Just the Facts

The product information contained in this Just the Facts will be announced to the general public March 22, 1994. Until that time, this information is Sun confidential. It may be used with customers who have signed nondisclosure agreements.

SPARCstorage™ Array: The Industry's Most Innovative Storage Solution

The Ultimate Combination of Availability, Scalability, Manageability, Flexibility, and Affordability

The SPARCstorage™ Array delivers storage solutions to open client-server systems unlike any other disk subsystem in the world. The unique combination of innovative features solves storage problems better than ever.

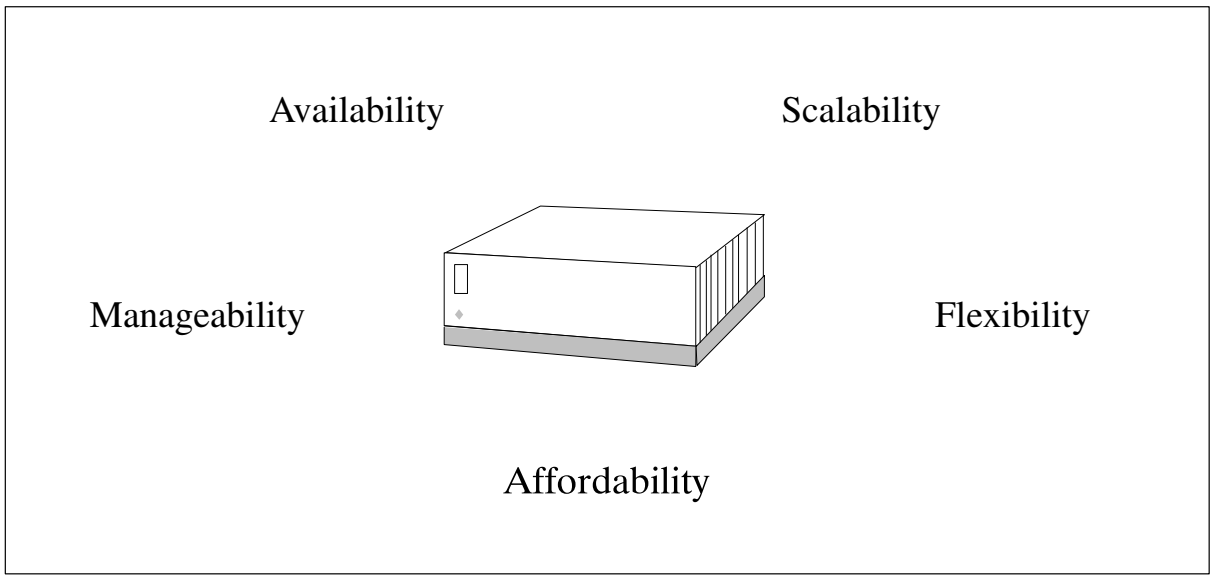
The SPARCstorage Array disk subsystem multiplies the power of the industry's most popular line of scalable UNIX® servers: The SPARCcenter™ 2000, SPARCserver™ 1000, and SPARCserver 10 systems. For the most demanding workstation applications, the SPARCstorage Array and the SPARCstation™ 10 system make an unbeatable combination.

Intelligent Innovation: Putting All the Pieces Together

The disk storage subsystem is just as integral to a server system as graphics is to a technical workstation. A server's capabilities are significantly impacted by how well the disk subsystem addresses the needs for high availability, scalability, manageability, and flexibility. A great server requires an outstanding disk subsystem.

The SPARCstorage Array features many innovations, such as Fibre Channel, an advanced RAID implementation, the integrated Volume Manager, Single Connector pluggable disks, and an ultracompact packaging design. But the greatest innovation of all is the intelligent combination of capabilities into one solution carefully crafted to fulfill the storage requirements of today and tomorrow.

Sun servers and high-end workstations are called upon to meet many challenges. The SPARCstorage Array answers your organization's computing needs in many ways.



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The SPARCstorage Array: The Industry's Most Innovative Storage Solution *(cont.)*

Intelligent Innovation: Putting All the Pieces Together *(cont.)*

- Availability: Information is available and users are productive when you need them to be
  - More than 99.99 percent uptime per SPARCstorage Array due to a unique high-reliability design; RAID levels 1, 0+1, and 5; the ability to defer maintenance; and easy serviceability. When even greater system availability is required, redundant Arrays and systems can be configured with no single point of failure
- Scalability: From small workgroup servers to mission-critical, terabyte data center systems
  - Performance scalability to feed data-intensive applications ranging from database to data acquisition, from file service to imaging, and from on-line transaction processing (OLTP) to video. More than 2000 I/O operations per second (IOPS) per Array for random access applications, such as database, file service, and OLTP. More than 15 MB per second sustained data rate per Array for sequential access applications such as imaging, multimedia, video, and data acquisition
  - Capacity scalability to hundreds of gigabytes per SPARCserver system with the Model 100 Series and to a terabyte and beyond with the Model 200 Series SPARCstorage Array
  - Performance scalability as multiple arrays are added to a system; the Array controller boosts I/O performance and offloads processing burden from the host CPUs
  - Capability scalability from the innovative Fibre Channel interface, which delivers much more performance and flexibility than SCSI and is an enabler for future clustered systems
- Manageability: Increase the efficiency and effectiveness of system operations
  - Easy, more effective administration through the SPARCstorage Volume Manager, a powerful and easy-to-use graphical interface that increases system administrator productivity
  - Easy to service because all hardware components are pluggable, cable-free, and customer serviceable
  - Easy to cable to the host system because a single thin fiber optic cable connects dozens of disk drives
- Flexibility: Construct your computing systems to fit your business, not the other way around
  - Flexible data organization so users are not stuck with just a RAID box. RAID levels 0, 1, 0+1, and 5, plus independent disks may be configured at the same time within a single Array, or even across Arrays. Easy reorganization as application requirements change over time
  - Flexible capacity from a few gigabytes to hundreds of gigabytes, or even terabytes
  - Flexible location of the compact, high-density Model 100 Series enclosure. Use as a tabletop unit or as a deskside tower, stack Arrays in the office stacking unit, or mount Arrays in data center cabinets. SPARCstorage Arrays operate up to two kilometers (1.25 miles) from the host system
- Affordability: Finally, a high-performance, richly featured disk array that makes economic sense
  - The SPARCstorage Array disk subsystem changes the economics of configuring a powerful server or high-end workstation, setting a new standard for price/performance, price/capacity, and overall price/benefit

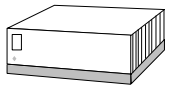
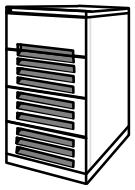
No other disk storage product packs so much power and capability into a single integrated solution.

The SPARCstorage Array: The Industry's Most Innovative Storage Solution *(cont.)*

Two Types of SPARCstorage Arrays for Different Needs

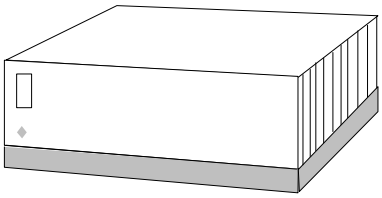
All SPARCstorage™ Array models share the same architecture and use the same intelligent Array controller and Volume Manager software. The difference between the Model 100 Series and the Model 200 Series is in the packaging.

