



# **Install and cable**

## **ONTAP Systems**

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# Install and cable

## Install and cable shelves for a new system installation - shelves with IOM12/IOM12B modules

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

### Requirements for installing and cabling disk shelves with IOM12/IOM12B modules for a new system installation

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

- You must have the installation and setup instructions for your platform model.

The installation and setup instructions address the complete procedure for your system installation, setup, and configuration. You only use this procedure (*Install and cable shelves for a new system installation*) in conjunction with the platform installation and setup instructions if you need detailed information about installing or cabling the disk shelves to your storage system.

Installation and setup instructions can be found by navigating to your platform model documentation.

[AFF and FAS System Documentation](#)

- 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 [Mini-SAS HD SAS optical cable rules](#).

### Considerations for installing and cabling disk shelves with IOM12/IOM12B 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/IOM12B modules are shipped with shelf IDs preset to 00.



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.

## **DS460C drive handling considerations**

- The drives are packaged separately from the shelf chassis.

You should take inventory of the drives along with the rest of the system equipment you received.

- After you unpack the drives, you should save the packaging materials for future use.



**Possible loss of data access:** If in the future, you move the shelf to a different part of the data center or transport the shelf to a different location, you need to remove the drives from the drive drawers to avoid possible damage to the drive drawers and drives.



Keep disk drives in their ESD bag until you are ready to install them.

- When handling the drives, always wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis to prevent static discharges.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling the disk drive.

## Install disk shelves with IOM12/IOM12B 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.

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.



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, although the drives are packaged separately, which makes the shelf lighter, an empty DS460C shelf still weighs approximately 132 lb (60kg); therefore, exercise the following caution when moving a shelf.



It is recommended that you use a mechanized lift or four people using the lift handles to safely move an empty DS460C shelf.

Your DS460C shipment was packaged with four detachable lift handles (two for each side). To use the lift handles, you install them by inserting the tabs of the handles into the slots in the side of the shelf and pushing up until they click into place. Then, as you slide the disk shelf onto the rails, you detach one set of handles at a time using the thumb latch. The following illustration shows how to attach a lift handle.



3. Reinstall any power supplies and IOMs you removed prior to installing your disk shelf into the rack.
4. If you are installing a DS460C disk shelf, install the drives into the drive drawers; otherwise, go to the next step.



Always wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis to prevent static discharges.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling the disk drive.

If you purchased a partially populated shelf, meaning that the shelf has less than the 60 drives it supports, for each drawer, install the drives as follows:

- Install the first four drives into the front slots (0, 3, 6, and 9).



**Risk of equipment malfunction:** To allow for proper air flow and prevent overheating, always install the first four drives into the front slots (0, 3, 6, and 9).

- For the remaining drives, evenly distribute them across each drawer.

The following illustration shows how the drives are numbered from 0 to 11 in each drive drawer within the shelf.



- a. Open the top drawer of the shelf.
- b. Remove a drive from its ESD bag.
- 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.



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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.



**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.
  - j. Attach the front bezel.
5. If you are adding multiple disk shelves, repeat this procedure for each disk shelf you are installing.



Do not power on the disk shelves at this time.

## Cable disk shelves with IOM12/IOM12B 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 [\[Requirements for installing and cabling disk shelves with IOM12 modules for a new system installation\]](#) 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 [shelf-to-shelf connection rules](#).

| If...   | Then...   |
|---|---|
| You are cabling a multipath HA, multipath, single-path HA, or single-path configuration | <p>Cable the shelf-to-shelf connections as “standard” connectivity (using IOM ports 3 and 1):</p> <ol style="list-style-type: none"> <li>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.</li> <li>Repeat substep a for IOM B.</li> <li>Repeat substeps a and b for each stack.</li> </ol>  |
| You are cabling a quad-path HA or quad-path configuration                               | <p>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.</p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>Repeat substeps a and b for IOM B.</li> <li>Repeat substeps a through c for each stack.</li> </ol> |

2. Identify the controller SAS port pairs that you can use to cable the controller-to-stack connections.
  - Check the controller-to-stack cabling worksheets and cabling examples to see whether a completed worksheet exists for your configuration.

[Controller-to-stack cabling worksheets and cabling examples for AFF and FAS platforms with onboard storage](#)

[Controller-to-stack cabling worksheets and cabling examples for common multipath HA configurations](#)

[Controller-to-stack cabling worksheet and cabling example for a quad-path HA configuration with two quad-port SAS HBAs](#)

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

| If...   | Then...  |
|---|--|
| There is a completed worksheet for your configuration | <p>Go to the next step.</p> <p>You use the existing completed worksheet.</p> |

| If...  | Then...   |
|--|---|
| There is no completed worksheet for your configuration | <p>Fill out the appropriate controller-to-stack cabling worksheet template:</p> <p><a href="#">Controller-to-stack cabling worksheet template for multipathed connectivity</a></p> <p><a href="#">Controller-to-stack cabling worksheet template for quad-pathed connectivity</a></p> |

