



SAS Nuts and Bolts

University Training Module

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Introduction

Serial Attached SCSI (SAS) is the current technology of choice for connecting RAID adapters to storage devices such as disk drives, solid state drives, and disk drive enclosures.

SAS provides high bandwidth and high speeds, is compatible with both SAS and Serial ATA (SATA) devices, and can be used to create storage systems that comprise far more devices (and storage space) than any other technology.

Read on to learn the basics of SAS. At the completion of this module, you should be able to:

- Identify at least four key features of SAS.
- Describe the difference between a phy, a SAS port, and a SAS connector.
- Understand in a basic way how SAS devices transfer data.
- Name three ways to connect devices to a SAS RAID adapter.
- Explain how many devices can be connected in a single SAS domain.
- Describe how SAS devices in a domain are identified.

A Note About Terminology

In this module, RAID adapters, disk drives, and external disk drive enclosures are referred to collectively as 'end devices'.

For convenience, SAS RAID adapters, SAS expanders, SAS and SATA disk drives, and external disk drive enclosures are referred to collectively as 'SAS devices'.

What is SAS?

Parallel SCSI was an interface that let devices such as computers and disk drives communicate with each other. Parallel SCSI moved multiple bits of data in parallel (at the same time), using the SCSI command set.

Serial Attached SCSI (SAS) was an evolution of parallel SCSI to a point-to-point serial interface. SAS moves multiple bits of data one at a time and data can move in both directions simultaneously across a SAS connection (or link).

SAS connects end devices (such as disk drives and disk drive enclosures) through direct-attach connections or through expander devices, and can support up to 128 disk drives per RAID adapter. (Parallel SCSI adapters supported up to 16 disk drives per channel only.)

These are the key features of SAS:

- Supports SATA and SAS disk drives simultaneously
- Supports more than 128 disk drives per RAID adapter, using an expander
- Supports single- and dual-port devices
- Uses unique SAS addresses to differentiate between devices
- Requires no bus termination (parallel SCSI buses always required termination)

Get to know these SAS terms

Phy. Phys are part of the physical connection between SAS devices. Each phy contains a transceiver that sends data back and forth between SAS devices. Phys are internal, within SAS connectors.

When a connection is formed between two end devices, a link is established from a phy in one port to a phy in the other port. As shown in the figure on [page 3](#), a wide port can support multiple independent links simultaneously.

SAS cables physically connect phys on one SAS device to phys on another SAS device.

SAS Port. A port is one or more phys. A narrow port contains one phy. A wide port typically contains four phys. (See the figure on [page 3](#).) Each port has its own unique SAS address, and all the phys in a port share that same SAS address.

SAS RAID adapter port options vary. For instance, a SAS RAID adapter with four phys could be configured one of three ways:

- With one wide port that comprises all four phys (a wide port with four phys is referred to as a 4-wide or 4x port)
- With two wide ports that comprise two phys each
- With four narrow ports each containing one phy

Note: Because the physical link between SAS devices is from phy to phy, rather than port to port, a “port” is more of a virtual concept, different from what is normally considered a port on other types of RAID adapters and storage devices.

SAS Address. Each SAS port is identified with a unique SAS address, which is shared by all phys on that port.

For example, a SAS disk drive might have two narrow ports. Each port has one unique SAS address. The single phy in each port uses its port’s SAS address.

In another example, a SAS device might have one 4-wide port. That port has one SAS address, which is shared by all four phys in the port.

SAS devices self-configure their SAS addresses. User intervention is not required to set SAS addresses, and SAS addresses cannot be modified.

SAS Connector. A SAS, mini-SAS, or mini-SAS HD (high-density) connector is the physical plug or receptacle that you see on a SAS device. It’s what you plug a SAS cable into, or the end of the SAS cable that’s being plugged in.

