



Sun StorEdge SRC/P Intelligent SCSI RAID Controller™ Installation Guide

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Manufacturer's Address: 140 Candace Drive
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407-830-5522

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Type of Equipment: SCSI Cards and Peripheral equipment

Model Number: PM2044U, PM2044UW, PM2144UW, PM3332UW, PM3334UW, PM3334UDW, PM2554UW, PM1554U2, PM1654U2, PM2554U2, PM2654U2, PM3754U2, PM3755U2B, SX4054U2, SX4055U2, SX4055F (class A), BB4050, RA4050, SM4050-4, SM4050-16, SM4050-64, DM4050-4, DM4050-16, DM4050-64 and RAIDStation (DPT-RS3 & DPT-RS3W)

to which the declaration relates is in conformity with the Title 47 of the US Code of Federal Regulations, Part 15 covering Class B personal computers and peripherals.

Operation is subject to the following two conditions:

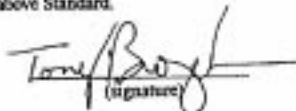
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Place: Maitland, FL, USA

Date: 10 Nov 98


(signature)

Tony Brogren
(Full Name)

V.P. Program Management
(Position)

DO-0957-004



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Standard to which Conformity is Declared :
EN55022 Class B, EN50082-1
EN60950, AS/NZS 3548

Manufacturer's Name: Distributed Processing Technology Corporation

Manufacturer's Address: 140 Candace Drive
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Germany 49-8992-40416-0 Central Milton Keynes
MK9 2EA 44-1-908-233-951

Australian Contact: 117 Phillip Avenue Australian Supplier Code N740
Watson ACT 2602
Australia 61-412-004-830

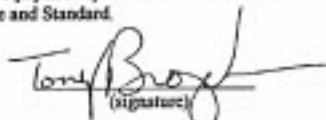
Type of Equipment: SCSI Boards and RAID Subsystems

Model Number: PM2021, PM2022, PM2024, PM2122, PM2124, PM3222, PM3224, PM2124W, PM3224W,
PM2041W, PM2042W, PM2142W, PM2044W, PM2044U, PM2044UW, PM2144W, PM2144UW, PM3332W,
PM3332UW, PM3334W, PM3334UW, PM3334UDW, SM4000, CM4000, DM4000, SX4000, SX4000W,
SX4010W, SX4010UW, SX4030UW, RC4040, RC4041, 3 Bay RAIDStation, PM1554U2, PM1654U2,
PM2554UW, PM2554U2, PM2654U2, PM3754U2, PM3755U2B, SX4054U2, SX4055U2, SX4055F (class A),
BB4050, RA4050, SM4050-4, SM4050-16, SM4050-64, DM4050-4, DM4050-16, DM4050-64

I, the undersigned, hereby declare that the equipment specified above conforms
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Place: Maitland, FL, USA

Date: 10 Nov 98


(signature)
Tony Broden
(Full Name)

DO-0923-010

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Preface

This guide describes how to install a Sun StorEdge SRC/P Intelligent SCSI RAID Controller™ card into a Sun Enterprise™ server and explains how to connect external storage devices to the controller.

You need to install the SRC/P Controller into the server before you can install the controller software or configure a drive array.

These instructions are designed for an experienced workgroup server administrator or a trained service provider.

Using UNIX Commands

This document may not contain information on basic UNIX® commands and procedures such as shutting down the system, booting the system, and configuring devices.

See one or more of the following for this information:

- *Solaris Handbook for Sun Peripherals*
- AnswerBook2™ online documentation for the Solaris™ operating environment
- Other software documentation that you received with your system

Typographic Conventions

Typeface	Meaning	Examples
AaBbCc123	The names of commands, files, and directories; on-screen computer output	Edit your <code>.login</code> file. Use <code>ls -a</code> to list all files. % You have mail.
AaBbCc123	What you type, when contrasted with on-screen computer output	% su Password:
<i>AaBbCc123</i>	Book titles, new words or terms, words to be emphasized	Read Chapter 6 in the <i>User's Guide</i> . These are called <i>class</i> options. You <i>must</i> be superuser to do this.
	Command-line variable; replace with a real name or value	To delete a file, type <code>rm filename</code> .

