The Serial Attached SCSI (SAS) Integrator’s Guide provides a quick reference to the menu of standard components required to assemble a SAS system, from the SAS drive (a hard drive or a solid state drive (SSD)) out to the enclosure level, including the associated box-to-box cabling. The standard cables shown assume that system boards, adapter cards, backplanes, etc. are pinned out per the SAS-4.1 standard. Refer to SAS-4.1 for detailed information on connectors, cable assemblies, pinouts, sideband wiring, etc.

Information in this document is specific to SAS-4.1 (INCITS 567). At the time of this document’s publication, SAS-4.1 has not been finalized. However, no technical changes are anticipated before its release.

**OBsolete Connectors and Cables**
With the introduction of SAS-4.1, some connectors and cable assemblies were removed due to lack of support for signal speeds defined in the standard and therefore will not be covered in detail in this guide. These unsupported connectors and cables include:

- SAS High Density Drive
- SAS (4i)
- Mini SAS (4i & 4x)

Refer to previous versions of the SAS standard for more information on these connectors and cables.
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1. Connectors & Cable Assemblies

1.1. SAS Connectors
The connectors defined in SAS-4.1 are shown in Table 1. Refer to Section 5.4.3 in SAS-4.1 for more information.

<table>
<thead>
<tr>
<th>Connector</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal SAS Drive</td>
<td>SFF-8482 (SFF-8223, SFF-8323, SFF-8523)</td>
</tr>
<tr>
<td>SAS Multilink Drive</td>
<td>SFF-8630</td>
</tr>
<tr>
<td>Multifunction 6X Unshielded</td>
<td>SFF-8639</td>
</tr>
<tr>
<td>Micro SAS</td>
<td>SFF-8486 (SFF-8147)</td>
</tr>
<tr>
<td>Mini SAS HD (4i, 8i, &amp; 16i)</td>
<td>SFF-8643</td>
</tr>
<tr>
<td>SlimSAS (4i &amp; 8i)</td>
<td>SFF-8654</td>
</tr>
<tr>
<td>SAS MiniLink (4i &amp; 8i)</td>
<td>SFF-8611 &amp; SFF-8612</td>
</tr>
<tr>
<td>External Mini SAS HD (4x, 8x, &amp; 16x)</td>
<td>SFF-8644</td>
</tr>
<tr>
<td>QSFP</td>
<td>SFF-8662 &amp; SFF-8672</td>
</tr>
</tbody>
</table>

1.2. SAS Cable Assemblies
The following cable assembly types are defined by SAS-4.1:

- Internal cable assemblies
  - Internal Drive cable assemblies
  - Internal symmetric cable assemblies
  - Internal fanout cable assemblies
- External cable assemblies

The requirements for these cables are further defined in the following subsections.
1.2.1. SAS Internal Cable Assemblies

1.2.1.1. SAS Internal Drive Cable Assemblies

The basic requirements, sideband requirements, and the specified cable assembly types for SAS internal Drive cable assemblies are described below. Refer to Section 5.4.4.1.1 in SAS-4.1 for more information.

BASIC REQUIREMENTS
A SAS Drive cable assembly has the following characteristics:

- Power, READY LED, and POWER DISABLE signal connections are vendor specific
- The SAS initiator device uses a SATA host plug connector for connection to a SAS Drive cable assembly
- The signal assignment for the SAS initiator or expander device with this connector is the same as that defined for a SATA host

SIDEBAND REQUIREMENTS
Sideband signals are not used for drive cables.

SAS INTERNAL DRIVE CABLE ASSEMBLY TYPES
The following internal Drive cable assembly types are defined in SAS-4.1. The first connector listed connects to the SAS target device. The second connector listed connects to the SAS initiator device or expander device. Refer to Section 5.4.4.1.1 in SAS-4.1 for more information.

- Single-port Drive cable connector to SATA signal cable connector
- Dual-port Drive cable connector to 2 SATA signal cable connectors
- SAS MultiLink Drive cable connector to 4 SATA signal cable connectors

Figure 1: Single-Port Drive Cable Connector to SATA Signal Cable Connector

Figure 2: Dual-Port Cable Connector to 2 SATA Signal Cable Connectors
Figure 3: MultiLink Drive Cable Connector to 4 SATA Signal Cable Connectors
1.2.1.2. **SAS Internal Symmetric Cable Assembly Types**

Symmetric cables are defined as having one connector at either end of the cable (NOTE: Connectors at either end of the cable do not have to be the same type). The basic requirements, sideband requirements, and the specified cable assembly types for SAS internal symmetric cable assemblies are described below. Refer to Section 5.4.4.1.2 in SAS-4.1 for more information.