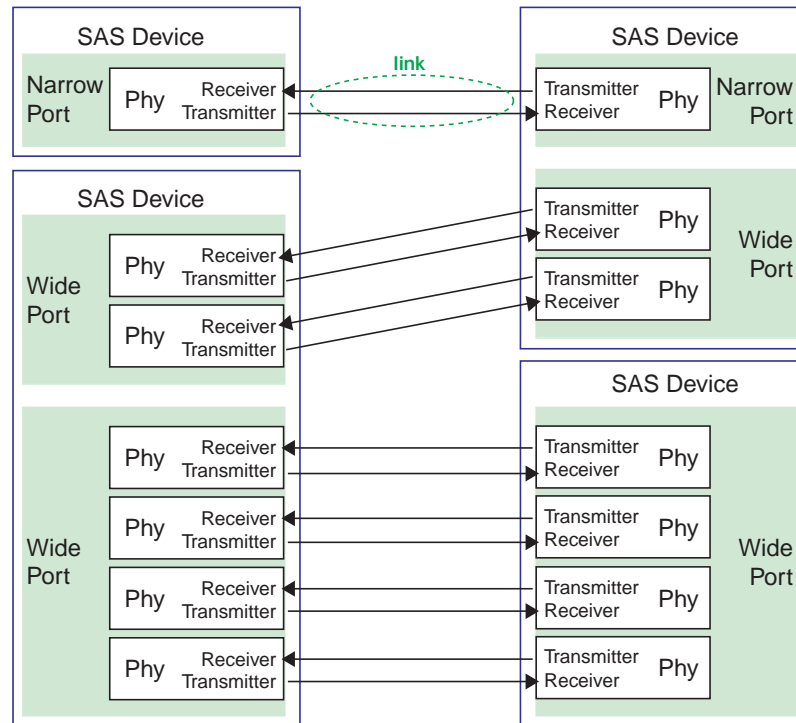
A connector is what forms physical links between phys. Some SAS connectors can support multiple links. The number of links a SAS connector can support is referred to as its width. Narrow connectors support a single link; wide connectors supports more than 1 link.

A single SAS device may have one or more connectors. A single SAS connector may help form links between more than two SAS devices. (For instance, as shown in the figure in the next section, the 4-wide internal SAS connector forms links with four independent disk drives.)

How do SAS devices communicate?

SAS devices communicate with each other through links. A link is a physical connection between two phys.

As shown in this figure, SAS devices contain ports, ports contain phys, and each phy contains one transmitter and one receiver—one transceiver. A phy can belong to one port only.



How fast does SAS go?

Original SAS speed is 3 Gb/sec per port. SAS 2.0 provides a maximum speed of 6 Gb/sec per port. The current generation of SAS technology provides a maximum speed of 12 Gb/sec per port.

What do SAS cables look like?

Internal standard SAS cables are narrow and their connectors vary in size depending on the number of links they support, from single link connectors to 4-wide (or larger) connectors.

Internal fan-out cables let you attach four disk drives to a single 4-wide connector.

Cables with mini-SAS connectors support both internal and external connections. Mini-SAS connectors are smaller than standard SAS connectors and support single and multi links with the ability to scale to future speed needs.

This table shows all available Adaptec SAS cables. You can use any of these cables to connect disk drives or storage enclosures to an Adaptec SAS RAID adapter, depending on system requirements:

The Adaptec 12Gb SAS HD Cable Family

Internal mini-SAS-HD x4 (SFF-8643) to mini-SAS-HD x4 (SFF-8643) cable
Connect a Series 8 SAS/SATA RAID adapter to a SAS/SATA backplane with mini-SAS HD connectors

- **Model Number:** ACK-I-HDmSAS-HDmSAS-.5M
Part Number: 2282200-R
Dimension: 0.5 Meter
- **Model Number:** ACK-I-HDmSAS-HDmSAS-1M
Part Number: 2282100-R
Dimension: 1.0 Meter



Internal right-angle mini-SAS-HD x4 (SFF-8643) to mini-SAS-HD x4 (SFF-8643) cable
Connect a Series 8 SAS/SATA RAID adapter to a SAS/SATA backplane with mini-SAS HD connectors

- **Model Number:** ACK-I-rA-HDmSAS-HDmSAS-.5M
Part Number: 2282500-R
Dimension: 0.5 Meter
- **Model Number:** ACK-I-rA-HDmSAS-HDmSAS-1M
Part Number: 2282800-R
Dimension: 1.0 Meter



External mini-SAS-HD x4 (SFF-8644) to mini-SAS-HD x4 (SFF-8644) cable
Connect a Series 8 RAID adapter to an external storage enclosure or tape drive

- **Model Number:** ACK-E-HDmSAS-HDmSAS-2M
Part Number: 2282600-R
Dimension: 2.0 Meters



The Adaptec 6Gb SAS HD Cable Family

Internal mini-SAS-HD x4 (SFF-8643) to mini-SAS (SFF-8087) x 4 cable
Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to a SAS/SATA backplane

- **Model Number:** ACK-I-HDmSAS-mSAS-1M
Part Number: 2279700-R
Dimension: 1.0 Meter



Internal right-angle mini-SAS-HD x4 (SFF-8643) to mini-SAS (SFF-8087) x4 cable
Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to a SAS/SATA backplane