Shell Prompts

Shell	Prompt
C shell	<i>machine_name</i> %
C shell superuser	<i>machine_name</i> #
Bourne shell and Korn shell	\$
Bourne shell and Korn shell superuser	#

Related Documentation

The following documents contain topics that relate to information in this guide.

TABLE P-1 Related Documentation

Title	Part Number
<i>Ultra Enterprise 450 Server Owner's Guide</i>	805-0429
<i>Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide</i>	806-4148
<i>Sun StorEdge MultiPack Installation</i>	805-3953
<i>Sun StorEdge MultiPack Storage Guide</i>	805-3955
<i>Sun StorEdge MultiPack User's Guide</i>	805-3954

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Sun StorEdge SRC/P Intelligent SCSI RAID Controller Installation

This guide describes how to install an SRC/P Intelligent SCSI RAID Controller into a PCI slot on a Sun Enterprise server and how to connect external storage devices to the controller. You need to install the SRC/P Controller into the server before you can install the controller software or configure a drive array.

See the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide* for information about software installation and array configuration.

About the SRC/P Controller

The SRC/P Controller is a host-based, three-channel UltraSCSI RAID controller card with a 64-bit PCI system interface and a dedicated processor.

The idea of RAID (redundant array of independent disks) is to combine multiple disk drives into an array of drives that provides better performance and more data protection than a single large drive. The server sees the array as a single logical storage unit.

The SRC/P Controller improves performance over software-based RAID because it off-loads RAID processing from the server CPU to the processor on the SRC/P Controller card.

Fault tolerance for data protection is provided by different types of RAID architecture. RAID levels 1, 5, 1+0, and 5+0 provide disk fault tolerance methods to protect data from being lost in the event of a hardware failure. Each RAID level offers different trade-offs in fault tolerance features and performance. In addition, RAID 0 offers no fault tolerance, but it does provide high I/O performance.

For additional data protection, hot spare drives are supported. Should an active drive fail, the hot spare drive assigned to the array replaces it and the data is automatically redirected to the hot spare drive.

The SRC/P Storage Manager, which is a graphical user interface (GUI), and a command-line management interface are included for RAID configuration, diagnostics, and event reporting. The SRC/P Controller automatically determines a RAID level and stripe size for your array based on your requirements for capacity, security, and performance. You can also manually select a specific RAID level through the GUI.

The SRC/P Controller uses read-ahead caching to reduce disk access time and improve performance. The controller automatically tallies I/O operations in cache RAM for analysis of storage subsystem I/O loading. You can view these numbers through the SRC/P Storage Manager. The controller analyzes these statistics to optimize the array architecture, cache, and stripe size for your system. You can tune and set cache parameters through the SRC/P Storage Manager.

The SRC/P Controller provides three independent single-ended channels with three high-density 68-pin external SCSI connectors that are Fast/Wide and Ultra/Wide capable and three 68-pin internal SCSI connectors that are Ultra/Wide capable. Each channel supports either internal disk drives (where applicable) or external storage devices, but not both.

Each SRC/P Controller supports 36 disk drives per card. The SRC/P Controller supports disk hot-plugging so that you can replace drives while the system is operational. For information about hot plug disk replacement, see the *Sun StorEdge Multipack Storage Guide* for external devices; for internal disk drives see the product notes or owner's guide for your server.

ECC (error checking and correcting) memory detects and corrects data errors in the entire data path through the controller cache and other controller hardware. With ECC you generate redundant information that you can use to detect and correct errors in stored or transmitted data.

If you are using a software RAID package such as Veritas or Solstice DiskSuite™ along with the SRC/P Controller, the software RAID package will recognize the logical devices created using the SRC/P Controller.

Onboard temperature and voltage sensors pass critical hardware management data to the SRC/P Storage Manager information windows for logging and notification to the system administrator. GUI windows also display status conditions with status flags on the drive or array icons.

The onboard battery backup module supports the cache. It protects data not yet written to the drives from being lost when the power is lost. Using the SRC/P Storage Manager, you can view the battery charge status, the date of initial calibration, and the date of the last maintenance calibration.

