SAS Disk Shelves

Installation and Cabling Guide

For DS460C, DS224C, and DS212C

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Installing and cabling disk shelves with IOM12 modules for a new system installation

If your new system—HA pair or single-controller configuration—did not come installed in a cabinet, you must install and cable the disk shelves in a rack.

Steps
1. Requirements for installing and cabling disk shelves with IOM12 modules for a new system installation on page 5
2. Considerations for installing and cabling disk shelves with IOM12 modules for a new system installation on page 5
3. Installing disk shelves with IOM12 modules for a new system installation on page 6
4. Cabling disk shelves with IOM12 modules for a new system installation on page 9

Requirements for installing and cabling disk shelves with IOM12 modules for a new system installation

You must meet certain requirements before installing and cabling the disk shelves.

- Disk shelves and controllers must not be powered on at this time.
- If you are using mini-SAS HD SAS optical cables, you must have met the rules in the “Mini-SAS HD SAS optical cable rules” section.
- You must have the “Installation and Setup Instructions” (ISI) that came with your new system. The ISI addresses system setup and configuration for your new system. You use the ISI in conjunction with this procedure to install and cable the disk shelves. ISIs are also available on the NetApp Support Site.
  \[\text{AFF and FAS Documentation Center}\]

Considerations for installing and cabling disk shelves with IOM12 modules for a new system installation

You should familiarize yourself with aspects and best practices about this procedure before installing and cabling the disk shelves.

General considerations

- Disk shelves with IOM12 modules are shipped with shelf IDs preset to 00.

  \[\text{Note}: \text{If you have an HA pair with at least two stacks, the disk shelf containing the root aggregates for the second stack has the shelf ID preset to 10}.\]

  You must set shelf IDs so they are unique within the HA pair or single-controller configuration. You can manually set shelf IDs or have shelf IDs automatically assigned for all disk shelves in the HA pair or single-controller configuration using a command in maintenance mode. Instructions for both methods are provided.
- Disk shelves containing the root aggregates can be identified by the labels on the disk shelf box and disk shelf chassis.
The labels show the stack number; for example, “Loop or Stack #: 1 ” and “Loop or Stack #: 2 ”. Disk shelves that do not contain the root aggregates only show the disk shelf serial number is on the labels.

- If at system setup and configuration, you do not configure the system to use automatic disk ownership assignment, you need to manually assign disk ownership.
- In-band Alternate Control Path (ACP) is automatically enabled. In-band ACP is not supported on single-path HA or single-path configurations.

### Best practice considerations

- The best practice is to have the current version of the Disk Qualification Package (DQP) installed. Having the current version of the DQP installed allows your system to recognize and utilize newly qualified disk drives; therefore, avoiding system event messages about having non-current disk drive information. You also avoid the possible prevention of disk partitioning because disk drives are not recognized. The DQP also notifies you of non-current disk drive firmware.
  
  *NetApp Downloads: Disk Qualification Package*

- The best practice is to download and run Config Advisor after a new system installation. Running Config Advisor after a new system installation allows you to verify SAS connections are cabled correctly and that shelf IDs are unique within the HA pair or single-controller configuration. If any SAS cabling or duplicate shelf ID errors are generated, follow the corrective actions provided.
  
  You need network access to download Config Advisor.
  
  *NetApp Downloads: Config Advisor*

### SAS cable handling considerations

- Visually inspect the SAS port to verify the proper orientation of the connector before plugging it in.
  
  The SAS cable connectors are keyed. When oriented correctly into a SAS port, the connector clicks into place and if the disk shelf power is on at the time, the disk shelf SAS port LNK LED illuminates green. For disk shelves, you insert a SAS cable connector with the pull tab oriented down (on the underside of the connector).
  
  For controllers, the orientation of SAS ports can vary depending on the platform model; therefore, the correct orientation of the SAS cable connector varies.

- To prevent degraded performance, do not twist, fold, pinch, or step on the cables. Cables have a minimum bend radius. Cable manufacturer specifications define the minimum bend radius; however, a general guideline for minimum bend radius is 10 times the cable diameter.

- Using Velcro wraps instead of tie-wraps to bundle and secure system cables allows for easier cable adjustments.

### Installing disk shelves with IOM12 modules for a new system installation

You install the disk shelves in a rack using the rack mount kits that came with the disk shelves.

#### Steps

1. Install the rack mount kit (for two-post or four-post rack installations) that came with your disk shelf using the installation flyer that came with the kit.
Attention: If you are installing multiple disk shelves, you should install them from the bottom to the top of the rack for the best stability.

Do not flange-mount the disk shelf into a telco-type rack; the disk shelf's weight can cause it to collapse in the rack under its own weight.

2. Install and secure the disk shelf onto the support brackets and rack using the installation flyer that came with the kit.

To make a disk shelf lighter and easier to maneuver, remove the power supplies and I/O modules (IOMs).

For DS460C disk shelves, you can also use the four detachable handles that shipped with your disk shelf. Handles (two on each side of the chassis) are installed by pushing up until they click into place. As you slide the disk shelf onto the rails, detach handles using the thumb latch.

It is recommended that you use a mechanical hoist or lift if you are moving a fully loaded DS460C disk shelf.

Attention: A fully loaded DS460C disk shelf can weigh approximately 247 lbs (112 kg).

3. If you are installing a DS460C disk shelf, install the components into the racked disk shelf; otherwise, go to the next step.

If you purchased a partially populated disk shelf which does not have a drive in every drive slot, you must ensure that:

- The first four slots (0, 3, 6, and 9) are occupied in each drawer. This ensures proper airflow in the disk shelf.

- In a shelf with 30 drives, the remaining ten drives are distributed evenly throughout the shelf in slots 1 and 10 of each drawer.

The following illustration shows how the drives are numbered from 0 to 11 in each drive drawer within the shelf. Slots 0, 3, 6, 9, and, in a shelf containing 30 drives, slots 1 and 10 in each drawer must contain drives.
a. Reinstall any power supplies and IOMs you removed prior to installing your disk shelf into the rack.

b. Open the top drawer of the shelf.

c. Raise the cam handle on the drive to vertical.

d. Align the two raised buttons on each side of the drive carrier with the matching gap in the drive channel on the drive drawer.

e. Lower the drive straight down, and then rotate the cam handle down until the drive snaps into place under the orange release latch.

f. Repeat the previous substeps for each drive in the drawer.

   You must be sure that slots 0, 3, 6, and 9 in each drawer contain drives.

g. Carefully push the drive drawer back into the enclosure.
Cabling disk shelves with IOM12 modules for a new system installation

You cable disk shelf SAS connections—shelf-to-shelf (as applicable) and controller-to-shelf—to establish storage connectivity for the system.

Before you begin

You must have met the requirements in the “Requirements for installing and cabling disk shelves with IOM12 modules for a new system installation” section and installed the disk shelves in the rack.

About this task

After you cable the disk shelves, you power them on, set the shelf IDs, and complete system setup and configuration.

Steps

1. Cable the shelf-to-shelf connections within each stack if the stack has more than one disk shelf; otherwise, go to the next step:

For a detailed explanation and examples of shelf-to-shelf “standard” cabling and shelf-to-shelf “double-wide” cabling, see the “shelf-to-shelf connection rules” section.

<table>
<thead>
<tr>
<th>If...</th>
<th>Then...</th>
</tr>
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</table>
| You are cabling a multipath HA, multipath, single-path HA, or single-path configuration | Cable the shelf-to-shelf connections as “standard” connectivity (using IOM ports 3 and 1):
| | a. Beginning with the logical first shelf in the stack, connect IOM A port 3 to the next shelf’s IOM A port 1 until each IOM A in the stack is connected. |
| | b. Repeat substep a for IOM B. |
| | c. Repeat substeps a and b for each stack. |
You are cabling a quad-path HA or quad-path configuration

Cable the shelf-to-shelf connections as “double-wide” connectivity:

You cable the standard connectivity using IOM ports 3 and 1 and then the double-wide connectivity using IOM ports 4 and 2.

a. Beginning with the logical first shelf in the stack, connect IOM A port 3 to the next shelf’s IOM A port 1 until each IOM A in the stack is connected.

b. Beginning with the logical first shelf in the stack, connect IOM A port 4 to the next shelf’s IOM A port 2 until each IOM A in the stack is connected.

c. Repeat substeps a and b for IOM B.

d. Repeat substeps a through c for each stack.

2. Identify the controller SAS port pairs that you can use to cable the controller-to-stack connections.

a. Check the controller-to-stack cabling worksheets and cabling examples sections to see whether a completed worksheet exists for your configuration.

b. The next step depends on whether a completed worksheet exists for your configuration:

<table>
<thead>
<tr>
<th>If...</th>
<th>Then...</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a completed worksheet for your</td>
<td>Go to the next step.</td>
</tr>
<tr>
<td>configuration</td>
<td>You use the existing completed worksheet.</td>
</tr>
<tr>
<td></td>
<td>Fill out a controller-to-stack cabling worksheet template.</td>
</tr>
<tr>
<td></td>
<td>Worksheet templates can be found towards the back of this guide.</td>
</tr>
</tbody>
</table>

3. Cable the controller-to-stack connections using the completed worksheet.

Instructions about how to read a worksheet to cable controller-to-stack connections can be found towards the back of this guide.