- The SPARCstorage Array Model 100 Series is a compact, easily serviceable enclosure using 3.5-inch disk drives. It is ideal for a wide range of environments, from small workgroups to the data center
- The Model 200 Series is best for building very large SPARCcenter 2000 systems. It uses large 5.25-inch disk drives

	Primary Positioning	**Advantages**
Model 100 Series 	• All SPARCserver 1000 and SPARCserver 10 systems • SPARCcenter 2000 systems with under a few hundred gigabyte capacity • SPARCstation 10 workstations requiring high performance or high-capacity I/O	• Compact, high-density enclosure for office or computer room • Incredibly easy to service • High ratio of disks to gigabytes, so greater random I/O performance at any capacity • Better price/IOPS than Model 200 Series
Model 200 Series 	• SPARCcenter 2000 systems that will grow to more than 500 GB • Upgrade existing differential SCSI equipment	• Greater total system capacity possible • Lower price/GB than Model 100 Series for large systems • Protects investment in differential SCSI

This is the formal announcement for the Model 100 Series. The SPARCstorage Array Model 200 Series is not being formally announced, but is being presented as a future direction.

SPARCstorage™ Array Model 100 Series: Extraordinary Power in a Small Package



The Model 100 Series uses a compact, high-density, customer serviceable enclosure designed to fit a wide range of applications and environments. The enclosure is the same size as the SPARCserver™ 1000 system. The Model 100 uses 535-MB disk drives, and the Model 101 uses 1.05-GB disks.

The SPARCstorage Array Model 100 Series is ideal for all but the largest server systems. In under 2 cubic feet of space, it packs more capacity, more power, and more capability than competitive products many times its size.

• **Features**	• **Benefits**
– Compact, high-capacity enclosure including drives, intelligent controller high-reliability power supply, status display, and an efficient cooling system	– Able to configure with larger capacity systems; no special power or air conditioning required
– 6 to 30 drives per Array subsystem	– Flexible capacity to 31.5 GB per Array
– Flexible placement on desktop, in tower stand, in stacking unit, or data center rack up to 2 kilometers from host system	– Users can match hardware configuration to their environment
– High throughput, scalable performance	– I/O power for demanding applications such as DBMS, file service, imaging, multimedia, imaging, computer aided design, and publishing
– High availability of data through unique high-reliability design, RAID, Hot Spares, Warm Plug, and dual-port controller	– Any required level of high data availability can be configured
– Up to two Arrays per SBus slot, with only one fiber optic cable to connect each Array	– Conservation of valuable SBus slots while providing a dramatic increase in maximum system capacity, with up to five dozen disks, or 63 GB per SBus slot
– Integrated, powerful, easy-to-use Volume Manager provides a GUI, status monitoring, and performance management and can perform many administrative tasks on line, while applications are running	– More effective and efficient system administration, better performance, and higher availability
– Easily serviceable by system administrator	– Lower cost of ownership and less downtime

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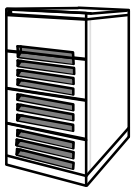
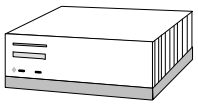
SPARCstorage Array Model 100 Series: Extraordinary Power in a Small Package *(cont.)*

	Maximum SBus Fibre Channel Cards	Maximum Model 100 Series Arrays	Maximum Array Storage Capacity Model 101
SPARCcenter™ 2000 	20	20	630 GB
SPARCserver 1000 	8	8	252 GB
SPARCserver 10/SPARCstation™ 10	2	2	63 GB

A Vital Part of Any Server System

In today's computing environment, nearly every Sun® server system requires one or more of the SPARCstorage Array's capabilities. Almost any Sun server system requiring growth to 10 or more gigabytes capacity should be configured with one or more SPARCstorage Arrays.

Power and Capacity for Demanding Workstation Applications

Some high-end workstation applications require the performance and capacity offered by the SPARCstorage Array Model 100 Series. If users need more than 5 to 10 gigabytes capacity or high-performance I/O, the SPARCstorage Array can be the right storage solution.

Tech Facts

- Single connector disk drives from Sun's Disk Tower 1000 and Disk Card products may be used in the Model 100 Series SPARCstorage Array, so investment in these drives is protected
- 535-MB and 1.05-GB drives can be mixed in the same Model 100 Series Array
- Larger capacity drives will be made available in SPARCstorage Arrays in the future

Availability

The SPARCstorage Array Model 100 Series may be ordered immediately and will begin shipping in the second calendar quarter of 1994. RAID level 5 functionality is scheduled for release in the third calendar quarter of 1994. All SPARCstorage Arrays shipped prior to RAID 5 release will be upgraded at no charge to the RAID 5 software and firmware. No hardware change will be required to upgrade.

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SPARCstorage™ Array Model 200 Series: Terabytes of Capacity and Investment Protection

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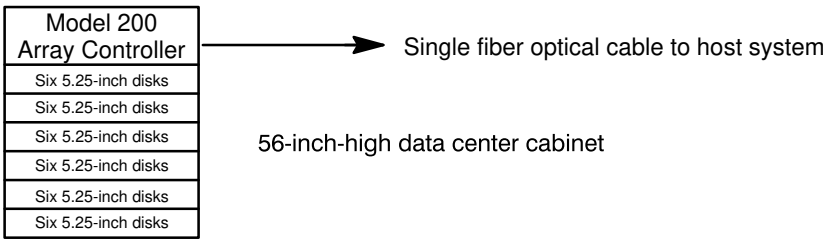

For the largest systems requiring up to terabytes of capacity, the SPARCstorage Array Model 200 Series is ideal. The Model 200 Series connects large capacity 5.25-inch differential SCSI-2 disk drives, and it enables the largest capacity SPARCcenter™ 2000 systems. It also may be used to upgrade existing Sun® differential SCSI equipment to the benefits of the SPARCstorage Array.

- **Features**
  - Identical intelligent Array controller and similar Volume Manager software as the Model 100 Series
  - High-capacity large form factor, large capacity disk drives
  - To reach any given capacity, fewer disk drives are required than with Model 100 Series
  - Sun 2.1-GB and 2.9 GB-data center differential SCSI disk drives, trays, cabinets, and cables can be connected to the Model 200 Series Array controller
  - More than 100 GB of disk capacity, plus the Model 200 Array controller, all within one cabinet, with only a single fiber optic cable connecting to the host
  - Up to two Arrays, or more than 200 GB per SBus slot
- **Benefits**
  - All the RAID, performance, configurability, and administration benefits of the Model 100 Series
  - Greater possible total system capacity than the Model 100 Series
  - Lower price per GB for large systems
  - Investment in existing equipment is protected and the capabilities of installed storage are enhanced
  - Easy, flexible, simple, and reliable cabling
  - Scalability to a terabyte and beyond, while conserving SBus slots

Ideal Solution for Very Large SPARCcenter 2000 Systems

For users needing more than 500 GB of capacity, the SPARCstorage Array Model 200 Series provides capacity scalability and low cost per megabyte. For systems requiring 100 to 500 GB, the Model 200 Series supplies lower cost per GB than the Model 100 Series, but the Model 100 Series has the advantage in price/performance and in serviceability.

Protecting Investments in Existing Equipment

On large server systems, much of the total cost of the system is disk storage. Protecting the value of that investment and providing an easy, low-cost way to upgrade the functionality of the equipment are important benefits of the SPARCstorage Array Model 200 Series. Customers can invest in Sun differential SCSI disk drives, trays, cabinets, and cables with confidence, knowing that a SPARCstorage Array controller can be added to the configuration later.