Features

All SRC/P Controllers include the following features:

- PCI Local Bus Rev. 2.1 compliant; 12.28-inch (31.19 cm) long card; 64-bit PCI bus; 33-MHz clock speed
- High-performance RISC processor
- Universal dual voltage signalling (3.3V and 5V)
- Three external and three internal 68-pin SCSI connectors that are Fast/Wide and Ultra/Wide capable and can support external, single-ended UltraSCSI disks
- SCSI data transfer rates of up to 40-Mbytes/sec peak throughput per channel at a 20-MHz bus clock rate
- One 64-Mbyte onboard ECC write-cache memory module
- Replaceable battery module that provides a backup time of 48 hours for 64-Mbyte cache
- Support for RAID levels 0, 1, 5, 1+0, and 5+0
- Support for hot spares, hot-plug disks, and transparent drive rebuild
- Tunable cache parameters
- Self-test capability
- Controller firmware that resides onboard in flash PROM and that can be upgraded without replacing any hardware chips
- Graphical and command-line management interface

Host System Requirements

Before installing the SRC/P Controller, make sure that the host system meets the following hardware and software requirements.

TABLE 1-1 Host System Requirements

Component	Description
Software	The operating environments supported are Solaris 2.6, Solaris 7 and later compatible operating environments.

TABLE 1-1 Host System Requirements *(Continued)*

Component	Description
Host systems	Sun Enterprise server.
Maximum controller cards per system	The maximum number of cards supported depends on the platform. For example: Sun Enterprise 250 - three SRC/P Controller cards Sun Enterprise 450 - six SRC/P Controller cards For information about other servers, see the platform Product Notes.
PCI slot selection	The SRC/P Controller can be installed in any 64-bit PCI slot.

Kit Contents

Your system may be configured-to-order with an SRC/P Controller already installed at the factory, or you may order the option kit listed below. Check that you have received all of the parts you ordered. Contact Sun Microsystems or your distributor/reseller if you are missing anything.

The Sun StorEdge SRC/P Intelligent SCSI RAID Controller kit contains the following components:

- Sun StorEdge SRC/P Intelligent SCSI RAID Controller with battery module and one 64-Mbyte memory module (FIGURE 1-1)
- Two 2m external cables (FIGURE 1-2)
- Electrostatic discharge (ESD) strap
- CD containing the controller software, graphical user interface, and online *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*
- *Sun StorEdge SRC/P Intelligent SCSI RAID Controller Installation Guide*
- *Sun StorEdge SRC/P Intelligent SCSI RAID Controller Release Notes*

Components

The following figures illustrate the controller card, the external ports, and the external cable.

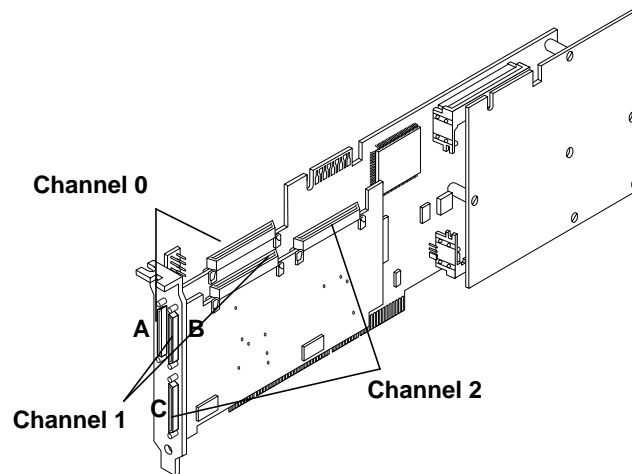


FIGURE 1-1 Sun StorEdge SRC/P Intelligent SCSI RAID Controller

Note – The internal connectors for Channel 0, Channel 1, and Channel 2 correspond to the external connectors labelled A, B, and C on the SRC/P Controller. Each channel supports either internal or external devices (but not both).