4. Connect the power supplies for each disk shelf:

a. Connect the power cords first to the disk shelves, securing them in place with the power cord retainer, and then connect the power cords to different power sources for resiliency.

b. Turn on the power supplies for each disk shelf and wait for the disk drives to spin up.

5. Set the shelf IDs and complete system setup:

You must set shelf IDs so they are unique within the HA pair or single-controller configuration, including the internal disk shelf in FAS2600 series and FAS2700 systems.
### If... Then...

**You are manually setting shelf IDs**

- **a.** Access the shelf ID button behind the left end cap.
- **b.** Change the shelf ID to a unique ID (00 through 99).
- **c.** Power-cycle the disk shelf to make the shelf ID take effect. Wait at least 10 seconds before turning the power back on to complete the power cycle. The shelf ID blinks and the operator display panel amber LED blinks until you power cycle the disk shelf.
- **d.** Power on the controllers and complete system setup and configuration as instructed by the “Installation and Setup Instructions” that came with your system.

**You are automatically assigning all shelf IDs in your HA pair or single-controller configuration**

**Note:** Shelf IDs are assigned in sequential order from 00-99. If you have FAS2600 series or FAS2700 series system, shelf ID assignment begins with the internal disk shelf.

- **a.** Power on the controllers.
- **b.** As the controllers start booting, press Ctrl-C to abort the AUTOBOOT process when you see the message *Starting AUTOBOOT press Ctrl-C to abort.*

  **Note:** If you miss the prompt and the controllers boot to ONTAP, halt both controllers, and then boot both controllers to the boot menu by entering `boot_ontap menu` at their LOADER prompt.

- **c.** Boot one controller to Maintenance mode:
  
  ```bash
  boot_ontap menu
  ```

  You only need to assign shelf IDs on one controller.

- **d.** From the boot menu, select option 5 for Maintenance mode.

- **e.** Automatically assign shelf IDs:
  
  ```bash
  sasadmin expander_set_shelf_id -a
  ```

- **f.** Exit Maintenance mode:
  
  ```bash
  halt
  ```

- **g.** Bring up the system by entering the following command at the LOADER prompt of both controllers:
  
  ```bash
  boot_ontap
  ```

  Shelf IDs appear in disk shelf digital display windows.

  **Note:** Before you boot the system, best practice is to take this opportunity to verify cabling is correct, a root aggregate is present, and run system-level diagnostics to identify any faulty components.

- **h.** Complete system setup and configuration as instructed by the “Installation and Setup Instructions” that came with your system.

### 6. If as part of system set up and configuration, you did not enable disk ownership automatic assignment, manually assign disk ownership; otherwise, go to the next step:

- **a.** Display all unowned disks:
  
  ```bash
  storage disk show -container-type unassigned
  ```

- **b.** Assign each disk:
  
  ```bash
  storage disk assign -disk disk_name -owner owner_name
  ```

  You can use the wildcard character to assign more than one disk at once.
7. Download and run Config Advisor as instructed by the “Installation and Setup Instructions” to verify SAS connections are cabled correctly and there are no duplicate shelf IDs within the system.

If any SAS cabling or duplicate shelf ID errors are generated, follow the corrective actions provided.

*NetApp Downloads: Config Advisor*

You can also run the `storage shelf show -fields shelf-id` command to see a list of shelf IDs already in use (and duplicates if present) in your system.

8. Verify that in-band ACP was automatically enabled.

`storage shelf acp show`

In the output, “in-band” is listed as “active” for each node.
Hot-adding disk shelves with IOM12 modules

You can hot-add one or more disk shelves with IOM12 modules to an existing stack of disk shelves with IOM12 modules or hot-add a stack of one or more disk shelves with IOM12 modules directly to a SAS HBA or an onboard SAS port on the controller.

Steps
1. Requirements for hot-adding disk shelves with IOM12 modules on page 13
2. Considerations for hot-adding disk shelves with IOM12 modules on page 14
3. Installing disk shelves with IOM12 modules for a hot-add on page 15
4. Cabling disk shelves with IOM12 modules for a hot-add on page 18

Requirements for hot-adding disk shelves with IOM12 modules

Your system must meet certain requirements before hot-adding disk shelves with IOM12 modules.

State of your system

- Your system and version of ONTAP must support the disk shelves you are hot-adding, including the IOMs, disk drives, and SAS cables.  
  NetApp Hardware Universe
- Your system must have less than the maximum number of disk drives supported, by at least the number of disk shelves you plan to hot-add.  
  You cannot have exceeded the maximum number of disk drives supported for your system after hot-adding disk shelves. 
  NetApp Hardware Universe
- If you are hot-adding a stack of one or more disk shelves (directly to the platform controllers), your system must have enough available PCI SAS HBA or onboard SAS ports or a combination of both.  
  Note: If you need to install an additional PCI SAS HBA, the best practice is to use 12Gb SAS HBAs to keep controller-to-stack connectivity at 12Gbs for maximum performance. Using 6Gb SAS HBAs or a combination of 6Gb SAS HBAs and 12Gb SAS HBAs is supported; however, IOM12 module connections to 6Gb SAS HBAs are negotiated down to 6Gbs, resulting in lower performance.
- Your system cannot have any SAS cabling error messages.  
  You must correct any cabling errors using the corrective actions provided by the error messages.

Using mini-SAS HD SAS optical cables

- If you are using mini-SAS HD SAS optical cables or a mix of mini-SAS HD SAS optical cables and SAS copper cables in the stack of disk shelves, you must have met the rules in the “Mini-SAS HD SAS optical cable rules” section.
- If you are hot-adding a disk shelf with mini-SAS HD SAS optical cables to a stack of disk shelves that is connected with SAS copper cables, you can temporarily have both cable types in the stack.  
  After hot-adding the disk shelf, you must replace the SAS copper cables for the rest of the shelf-to-shelf connections in the stack and the controller-to-stack connections so that the stack meets...
the rules in the “Mini-SAS HD SAS optical cable rules” section. This means that you must have ordered the appropriate number of mini-SAS HD SAS optical cables.

Considerations for hot-adding disk shelves with IOM12 modules

You should familiarize yourself with aspects and best practices about this procedure before hot-adding disk shelves.

General considerations

- If you are hot-adding a disk shelf with IOM12 modules to an existing stack (of disk shelves with IOM12 modules), you can hot-add the disk shelf to either end—the logical first or last disk shelf—of the stack.
  For FAS2600 series and FAS2700 systems single-path HA and single-path configurations, you hot-add disk shelves to the end of the stack that does not have controller connections.
- You can hot-add a stack of disk shelves with IOM12 modules to a system that has existing stacks of disk shelves with IOM6 and IOM3 modules.
  Disk shelves with IOM12 modules must be in their own unique stack.
- A system can have multipathed and quad-pathed stacks of disk shelves with IOM12 modules.
  If you have an HA pair, ONTAP shows the system configuration as “multipath HA”. If you have a single-controller configuration, ONTAP shows the system configuration as “multipath”.
- This procedure assumes your configuration is using in-band ACP.
  For configurations that have in-band ACP enabled, in-band ACP is automatically enabled on hot-added disk shelves. For configurations in which in-band ACP is not enabled, hot-added disk shelves operate without any ACP functionality.
- Nondisruptive stack consolidation is not supported.
  You cannot use this procedure to hot-add disk shelves that were hot-removed from another stack in the same system when the system is powered on and serving data (I/O is in progress).

Best practice considerations

- The best practice is to have the current version of the Disk Qualification Package (DQP) installed before hot-adding a disk shelf.
  Having the current version of the DQP installed allows your system to recognize and utilize newly qualified disk drives; therefore, avoiding system event messages about having non-current disk drive information. You also avoid the possible prevention of disk partitioning because disk drives are not recognized. The DQP also notifies you of non-current disk drive firmware.
  NetApp Downloads: Disk Qualification Package

- The best practice is to run Config Advisor before and after hot-adding a disk shelf.
  Running Config Advisor before hot-adding a disk shelf provides a snap shot of the SAS connectivity, verifies disk shelf (IOM) firmware versions, and allows you to verify shelf IDs already in use on your system. Running Config Advisor after hot-adding a disk shelf allows you to verify SAS connections are cabled correctly and that shelf IDs are unique within the HA pair or single-controller configuration.
  If any SAS cabling or duplicate shelf ID errors are generated, follow the corrective actions provided.
  You need network access to download Config Advisor.
  NetApp Downloads: Config Advisor

- The best practice is to have the current versions of disk shelf (IOM) firmware and disk drive firmware on your system before adding new disk shelves, shelf FRU components, or SAS cables.
Current versions of firmware can be found on the NetApp Support Site.

NetApp Downloads: Disk Shelf Firmware
NetApp Downloads: Disk Drive and Firmware

SAS cable handling considerations

• Visually inspect the SAS port to verify the proper orientation of the connector before plugging it in.

  The SAS cable connectors are keyed. When oriented correctly into a SAS port, the connector clicks into place and if the disk shelf power is on at the time, the disk shelf SAS port LNK LED illuminates green. For disk shelves, you insert a SAS cable connector with the pull tab oriented down (on the underside of the connector).

  For controllers, the orientation of SAS ports can vary depending on the platform model; therefore, the correct orientation of the SAS cable connector varies.