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SPARCstorage Array Model 200 Series: Terabytes of Capacity and Investment Protection *(cont.)*

Key Facts

- Model 100 Series Arrays and Model 200 Series Arrays may coexist on the same server system
- Although the Model 200 Series is designed primarily for SPARCcenter 2000 systems, it also can upgrade differential SCSI equipment on SPARCserver 1000 systems

Tech Facts

- The SPARCstorage Array Model 200 Series supports
  - Sun 2.9-GB fast/wide differential SCSI disk drives and data center trays
  - Sun 2.1-GB fast differential SCSI disk drives and data center trays
- The Model 200 Series uses the same Array controller board design as the Model 100 Series. In the Model 200 Series, each of the six SCSI processors on the controller communicates with a tray of large differential SCSI disks, rather than a string of small single-ended SCSI drives. In the Model 200, up to six disks are connected per SCSI processor, whereas the Model 100 has a maximum of five disks per SCSI
- The Model 200 Series uses a SCSI board, which plugs into the same backplane as the Array controller board, power supply, and cooling system. The SCSI board provides 68-pin external connectors, which the differential SCSI disk trays can be plugged into
- Upgrading existing differential SCSI equipment is easy. Only a SPARCstorage Array Model 200 and an SBus Fibre Channel card need to be purchased. The Model 200 Array is installed in an existing 56-inch data center cabinet. Differential SCSI disk cables are unplugged from DSBE/S or DWIS/S SBus cards in the host system and plugged into the SCSI boards in the Model 200 Array. An SBus Fibre Channel card is installed in the host server, and a fiber cable from the Array controller is connected

Availability

The SPARCstorage Array Model 200 Series will be available for ordering and shipment the second half of calendar year 1994. Complete product details, plus configurations and pricing, will be available at that time.

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SPARCstorage™ Array Controller: Industry-Leading Performance and Connectivity

The centerpiece of SPARCstorage™ Array architecture is its intelligent controller. The Array controller designed by Sun delivers higher performance, and much greater storage per SBus slot, than previously available for SPARCserver™ and high-end SPARCstation™ systems.

The SPARCstorage Array architecture delivers high performance for both random and sequential I/O applications. It can deliver more than 2000 IOPS for random access applications and more than 15 MB/sec. for sequential access.

• **Features**	• **Benefits**
– Intelligent Array controller based on SPARC® technology with advanced Sun® ASICs	– I/O processing burden is offloaded from host CPU for excellent performance scalability as multiple Arrays are added to a system
– Intelligently managed 4-MB NVRAM cache for fast writes	– Significant boost to write performance, while cached data is safeguarded by battery
– Fibre Channel interface to host system	– Higher performance and availability, with more configuration flexibility than SCSI
– Dual-port controller can configure redundant failover systems with no single points of failure	– Solution for the most stringent high availability requirements
– Fibre Channel host interface allows location of on-line redundant data 2 kilometers from the host system	– Data availability even in the event of disasters such as a fire
– Fibre Channel SBus card allows two Arrays, and dozens of disk drives, to be connected per SBus slot	– Much higher disk connectivity per system than strings of SCSI disks, while conserving SBus slots

Tech Facts

- The controller board is highly integrated, with three new ASICs designed by Sun on a double-sided, 12-layer, 4.3 x 13.3-inch circuit board. The controller delivers not only a lot of power in a small space but also high reliability through a low number of parts
- The two internal SBuses on the controller board are used for data and control flow within the Array controller. All processor chips on the controller have an SBus interface. This includes the microSPARC™ processor, the SOC and BIANCA ASICs, and six SCSI processors
- The main CPU on the controller is the microSPARC chip, the same one used on the SPARCstation LX and SPARCclassic™ workstations. The controller firmware running on the microSPARC is a real-time executive written in C and SPARC assembler by Sun
- Disk drives are spread across six SCSI-2 channels in the Array, allowing a high degree of parallelism. Each SCSI channel is fast/wide (20 MB/sec.), using a RISC-based, intelligent, low-overhead SCSI controller chip developed for the SPARCstorage Array. These are the same SCSI controller chips used in Sun's DWIS/S host adapter card

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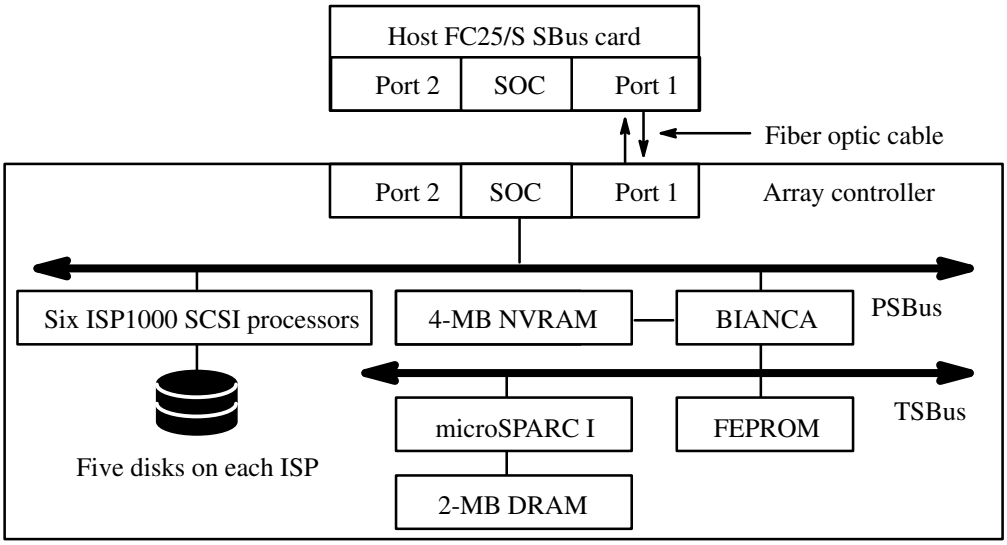
SPARCstorage Array Controller: Industry-Leading Performance and Connectivity *(cont.)*



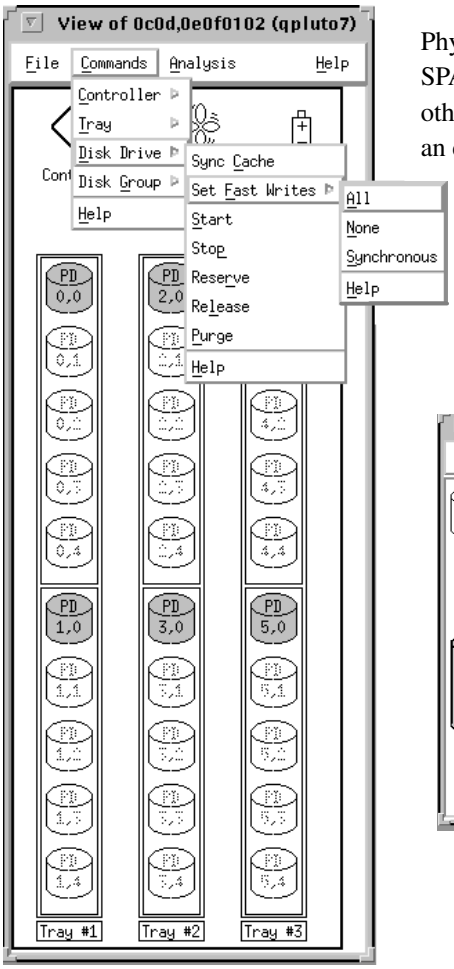
Tech Facts *(cont.)*

- All data written to or read from the SPARCstorage Array controller flows through the nonvolatile random access memory (NVRAM) cache
  - Customers can set the Fast Write NVRAM feature on a per controller or per drive basis. There are three settings: enabled, disabled, and synchronous
  - When set to enabled, all writes are acknowledged back to the host as being completed as soon as they are safely in the NVRAM, without waiting for the physical write to the disk media
  - When disabled, writes are not acknowledged until data is successfully written to the disk
  - With the synchronous setting, synchronous writes are fast acknowledged, and asynchronous writes are not. This provides Prestoserve-like functionality
  - Upon power-up, the SPARCstorage Array firmware flushes any data not yet written to disk from the NVRAM cache to the appropriate disk drives
- The SPARCstorage Array NVRAM cache may be used in conjunction with Prestoserve on the host system to provide two-stage write caching
- The controller implements the SCSI Reserve and Release commands, which ensure data integrity in a dual-host configuration
- The dual-port Array controller may be used in a dual-host, high availability, system failover configuration. Software to manage and control such a configuration and to ensure only one system at a time attempts to access a disk drive must be run on the host systems. This is not delivered as part of the SPARCstorage Array software
- Two host systems can share a single SPARCstorage Array so that each system “owns” some of the drives. For example, one system can reserve 10 drives while the second system reserves the other 20. In this way, users supply the benefits of the SPARCstorage Array to two systems without purchasing two Arrays