- **Model Number:** ACK-I-rA-HDmSAS-mSAS-.8M
Part Number: 2280200-R
Dimension: 0.8 Meter



Internal mini-SAS-HD x4 (SFF-8643) to (4) x1 SATA (adapter based) fan-out cable with sideband signals

Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to SATA drives or a SAS/SATA backplane

- **Model Number:** ACK-I-HDmSAS-4SATA-SB-.8M
Part Number: 2279800-R
Dimension: 0.8 Meter



Internal right-angle mini-SAS-HD x4 (SFF-8643) to (4) x1 SATA (adapter based) fan-out cable with sideband signals

Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to SATA drives or a SAS/SATA backplane

- **Model Number:** ACK-I-rA-HDmSAS-4SATA-SB-.8M
Part Number: 2280000-R
Dimension: 0.8 Meter



Internal right-angle mini-SAS-HD x4 (SFF-8643) to right-angle (4) x1 SATA fan-out cable with sideband signals

Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to SATA drives or a SAS/SATA backplane

- **Model Number:** ACK-I-rA-HDmSAS-4rASATA-SB-.8M
Part Number: 2279900-R
Dimension: 0.8 Meter



Internal mini-SAS-HD x4 (SFF-8643) to (4) x1 SAS (SFF-8482 adapter based) fan-out cable with sideband signals

Connect a Series 7/7Q or 8/8Q RAID adapter or Series 7H host bus adapter to SAS drives

- **Model Number:** ACK-I-HDmSAS-4SAS-SB-.8M
Part Number: 2280100-R
Dimension: 0.8 Meter



Internal right-angle mini-SAS-HD x4 (SFF-8643) to (4) x1 SAS (SFF-8482, adapter based) fan-out cable with sideband signals

Connect a Series 7/7Q or 8/8Q RAID adapter or Series 7H host bus adapter to SAS drives

- **Model Number:** ACK-I-rA-HDmSAS-4SAS-SB-.8M
Part Number: 2279600-R
Dimension: 0.8 Meter



External mini-SAS-HD x4 (SFF-8644) to external mini-SAS (SFF-8088) cable

Connect a Series 7/7Q RAID adapter or Series 7H host bus adapter to an external storage enclosure or tape drive

- **Model Number:** ACK-E-HDmSAS-E-mSAS-2M
Part Number: 2280300-R
Dimension: 2.0 Meters

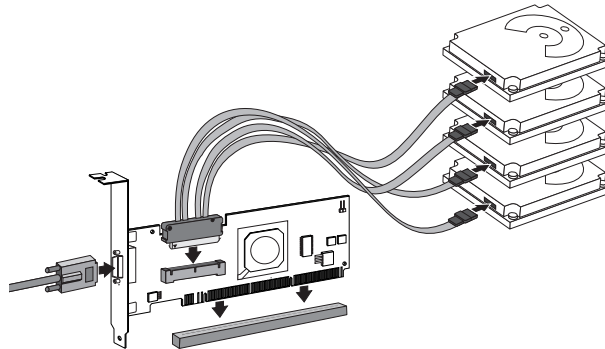


How do you connect?

You can connect end devices to each other through direct cable connections or through backplane connections. When you use one or more expander devices, you can create large configurations.

Direct-attach Connections

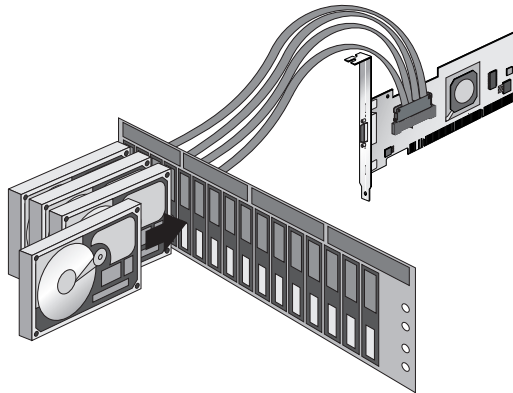
In a direct-attach connection, SAS or SATA disk drives are connected directly to a SAS RAID adapter. One disk drive is attached to one SAS/mini-SAS connector with SAS cable; or, multiple disk drives are attached to one SAS/mini-SAS connector with one fanout cable). This figure shows an example of direct-attach connections.



The number of direct-attached disk drives is limited to the number of phys supported by the SAS RAID adapter. (Remember that there may be multiple phys within a single connector.)