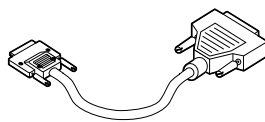


FIGURE 1-2 2m External Cable (Kit Includes Two Cables)

Hardware Configuration Information

The SRC/P Controller has three independent UltraSCSI channels. Each channel supports either internal or external devices (but not both). External SCSI devices are supported via the three external 68-pin SCSI connectors located on the SRC/P Controller card. These buses support additional external single-ended UltraSCSI disks.

Note – Do not connect external SCSI devices to a SCSI channel that is used to support internal drives.

Note – Internal connectors are not supported in all systems.

External Target Devices

Each channel on the controller supports one 6-drive Sun StorEdge MultiPack unit or one 12-drive Sun StorEdge MultiPack unit for a maximum of 36 hot-plug disk drives per controller card.

A 6-drive MultiPack can operate on the external SCSI bus at 40 Mbytes/sec or up to seven devices per channel; a 12-drive MultiPack can operate on the external SCSI bus at 20 Mbytes/sec or up to 15 devices per channel.

Disk Drive Information

Use Sun StorEdge 6-drive or 12-drive MultiPacks only. Only single-ended UltraSCSI disks are supported.

Sun StorEdge MultiPack-6 drives:

- 6x 4.2 GByte 7200 Ultra
- 6x 4.2 GByte 7200 F/W
- 6x 9.1 Gbyte 7200 LP Ultra
- 6x 9.1 GByte 7200 HH F/W

Sun StorEdge MultiPack-12 drives:

- 12x 4.2 GByte 7200
- 12x 2.1 GByte 7200

SCSI IDs

Each SCSI device on the SCSI bus needs a unique SCSI ID. Target addresses for the SCSI bus (also known as SCSI IDs) are available in a range of 0 through 15. Target address 7 is reserved for the SRC/P Controller. It cannot be used for any other device.

Your hardware configuration determines the number and distribution of SCSI addresses available. For the Sun StorEdge MultiPack devices, SCSI IDs are hardcoded. You do not need to set jumpers. You can view SCSI IDs through Storage Manager, the graphical user interface (GUI).

See the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide* for information about using the GUI.

For device-specific information about checking and setting jumpers, see the documentation accompanying the drive. For MultiPack information, see the *Sun StorEdge MultiPack User's Guide* that applies to your unit.

SCSI Bus Length

For Fast/Wide performance on the external SCSI bus, the maximum SCSI bus length is 2 meters. If you are using internal storage you must include the internal bus length in your bus length calculation. The total length of all external cables and internal bus lengths affect the SCSI bus speeds. See your server owner's guide for information about the internal bus length.

Multi-initiator Support

The SCSI implementation of the system includes multi-initiator support: any SRC/P Controller on the bus can drive TERMPOWER. This means that if the system should lose power, the devices on the SCSI bus (except those powered by the system) can continue to operate. For more information about TERMPOWER, see the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*.

External SCSI Cabling and Termination

Use the following cabling guidelines to ensure proper device cabling and termination on the external SCSI bus. For additional cabling guidelines, see Appendix B.

- In order to maintain UltraSCSI performance, all cables used must be UltraSCSI compliant.
- Use the two 2m cables shipped with the SRC/P Controller to connect to Channel A and Channel B. If you are connecting to the third channel (Channel C) you will need to order another 2m cable.

Note – Two-meter cable connectors that are not from Sun Microsystems may not fit in Channels A and B.

- The controller supports 68-pin devices only.
- The external SCSI bus must be correctly terminated. Most Sun devices use autotermination. See the documentation supplied with the device.
- The devices on each physical end of a SCSI cable must be terminated. Depending on how you cable your system, you will either terminate two SCSI devices (such as hard drives) or the SCSI controller and one other SCSI device. The SCSI cable supplied with your controller has a terminator pre-installed on the end of the cable.
- SCSI termination is enabled on the controller by default or configured through the Storage Manager GUI. See the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide* for instructions.

First-Time Installation Information

Installing the SRC/P Controller card into a Sun server is one step in the installation process. You need to complete all of the steps in TABLE 1-2 to fully install your storage option.