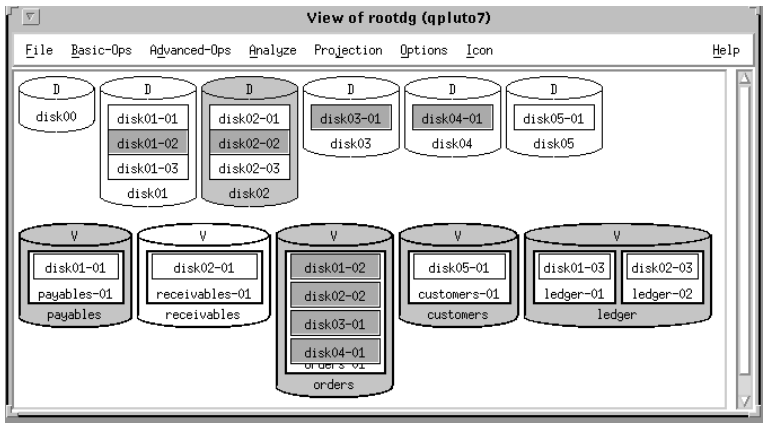
SPARCstorage™ Volume Manager: Powerful, Easy Administration

If configuring SPARCserver™, SPARCcenter™, or SPARCstation™ systems with large storage capacity, you need more than just a way to plug in lots of disk drives. Unlike other disk array subsystems, the SPARCstorage™ Array provides tools and features designed specifically to make system administrators more effective and more efficient. And that makes your business more productive.

A key part of the SPARCstorage Array is the integrated Volume Manager software. The SPARCstorage Volume Manager, combined with the other SPARCstorage Array features, provides a tightly integrated, complete storage solution.



Physical disk views show distribution of disks in SPARCstorage Arrays, as well as status displays for other Array components. Command menus provide an easy interface to the Array hardware



Virtual disk views allow easy creation and management of disk volumes. Performance displays provide easy identification of bottlenecks. Storage can be reorganized on line, while volumes are active

SPARCstorage™ Volume Manager: Powerful, Easy Administration *(cont.)*

The SPARCstorage Volume Manager supplies storage management, administration, availability, and performance features not found in other disk arrays.

• Features	• Benefits
– Virtual storage management allows logical data layout to be independent of physical disk drives	– Disk space organizes into easy to manage pools of storage, without administrators having to be concerned with physical data layouts
– Volumes appear to applications, file systems, and database management systems as regular disk partitions	– Applications do not need to be changed to take advantage of the Volume Manager
– Point-and-click, drag-and-drop GUI administration	– Easier to use, requires less operator training, lower likelihood of operator errors, and more efficient system administration
– Visual performance displays	– Easy identification of performance bottlenecks
– Data can be reorganized on line, while file systems or databases are being accessed, without impacting users or applications	– Users continue being productive even during performance tuning or other administrative activities
– X/Motif®-based GUI	– Administration can be done remotely
– Command line interface provided in addition to GUI	– With scripts, users can perform administration, or users can administer Arrays from character-oriented terminal
– Error notification on GUI, in files, and on liquid crystal display (LCD) panel	– Complete error notification for administrators
– Physical views of Arrays in GUI laid out similarly to LCD panel on Array	– Easy to understand status
– Management of all disks on a system, not just those in SPARCstorage Arrays	– Uniform storage administration for the whole system

Key Facts

- The Volume Manager software is shipped with every SPARCstorage Array and is not available as an unbundled software product from Sun
- The SPARCstorage Volume Manager may be used to manage disk drives that are not in SPARCstorage Array, as long as at least one SPARCstorage Array is connected to the host system. This allows a single storage management environment to handle all disk drives on a system. Striped data configurations (RAID 5, 0, and 0+1) are supported only on SPARCstorage Array disks
- Although the Volume Manager is bundled with the SPARCstorage Array, customers are not required to use it. Two other alternatives are available:
  - Sun's Online: DiskSuite™ utility may be used to manage the SPARCstorage Array disks
  - The disks in the SPARCstorage Array may also be accessed directly as 30 independent SCSI disks, without the Volume Manager or Online: DiskSuite

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SPARCstorage Volume Manager: Powerful, Easy Administration *(cont.)*

Tech Facts

- The SPARCstorage Volume Manager runs on the host server or workstation system
- Administration with the Volume Manager can be performed from any workstation on the network through remote X
- The Volume Manager interposes a virtual disk partition, known as a "volume," between physical disk devices and higher-level system entities, such as a UNIX® file system, a DBMS, or an application. The Volume Manager GUI displays both physical and logical views of SPARCstorage Arrays
- The SPARCstorage Volume Manager allows administrators to group and name volumes, as they prefer
- The Volume Manager manages all aspects of RAID 0, 1, 0+1, and 5 operation
- The Volume Manager allows volumes, and therefore file systems, to span multiple disk drives, so file systems may be larger than a single physical disk drive
- Once a bottleneck is identified using the performance analysis tool, performance may be improved, while applications are running, in one of several ways
  - Moving the data to another disk drive
  - Creating a duplicate copy (mirror) of the data, so that read requests can be serviced from multiple physical disk drives
  - Reorganizing the data. For example, a simple volume can be reorganized into a striped volume to spread the I/O load across multiple physical spindles

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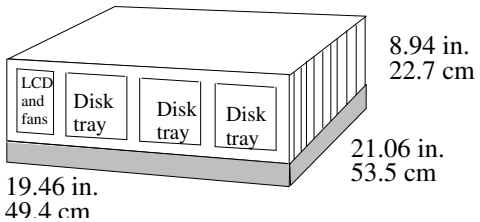
SPARCstorage™ Array Model 100 Series Packaging: Unique Reliability, Serviceability, and Density

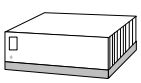
Breakthrough Packaging Design

From the exterior of the SPARCstorage Array Model 100 Series, it is hard to believe that it packs so much power and so much capacity into a space scarcely larger than some PCs. The Model 100 Series' amazing density results from the most innovative package design in the industry. The clean design gives the SPARCstorage Array Model 100 Series uniquely high reliability.