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

If needed, instructions for how to read a worksheet to cable controller-to-stack connections are available:

[How to read a worksheet to cable controller-to-stack connections for multipathed connectivity](#)

[How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity](#)

4. Connect the power supplies for each disk shelf:

- 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.
- 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 applicable systems.

| If...                              | Then...   |
|------------------------------------|---|
| You are manually setting shelf IDs | <ol style="list-style-type: none"> <li>Access the shelf ID button behind the left end cap.</li> <li>Change the shelf ID to a unique ID (00 through 99).</li> <li>Power-cycle the disk shelf to make the shelf ID take effect. <p>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.</p> </li> <li>Power on the controllers and complete system setup and configuration as instructed by the installation and setup instructions for your platform model.</li> </ol> |

| If...  | Then...   |
|--|---|
| <p>You are automatically assigning all shelf IDs in your HA pair or single-controller configuration</p> <div>  <p>Shelf IDs are assigned in sequential order from 00-99. For systems with an internal disk shelf, shelf ID assignment begins with the internal disk shelf.</p> </div> | <ol style="list-style-type: none"> <li>Power on the controllers.</li> <li>As the controllers start booting, press <code>Ctrl-C</code> to abort the AUTOBOOT process when you see the message <code>Starting AUTOBOOT press Ctrl-C to abort.</code> <div>  <p>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 <code>boot_ontap</code> menu at their LOADER prompt.</p> </div> </li> <li>Boot one controller to Maintenance mode:<code>boot_ontap</code> menu <p>You only need to assign shelf IDs on one controller.</p> </li> <li>From the boot menu, select option 5 for Maintenance mode.</li> <li>Automatically assign shelf IDs: <code>sasadmin expander_set_shelf_id -a</code></li> <li>Exit Maintenance mode:<code>halt</code></li> <li>Bring up the system by entering the following command at the LOADER prompt of both controllers:<code>boot_ontap</code> <p>Shelf IDs appear in disk shelf digital display windows.</p> <div>  <p>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.</p> </div> </li> <li>Complete system setup and configuration as instructed by the installation and setup instructions for your platform model.</li> </ol> |

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:

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

7. Download and run Config Advisor as instructed by the installation and setup instructions for your platform model 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.

## Move or transport DS460C shelves

If in the future, you move DS460C shelves to a different part of the data center or transport the shelves to a different location, you need to remove the drives from the drive drawers to avoid possible damage to the drive drawers and drives.

- If when you installed DS460C shelves as part of your new system installation, you saved the drive packaging materials, use these to repackage the drives before moving them.

If you did not save the packaging materials, you should place drives on cushioned surfaces or use alternate cushioned packaging. Never stack drives on top of each other.

- Before handling drives, wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling a drive.

- You should take steps to handle drives carefully:
  - Always use two hands when removing, installing, or carrying a drive to support its weight.



Do not place hands on the drive boards exposed on the underside of the drive carrier.

- Be careful not to bump drives against other surfaces.
- Drives should be kept away from magnetic devices.



Magnetic fields can destroy all data on a drive and cause irreparable damage to the drive circuitry.

## Hot-add a shelf - shelves with IOM12/IOM12B modules

You can hot-add one or more disk shelves with IOM12/IOM12B modules to an existing stack of disk shelves with IOM12/IOM12B modules or hot-add a stack of one or more disk

shelves with IOM12/IOM12B modules directly to a SAS HBA or an onboard SAS port on the controller.

### About this task

You cannot use this procedure to mix a stack: hot-add a shelf with IOM12/IOM12B modules to a stack of shelves that has IOM6 modules. If you need to mix a stack, use [Hot-add IOM12 shelves to a stack of IOM6 shelves](#).

## Requirements for hot-adding disk shelves with IOM12/IOM12B modules

Your system must meet certain requirements before hot-adding disk shelves with IOM12/IOM12B 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.



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.

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

You must correct any cabling errors using the corrective actions provided by the error messages.

[NetApp Downloads: Config Advisor](#)

### 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 [Mini-SAS HD SAS optical cable rules](#).
- 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 [Mini-SAS HD SAS optical cable rules](#). 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/IOM12B 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/IOM12B modules to an existing stack (of disk shelves with IOM12/IOM12B modules), you can hot-add the disk shelf to either end—the logical first or last disk shelf—of the stack.

For single-path HA and single-path configurations, as applicable to AFF A200, AFF A220, FAS2600 series, and FAS2700 systems, you hot-add disk shelves to the end of the stack that does not have controller connections.

- Disk shelves with IOM12/IOM12B modules must be in their own unique stack; they cannot be added to a stack that has shelves with IOM6 modules or IOM3 modules.

This procedure does not address mixing a stack: hot-adding a shelf with IOM12/IOM12B modules to a stack of shelves with IOM6 modules.

- A system can have multipathed and quad-pathed stacks of disk shelves with IOM12/IOM12B 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 snapshot 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 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.

### DS460C drive handling considerations

- The drives are packaged separately from the shelf chassis.