TABLE 1-2 First-Time Installation Steps

Task	For Information, See...
1 Review the features of the SRC/P Controller and read the general information.	This chapter.
2 Verify that you have received all of the parts you have ordered.	"Kit Contents" on page 4 of this guide.
3 Back up any data on the disks, if necessary.	AnswerBook online documentation for the Solaris software environment.
4 Install the SRC/P Controller card into the server.	"Installing the SRC/P Controller" on page 11 of this guide.
5 Install the software and configure RAID arrays.	The document included with your SRC/P software and the <i>Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide</i> .
6 Restore data to disks, if necessary.	AnswerBook online documentation for the Solaris software environment.

Installing the SRC/P Controller

This chapter describes how to install the SRC/P Controller into a PCI slot and connect any external devices.

How to Install the SRC/P Controller



Caution – Persons who access this equipment must observe all safety precautions described in Appendix C of the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*. If you are installing the SRC/P Controller in a system other than a Sun Enterprise 450 server or a Sun Enterprise 250 server, the procedures in this guide assume that you are a qualified service-trained maintenance provider.

Before You Begin

- Verify that you have received all of the parts you ordered; see “Kit Contents” on page 4. Contact Sun Microsystems or your distributor/reseller if you are missing anything.
- Locate the following items:
 - Screwdriver, Phillips #1
 - Electrostatic discharge mat, Sun PN 250-1088, or equivalent
 - Grounding wrist or foot strap
- Locate the following manuals:
 - *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*
 - *Sun StorEdge MultiPack Installation Manual*
- Back up data on the disks, if necessary. Refer to the Solaris AnswerBook online documentation for information on data backup.

What to Do



Caution – Ensure that installing the SRC/P Controller does not make your configuration exceed the system power budget; see “How to Determine System Power Requirements” in the server owner’s guide for more information.

Note – To save time, locate the server owner’s guide before you start this procedure.

Note – The server shown in the illustrations is a Sun Enterprise 250 server. Your server may be different.

1. **Power off the server.**
See “How to Power Off the System” in your server owner’s guide for instructions.
2. **Turn off any peripheral devices attached to the server.**
3. **Remove the system access panel.**
4. **Unpack the SRC/P Controller and place it on an antistatic surface.**
5. **Attach the antistatic wrist strap to your wrist and to a metal component on the server chassis.**

6. Insert the SRC/P Controller into the appropriate PCI slot on the main logic board.

You can install the controller in any 64-bit PCI slot. See the label on your server chassis for PCI slot information or see your server owner's guide for detailed PCI information.

a. Remove the filler panel from the PCI slot you intend to use.

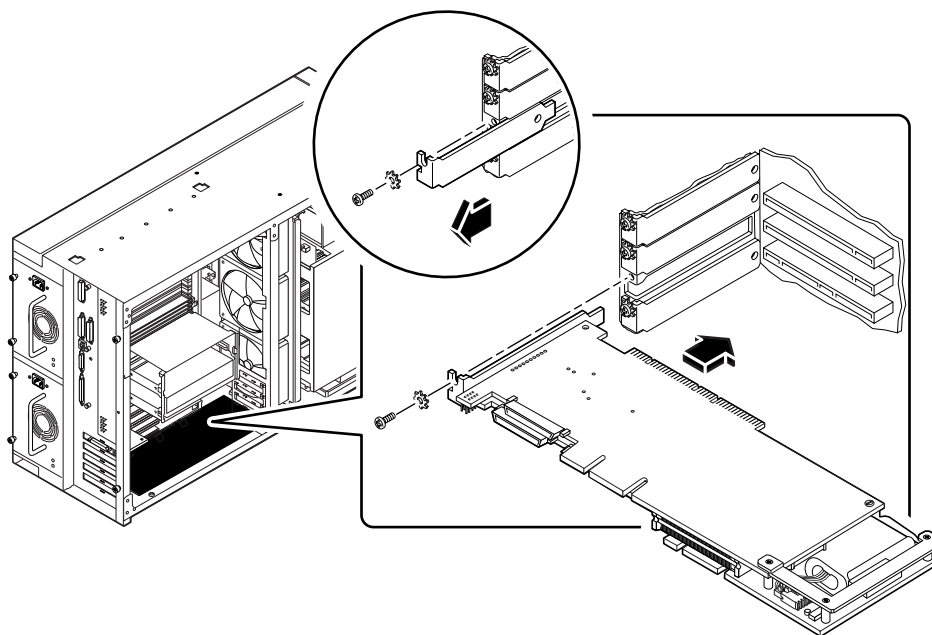
Remove the Phillips screw that secures the filler panel to the back panel.

b. Insert the SRC/P Controller into the appropriate opening on the back panel.