• To prevent degraded performance, do not twist, fold, pinch, or step on the cables.

  Cables have a minimum bend radius. Cable manufacturer specifications define the minimum bend radius; however, a general guideline for minimum bend radius is 10 times the cable diameter.

• Using Velcro wraps instead of tie-wraps to bundle and secure system cables allows for easier cable adjustments.

Installing disk shelves with IOM12 modules for a hot-add

For each disk shelf you are hot-adding, you install the disk shelf into a rack, connect the power cords, power on the disk shelf, and set the disk shelf ID before cabling the SAS connections.

Steps

1. Install the rack mount kit (for two-post or four-post rack installations) that came with your disk shelf using the installation flyer that came with the kit.

   Attention: If you are installing multiple disk shelves, you should install them from the bottom to the top of the rack for the best stability.

   Do not flange-mount the disk shelf into a telco-type rack; the disk shelf's weight can cause it to collapse in the rack under its own weight.

2. Install and secure the disk shelf onto the support brackets and rack using the installation flyer that came with the kit.

   To make a disk shelf lighter and easier to maneuver, remove the power supplies and I/O modules (IOMs).

   For DS460C disk shelves, you can also use the four detachable handles that shipped with your disk shelf. Handles (two on each side of the chassis) are installed by pushing up until they click into place. As you slide the disk shelf onto the rails, detach handles using the thumb latch.

   It is recommended that you use a mechanical hoist or lift if you are moving a fully loaded DS460C disk shelf.

   Attention: A fully loaded DS460C disk shelf can weigh approximately 247 lbs (112 kg).
3. If you are installing a DS460C disk shelf, install the components into the racked disk shelf; otherwise, go to the next step.

If you purchased a partially populated disk shelf which does not have a drive in every drive slot, you must ensure that:

- The first four slots (0, 3, 6, and 9) are occupied in each drawer. This ensures proper airflow in the disk shelf.
- In a shelf with 30 drives, the remaining ten drives are distributed evenly throughout the shelf in slots 1 and 10 of each drawer.

The following illustration shows how the drives are numbered from 0 to 11 in each drive drawer within the shelf. Slots 0, 3, 6, 9, and, in a shelf containing 30 drives, slots 1 and 10 in each drawer must contain drives.

a. Reinstall any power supplies and IOMs you removed prior to installing your disk shelf into the rack.

b. Open the top drawer of the shelf.

c. Raise the cam handle on the drive to vertical.

d. Align the two raised buttons on each side of the drive carrier with the matching gap in the drive channel on the drive drawer.
Raised button on the right side of the drive carrier

e. Lower the drive straight down, and then rotate the cam handle down until the drive snaps into place under the orange release latch.

f. Repeat the previous substeps for each drive in the drawer.

   You must be sure that slots 0, 3, 6, and 9 in each drawer contain drives.

g. Carefully push the drive drawer back into the enclosure.

   **Attention: Possible loss of data access** – Never slam the drawer shut. Push the drawer in slowly to avoid jarring the drawer and causing damage to the storage array.

h. Close the drive drawer by pushing both levers towards the center.

i. Repeat these steps for each drawer in the disk shelf.

4. If you are adding multiple disk shelves, repeat the previous steps for each disk shelf you are installing.

5. Connect the power supplies for each disk shelf:
   
   a. Connect the power cords first to the disk shelves, securing them in place with the power cord retainer, and then connect the power cords to different power sources for resiliency.
   
   b. Turn on the power supplies for each disk shelf and wait for the disk drives to spin up.

6. Set the shelf ID for each disk shelf you are hot-adding to an ID that is unique within the HA pair or single-controller configuration.

   If you have a FAS2600 series or FAS2700 series system, shelf IDs must be unique across the internal disk shelf and externally attached disk shelves.

   You can use the following substeps to change shelf IDs, or for more detailed instructions, use the procedure in the “Changing the disk shelf ID” section.

   a. If needed, verify shelf IDs already in use by running Config Advisor.
You can also run the `storage shelf show -fields shelf-id` command to see a list of shelf IDs already in use (and duplicates if present) in your system.

b. Access the shelf ID button behind the left end cap.

c. Change the shelf ID to a valid ID (00 through 99).

d. Power-cycle the disk shelf to make the shelf ID take effect.

   Wait at least 10 seconds before turning the power back on to complete the power cycle.
   The shelf ID blinks and the operator display panel amber LED blinks until you power cycle the disk shelf.

e. Repeat substeps a through d for each disk shelf you are hot-adding.

### Cabling disk shelves with IOM12 modules for a hot-add

You cable the SAS connections—shelf-to-shelf and controller-to-stack—as applicable for hot-added disk shelves so they have connectivity to the system.

#### Before you begin

You must have met the requirements in the “Requirements for a hot-adding disk shelves with IOM12 modules” section and installed, powered on, and set shelf IDs for each disk shelf as instructed in the “Installing disk shelves with IOM12 modules for a hot-add” section.

#### About this task

- For an explanation and examples of shelf-to-shelf “standard” cabling and shelf-to-shelf “double-wide” cabling, see the “Shelf-to-shelf SAS connection rules” section.
- Instructions about how to read a worksheet to cable controller-to-stack connections can be found towards the back of this guide.
- After you have cabled the hot-added disk shelves, ONTAP recognizes them: disk ownership is assigned if disk ownership automatic assignment is enabled; disk shelf (IOM) firmware and disk drive firmware should automatically update if needed; and if in-band ACP is enabled on your configuration, it is automatically enabled on the hot-added disk shelves.

   **Note:** Firmware updates can take up to 30 minutes.

#### Steps

**1.** If you want to manually assign disk ownership for the disk shelves you are hot-adding, you need to disable disk ownership automatic assignment if it is enabled; otherwise, go to the next step.

   You need to manually assign disk ownership if disks in the stack are owned by both controllers in an HA pair.

   You disable disk ownership automatic assignment before cabling the hot-added disk shelves and then later, in step 7, you reenable it after cabling the hot-added disk shelves.

   a. Verify if disk ownership automatic assignment is enabled:

   ```
   storage disk option show
   ```

   If you have an HA pair, you can enter the command at the console of either controller.

   If disk ownership automatic assignment is enabled, the output shows “on” (for each controller) in the “Auto Assign” column.

   b. If disk ownership automatic assignment is enabled, you need to disable it:
You need to disable disk ownership automatic assignment on both controllers in an HA pair.

2. If you are hot-adding a stack of disk shelves directly to a controller, complete the following substeps; otherwise, go to step 3.
   a. If the stack you are hot-adding has more than one disk shelf, cable the shelf-to-shelf connections; otherwise, go to substep b.

<table>
<thead>
<tr>
<th>If...</th>
<th>Then...</th>
</tr>
</thead>
</table>
| You are cabling a stack with multipath HA, multipath, single-path HA, or single-path connectivity to the controllers | Cable the shelf-to-shelf connections as “standard” connectivity (using IOM ports 3 and 1):
   i. Beginning with the logical first shelf in the stack, connect IOM A port 3 to the next shelf’s IOM A port 1 until each IOM A in the stack is connected.
   ii. Repeat substep i for IOM B. |
| You are cabling a stack with quad-path HA or quad-path connectivity to the controllers | Cable the shelf-to-shelf connections as “double-wide” connectivity:
   You cable the standard connectivity using IOM ports 3 and 1 and then the double-wide connectivity using IOM ports 4 and 2.
   i. Beginning with the logical first shelf in the stack, connect IOM A port 3 to the next shelf’s IOM A port 1 until each IOM A in the stack is connected.
   ii. Beginning with the logical first shelf in the stack, connect IOM A port 4 to the next shelf’s IOM A port 2 until each IOM A in the stack is connected.
   iii. Repeat substeps i and ii for IOM B. |

b. Check the controller-to-stack cabling worksheets and cabling examples sections to see whether a completed worksheet exists for your configuration.

c. If there is a completed worksheet for your configuration, cable the controller-to-stack connections using the completed worksheet; otherwise, go to the next substep.

d. If there is no completed worksheet for your configuration, fill out a worksheet template, and then cable the controller-to-stack connections using the completed worksheet.

   Worksheet templates can be found towards the back of this guide.

e. Verify that all cables are securely fastened.

3. If you are hot-adding one or more disk shelves to an end—the logical first or last disk shelf—of an existing stack, complete the applicable substeps for your configuration; otherwise, go to the next step.
If you are...

Hot-adding a disk shelf to an end of a stack that has multipath HA, multipath, quad-path HA, or quad-path connectivity to the controllers

Then...

a. Disconnect any cables from IOM A of the disk shelf at the end of the stack that are connected to any controllers; otherwise, go to substep e. Leave the other end of these cables connected to the controllers, or replace cables with longer cables if needed.

b. Cable the shelf-to-shelf connection(s) between IOM A of the disk shelf at the end of the stack and IOM A of the disk shelf you are hot-adding.

c. Reconnect any cables that you removed in substep a to the same port(s) on IOM A of the disk shelf you are hot-adding; otherwise, go to the next substep.

d. Verify that all cables are securely fastened.

e. Repeat substeps a through d for IOM B; otherwise, go to Step 4.

4. If you hot-added a disk shelf with mini-SAS HD SAS optical cables to a stack of disk shelves connected with SAS copper cables, replace the SAS copper cables; otherwise, go to the next step. The stack must meet the requirements stated in the “Requirements for hot-adding disk shelves with IOM12 modules” section of this procedure.

