	With brackets, slides, & cables Nominal 59 kg (130 lb) Maximum 92 kg (202 lb)

Environmental		
Temperature	Operating	10–35° C (50–95° F)
	Storage (60 days)	–40 to 66° C (–40 to 151° F)
	Rate of change	11° C/hr (20° F/hr)
Relative humidity	Operating	20–80%
	Nonoperating	20–80%
	Storage (60 days)	10–95%
	Rate of change	20%/hr.
Maximum wet bulb temperature	Operating	28° C (82° F)
	Storage (60 days)	46° C (115° F)
Minimum dew point temperature	Operating	2° C (36° F)
Heat dissipation	Nominal	Maximum
Tower and Rack	900 w, 3074 BTU/hr	1300 w, 4440 BTU/hr
Pedestal	1480 w, 5054 BTU/hr	2400 w, 8196 BTU/hr
H9A10/H9A15	Configuration dependent	4800 w, 16392 BTU/hr
Airflow and quality	Intake location	Front
	Exhaust location	Rear–Tower, Pedestal, Rack Rear/Top–H9A10/H9A15
Altitude	Operating	3037 m (10,000 ft)
	Nonoperating	12,190 m (40,000 ft)
Vibration	Operating	10–500 Hz .1 G peak
Mechanical shock	Operating	
	Tower/Pedestal	7.5 G, 10 +/– 3ms
	M-Series Cabinet	5.0 G, 10 +/– 3ms

Acoustics—Declared values per ISO 9296 and ISO 7779
Current values for specific configurations are available from Compaq. 1 B = 10 dBA

Acoustics	L_{Wad} , B	L_{pAm} , dBA (bystander position)
Idle	6.6	48
Operating	6.6	48

Table 3 ***AlphaServer*** **ES40 Electrical Characteristics**

Nominal voltage (Vac)	100	120	200–240
Voltage range (Vac) temporary condition)	90–110	110–128	180–250
Power source phase	Single	Single	Single
Nominal frequency (Hz)	50/60	50/60	50/60
Frequency range (Hz)	49–51/59–61	49–51/59–61	49–51/59–61
RMS current (max. steady state)			
Tower and Rackmount			
Single power cord	11.0 A	8.5 A	5.0 A
Multiple power cords	6.5 A	5.3 A	3.0 A
Pedestal			
Each power cord	12.0 A	10.5 A	7.0 A
M-Series cab config.-dependent			
Nominal voltage (Vac)	100	120	220–240
Each power cord	24 A	24 A	16 A

NOTE: Power supplies are universal, PFC, auto ranging, 100 / 120 / 200–240 Vac.