See your server owner's guide or service manual for specific instructions.

c. Push the SRC/P Controller securely into the slot.

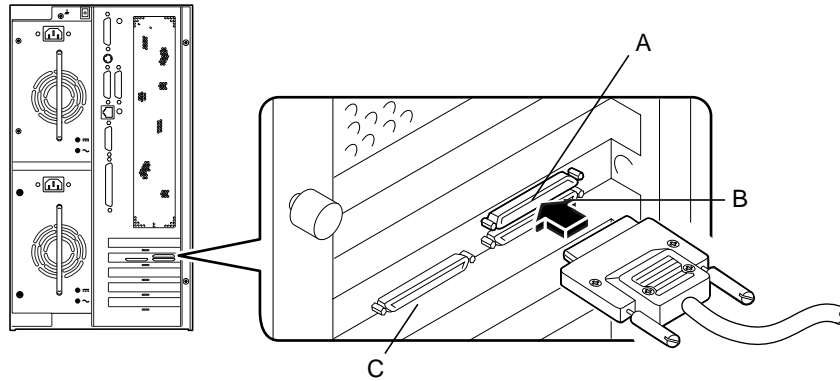
7. Secure the faceplate to the back panel with the Phillips screw.



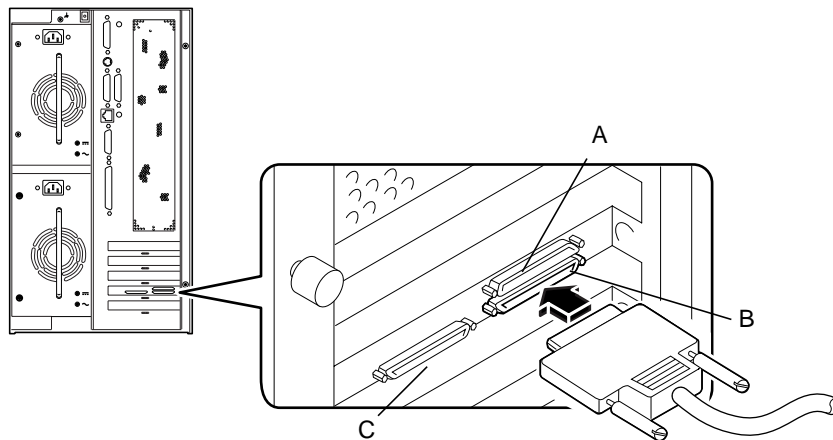
8. Connect any external storage devices to the SRC/P Controller.

Use the external 2m cables supplied with the SRC/P Controller option kit. The cable connectors are keyed so that they can only connect one way. Refer to "Components" on page 5 to locate the channels on the controller.

- *If you are connecting an external storage device to channel A on the controller, insert the connector with the flat side facing down.*



- *If you are connecting an external storage device to channel B or channel C on the controller, insert the connector with the flat side facing up.*



9. Reinstall the system access panel.

After reassembling the system, you need to perform the steps in the next section to verify the installation and reboot your system.

How to Verify the Installation

After you have installed the SRC/P Controller, use this procedure to verify the installation and perform a reconfiguration boot of the system. Refer to the *Solaris Handbook for Sun Peripherals* for detailed instructions.

1. Power on the system.

See “How to Power On the System” in your server owner’s guide for instructions.

2. When the system banner is displayed on the monitor, immediately enter the Stop-a sequence on the Sun keyboard to get to the `ok` prompt.

If you are using an alphanumeric terminal instead of a monitor, press the Break key on the terminal’s keyboard.