5. Download and run Config Advisor to verify that your SAS connections are cabled correctly.

   NetApp Downloads: Config Advisor

   If any SAS cabling errors are generated, follow the corrective actions provided.

6. Verify SAS connectivity for each hot-added disk shelf:

   `storage shelf show -shelf shelf_name -connectivity`

   You must run this command for each disk shelf you hot-added.

   For example, the following output shows hot-added disk shelf 2.5 is connected to initiator ports 1a and 0d (port pair 1a/0d) on each controller (in a FAS8080 multipath HA configuration with one quad-port SAS HBA):

```
cluster1::> storage shelf show -shelf 2.5 -connectivity

   Shelf Name: 2.5
   Stack ID: 2
   Shelf ID: 5
   Shelf UID: 40:0a:09:70:02:2a:2b
   Serial Number: 101033373
   Module Type: IOM12
   Model: DS224C
   Shelf Vendor: NETAPP
   Disk Count: 24
   Connection Type: SAS
   Shelf State: Online
   Status: Normal

   Paths:
```
7. If you disabled disk ownership automatic assignment in Step 1, manually assign disk ownership, and then reenable disk ownership automatic assignment if needed:

a. Display all unowned disks:

   `storage disk show -container-type unassigned`

b. Assign each disk:

   `storage disk assign -disk disk_name -owner owner_name`

   You can use the wildcard character to assign more than one disk at once.

c. Reenable disk ownership automatic assignment if needed:

   `storage disk option modify -node node_name -autoassign on`

   You need to reenable disk ownership automatic assignment on both controllers in an HA pair.

8. If your configuration is running in-band ACP, verify that in-band ACP was automatically enabled on hot-added disk shelves:

   `storage shelf acp show`

   In the output, “in-band” is listed as “active” for each node.
Changing the disk shelf ID

You can nondisruptively change a shelf ID on a disk shelf with IOM12 modules in a system when ONTAP is not yet running or when ONTAP is up and running (controllers are available to serve data).

Before you begin

- Your system cannot be serving data (there cannot be I/O activity).
  Changing a shelf ID is a disruptive action on systems with I/O activity.
- You can verify shelf IDs already in use in your system by running Config Advisor or using the `storage shelf show -fields shelf-id` command.

NetApp Downloads: Config Advisor

About this task

- A valid shelf ID is 00 through 99.
- Shelf IDs must be unique within an HA pair or single-controller configuration.
  If you have a platform with internal storage, shelf IDs must be unique across the internal disk shelf and any externally attached disk shelves.
- In order for a changed shelf ID to take effect, you must power cycle the disk shelf.

Steps

1. Turn on the power to the disk shelf if it is not already on.
2. Remove the left end cap to locate the button near the shelf LEDs.
3. Change the first number of the shelf ID by pressing and holding the orange button until the first number on the digital display blinks, which can take up to three seconds.
   
   **Note:** If the ID takes longer than three seconds to blink, press the button again, making sure to press it in all the way.
   
   This activates the disk shelf ID programming mode.
4. Press the button to advance the number until you reach the desired number from 0 to 9.
   
   The first number continues to blink.
5. Change the second number of the shelf ID by pressing and holding the button until the second number on the digital display blinks, which can take up to three seconds.
   
   The first number on the digital display stops blinking.
6. Press the button to advance the number until you reach the desired number from 1 to 9.
   
   The second number continues to blink.
7. Lock in the desired number and exit the programming mode by pressing and holding the button until the second number stops blinking, which can take up to three seconds.
   
   Both numbers on the digital display start blinking and the amber LED on the operator display panel illuminates after about five seconds, alerting you that the pending disk shelf ID has not yet taken effect.
8. Power cycle the disk shelf to make the shelf ID take effect.
If ONTAP is not yet running, wait at least 10 seconds before turning the power back on to complete the power cycle. If ONTAP is running (controllers are available to serve data), you must wait at least 70 seconds before turning the power back on to complete the power cycle. This time allows ONTAP to properly delete the old disk shelf address and update the copy of the new disk shelf address.

9. Replace the left end cap.

10. Repeat Steps 1 through 9 for each additional disk shelf.

11. If you manually assigned shelf IDs, verify that your system does not have duplicate shelf IDs. When two or more disk shelves have the same ID, the system assigns the duplicate disk shelf a soft ID number equal to or greater than 100. You must change the soft ID (duplicate) number.

   a. Run Config Advisor to check for duplicate shelf ID alerts or run the `storage shelf show -fields shelf-id` command to see a list of shelf IDs already in use including any duplicate IDs.

   b. If your system has any duplicate shelf IDs, change the duplicate shelf IDs by repeating this procedure.
Controller-to-stack cabling worksheets and cabling examples for common multipath HA configurations

You can use the controller-to-stack cabling worksheets and cabling examples to cable your HA pair as a multipath HA configuration.

- If needed, you can refer to the “SAS cabling rules” section for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

- If needed, you can refer to the “How to read a worksheet to cable controller-to-stack connections for multipathed connectivity” section.

- Cabling examples show controller-to-stack cables as solid or dashed to distinguish controller A and C port connections from controller B and D port connections.

<table>
<thead>
<tr>
<th>Controller-to-Stack Cable Type Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Type</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>🟩</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>🟩</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- Cables in the cabling examples and their corresponding port pairs in the worksheets are color-coded to distinguish connectivity to each stack in the HA pair.

<table>
<thead>
<tr>
<th>Controller-to-Stack Cable Color Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Color</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>🟩</td>
</tr>
<tr>
<td>🟩</td>
</tr>
<tr>
<td>🟩</td>
</tr>
<tr>
<td>🟩</td>
</tr>
</tbody>
</table>

- Worksheets and cabling examples show cabling port pairs in the order in which they are listed in the worksheet.
Controller-to-stack cabling worksheets and cabling examples for multipath HA configurations with quad-port SAS HBAs

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable common multipath HA configurations that have quad-port SAS HBAs. These controllers do not have onboard SAS ports.

**Multipath HA with one quad-port SAS HBA and one single-shelf stack**

The following worksheet and cabling example uses port pair 1a/1d:

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1</td>
<td>First</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>First</td>
<td>B</td>
</tr>
<tr>
<td>B and D</td>
<td>1</td>
<td>Last</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Last</td>
<td>A</td>
</tr>
</tbody>
</table>

**Multipath HA configuration**

**Multipath HA with one quad-port SAS HBA and two single-shelf stacks**

The following worksheet and cabling example uses port pairs 1a/1d and 1c/1b.
Multipath HA with two quad-port SAS HBAs and two multi-shelf stacks

Four port pairs are available for this configuration: 1a/2b, 2a/1d, 1c/2d, and 2c/1b. You can cable port pairs in the order in which they are identified (listed in the worksheet) or you can cable every other port pair (skip port pairs).

Note: When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.

The following worksheet and cabling example shows port pairs being used in the order in which they are listed in the worksheet: 1a/2b, 2a/1d, 1c/2d, and 2c/1b.
The following worksheet and cabling example shows port pairs being skipped to use every other one in the list: 1a/2b and 1c/2d.

**Note:** If a third stack is added later, you use the port pair that was skipped.

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1 First A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 First B</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>B and D</td>
<td>1 Last B</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Last A</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Controller-to-Stack Cabling Worksheet for Multipathed Connectivity
Controller-to-stack cabling worksheets and cabling examples for multipath HA configurations with four onboard SAS ports

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable common multipath HA configurations that have four onboard SAS ports.

Multipath HA with four onboard SAS ports and one single-shelf stack

The following worksheet and cabling example uses port pair 0a/0d:

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1</td>
<td>First</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>First</td>
<td>B</td>
</tr>
<tr>
<td>B and D</td>
<td></td>
<td>Last</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
</tbody>
</table>
**Multipath HA with four onboard SAS ports and two single-shelf stacks**

The following worksheet and cabling example uses port pairs 0a/0d and 0c/0b:

### Controller-to-Stack Cabling Worksheet for Multipathed Connectivity

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1</td>
<td>First</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>First</td>
<td>B</td>
</tr>
<tr>
<td>B and D</td>
<td>1</td>
<td>Last</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Last</td>
<td>A</td>
</tr>
</tbody>
</table>

---

**Multipath HA configuration**
Multipath HA with four onboard SAS ports, a quad-port SAS HBA, and two multi-shelf stacks

Four port pairs are available for this configuration: 0a/1b, 1a/0d, 0c/1d, and 1c/0b. You can cable port pairs in the order in which they are identified (listed in the worksheet) or you can cable every other port pair (skip port pairs).

**Note:** When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system’s performance.

The following worksheet and cabling example shows port pairs being used in the order in which they are listed in the worksheet: 0a/1b, 1a/0d, 0c/1d, and 1c/0b.

<table>
<thead>
<tr>
<th>Controller-to-Stack Cabling Worksheet for Multipathed Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controller SAS ports</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A and C</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>B and D</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Note:** If a third stack is added later, you use the port pair that was skipped.

The following worksheet and cabling example shows port pairs being skipped to use every other one in the list: 0a/1b and 0c/1d.