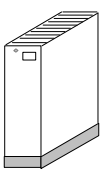


- **Features**
  - Ultracompact enclosure occupies less than 2 cubic feet (0.06 cubic meters), for the industry's highest storage density
  - High ratio of disk drives to gigabytes using small form factor drives
  - Cable-free internal design
  - All components are pluggable and easily serviceable by system administrator
  - LCD panel provides complete status information
  - Quiet, efficient cooling system
  - Innovative, Single Connector disk drives developed by Sun
  - Warm Plug service under power drive replacement
  - Unusually high-reliability power supply, fans, and controller board
  - Versatile packaging: tabletop, tower, stack, or rack
- **Benefits**
  - Significantly less space, power, and air conditioning needed for building larger systems
  - Superior optimization of random IOPS and price/performance to products using larger drives
  - Inherent high reliability
  - Less downtime for service and lower total cost of ownership
  - User sees status at a glance, without looking at operator's console
  - High reliability, low noise level
  - New standard for serviceability and reliability
  - No need to power down Array subsystem to replace a drive or reboot host system
  - Higher reliability, and higher data availability, than other disk subsystems
  - Flexibility in a wide variety of customer environments

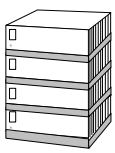
Tabletop packaging



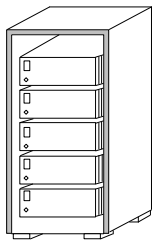
Tower stand for deskside orientation



Stacking unit for Arrays and SPARCserver™ 1000 systems



Standard rack for multiple Arrays in data centers



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SPARCstorage Array Model 100 Series Packaging: Unique Reliability, Serviceability, and Density *(cont.)*

Key Innovation: The Single Connector Drive

Many disk array subsystems provide pluggable disks. Unfortunately, they are inherently unreliable and costly; they are also not compact. To be pluggable, they enclose a standard disk drive in a carrier made of plastic or metal. Inside the carrier are multiple flex cables, jumpers, and other wires — parts that increase the likelihood of failures. These pluggable drive schemes actually cause a disk subsystem to be *less* reliable.

For the SPARCstorage Array, Sun coinvented a new type of drive connector scheme, called the Single Connector. In the Single Connector, all electric signals for fast/wide SCSI, power, and jumpers are passed through a single small connector, which is integrated directly onto the disk drive's printed circuit board. So the drive plugs directly into the SPARCstorage Array backplanes with no unwieldy drive carrier, and without any jumpers to set.

The most important benefit is significantly higher reliability. But the Single Connector has three other valuable advantages. First, it is one of the keys to the unprecedented storage density of the Model 100 Series. Second, it costs less than pluggable drive carrier schemes. Third, it is much more customer serviceable. With other pluggable drive schemes, removing the failed drive from the carrier and replacing it with a new drive is tedious, time consuming, and fraught with opportunities for mistakes.

The Single Connector design has been made available to the ANSI SCSI committee and is produced by multiple disk drive manufacturers.

Tech Facts

- The disk drives are 3.5-inch, low-profile form factor (1 x 4.02 x 5.77 inches, or 25.4 x 102.1 x 146.6 mm)
- The disk trays and the LCD/fan tray plug into the centerplane from the front
- The power supply and Array controller board plug into the centerplane from the rear
- There are three pluggable disk trays, each containing two SCSI buses and up to ten disk drives
- Each drive tray has a light emitting diode (LED) that indicates whether the disk drives are spun down and it is safe to remove the tray
- The LCD panel and fan tray are integrated into a single pluggable unit
- The fan tray includes three independent, thermostatically controlled fans. Fan speed varies according to the environmental conditions to always provide optimal air flow. If a fan fails, notification is given, but the Array keeps running until internal overheating causes automatic shutdown. Depending on the environment, an Array may keep running with one inoperative fan for a long time
- The LCD panel provides status information on drives, controller, Fibre Channel links, fans, and the NVRAM battery. It also displays self-test information and the last four characters of the subsystem's worldwide name
- The worldwide name is a 16-digit number (somewhat like an Ethernet address) that is guaranteed to be unique among all SPARCstorage Arrays. Worldwide names are programmed into the controller PROM at the factory
- The pluggable autoranging power supply operates at 100-240 VAC and 47-63 Hz

SPARCstorage™ Array RAID Features: High Availability and Peace of Mind

Flexible Configuration to Match Your Business Needs

The SPARCstorage™ Array redundant array of independent disks (RAID) implementation allows users to achieve the ideal balance of high data availability, performance, capacity, and cost. And because the SPARCstorage Array is easily reconfigured, it adapts to users' changing requirements.

Different Data Organizations for Different Applications

Independent Disks	Best for most applications No redundant data protection Lowest cost per usable MB
Striping (RAID 0)	Spreads data across multiple disk spindles for better performance Can be tuned to optimize either random or sequential I/O performance No redundant data protection, lower reliability than independent disks Same low cost per usable MB as independent disks
Mirroring (RAID 1)	Duplicate copies of data, so if a disk fails, data is still available and applications keep running Performance roughly the same as independent disks Highest cost per usable MB
Mirroring Stripes (RAID 0+1)	Duplicate copies of striped data remain available even if a disk fails Combines performance of striping with data protection of mirroring Has cost per usable MB disadvantages of mirroring
Striping with Parity (RAID 5)	Data protection by storage of parity information so data remain available even if a disk fails Stripes data across multiple disk spindles to optimize random or sequential performance Higher cost/MB than independent disks or RAID 0, but much lower than RAID 1 or 0+1 Lower performance on small-sized writes than in RAID 1, 0, 0+1, or independent disks

- **Features**
  - Independent disks, plus RAID levels 5, 1, 0, and 0+1, all at the same time within the same Array
  - RAID groups may even span multiple Arrays
  - RAID levels 5, 1, and 0+1 yield predicted steady-state uptimes in excess of 99.99 percent per Array and mean time between data loss (MTBDL) in the millions of hours
  - Optional Hot Spares are automatically swapped in to replace any failed disk in a RAID 5, 1, or 0+1 group without human intervention
  - RAID stripe sizes are adjustable to optimize for either random or sequential I/O patterns

- **Benefits**
  - Easily match data layouts to meet users' specific requirements for capacity, performance, high availability, and cost
  - Greater flexibility; allows creation of fully redundant configurations
  - New levels of high availability for Sun systems, so users can be confident that data will not be lost, and that data will be available when needed
  - Continuous redundant data protection even if a disk fails; maintenance deferral for days, weeks, or even months
  - Users can tune performance to their specific applications

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SPARCstorage Array RAID Features: High Availability and Peace of Mind *(cont.)*

Tech Facts

- Hot Spares are extra disk drives in the Array that are powered up and ready to use. If a drive in a RAID 5, 1, or 0+1 group fails, the Volume Manager detects the failure and automatically rebuilds the data from the failed drive onto a Hot Spare drive. In some competitive hot plug designs, the RAID runs without data protection and at degraded performance, until an operator physically changes a failed drive
- Each Array can have one or more Hot Spare drives. A Hot Spare drive can be tied to one or more particular drives, or one or more particular RAID groups, or it can be designated as a spare for any drive in any RAID group
- The combination of Hot Spares with Warm Plug provides new levels of high availability and administrative flexibility. Hot Spares allow maintenance to be deferred for long periods, and Warm Plug means that Array downtime is brief when a failed drive is eventually changed
- Because RAID is not ideal for many situations, users can configure disk drives as regular, independent disks, rather than using RAID
- Striped data organizations (RAID 0, 0+1, and 5) can be tuned to optimize for either random or sequential I/O performance
- To optimize for random performance, striping evenly balances the I/O load across disk spindles in the RAID. This is done by setting the stripe width as large or larger than the typical application I/O request. For example, if the typical I/O request is 8 KB, setting the stripe width to 16 KB might be appropriate. This tends to evenly distribute I/O requests across all the disk drives in the RAID, and a single disk drive services each I/O request
- Sequential performance is optimized when data is spread out so that each application I/O request spans all the drives in the RAID group. This requires setting the stripe width so that it is small relative to the size of the typical I/O request. For example, in a RAID group four data disks wide, if typical application I/O size is 8 to 64 KB, a stripe width of 2 KB may be best
- The SPARCstorage Array provides levels of high availability that meet or exceed the vast majority of customer needs, with over 99.99 percent predicted uptime per Array. For this reason, it is not burdened by redundant components, which add cost and complexity and are usually unnecessary
- Fully redundant systems can be configured for situations where no single points of failure can be allowed in the system. Multiple SPARCstorage Arrays, with data mirrored across the Arrays, can be configured for any desired level of redundancy. When configured in this manner, any Array component can fail and can be replaced without interrupting data service or causing system downtime. Redundant SPARCstorage Array configurations often cost less than competitive disk arrays with redundancy built into a single subsystem, yet provide the same benefits

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SPARCstorage™ Array RAID Implementation: Intelligent Hybrid for Flexibility and Performance

Host-Based vs. Controller-Based RAID

Redundant array of independent disks (RAID) functionality can be implemented on the host system in software. Or it can be implemented on an array controller. Each method has its advantages.