3. Use the `show-devs` command to list system devices. When the `ok` prompt is displayed, enter the following command:

```
ok show-devs
```

The listing should include a line similar to the following (`scsis` identifies the SRC/P Controller card):

```
/pci@4,4000/pci@4/scsis@4/scsi@0
```

If the Sun StorEdge SRC/P Controller is not listed, check that the card is properly seated. Reinstall the card if necessary.

4. Enter the following command to perform a reconfiguration boot:

```
ok boot -r
```

This command rebuilds the device trees for the system, incorporating any newly installed options. After a device has been added to a device tree, it can be recognized by the system. After the reconfiguration reboot has successfully completed, the system prompt will be displayed.

What Next

- *If this is the first SRC/P Controller that you have installed in your server, the next step is to install the software necessary to run the SRC/P Controller. See the installation document included with the controller software and the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*.*
- *If you have already installed the software for a different SRC/P Controller, you are ready to configure drive arrays. See "How to Create an Array" in the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide*.*

Note – When you install a new SRC/P Controller, the controller automatically initiates the initial calibration cycle for the battery. The calibration cycle requires approximately 24 hours to complete. During the calibration cycle, the SRC/P Controller cache is operating in Write-through mode and you should not use it for performance testing. When the process is completed, the battery module is ready to provide backup protection and the controller automatically switches to Write-back mode. See the *Sun StorEdge SRC/P Intelligent SCSI RAID Controller User's Guide* for more information.

Specifications

This appendix provides a functional description and a reference for physical, performance, electrical, and environmental specifications.

Functional Description

TABLE A-1 Functional Description

Component	Description
Processor	High-performance RISC processor
Firmware	Operational firmware is stored in flash memory and can be updated using host utilities without requiring component replacements
PCI	PCI Rev. 2.1 compliant, 64-bit, 33-MHz PCI bus; up to 264-Mbytes/sec transfer rate; Universal PCI compliant
SCSI	Clock Rate: 20 MHz Three internal 68-pin connectors Three external 68-pin VHDCI connectors Support of ANSI X3.131:1994, SCSI-2 specification Support of ANSI X3.277:1996, FAST-20 specification UltraSCSI synchronous wide (16-bit) data transfers up to 40 Mbytes/sec UltraSCSI synchronous narrow (8-bit) data transfers up to 20 Mbytes/sec UltraSCSI single-ended bus operation

TABLE A-1 Functional Description (*Continued*)

Component	Description
Memory	64-Mbyte DIMM DIMMs to be installed in the controller must conform to the following specifications: Speed: 60-ns EDO Size: 64 Mbytes Width: 32 bit Configuration: 72 pin, small-outline Voltage 3.3V
Battery	Type: Nickel Metal Hydride Capacity: 3800 mAH Backup time: 48 hours (with 64-Mbyte cache installed); 65 hours (with 16-Mbyte cache installed) Charge time: 3 hours Operating temperature: 10 °C to 40 °C
DC power requirements	Measurement: 5V +/-5%; 3.3V +/-0.3V Voltage: 5V + 5% Ripple and noise: 50 mv peak-to-peak max Current: 3.27A typical (3 channel configuration) Voltage: 3.3V + 5% Ripple and noise: 50 mv peak-to-peak max

Physical Dimensions

TABLE A-2 Physical Dimensions

Dimension	Measurement
Length of SRC/P Controller with expansion card and battery backup unit	12.28 in (31.19 cm)
Width of SRC/P Controller card	4.2 in (10.67 cm)
Length of basic SRC/P Controller card (measurement does not include length of expansion card and battery backup unit)	10.25 in (26.03 cm)
Component height (not including PCB):	
Primary component side	0.570 in (14.48 mm)
Back side	0.105 in (2.67 mm)

TABLE A-2 Physical Dimensions *(Continued)*

Dimension	Measurement
Length of expansion card (daughter card)	5.575 in (141.6 mm)
Width of expansion card	3.46 in (81.3 mm)
Length of battery module	4.475 in (113.7 mm)
Width of battery module	3.875 in (98.4 mm)