**Note:** If a third stack is added later, you use the port pair that was skipped.
Controller-to-stack cabling worksheets and cabling examples for common multipath HA configurations
Controller-to-stack cabling worksheets and cabling examples for common FAS2600 series and FAS2700 configurations

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable common FAS2600 series and FAS2700 configurations.

- If needed, you can refer to the “SAS cabling rules” section for information about supported configurations, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including FAS2600 series and FAS2700 port 0b same domain connectivity).

- Cabling examples show controller-to-stack cables as solid or dashed to distinguish controller 0b port connections from controller 0a port connections.

<table>
<thead>
<tr>
<th>FAS2600/FAS2700 Series Controller-to-Stack Cable Type Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Type</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>————</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>————</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- Cabling examples show controller-to-stack connections and shelf-to-shelf connections in two different colors to distinguish connectivity through IOM A (domain A) and IOM B (domain B).

<table>
<thead>
<tr>
<th>FAS2600/FAS2700 Series Cable Color Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cable Color</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Light blue</td>
</tr>
<tr>
<td>Purple</td>
</tr>
</tbody>
</table>

**FAS2600 series and FAS2700 multipath HA configuration with one multi-shelf stack**

The following worksheet and cabling example uses port pair 0a/0b:
FAS2600 series multipath configuration with one multi-shelf stack

The following worksheets and cabling examples use port pair 0a/0b.

In this example, the controller is installed in slot A of the chassis. When a controller is located in slot A of the chassis, its internal storage port (0b) is in domain A (IOM A); therefore, port 0b must connect to domain A (IOM A) in the stack.

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1 First</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2 First</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B and D</td>
<td>1 Last</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2 Last</td>
<td>B</td>
<td>3</td>
</tr>
</tbody>
</table>
In this example, the controller is installed in slot B of the chassis. When a controller is located in slot B of the chassis, its internal storage port (0b) is in domain B (IOM B); therefore, port 0b must connect to domain B (IOM B) in the stack.
FAS2600 series multipath configuration

(Chassis slot A is empty)

Controller 2
(In chassis slot B)

IOI A

Stack 1

First shelf

IOI B

Last shelf
Controller-to-stack cabling worksheet and cabling example for a quad-path HA configuration with two quad-port SAS HBAs

You can use the completed controller-to-stack cabling worksheet and cabling example to cable a quad-path HA configuration that has two quad-port SAS HBAs.

- If needed, you can refer to the “SAS cabling rules” section for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

- If needed, you can refer to the “How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity” section.

- The cabling example shows controller-to-stack cables as solid or dashed to distinguish controller A and C port connections from controller B and D port connections.

<table>
<thead>
<tr>
<th>Controller-to-Stack Cable Type Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable Type</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- Cables in the cabling examples and their corresponding port pairs in the worksheets are color-coded to distinguish connectivity to each stack in the HA pair.

<table>
<thead>
<tr>
<th>Controller-to-Stack Cable Color Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable Color</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Orange</td>
</tr>
</tbody>
</table>

- The cabling example visually distinguishes the two sets of multipathed cabling needed to achieve quad-pathed connectivity for each controller to each stack in an HA pair or single-controller configuration.

The first set of multipathed cabling is referred to as “multipathed”. The second set of multipathed cabling is referred to as “quad-pathed”. The second set of cabling is referred to as “quad-pathed” because completing this set of cabling gives you the quad-pathed connectivity.
The worksheet example shows port pairs designated for multipathed cabling or quad-pathed cabling to the applicable stack. Each port pair designated for multipathed cabling is encircled by an oval that is the color associated with the stack it is cabled to. Each port pair designated for quad-pathed cabling is encircled by a rectangle that is the color associated with the stack it is cabled to.

**Quad-path HA with two quad-port SAS HBAs and two multi-shelf stacks**

The following worksheet and cabling example uses port pairs 1a/2b (multipathed) and 2a/1d (quad-pathed) for stack 1, and port pairs 1c/2d (multipathed) and 2c/1b (quad-pathed) for stack 2.

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shelf IOM</td>
<td></td>
</tr>
<tr>
<td>A and C</td>
<td></td>
<td>Port</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multipathed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>First</td>
<td>A</td>
<td>1a, 2a</td>
</tr>
<tr>
<td>2</td>
<td>First</td>
<td>B</td>
<td>1b, 2b</td>
</tr>
<tr>
<td>B and D</td>
<td></td>
<td>Quad-pathed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Port</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multipathed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1c, 2c</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1d, 2d</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1b</td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controller SAS ports</strong></td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A and C</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>B and D</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
Quad-path HA configuration

Controller 1

 Slot 1
   A
   B
   C
   D

 Slot 2

 IOM A

 First shelf

 IOM B

 Stack 1

 Controller 2

 Slot 1
   A
   B
   C
   D

 Slot 2

 IOM A

 Stack 2

 IOM B

 Last shelf

 Stack 1

 Stack 2
SAS cabling rules

Disk shelves with IOM12 modules can be cabled in HA pair and single-controller configurations (for supported platforms) by applying the SAS cabling rules: configuration rules, controller slot numbering rules, shelf-to-shelf connection rules, controller-to-stack connection rules, and if applicable, mini-SAS HD SAS optical cable rules.

Note: The SAS cabling rules regarding controller slot numbering rules, shelf-to-shelf connection rules, and controller-to-stack connection rules described in this guide are the same rules that apply to all SAS disk shelves, whether they have IOM12, IOM6, or IOM3 modules. However, the information in this guide is specific to the unique characteristics of disk shelves with IOM12 modules and their use in supported configurations.

The SAS cabling rules regarding configuration rules and mini-SAS HD SAS optical cable rules described in this guide are specific to disk shelves with IOM12 modules.

The SAS cabling rules described in this guide balance SAS cabling between the on-board SAS ports and host bus adapter SAS ports to provide highly available storage controller configurations and meet the following goals:

- Provide a single, easily understood universal algorithm for all SAS products and configurations
- Yield the same physical cabling when generating the Bill of Materials (BOM), followed in the factory, and in the field
- Are verifiable by configuration-checking software and tools
- Provide maximum possible resilience to maintain availability and minimize the reliance on controller takeovers

You should avoid deviating from the rules; deviations might reduce reliability, universality, and commonality.

Configuration rules

Disk shelves with IOM12 modules are supported in specific types of HA pair and single-controller configurations.

- HA pair configurations must be cabled as multipath HA or quad-path HA configurations with the following exceptions:
  - FAS2600 series and FAS2700 HA pair configurations (with external disk shelves) can be cabled as single-path HA configurations to support connectivity to an external SAS tape backup device.
  - FAS2600 series and FAS2700 series HA pair configurations do not support quad-path HA connectivity.

- Single-controller configurations must be cabled as multipath or quad-path configurations, with the following exceptions:
  - FAS2600 series single-controller configurations (with external disk shelves) can be cabled as single-path configurations.
    Because the internal storage uses single-path connectivity, ONTAP issues occasional warnings that mixed paths are detected. To avoid these warnings, you can use single-path connectivity to the external disk shelves. Additionally, you can use single-path connectivity when an external SAS tape backup device is used.
Controller slot numbering rules

For the purpose of applying cabling rules across all supported HA pairs and single-controller configurations, a controller slot numbering convention is used.

- For all HA pairs and single-controller configurations, the following applies:
  - A SAS HBA in a physical PCI slot is defined as occupying PCI slot 1, 2, 3, and so on regardless of the slot's physical label on a controller.
    For example, if SAS HBAs occupied physical PCI slots 3, 5, and 7, they would be designated as slots 1, 2, and 3 for the purpose of applying the SAS cabling rules.
  - An onboard SAS HBA is defined as occupying PCI slot 0 just as it is labeled on a controller.
  - Each port in each slot is defined just as it is labeled on a controller.

For example, slot 0 with two ports is referred to as 0a and 0b. Slot 1 with four ports is referred to as 1a, 1b, 1c, and 1d.

Shelf-to-shelf connection rules

When you have more than one disk shelf in a stack of disk shelves, they connect to each other through each SAS domain (IOM A and IOM B) using the applicable “standard” or “double-wide” shelf-to-shelf cabling. Your use of “standard” or “double-wide” shelf-to-shelf cabling depends on the configuration you have.

Standard shelf-to-shelf connectivity

- Standard shelf-to-shelf connectivity is used in multipath HA, multipath, single-path HA, and single-path configurations.
- Standard shelf-to-shelf connectivity is what is being used in existing SAS storage configurations with IOM3 and IOM6 modules: one cable connection is needed between disk shelves in each domain—domain A (IOM A) and domain B (IOM B).
- Best practice is to use IOM ports 3 and 1 for standard shelf-to-shelf connectivity.
  From the logical first shelf to the logical last shelf in a stack, you connect IOM port 3 to the next shelf's IOM port 1 in domain A and then domain B.
Double-wide shelf-to-shelf connectivity

- Double-wide shelf-to-shelf connectivity is used in quad-pathed (quad-path HA and quad-path) configurations.

- Double-wide shelf-to-shelf connectivity requires two cable connections between disk shelves in each domain—domain A (IOM A) and domain B (IOM B).
  The first cable connection is cabled as standard shelf-to-shelf connectivity (using IOM ports 3 and 1); the second cable connection is cabled as double-wide shelf-to-shelf connectivity (using IOM ports 4 and 2).
  From the logical first shelf to the logical last shelf in a stack, you connect IOM port 3 to the next shelf's IOM port 1 in domain A and then domain B. From the logical first shelf to the logical last shelf in a stack, you connect IOM port 4 to the next shelf's IOM port 2 in domain A and then domain B. (IOM ports cabled as double-wide connectivity are shown with blue.)