The primary advantage of host-based software RAID is flexibility. In this type of implementation, software on the host system controls RAID configuration, as well as management and redundant data synchronization operations. This allows a high degree of flexibility, allowing many different RAID levels to be configured, even allowing RAID groups to span multiple disk controllers. RAID functionality is not tied to a specific RAID box. Host software RAID also allows configurations to be easily changed over time, as your business needs change.

When RAID is implemented on an array controller, separate from the host computer system, this is often termed "hardware RAID." This is usually a misnomer, because most of the RAID functions are actually performed in software on the controller, not in hardware. It is generally believed that controller-based RAID delivers higher performance than host-based RAID. This is frequently not true, because many array controllers suffer from the weakness of underpowered processor chips, insufficient bandwidth, or other architectural shortcomings. Controller-based RAID does have the advantage of requiring fewer host system resources for I/O.

Combining the Best

In the SPARCstorage™ Array, the RAID implementation combines host-based software, controller-based software, and specialized controller hardware. This delivers a high degree of flexibility and configurability, while also delivering high performance and limiting host system overhead.

In the SPARCstorage Array, configuration, synchronization, and management of RAID 0, 1, 0+1, or 5 groups is performed by the Volume Manager software running on the host SPARCserver™ or SPARCstation™ system. This provides maximum flexibility and configurability.

To maximize performance, and minimize host system overheads, the powerful SPARCstorage Array controller takes on most of the I/O processing burden. And the resource-intensive read-modify-write sequence in RAID level 5 occurs completely on the SPARCstorage Array controller and uses special hardware for parity calculation.

The synergistic integration of the Array controller hardware with the Volume Manager software gives users the best of both worlds.

- **Features**
  - Configuration and management of RAID groups performed on host system
  - RAID 5 read-modify-write sequence performed on controller, with hardware assist from specialized ASIC
  - RAID 5 implementation is tunable for either high-random I/O performance or RAID 3-like sequential performance
- **Benefits**
  - Greater flexibility and configurability. With the Volume Manager GUI, configurations are easy to create and change, and RAID groups can even span Arrays
  - Higher-performance RAID 5 writes, with less system overhead
  - Different performance needs can use both RAID levels 3 and 5

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SPARCstorage Array RAID Implementation: Intelligent Hybrid for Flexibility and Performance *(cont.)*

Key Innovation: The BIANCA ASIC

An important part of the SPARCstorage Array controller is the bus interface and NVRAM Controller ASIC (BIANCA), a two-chip ASIC chipset that handles several functions. First, it manages the NVRAM cache. Second, it is the controller for one of the two internal SBuses. Third, it manages the flow of data between the two SBuses and the various SBus devices. Finally, it includes hardware eXclusive-OR (XOR) logic for calculating parity in RAID 5.

In RAID level 5, an inherent problem with small-block write performance, the read-modify-write problem, occurs because when an application issues a single logical write command to one of the disk drives in a RAID 5 group, several physical I/O operations must be performed. Each logical write to a RAID 5 disk normally results in two physical reads, two parity calculations, and two physical writes.

In the SPARCstorage Array's advanced RAID implementation, the read-modify-write sequence is all performed on the controller, to minimize system overhead and reduce host I/O traffic.

A second performance benefit is achieved using the BIANCA hardware parity logic, rather than doing the XOR operations in software on the Array controller's microSPARC™ CPU or on the host system.

Tech Facts

- When RAID 5 groups span multiple Arrays, the controller's performance enhancing read-modify-write and XOR operations cannot be used. In this situation, the read-modify-write and XOR operations are performed on the host system in software
- The SPARCstorage Array's RAID 5 implementation delivers the kind of high sustained sequential I/O performance usually associated with RAID 3
  - Adjustable stripe sizing enables RAID 5 I/Os to be spread across all drives in a RAID group
  - The RAID 5 algorithm recognizes full stripe writes and avoids multiple read-modify-write sequences

Fibre Channel: Sun Leadership Delivers Unique Customer Advantages

The First Fibre Channel Disk Array

The SPARCstorage™ Array is the world's first Fibre Channel disk array from a major manufacturer. Sun Microsystems has led the development of the Fibre Channel standard and now is the leader in delivering the benefits of Fibre Channel in a high-performance, richly featured, yet economical disk array subsystem.

Fibre Channel will give users the capabilities needed to successfully run their businesses through the rest of the century.

• **Features**	• **Benefits**
– 25 MB/sec. full duplexed bandwidth compared to fast/wide SCSI at 20 MB/sec. half duplex	– More than double the channel bandwidth, so users will not outgrow the SPARCstorage Array's Fibre Channel speed as they might with SCSI
– Fiber optic interface allows cabling up to 2 kilometers (1.25 miles), compared to the SCSI limits of 6 to 25 meters	– Greater configuration flexibility within the data center or a large building or between buildings
– Fiber optic interface provides electrical isolation from host system and is inherently more reliable than copper cabling	– Electrical problems in host are not propagated to Array; host system and Array may be on separate power circuits to improve system reliability
– Growth path to 100 MB/sec. channels and an enabler for future system clustering capabilities	– Technology with a future
– Single fiber optic cable connects dozens of disk drives	– No more jumbles of cables

High Performance I/O for the 90s

An emerging industry standard for high-performance I/O interconnect, Fibre Channel supplies bandwidths far in excess of other types of channels like SCSI. Whereas SCSI-2 is defined up to a maximum of 20 MB/sec. half duplex, Fibre Channel takes up where SCSI leaves off. Sun's first implementation is 25 MB/sec. full duplex. Fibre Channel is presently well defined up to 100 MB/sec., and even faster versions are in development.

Fibre Channel is a general-purpose point-to-point interface that moves data from a source to a destination. Higher-level protocols, which are mapped on top of Fibre Channel, are used to provide specific services. In the SPARCstorage Array, the SCSI protocol is mapped on top of Fibre Channel.

Other protocols can be mapped on top of Fibre Channel, including networking protocols such as IP.

The Fibre Channel standard has been under development in the American National Standards Institute (ANSI) since 1988. In the next several years, it will emerge as the leading high-performance I/O interface, implemented by most major system and peripheral manufacturers.

Fibre Channel: Sun Leadership Delivers Unique Customer Advantages *(cont.)*

Key Innovation: The SOC Fibre Channel ASIC

For the SPARCstorage Array, Sun has developed a highly advanced Fibre Channel ASIC chip, the serial optical channel (SOC). Each SPARCstorage Array controller board has one SOC ASIC, as does each Fibre Channel SBus card.