Backplane Connections

In a backplane connection, disk drives and SAS RAID adapters are attached to and communicate with each other through a system backplane, as shown in this figure:



Note: When you connect a SAS RAID adapter to a backplane, you must properly connect the disk drive LEDs as well, or you won't be able to monitor disk drive status.

The number of end devices is limited to the number of slots available on the backplane. Some backplanes support daisy-chain expansion to other backplanes.

SAS Expander Connections

A SAS expander literally expands the number of end devices that you can connect. SAS expanders, typically embedded into a system backplane, support large configurations of SAS end devices, including SAS RAID adapters and SAS and SATA disk drives.

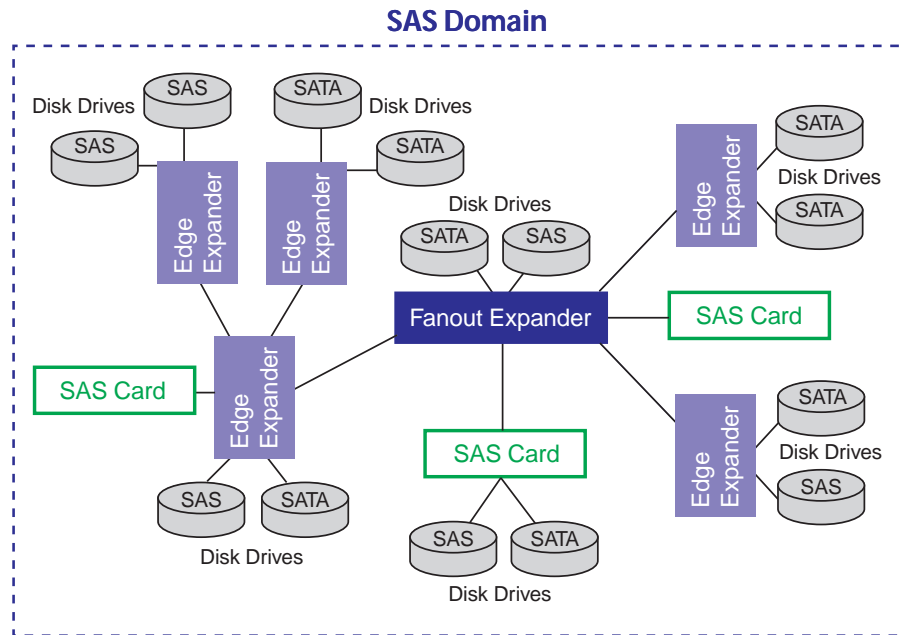
With SAS expanders, you can build large and complex storage systems, or domains. (A SAS domain comprises all the SAS RAID adapters, SAS and SATA disk drives, enclosures, and expander devices in a single data storage system.)

There are two types of SAS expanders—fanout expanders and edge expanders. Each performs a different role in a storage system:

- You can connect up to 128 SAS ports to an edge expander. (A single edge expander can therefore support up to 128 SAS addresses.)
- You can connect up to 128 edge expanders to a fanout expander. You can use only 1 fanout expander in any single SAS domain.

A single SAS domain can therefore comprise up to 16,384 SAS ports (and therefore up to 16,384 SAS addresses including the fanout expander).

This figure illustrates (in very basic terms) a SAS domain and shows how SAS RAID adapters, SAS and SATA disk drives, and expander devices can fit together in a large data storage system.



How many devices can you connect?

Individual SAS RAID adapters can typically support up to 128 end devices with the use of SAS expanders, and can communicate with both SAS and SATA devices.

Note: Although you can use both SAS and SATA disk drives in the same SAS domain (see page 93), we recommend that you not combine SAS and SATA disk drives within the same array or logical drive. The difference in performance between the two types of disk drives may adversely affect the performance of the array.

However, as you read in the previous section, with the use of fanout and edge expanders, a single SAS domain can comprise up to 16,384 SAS ports.

How are SAS devices identified?

SAS uses unique SAS addresses (see [page 2](#)) to differentiate between devices in a domain.

SAS devices self-configure their SAS addresses. User intervention is not required to set SAS addresses, and SAS addresses cannot be modified.

In storage management tools, such as ARCCONF and Adaptec Storage Manager, SAS devices are identified by SAS addresses in these formats:

- Direct-attach connections
CNX:DevY = Device Y is attached to Connector X
- Backplane connections
BoxX:SlotX = Enclosure X is attached to a disk drive in Slot X
- Expander connections
ExpX:PhyX = Expander X is attached to Phy X, where X is the count number.

Note: Devices other than disk drives (tape drives and so on) are listed in order after your system disk drives.

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