Controller-to-stack connection rules

You can correctly cable the SAS connections from each controller to each stack in an HA pair or in a single-controller configuration by understanding that SAS disk shelves use software-based disk...
ownership, how controller ports A/C and B/D are connected to stacks, how controller ports A/C and B/D are organized into port pairs, and how FAS2600 series and FAS2700 ports 0b and 0a are connected to stacks.

**SAS disk shelf software-based disk ownership rule**

SAS disk shelves use software-based disk ownership (not hardware-based disk ownership). This means that disk drive ownership is stored on the disk drive rather than it being determined by the topology of the storage system's physical connections (as it is for hardware-based disk ownership). Specifically, disk drive ownership is assigned by ONTAP (automatically or by CLI commands), not by how you cable the controller-to-stack connections.

SAS disk shelves should never be cabled using the hardware-based disk ownership scheme.

**Controller A and C port connection rules (for non FAS2600 series and FAS2700 configurations)**

- A and C ports are always the primary paths to a stack.
- A and C ports always connect to the logical first disk shelf in a stack.
- A and C ports always connect to disk shelf IOM ports 1 and 2.
  IOM port 2 is only used for quad-path HA and quad-path configurations.
- Controller 1 A and C ports always connect to IOM A (domain A).
- Controller 2 A and C ports always connect to IOM B (domain B).

The following illustration highlights how controller ports A and C connect in a multipath HA configuration with one quad-port HBA and two stacks of disk shelves. Connections to stack 1 are shown in blue. Connections to stack 2 are shown in orange.

**Controller B and D port connection rules (for non FAS2600 series and FAS2700 configurations)**

- B and D ports are always the secondary paths to a stack.
B and D ports always connect to the logical last disk shelf in a stack.

B and D ports always connect to disk shelf IOM ports 3 and 4. IOM port 4 is only used for quad-path HA and quad-path configurations.

Controller 1 B and D ports always connect to IOM B (domain B).

Controller 2 B and D ports always connect to IOM A (domain A).

B and D ports are connected to the stacks by offsetting the order of the PCI slots by one so that the first port on the first slot is cabled last.

The following illustration highlights how controller ports B and D connect in a multipath HA configuration with one quad-port HBA and two stacks of disk shelves. Connections to stack 1 are shown in blue. Connections to stack 2 are shown in orange.

**Port pair connection rules (for non FAS2600 series and FAS2700 configurations)**

Controller SAS ports A, B, C, and D are organized into port pairs using a method that leverages all of the SAS ports for system resiliency and consistency when cabling controller-to-stack connections in HA pair and single-controller configurations.

- Port pairs consist of a controller A or C SAS port and a controller B or D SAS port. A and C SAS ports connect to the logical first shelf in a stack. B and D SAS ports connect to the logical last shelf in a stack.

- Port pairs use all SAS ports on each controller in your system. You increase system resiliency by incorporating all SAS ports (on an HBA in a physical PCI slot [slot 1-N] and on board the controller [slot 0]) into port pairs. Do not exclude any SAS ports.

- Port pairs are identified and organized as follows:
  1. List A ports and then C ports in sequence of slots (0,1, 2, 3, and so on). For example: 1a, 2a, 3a, 1c, 2c, 3c
  2. List B ports and then D ports in sequence of slots (0,1, 2, 3, and so on). For example: 1b, 2b, 3b, 1d, 2d, 3d
3. Rewrite the D and B port list so that the first port in the list is moved to the end of the list.

For example:

\[
\begin{array}{cccc}
X & 2b & 3b & 1d & 2d & 3d & 1b \\
\end{array}
\]

Offsetting the order of the slots by one balances port pairs across multiple slots (physical PCI slots and onboard slots) when more than one slot of SAS ports is available; therefore, preventing a stack from being cabled to a single SAS HBA.

4. Pair the A and C ports (listed in step 1) to the D and B ports (listed in step 2) in the order that they are listed.

For example: 1a/2b, 2a/3b, 3a/1d, 1c/2d, 2c/3d, 3c/1b.

**Note:** For an HA pair, the list of port pairs you identify for the first controller is also applicable to the second controller.

- When cabling your system, you can use port pairs in the order in which you identified them or you can skip port pairs:
  - Use port pairs in the order in which you identified (listed) them when all port pairs are needed to cable the stacks in your system.
    - For example, if you identified six port pairs for your system and you have six stacks to cable as multipath, you cable the port pairs in the order in which you listed them:
      1a/2b, 2a/3b, 3a/1d, 1c/2d, 2c/3d, 3c/1b
  - Skip port pairs (use every other port pair) when not all port pairs are needed to cable the stacks in your system.
    - For example, if you identified six port pairs for your system and you have three stacks to cable as multipath, you cable every other port pair in your list:
      1a/2b, 3a/1d, 1c/2d, 3c/1b

**Note:** When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system’s performance.

Controller-to-stack cabling worksheets are convenient tools for identifying and organizing port pairs so that you can cable the controller-to-stack connections for your HA pair or single-controller configuration.

- **Controller-to-stack cabling worksheet template for multipathed connectivity** on page 47
- **Controller-to-stack cabling worksheet template for quad-pathed connectivity** on page 52

**FAS2600 series and FAS2700 controller 0b and 0a port connection rules to external disk shelves**

The FAS2600 series and FAS2700 have a unique set of connection rules because each controller must maintain same domain connectivity between the internal storage (port 0b) and the stack. This means that when a controller is located in slot A of the chassis (controller 1) it is in domain A (IOM A) and therefore port 0b must connect to IOM A in the stack. When a controller is located in slot B of the chassis (controller 2) it is in domain B (IOM B) and therefore port 0b must connect to IOM B in the stack.

**Note:** If you do not connect the 0b port to the correct domain (cross-connect domains), you expose your system to resiliency issues that prevent you from performing nondisruptive procedures safely.

- **Controller 0b port (internal storage port):**
  - Controller 1 0b port always connects to IOM A (domain A).
  - Controller 2 0b port always connects to IOM B (domain B).
Port 0b is always the primary path.
- Port 0b always connects to the logical last disk shelf in a stack.
- Port 0b always connects to disk shelf IOM port 3.

- Controller 0a port (internal HBA port):
  - Controller 1 0a port always connects to IOM B (domain B).
  - Controller 2 0a port always connects to IOM A (domain A).
  - Port 0a is always the secondary path.
  - Port 0a always connects to the logical first disk shelf in a stack.
  - Port 0a always connects to disk shelf IOM port 1.

The following illustration highlights internal storage port (0b) domain connectivity for a FAS2600 series and FAS2700 multipath HA configuration:

**Mini-SAS HD SAS optical cable rules**

You can use mini-SAS HD SAS optical cables—multimode active optical cable (AOC) cables with mini-SAS HD-to-mini-SAS HD connectors and multimode (OM4) breakout cables with mini-SAS...
HD-to-LC connectors—to achieve long distance SAS connectivity for certain configurations that have disk shelves with IOM12 modules.

- Your platform and version of ONTAP must support the use of mini-SAS HD SAS optical cables: multimode active optical cable (AOC) cables with mini-SAS HD-to-mini-SAS HD connectors and multimode (OM4) breakout cables with mini-SAS HD-to-LC connectors.

**NetApp Hardware Universe**

- SAS optical multimode AOC cables with mini-SAS HD-to-mini-SAS HD connectors can be used for controller-to-stack and shelf-to-shelf connections, and are available in lengths up to 50 meters.

- If you are using SAS optical multimode (OM4) breakout cables with mini-SAS HD-to-LC connectors (for patch panels), the following rules apply:
  - You can use these cables for controller-to-stack and shelf-to-shelf connections.
  - If you use multimode breakout cables for shelf-to-shelf connections, you can only use them once within a stack of disk shelves. You must use multimode AOC cables to connect the remaining shelf-to-shelf connections.
  - For quad-path HA and quad-path configurations, if you use multimode breakout cables for the shelf-to-shelf double-wide connections between two disk shelves, the best practice is to use identically paired breakout cables.
  - You must connect all eight (four pairs) of the LC breakout connectors to the patch panel.
  - You need to supply the patch panels and inter-panel cables. The inter-panel cables must be the same mode as the breakout cable: OM4 multimode.
  - Up to one pair of patch panels can be used in a path.
  - The point-to-point (mini-SAS HD-to-mini-SAS HD) path of any multimode cable cannot exceed 100 meters. The path includes the set of breakout cables, patch panels, and inter-panel cables.
  - The total end-to-end path (sum of point-to-point paths from the controller to the last shelf) cannot exceed 300 meters. The total path includes the set of breakout cables, patch panels, and inter-panel cables.