The SOC chip is an SBus to Fibre Channel interface. On the Fibre Channel side of the chip, there are dual, full duplex, 531 Mb/sec. (50 MB/sec.) Fibre Channel ports. The SOC ASIC is microprogrammable and runs downloadable firmware. It is highly integrated, packing all this capability into a single 288-pin TAB package.

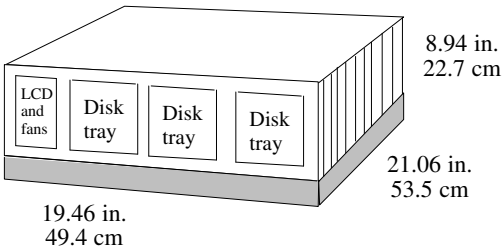
On the SPARCstorage Array controller, the SBus side of the chip communicates to the Array controller's internal SBus. The dual port of the SOC allows two Fibre Channel Optical Modules to be plugged into the Array controller, supplying dual porting to multiple hosts.

Exactly the same SOC ASIC is used on the Fibre Channel SBus card, which is plugged into an SBus slot on the host system. The dual ports on the SOC allow up to two Fibre Channel Optical Modules and two SPARCstorage Arrays to be connected per SBus slot.

Tech Facts

- The Fibre Channel Optical Modules require two fibers per link, one fiber in each direction. Fiber type is 50 micrometer multimode. Sun offers duplexed fiber optic cables in both 2 meter and 15 meter lengths. Longer cables will be available from other sources
- The SOC ASIC is designed to drive dual 50 MB/sec. full-duplex Fibre Channel interfaces, although Sun is presently using 25 MB/sec. optical modules. In the future, 50 MB/sec. optical modules will be available
- The SPARCstorage Array's Fibre Channel implementation complies with the following standards
  - ANSI Fibre Channel FC-PH Rev. 4.2, X3T11-755D
  - ANSI SCSI Fibre Channel Protocol (SCSI-FCP) Rev. 8, X3T10-993D
- Sun Microsystems, IBM®, and Hewlett-Packard announced the Fibre Channel Systems Initiative (FCSI) in February 1993. The purpose of FCSI is to shepherd the emerging Fibre Channel standard to widespread adoption and to ensure that different implementations are interoperable
- Fibre Channel is a point-to-point interface. However, a key part of the Fibre Channel standard is the definition of switches, or fabrics, which provide many-to-many connections between Fibre Channel nodes. This capability furnishes virtually unlimited storage connectivity and is particularly useful in clustered systems
- The 25 MB/sec. Fibre Channel SBus Card (FC25/S) has a 64-bit SBus interface for higher bandwidth on host systems with 64-bit SBus capability

Configurations and Options: Model 100 Series



SPARCstorage Array Model 100 Series

- SPARCstorage™ Array Model 101
  - 6 x 1.05 GB (6.3 GB) — X653A
  - 18 x 1.05 GB (18.9 GB) — X654A
  - 30 x 1.05 GB (31.5 GB) — X655A

Options

- SBus host adapters and optical modules
  - 25 MB/sec. Fibre Channel SBus card (FC25/S) — X1057A
  - 25 MB/sec. Fibre Channel optical module (FC25/OM) — X595A
- Additional disk drives for the SPARCstorage Array Model 100 Series
  - 1.05 GB Single Connector drive — X651A
  - 6 x 1.05 GB Single Connector drives — X652A
  - 535-MB Single Connector drive — X590A
- Mounting options
  - Tower stand — X962A
  - Stacker unit including power base and four locking modules — X964A(V3,V4)
  - Locking module — X963A
  - Rack mount kit — X965A
  - 56-inch data center expansion cabinet — X955A
- Additional fiber optic cables
  - 2-meter Fibre Channel cable — X973A
  - 15-meter Fibre Channel cable — X978A
- Field replaceable units (for self-service)
  - Controller board (without FC25/OM or battery module) — F501-2080
  - NVRAM battery module — F501-2028
  - Power supply — F540-2465
  - LCD/fan tray — F540-2573
  - Disk drive tray — F540-2245

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Configurations and Options: Model 100 Series *(cont.)*

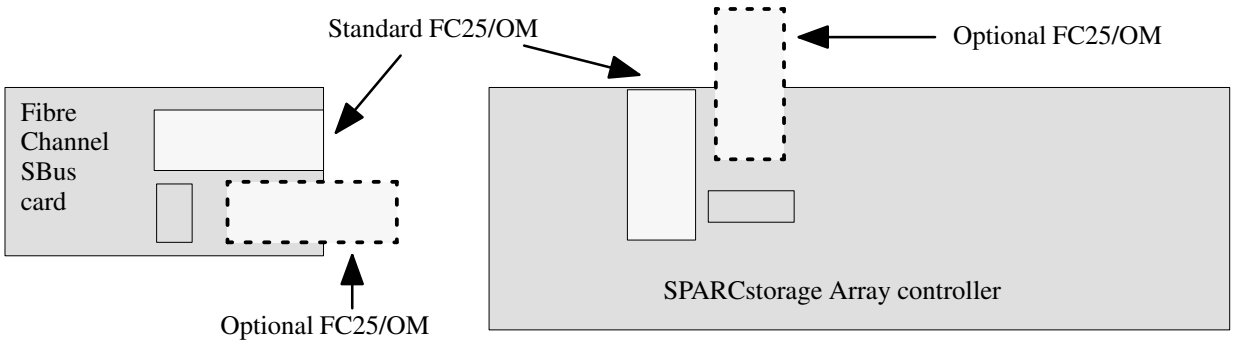
Options *(cont.)*

- Localized power cord kits (no charge)

	Part number
– North American/Asian	X311L
– Australian	X386L
– Continental Europe	X312L
– Swiss	X314L
– U.K.	X317L
– Danish	X383L
– Italian	X384L

Configuration Guidelines

- The SPARCstorage Array requires Solaris® 2.3 operating environment
- No-charge localized power cord kits must be ordered separately
- All Array subsystem configurations include a chassis, controller board with one FC25/OM, power supply, LCD/fan tray, three drive trays, one 2-meter fiber optic cable, and SPARCstorage Volume Manager software. FC25/S SBus cards and power cords are not included and must be ordered separately
- Each FC25/S card is shipped with one FC25/OM module preinstalled
- Each fiber connection requires one FC25/OM at each end of the fiber cable
- Up to two Arrays may be connected per SBus slot. To add a second Array to an FC25/S SBus card, order one additional FC25/OM



Tech Facts

- 535-MB and 1.05-GB disks can be mixed in the same Model 100 Series subsystem. For optimal performance, all disk drives within a RAID group should be the same type
- Although the Model 100 Series Array hardware is customer serviceable, a SunSpectrum℠ service contract is still useful because it provides SunService support for all software and firmware. It also covers replacement parts

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SunSpectrum℠ Customer Service Program

SunSpectrum℠ support programs are designed to meet customers' complete system needs, from total business support to self-maintenance and any level in-between. The SunSpectrum program supports a flexible range of services, allowing customers complete systems coverage for hardware, software, network applications, and network interoperability problems. A single fee covers the support for customers' entire SPARCstorage™ Array — no matter what the configuration — making ordering and support administration easy and painless. Customers should check with their local customer support representative for program/feature variance and availability in their area.