**BASIC REQUIREMENTS**

A SAS internal symmetric cable assembly has the following characteristics:

- TX signals on one end of the cable connect to RX signals on the other end (e.g., TX+ connects to RX+)
- SAS internal symmetric cable assemblies should be labeled to indicate how many physical links are included (e.g., 1X, 2X, 3X, or 4X on each connector’s housing)
- One or more of the signal returns (ground signals) may be connected together (commoned) in cable assemblies

**SIDEBAND REQUIREMENTS**

The following sideband requirements apply for all SAS internal symmetric cable assemblies:

- For controller-to-backplane applications:
  - If cable assemblies have the same type of connector on each end, SIDEBAND signals on the controller are attached to the corresponding SIDEBAND signals on the backplane (e.g., SIDEBAND 0 of the controller is attached to SIDEBAND 0 of the backplane)
  - If cable assemblies have different connector types on each end, then the applicable pin assignment tables in Section 5.4.3.3 of SAS-4.1 may require different signal connections than shown in the figures of the standard to attach the corresponding SIDEBAND signals, depending on the connector type that is connected to the controller
  - NOTE: The SIDEBAND + and SIDEBAND – signals are not supported on the Mini SAS HD 4i and 8i cable plug connectors
- For controller-to-controller applications:
  - SIDEBAND signals on one controller are not attached to their corresponding SIDEBAND signals on the other controller (e.g., SIDEBAND 0 of one controller is connected to SIDEBAND 7 of the other controller)
  - NOTE: The SIDEBAND 8 and SIDEBAND 9 signals are not supported on Mini SAS HD 4i or 8i cable plug connectors

There are multiple applications for these cable assemblies that involve interfaces other than SAS. SFF-9402 provides a reference for signal assignments of SAS and PCIe for specific cable assemblies defined in SAS-4.1. For compatibility of SIDEBAND signals, the recommended SIDEBAND signal pin assignment is provided in SFF-8448.
SAS INTERNAL SYMMETRIC CABLE ASSEMBLY TYPES

The following internal symmetric cables are defined by SAS-4.1:

- Mini SAS HD 4i to Mini SAS HD 4i
- Mini SAS HD 8i to Mini SAS HD 8i
- SlimSAS 4i to SlimSAS 4i
- SlimSAS 4i to Mini SAS HD 4i
- SlimSAS 8i to SlimSAS 8i
- SlimSAS 8i to Mini SAS HD 8i
- SAS MiniLink 4i to SAS MiniLink 4i
- SAS MiniLink 4i to Mini SAS HD 4i
- SAS MiniLink 8i to SAS MiniLink 8i
- SAS MiniLink 8i to Mini SAS HD 8i

Figure 4: SlimSAS 4i to Mini SAS HD 4i
Figure 5: MiniLink 8i to Mini SAS HD 8i
1.2.1.3. SAS Internal Fanout Cable Assembly Types

Fanout cables have a single connector on one end of the cable and multiple connectors on the other end. The basic requirements, sideband requirements, and the specified cable assembly types for SAS internal fanout cable assemblies are described below. Refer to Section 5.4.4.1.3 in SAS-4.1 for more information.

BASIC REQUIREMENTS

A SAS internal fanout cable assembly has the following characteristics:

- TX signals on one end of the cable connect to RX signals on the other end (e.g., TX+ connects to RX+)
- Each signal return on one end of the cable assembly is connected to at least one signal return on the other end of the cable assembly
- One or more signal returns may be connected together (commoned) in the cable assembly

SIDEBAND REQUIREMENTS

The following sideband requirements apply for all SAS internal fanout cable assemblies:

- For controller-to-backplane applications:
  - If cable assemblies have the same type of connector on each end, SIDEBAND signals on the controller are attached to the corresponding SIDEBAND signals on the backplane (e.g., SIDEBAND 0 of the controller is attached to SIDEBAND 0 of the backplane)
  - If cable assemblies have different connector types on each end, then the applicable pin assignment tables in Section 5.4.3.3 of SAS-4.1 may require different signal connections than shown in the specification to attach the corresponding SIDEBAND signals, depending on the connector type that is connected to the controller
  - NOTE: The SIDEBAND + and SIDEBAND – signals are not supported on the Mini SAS HD 4i or 8i cable plug connectors
  - NOTE: No sidebands are supported on the SAS Drive cable receptacle connector or the SATA signal cable receptacle connector

- For controller-to-controller applications:
  - SIDEBAND signals on one controller are not attached to their corresponding SIDEBAND signals on the other controller (e.g., SIDEBAND 0 of one controller is attached to SIDEBAND 7 of the other controller)
  - The SIDEBAND 8 and SIDEBAND 9 signals are not supported on the Mini SAS HD 4i or 8i cable plug connectors
  - No sidebands are supported on the SAS Drive cable receptacle or the SATA signal cable receptacle connector
**SAS INTERNAL FANOUT CABLE ASSEMBLY TYPES**

The following internal fanout cables are defined by SAS-4.1:

- Mini SAS HD 4i to 4 SAS Drive
- SlimSAS 4i to 4 SAS Drive
- SlimSAS 4i to 4 SATA Signal
- SlimSAS 8i to 2 SlimSAS 4i
- SlimSAS 8i to 2 Mini SAS HD 4i
- SAS MiniLink 4i to 4 SAS Drive
- SAS MiniLink 4i to 4 SATA Signal
- SAS MiniLink 8i to 2 SAS MiniLink 4i
- SAS MiniLink 8i to 2 Mini SAS HD 4i
- 4 SATA to Mini SAS HD 4i

![Figure 6: SlimSAS 4i to 4 SAS Drive](image1)

![Figure 7: SAS MiniLink 8i to 2 Mini SAS HD 4i](image2)
1.2.2. SAS External Cable Assemblies
The basic requirements, sideband requirements, and the specified cable assembly types for SAS external cable assemblies (symmetric and fanout) are described below. Refer to Section 5.4.4.2 in SAS-4.1 for more information.

BASIC REQUIREMENTS
A SAS external cable assembly has the following characteristics:

- SAS external cable assemblies do not include:
  - Power
  - READY LED signal
  - POWER DISABLE signal

- The connector always supports four or eight physical links, but the cable may support between one and eight physical links. SAS external cable assemblies should be labeled to indicate how many physical links are included (e.g., 1X, 2X, 3X, etc.)

- The TX signals on one end are connected to the corresponding RX signals on the other end (e.g., TX 0+ of one connector is connected to RX 0+ on the other connector)

- Signal returns are not connected to CHASSIS GROUND in the cable assembly

SIDEBAND REQUIREMENTS
None. All communication between devices is done in-band.

SAS EXTERNAL CABLE ASSEMBLY TYPES
The following external (symmetric and fanout) cables are defined by SAS-4.1:

- Mini SAS HD 4x to Mini SAS HD 4x
- Mini SAS HD 8x to Mini SAS HD 8x
- Mini SAS HD 8x to 2 Mini SAS HD 4x
- QSFP to QSFP

Figure 8: Mini SAS HD 8x to 2 Mini SAS HD 4x
Figure 9: QSFP to QSFP
2. Plugfests
One of the SCSI Trade Association’s most important roles is promoting the interoperability and configurability of SAS / SCSI infrastructure. The best way to demonstrate this is through interoperability test events known as plugfests. As the current standard is becoming stable, STA will begin to hold plugfests to test conformance to the standard. By bringing multiple SAS component vendors together at a third party test site, these vendors can test the interoperability of their SAS equipment with other suppliers. This is the best way to ensure that the standard is written so that everyone is interoperating the same way, ensuring interoperability and fewer problems for the end user.

For information about upcoming STA-sponsored plugfests, visit our website: https://www.scsita.org/sas-plugfest-program/.

3. Stay in Touch
Please visit our website (https://www.scsita.org/) to learn more about STA.

To stay up to date on the latest SAS developments, sign up for our email newsletter: https://www.scsita.org/content/newsletter-archive/.

Find us on:
- YouTube: https://www.youtube.com/channel/UCdvnGYWh1FC6tHviciCtmeg
- Twitter: https://twitter.com/SAS_Storage
- LinkedIn: https://www.linkedin.com/company/755798

Comments or Suggestions?
Thank you for reading the second edition of the SCSI Trade Association’s (STA) SAS Integrator’s Guide. We view this as an ongoing work within STA. We would appreciate any comments or suggestions you have about this edition. If you have any feedback or would like to receive future editions of the SAS Integrator’s Guide, please email us at info@scsita.org.
4. References

The following standards and specifications are referenced in this document:

- INCITS 567: Serial Attached SCSI (SAS-4.1)
- SFF-8147: 54mm X 78.5mm Form Factor with Micro SAS Connector
- SFF-8223: 2.5” Form Factor Drive with Serial Attached Connector
- SFF-8323: 3.5” Form Factor Drive with Serial Attached Connector
- SFF-8482: Serial Attachment 2X Unshielded Connector
- SFF-8486: Serial Attachment 4X Unshielded Connector
- SFF-8523: 5.25” Drive Form Factor with Serial Connector
- SFF-8611: MiniLink 4/8X I/O Cable Assemblies
- SFF-8612: MiniLink 4/8X I/O Shielded Connector
- SFF-8630: Serial Attachment 4X Unshielded Connector
- SFF-8643: Mini Multilane 4/8X 12 Gb/s Unshielded Cage/Connector (HD12un)
- SFF-8644: Mini Multilane 4/8X 12 Gb/s Shielded Cage/Connector (HD12sh)
- SFF-8654: 0.6mm 4/8X Unshielded I/O Connector
- SFF-8662: QSFP+ 4X 28 Gb/s Connector (Style A)
- SFF-8672: QSFP+ 4X 28 Gb/s Connector (Style B)

INCITS documents are available at: https://www.incits.org

SFF specifications are available at: https://www.snia.org/technology-communities/sff/specifications