- The SAS cables can be SAS copper, SAS optical, or a mix.
  - Shelf-to-shelf connections in a stack must be all SAS copper cables or all SAS optical cables.
  - If the shelf-to-shelf connections are SAS optical cables, the controller-to-stack connections to that stack must also be SAS optical cables.
  - If the shelf-to-shelf connections are SAS copper cables, the controller-to-stack connections to that stack can be SAS optical cables or SAS copper cables.
Controller-to-stack cabling worksheet template for multipathed connectivity

By completing the worksheet template, you can define the controller SAS port pairs you can use to cable controllers to stacks of disk shelves with IOM12 modules to achieve multipathed connectivity in an HA pair or single-controller configuration. You can also use the completed worksheet to walk yourself through cabling the multipathed connections for your configuration.

Before you begin

Your HA pair or single-controller configuration cannot be a FAS2600 series or FAS2700 configuration. FAS2600 series and FAS2700 configurations use a unique worksheet; see the “Controller-to-stack cabling worksheets and cabling examples for common FAS2600 series and FAS2700 configurations” section.

About this task

- This procedure and worksheet template is applicable to cabling multipathed connectivity for a multipath HA or multipath configuration with one or more stacks.

Examples of completed worksheets are provided for multipath HA and multipath configurations. A configuration with two quad-port SAS HBAs and two stacks of disk shelves with IOM12 modules is used for the worksheet examples.

- The worksheet template allows for up to six stacks; you need to add more columns if needed.

- If needed, you can refer to the “SAS cabling rules” section for information about supported configurations, the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including use of port pairs).

- If needed, after you complete the worksheet, you can refer to the “How to read a worksheet to cable controller-to-stack connections for multipathed connectivity” section.

### Controller-to-Stack Cabling Worksheet Multipathed Connectivity

<table>
<thead>
<tr>
<th>Controller SAS ports</th>
<th>Controllers</th>
<th>Cable to disk shelf IOMs</th>
<th>Stacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Shelf</td>
<td>IOM</td>
</tr>
<tr>
<td>A and C</td>
<td>1</td>
<td>First</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>First</td>
<td>B</td>
</tr>
<tr>
<td>B and D</td>
<td>1</td>
<td>Last</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Last</td>
<td>A</td>
</tr>
</tbody>
</table>

Steps

1. In the boxes above the gray boxes, list all SAS A ports on your system, and then all SAS C ports on your system in sequence of slots (0, 1, 2, 3, and so on).

Example

For example: 1a, 2a, 1c, 2c
2. In the gray boxes, list all SAS B ports on your system, and then all SAS D ports on your system in sequence of slots (0, 1, 2, 3 and so on).

   **Example**
   For example: 1b, 2b, 1d, 2d

3. In the boxes below the gray boxes, rewrite the D and B port list so that the first port in the list is moved to the end of the list.

   **Example**
   For example: 2b, 1d, 2d, 1b

4. Circle (designate) a port pair for each stack.

   When all port pairs are being used to cable the stacks in your system, circle port pairs in the order in which they are defined (listed) in the worksheet.

   For example, in a multipath HA configuration with eight SAS ports and four stacks, port pair 1a/2b is cabled to stack 1, port pair 2a/1d is cabled to stack 2, port pair 1c/2d is cabled to stack 3, and port pair 2c/1b is cabled to stack 4.

   When not all port pairs are needed to cable the stacks in your system, skip port pairs (use every other port pair).

   For example, in a multipath HA configuration with eight SAS ports and two stacks, port pair 1a/2b is cabled to stack 1 and port pair 1c/2d is cabled to stack 2. If two additional stacks are hot-added later, port pair 2a/1d is cabled to stack 3 and port pair 1c/2d is cabled to stack 4.

**Note:** When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system's performance.
You can use your completed worksheet to cable your system.

5. If you have a single-controller (multipath) configuration, cross out the information for controller 2.

You can use your completed worksheet to cable your system.
How to read a worksheet to cable controller-to-stack connections for multipathed connectivity

You can use this example to guide you through how to read and apply a completed worksheet to cable controller-to-stack connections for disk shelves with IOM12 modules for multipathed connectivity.

Before you begin

Your HA pair or single-controller configuration cannot be a FAS2600 series or FAS2700 configuration. FAS2600 series and FAS2700 configurations use a unique worksheet; see the “Controller-to-stack cabling worksheets and cabling examples for common FAS2600 series and FAS2700 configurations” section.

About this task

• This procedure references the following worksheet and cabling example to demonstrate how to read a worksheet to cable controller-to-stack connections.

The configuration used in this example is a multipath HA configuration with two quad-port SAS HBAs (eight SAS ports) on each controller and two stacks of disk shelves with IOM12 modules. Port pairs are cabled by skipping every other port pair in the worksheet.

Note: When you have more port pairs than you need to cable the stacks in your system, the best practice is to skip port pairs to optimize the SAS ports on your system. By optimizing SAS ports, you optimize your system’s performance.

• If you have a single-controller configuration, skip substeps b and d for cabling to a second controller.

• If needed, you can refer to the “SAS cabling rules” section for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

The port pairs are cabled using every other port pair in the worksheet: 1a/2b and 1c/2d....The port pairs being skipped to use every other one in the list: 1a/2b and 1c/2d.
How to read a worksheet to cable controller-to-stack connections for multipathed connectivity

Steps

1. Cable port pair 1a/2b on each controller to stack 1:
   a. Cable controller 1 port 1a to stack 1, first shelf IOM A port 1.
   b. Cable controller 2 port 1a to stack 1, first shelf IOM B port 1.
   c. Cable controller 1 port 2b to stack 1, last shelf IOM B port 3.
   d. Cable controller 2 port 2b to stack 1, last shelf IOM A port 3.

2. Cable port pair 1c/2d on each controller to stack 2:
   a. Cable controller 1 port 1c to stack 2, first shelf IOM A port 1.
   b. Cable controller 2 port 1c to stack 2, first shelf IOM B port 1.
   c. Cable controller 1 port 2d to stack 2, last shelf IOM B port 3.
   d. Cable controller 2 port 2d to stack 2, last shelf IOM A port 3.
Controller-to-stack cabling worksheet template for quad-pathed connectivity

By completing the worksheet template, you can define the controller SAS port pairs you can use to cable controllers to stacks of disk shelves with IOM12 modules to achieve quad-pathed connectivity in an HA pair or single-controller configuration. You can also use the completed worksheet to walk yourself through cabling the quad-pathed connections for your configuration.

About this task

• This procedure and worksheet template is applicable to cabling quad-pathed connectivity for a quad-path HA or quad-path configuration with one or more stacks. Examples of completed worksheets are provided for quad-path HA and quad-path configurations.

• The worksheet template allows for up to two stacks; you need to add more columns if needed.

• Quad-pathed connectivity for controller-to-stack connections consists of two sets of multipathed cabling: the first set of cabling is referred to as “multipathed”; the second set of cabling is referred to as “quad-pathed”.

• Disk shelf IOM ports 1 and 3 are always used for multipathed cabling and IOM ports 2 and 4 are always used for quad-pathed cabling, as designated by the worksheet column headings.

• In the worksheet examples, port pairs are designated for multipathed cabling or quad-pathed cabling to the applicable stack.

• If needed, you can refer to the “SAS cabling rules” section for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

• If needed, after you complete the worksheet, you can refer to the “How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity” section.

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</tr>
<tr>
<td>A and C</td>
<td>First</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>First</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>B and D</td>
<td>Last</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Last</td>
<td>A</td>
<td>3</td>
</tr>
</tbody>
</table>
Steps

1. In the boxes above the gray boxes, list all SAS A ports on your system, and then all SAS C ports on your system in sequence of slots (0, 1, 2, 3, and so on).

   Example
   For example: 1a, 2a, 1c, 2c

2. In the gray boxes, list all SAS B ports on your system, and then all SAS D ports on your system in sequence of slots (0, 1, 2, 3 and so on).

   Example
   For example: 1b, 2b, 1d, 2d

3. In the boxes below the gray boxes, rewrite the D and B port list so that the first port in the list is moved to the end of the list.

   Example
   For example: 2b, 1d, 2d, 1b

4. Identify the two sets of port pairs to connect to stack 1 by drawing an oval around the first set of port pairs and a rectangle around the second set of port pairs.

   Both sets of cabling are needed to achieve quad-pathed connectivity from each controller to stack 1 in your HA pair or single-controller configuration.

   The following example uses port pair 1a/2b for the multipathed cabling and port pair 2a/1d for the quad-pathed cabling to stack 1.

5. Identify the two sets of port pairs to connect to stack 2 by drawing an oval around the first set of port pairs and a rectangle around the second set of port pairs.

   Both sets of cabling are needed to achieve quad-pathed connectivity from each controller to stack 1 in your HA pair or single-controller configuration.

   The following example uses port pair 1c/2d for the multipathed cabling and port pair 2c/1b for the quad-pathed cabling to stack 2.
6. If you have a quad-path (single-controller) configuration, cross out the information for controller 2; you only need controller 1 information to cable the controller-to-stack connections.

The following example shows that the information for controller 2 is crossed out.

| Controller SAS ports | Controllers | | | | | |
|----------------------|-------------|------------------|---|---|---|
|                      |             | **Cable to disk shelf IOMs** | **Stacks** | | |
|                      |             | **Shelf** | **IOM** | **Port** | **1** | **2** |
|                      |             | **Multipathed** | **Quad-pathed** | **Port pairs** | | |
| A and C              | 1 First A   | 1 2           | 1a 2a 1c 2c |
|                      | 2 First B   | 1 2           | 1b 2b 4d 2d |
| B and D              | 1 Last B    | 3 4           | 2b 1d 2d 1b |
|                      | 2 Last A    | 3 4           | 2b 1d 2d 1b |
How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity

You can use this example to guide you through how to read and apply a completed worksheet to cable stacks of disk shelves with IOM12 modules for quad-pathed connectivity.