Services	SunSpectrum Platinum℠ program	SunSpectrum Gold℠ program	SunSpectrum Silver℠ program	SunSpectrum Bronze℠ program
Telephone assistance, unlimited	Seven day, 24 hour	Seven day, 24 hour	8AM-8PM, M-F	8AM-5PM, M-F
On-site response	Seven day, 24 hour	8AM-8PM, M-F	8AM-5PM, M-F	
Customer defined priority	✓	✓	✓	
Urgent (phone/on site)	Live/two hour	Live/four hour	Live/four hour	Four hour/NA
Serious (phone/on site)	Two hour/ four hour	Two hour/ next day	Two hour/ next day	Four hour/NA
Non-critical (phone/on site)	Four hour/ customer convenience	Four hour/ customer convenience	Four hour/ customer convenience	Four hour/NA
Remote dial-in analysis	✓	✓	✓	✓
Replacement hardware parts	On-site technician	On-site technician	On-site technician	Courier, two business days
Solaris® enhancement releases	✓	✓	✓	✓
Patches and maintenance releases	✓	✓	✓	✓
SunSolve™ license	✓	✓	✓	✓
EarlyNotifier™ service	✓	✓	✓	✓
Seven-day, 24-hour telephone coverage	✓	✓	Option	
Seven-day, 24-hour on-site coverage	✓	Option	Option	
Two-hour on-site response	✓	Option	Option	
Self-paced education library	✓	✓	Option	
Personal technical account support	✓	✓	Option	
On-site technical support reviews	Quarterly	Semiannual	Option	
Technical support plan	✓			
99% server uptime guarantee	✓			
Site activity log	✓	✓		
Coaching and training service	15 days per year			

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SPARCstorage Array Glossary

Array controller	The electronic device within a SPARCstorage™ Array that manages commands and data transfers between the host and the Array's disk drives and removes much of the burden of I/O processing from the host system.
ASIC	Application specific integrated circuit. A chip designed to implement a special-purpose set of functions.
Bandwidth	A measure of the capacity of a communication channel, usually specified in megabytes per second.
BIANCA	Bus interface and NVRAM controller ASIC. An ASIC chipset developed for the SPARCstorage Array.
Disk array	A subsystem that contains multiple disk drives, designed to provide performance, high availability, serviceability, or other benefits.
DSBE/S	SBus fast Differential SCSI–2/buffered Ethernet card, option number 1052A.
DWIS/S	SBus Differential Fast/Wide Intelligent SCSI–2 host adapter, option number 1062A.
Fast Write	A feature of the SPARCstorage Array NVRAM Cache implementation. Allows disk write commands to be safely acknowledged to the host system as completed before the data is actually written to the disk media.
FCSI	Fibre Channel Systems Initiative, jointly sponsored by Sun, HP®, and IBM®. This is an effort to guide the emerging Fibre Channel standard to widespread implementation and to guarantee that different implementations are interoperable.
Fibre Channel	A high-performance data movement interface developed under the auspices of the American National Standards Institute (ANSI).
Full duplex	Refers to an interface such as Fibre Channel that can move data both in and out at the same time. Thus, a 25-MB/sec. Fibre Channel interface has a total bandwidth of 50 MB/sec. See half duplex.
GUI	Graphical user interface.
Half duplex	Refers to an interface such as SCSI that can transmit data in only one direction at a time. See full duplex.
Host adapter	A device that connects a peripheral device I/O protocol and medium to the computer system's I/O bus. The FC25/S card is a host adapter connecting Fibre Channel to SBus.
Hot Spare	A drive in an array that is held in reserve to replace any other drive that fails.
IOPS	Input/output operations per second. A measure of I/O performance, this is usually used to quote random I/O performance. See throughput.

SPARCstorage Array Glossary *(cont.)*

MTBDL	Mean time between data loss. In a RAID, this is the average expected time between two rapid disk failures that would cause irreparable data loss.
MTBF	Mean time between failures. A measure of reliability, this is the average expected time between failures of equipment, usually measured in operating hours.
NVRAM Cache	A nonvolatile (battery-backed) random access memory area used as an intermediate store for data between the host computer system and disk drives. See Fast Write.
RAID	Redundant array of independent disks, a set of disk drives that appear to be a single logical disk drive to an application such as a database or file system. Different RAID levels provide different capacity, performance, high availability, and cost characteristics.
Release	A SCSI command to release a previously granted reservation. See Reserve.
Reserve	A SCSI command issued by a host system to reserve access to a controller or disk drive. Once a reservation is granted to a system, commands to the controller or disk drive by any other system are rejected. This is a valuable safety feature in dual-hosted SPARCstorage Array configurations.
Single Connector	A new SCSI disk connector technology coinvented by Sun Microsystems.
SOC	Serial optical channel, an ASIC developed for the SPARCstorage Array.
Striping	Spreading, or interleaving, logically contiguous blocks of data across multiple independent disk spindles. The amount of data written on each disk before moving to the next drive is the stripe width.
TAB	Tape automated bonding. A type of chip packaging and mounting technology used in the SPARCstorage Array controller's microSPARC™ and SOC chips.
Throughput	A measure of sequential I/O performance, quoted as MB/sec. See IOPS.
Volume	In the SPARCstorage Volume Manager, a volume is a virtual disk partition, into which a file system, DBMS, or other application can place data. A volume can physically be a single disk partition or multiple disk partitions on one or more physical disk drives. Applications that use volumes do not need to be aware of their underlying physical structure. The Volume Manager handles mapping of virtual partition addresses to physical addresses.
Warm Plug	The ability to replace a failed disk drive without powering down a SPARCstorage Array and without rebooting the host computer system. This is an important aspect of high availability.
XOR	eXclusive OR. A binary mathematical operation performed on data to produce parity information. In RAID level 5, parity is generated from user data and is used to regenerate any user data lost due to a drive failure.

SPARCstorage Array Materials Abstract

All materials will be available on SunWIN by March 22, except where noted otherwise.

Collateral	Description	Purpose	Distribution	Token #
Power Pack				
– *The SPARCstorage™ Array: New Solutions for the Enterprise* customer presentation	SPARCstorage Array overview; slide notes for presentation	Sales tool	SunWIN, Reseller Resource CD	31615 31617
– *Just the Facts*	Reference guide for the SPARCstorage Array	Training	SunWIN, Reseller Resource CD	31619
References				
– *Sun Intro*	Introduction e-mail	Training	SunWIN, Reseller Resource CD, e-mail	31621
– *SPARCstorage Array Product Line Overview*	Quick reference card (available end of April)	Training	SunWIN, Reseller Resource CD, Mail	32118
Intro to Go training kit				
– Traning video	Training video for system engineers on the SPARCstorage Array features and technical review of product	Training	Mail	
– Facilitator's Guide	Guide to planning a training seminar	Training	Mail	
Technical Presentation				
– Technical Customer Presentation	SE customer-ready presentation	Sales tool	SunWIN, Reseller Resource CD	32127
Product literature				
– *SPARCstorage Array* datasheet	Datasheet (available from Hibbert)	Sales tool	Mail	DE554–0
Competition				
– *SPARCstorage Array Competitive Brief*	Price/performance and functionality comparison with competitive products	Sales tool	SunWIN Reseller Resource CD	32132

SPARCstorage Array Materials Abstract *(cont.)*

All materials will be available on SunWIN by March 22, except where noted otherwise.

Collateral	Description	Purpose	Distribution	Token #
White papers				
– *Fibre Channel*	Fibre channel standards	Sales tool	SunWIN, Reseller Resource CD	32134
– *SPARCstorage Array Architecture*	Technical overview of SPARCstorage Array system design	Sales tool	SunWIN, Reseller Resource CD	32138 32219
– *Understanding Disk Arrays*	Technical overview of Disk Arrays	Sales tool	SunWIN, Reseller Resource CD	11375 21469 21472 21475
Video				
– *SPARCstorage Array Sales Video*	High-Level, customer ready highlights of the SPARCstorage Array features (available beginning of April)	Sales tool	Mail	

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