Performance Specifications

TABLE A-3 Performance Specifications

Feature	Specification
PCI clock	16–33 MHz
PCI data burst transfer rate	132 Mbytes/sec (32-bit PCI) 264 Mbytes/sec (64-bit PCI)
SCSI synchronous transfer rate	40 Mbytes/sec (Ultra)
SCSI asynchronous transfer rate	Device dependent
SCSI transfer size	64K blocks
PCI data address lines	64-bit PCI (63-0)
PCI modes	32-bit/64-bit PCI
Capacitance per PCI signal line	10 pf (maximum)
SCSI interface	16-bit single-ended SCSI
SCSI bus parity	Yes
SCSI 8-bit devices	No
SCSI 16-bit devices	Yes

Environmental Specifications

TABLE A-4 Environmental Specifications

Condition	Operating Specification	Storage Specification
Temperature	10 °C to 40 °C	0 °C to 40 °C
Relative humidity	10%–90% (non-condensing)	10%–90% (non-condensing)
Altitude	3000 meters (10,000 feet)	

Guidelines for Cabling Single-Ended SCSI

You should use the 2m cables included in your controller kit. The following guidelines provide additional information.

- **Avoid stub clustering.** Avoid spacing SCSI devices on the cable closer than 0.3 meters apart. When devices are clustered closely on the SCSI cable, their capacitances add together to create an impedance discontinuity and thus reflections. You should space SCSI devices as evenly as possible.
- **Cable stub length should not exceed 0.1 meters.** Some SCSI devices can create stubs internal to the device that exceed this value, resulting in excessive capacitive loading and signal reflections. This parameter is under the control of the SCSI device manufacturer. The SCSI cabling itself should include no stubs.
- **Watch out for capacitance.** As you add devices to a SCSI bus, capacitance is introduced to each signal from the connectors, receivers, and PC board traces. The SCSI-3 working specification limits this capacitance to 25pF since added capacitance lowers the impedance of the cable near the device and adds delay. Look for input filters that can be attached to the SCSI front-end of the device's printed circuit board. These filters add capacitance.
- **Avoid unnecessary connector converters.** They cause impedance discontinuity and signal reflections.
- **Route the cable with care.** Avoid rolling the cable up on itself, running the cable alongside of metal for long lengths, or routing the cable past noise generators (that is, power supplies). Placing the cable near ground planes created by grounded metal cabinetry reduces its impedance. The SCSI-3 working committee suggests that in order to minimize discontinuity due to local impedance variation, you should space a flat cable at least 1.27 mm (0.050 in.) from other cables, any other conductor, or the cable itself when the cable is folded.
- **Follow the SCSI specification for cable impedance.** Cable impedance for 10-MHz Fast SCSI systems should be limited to 84+/-12 ohms. Cable impedance for 20-MHz Fast-20 SCSI systems should be limited to 90+/-12 ohms for REQ and ACK signals and 90+/-10 ohms for all other signals.

- **Avoid mixing cable types.** Select either flat or round, shielded or non-shielded cables. Typically mixing cables mixes impedances. Cable impedance mis-match is a common problem resulting in signal reflections. Internal cables are typically flat ribbon cables, while external cables should be shielded. Where they offer easier routing, size advantages, and better air flow, you can use round cables internally as well. This may be desirable if it allows for better impedance matching to the external cable.
- **When round cable is used, select a cable that uses a wise placement of signals within the cable.** Ribbon cable shows fairly good crosstalk rejection characteristics due to the GND-Signal-GND layout. However, you need to take more care to ensure adequate performance when round cable is employed. With standard 25-pair round cable, pairs are arranged in three layers. The closer a pair is to the cable center, the higher the impedance. Using centrally located high-impedance pairs for speed-critical signals such as REQ and ACK is desired. By locating data pairs in the outermost layer of the cable, crosstalk between REQ, ACK, and the data lines is minimized. The middle layer might contain status lines such as C/D, I/O, MSG, ATN, and so forth. Make sure that the lowest impedance wire in the cable is used for TERMPWR to minimize transmission line effects on this voltage supply line. Some SCSI cables have a low-impedance conductor for this purpose.