About this task

• This procedure references the following worksheet and cabling example to demonstrate how to read a worksheet to cable controller-to-stack connections.
  The configuration used in this example is a quad-path HA configuration with two quad-port SAS HBAs on each controller and two stacks of disk shelves with IOM12 modules.

• If you have a single-controller configuration, skip substeps b and d for cabling to a second controller.

• If needed, you can refer to the “SAS cabling rules” section for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

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<td>2</td>
<td>First</td>
<td>B</td>
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<td>B and D</td>
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<td>1</td>
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<td>B</td>
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<tr>
<td></td>
<td>2</td>
<td>Last</td>
<td>A</td>
</tr>
</tbody>
</table>
Steps

1. Cable port pair 1a/2b on each controller to stack 1:
   This is the multipathed cabling for stack 1.
   a. Cable controller 1 port 1a to stack 1, first shelf IOM A port 1.
   b. Cable controller 2 port 1a to stack 1, first shelf IOM B port 1.
   c. Cable controller 1 port 2b to stack 1, last shelf IOM B port 3.
   d. Cable controller 2 port 2b to stack 1, last shelf IOM A port 3.

2. Cable port pair 2a/1d on each controller to stack 1:
   This is the quad-pathed cabling for stack 1. Once completed, stack 1 has quad-pathed connectivity to each controller.
   a. Cable controller 1 port 2a to stack 1, first shelf IOM A port 2.
   b. Cable controller 2 port 2a to stack 1, first shelf IOM B port 2.
   c. Cable controller 1 port 1d to stack 1, last shelf IOM B port 4.
   d. Cable controller 2 port 1d to stack 1, last shelf IOM A port 4.

3. Cable port pair 1c/2d on each controller to stack 2:
   This is the multipathed cabling for stack 2.
   a. Cable controller 1 port 1c to stack 2, first shelf IOM A port 1.
   b. Cable controller 2 port 1c to stack 2, first shelf IOM B port 1.
c. Cable controller 1 port 2d to stack 2, last shelf IOM B port 3.
d. Cable controller 2 port 2d to stack 2, last shelf IOM A port 3.

4. Cable port pair 2c/1b on each controller to stack 2:
This is the quad-pathed cabling for stack 2. Once completed, stack 2 has quad-pathed connectivity to each controller.

a. Cable controller 1 port 2c to stack 2, first shelf IOM A port 2.
b. Cable controller 2 port 2c to stack 2, first shelf IOM B port 2.
c. Cable controller 1 port 1b to stack 2, last shelf IOM B port 4.
d. Cable controller 2 port 1b to stack 2, last shelf IOM A port 4.
Recommended AC power line sizes

When installing your storage system, you must determine the AC power line lengths running from the storage system to the power source.

By properly designing longer AC power feeds, you can preserve voltage levels to the equipment. The longer power feeds—the wiring from the breaker panel to the power strip, which supplies power to the storage system and disk shelves—can often exceed 50 feet.

**Note:** Total AC wire length = breaker to wall or ceiling outlet + extension cable or ceiling drop.

The following tables list the recommended conductor size for 2 percent voltage drop for a particular distance measured in feet (taken from the Radio Engineer’s Handbook). The circuits in the following tables are described in American Wire Gauge (AWG) measurements:

<table>
<thead>
<tr>
<th>110V, single-phase</th>
<th>20A circuit</th>
<th>30A circuit</th>
<th>40A circuit</th>
<th>50A circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 feet</td>
<td>12 AWG</td>
<td>10 AWG</td>
<td>8 AWG</td>
<td>8 AWG</td>
</tr>
<tr>
<td>50 feet</td>
<td>8 AWG</td>
<td>6 AWG</td>
<td>6 AWG</td>
<td>4 AWG</td>
</tr>
<tr>
<td>75 feet</td>
<td>6 AWG</td>
<td>4 AWG</td>
<td>4 AWG</td>
<td>2 AWG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>220V, single-phase</th>
<th>20A circuit</th>
<th>30A circuit</th>
<th>40A circuit</th>
<th>50A circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 feet</td>
<td>14 AWG</td>
<td>12 AWG</td>
<td>12 AWG</td>
<td>10 AWG</td>
</tr>
<tr>
<td>50 feet</td>
<td>12 AWG</td>
<td>10 AWG</td>
<td>8 AWG</td>
<td>8 AWG</td>
</tr>
<tr>
<td>75 feet</td>
<td>10 AWG</td>
<td>8 AWG</td>
<td>6 AWG</td>
<td>6 AWG</td>
</tr>
</tbody>
</table>

The following table lists the approximate equivalent wire gauge (AWG to Harmonized Cordage).

<table>
<thead>
<tr>
<th>AWG</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonized, mm-mm</td>
<td>4.0</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>mm-mm = millimeter squared</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Document update record

When updates are made to this document, they are logged for your reference.

<table>
<thead>
<tr>
<th>Feature release date</th>
<th>Feature updates</th>
</tr>
</thead>
</table>
| May 2019             | • For DS460C disk shelves, information about using the detachable handles was added to the new system installation and hot-adding procedures.  
                          • FAS2700 system information added to the document. |
| August 2017          | • Added bullet items in the “Controller-to-stack connection rules” section under “Port pair connection rules (for non FAS2600 series configurations)”:  
                          ◦ You must include all SAS ports in your HA pair or single-controller configuration when defining port pairs.  
                          ◦ When you should use (cable) port pairs in the order in which you identified (listed) them and when you should skip port pairs.  
                          • Updated the “Controller-to-stack cabling worksheets and cabling examples for common multipath HA configurations” section to include examples for skipping port pairs.  
                          • Updated the “Controller-to-stack cabling worksheet template for multipathed connectivity” section to include an example for skipping port pairs.  
                          • Updated the “How to read a worksheet to cable controller-to-stack connections for multipathed connectivity” section to include an example for skipping port pairs.  
                          • Added a bullet item in the “Considerations for hot-adding disk shelves with IOM12 modules” stating that nondisruptive stack consolidation is not supported.  
                          • Updated the “Controller-to-stack connection rules” section to more concisely group port connection rules for non FAS2600 series configurations and FAS2600 series configurations.  
                          • Removed the “SAS disk shelf safety information” section. All safety information can be found in the “Safety Information and Regulatory Notices” document on the NetApp Support Site.  
                          • Updated headings for multipathed connectivity worksheets to specify “multipathed connectivity”. (Headings previously stated “using IOM ports 1 and 3”.) |
<table>
<thead>
<tr>
<th>Feature release date</th>
<th>Feature updates</th>
</tr>
</thead>
</table>
| January 2017        | • Updated content as needed to support the DS460C disk shelf:  
|                     |   ◦ Procedure for “Installing and cabling disk shelves with IOM12 modules for a new system installation” 
|                     |   ◦ Procedure for “Hot-adding disk shelves with IOM12 modules”  
|                     |   ◦ Title of this document: *Installation and Cabling Guide for DS460C, DS224C, and DS212C* 
|                     | **Note:** Although cabling illustrations show disk shelves with the IOM12 modules arranged side-by-side as in a DS224C or DS212C disk shelf, the illustrations can be applied to configurations with DS460C disk shelves.  
|                     | • Updated the “Considerations for installing and cabling disk shelves with IOM12 modules for a new system installation” section to explain that disk shelves are shipped with shelf IDs preset to 00, the exception to this rule, and how to identify boxes containing disk shelves with the root aggregates. 
|                     | • Updated the “Cabling disk shelves with IOM12 modules for a new system installation” section to include instructions for automatically assigning shelf IDs in an HA pair or single-controller configuration. 
|                     | • Updated the “Cabling disk shelves with IOM12 modules for a new system installation”, “Installing a disk shelf with IOM12 modules for a hot-add”, and “Changing the disk shelf ID” sections to state a valid shelf ID is 00-99 (00 is not reserved for the internal disk shelf of a FAS2600 series configuration). 
|                     | • Added the new “Controller-to-stack cabling worksheet template for quad-pathed connectivity” section. 
|                     | • Added the new “How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity” section. 
|                     | • Updated the “Controller-to-stack cabling worksheet template for multipathed connectivity” title and section to broaden the context to include cabling for an entire HA pair or single-controller configuration, or individual stacks. 
|                     | • Updated the “How to read a worksheet to cable controller-to-stack connections for multipathed connectivity” title and section to broaden the context to include cabling for an entire HA pair or single-controller configuration, or individual stacks. And to correct an erroneous port used in step 2c and step 2d. 
|                     | • Updated the “Requirements for hot-adding disk shelves with IOM12 modules” section to specify that only IOM12 connections to 6Gb SAS HBAs are negotiated down to 6Gbs. IOM12 connections to 12Gb SAS HBAs operate at 12Gbs and IOM12 connections to 6Gb SAS HBAs operate at 6Gbs.
<table>
<thead>
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<th>Feature release date</th>
<th>Feature updates</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2016</td>
<td>Initial release of the <em>Installation and Cabling Guide for DS224C and DS212C</em>.</td>
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