You should take inventory of the drives.

- After you unpack the drives, you should save the packaging materials for future use.



**Possible loss of data access:** If in the future, you move the shelf to a different part of the data center or transport the shelf to a different location, you need to remove the drives from the drive drawers to avoid possible damage to the drive drawers and drives.



Keep disk drives in their ESD bag until you are ready to install them.

- When handling the drives, always wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis to prevent static discharges.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling the disk drive.

## Installing disk shelves with IOM12/IOM12B 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.



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, although the drives are packaged separately, which makes the shelf lighter, an empty DS460C shelf still weighs approximately 132 lb (60kg); therefore, exercise the following caution when moving a shelf.



It is recommended that you use a mechanized lift or four people using the lift handles to safely move an empty DS460C shelf.

Your DS460C shipment was packaged with four detachable lift handles (two for each side). To use the lift handles, you install them by inserting the tabs of the handles into the slots in the side of the shelf and pushing up until they click into place. Then, as you slide the disk shelf onto the rails, you detach one set of handles at a time using the thumb latch. The following illustration shows how to attach a lift handle.





3. Reinstall any power supplies and IOMs you removed prior to installing your disk shelf into the rack.
4. If you are installing a DS460C disk shelf, install the drives into the drive drawers; otherwise, go to the next step.



Always wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis to prevent static discharges.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling the disk drive.

If you purchased a partially populated shelf, meaning that the shelf has less than the 60 drives it supports, for each drawer, install the drives as follows:

- Install the first four drives into the front slots (0, 3, 6, and 9).



**Risk of equipment malfunction:** To allow for proper air flow and prevent overheating, always install the first four drives into the front slots (0, 3, 6, and 9).

- For the remaining drives, evenly distribute them across each drawer.

The following illustration shows how the drives are numbered from 0 to 11 in each drive drawer within the shelf.



- a. Open the top drawer of the shelf.
- b. Remove a drive from its ESD bag.
- 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.



1

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.



**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.
  - j. Attach the front bezel.
5. If you are adding multiple disk shelves, repeat the previous steps for each disk shelf you are installing.
  6. 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.
  7. 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 platform model with an internal disk shelf, 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 [Change a shelf ID](#).

- 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/IOM12B 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 [\[Requirements for hot-adding disk shelves with IOM12 modules\]](#) and installed, powered on, and set shelf IDs for each disk shelf as instructed in [\[Installing disk shelves with IOM12 modules for a hot-add\]](#).

### About this task

- For an explanation and examples of shelf-to-shelf “standard” cabling and shelf-to-shelf “double-wide” cabling, see [Shelf-to-shelf SAS connection rules](#).
- For instructions about how to read a worksheet to cable controller-to-stack connections, see [How to read a worksheet to cable controller-to-stack connections for multipathed connectivity](#) or [How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity](#).
- 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.



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:`storage disk option`

```
modify -node _node_name -autoassign off
```

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.

| If...  | Then...   |
|--|---|
| You are cabling a stack with multipath HA, multipath, single-path HA, or single-path connectivity to the controllers | <p>Cable the shelf-to-shelf connections as “standard” connectivity (using IOM ports 3 and 1):</p> <ol style="list-style-type: none"><li>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.</li><li>ii. Repeat substep i for IOM B.</li></ol>   |
| You are cabling a stack with quad-path HA or quad-path connectivity to the controllers                               | <p>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.</p> <ol style="list-style-type: none"><li>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.</li><li>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.</li><li>iii. Repeat substeps i and ii for IOM B.</li></ol> |

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

[Controller-to-stack cabling worksheets and cabling examples for AFF and FAS platforms with onboard storage](#)

[Controller-to-stack cabling worksheets and cabling examples for common multipath HA configurations](#)

[Controller-to-stack cabling worksheet and cabling example for a quad-path HA configuration with two quad-port SAS HBAs](#)

- 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 the appropriate worksheet template, and then cable the controller-to-stack connections using the completed worksheet.

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.



Make sure that you wait at least 70 seconds between disconnecting a cable and reconnecting it, and if you are replacing a cable for a longer one.

| If you are...   | Then...  |
|---|--|
| 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   | <p>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.</p> <p>Leave the other end of these cables connected to the controllers, or replace cables with longer cables if needed.</p> <p>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.</p> <p>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.</p> <p>d. Verify that all cables are securely fastened.</p> <p>e. Repeat substeps a through d for IOM B; otherwise, go to Step 4.</p> |
| <p>Hot-adding a disk shelf to an end of the stack in a single-path HA or single-path configuration, as applicable to AFF A200, AFF A220, FAS2600 series and FAS2700 systems.</p> <p>These instructions are for hot-adding to the end of the stack that does not have controller-to-stack connections.</p> | <p>a. Cable the shelf-to-shelf connection between IOM A of the disk shelf in the stack and IOM A of the disk shelf you are hot-adding.</p> <p>b. Verify that the cable is securely fastened.</p> <p>c. Repeat applicable substeps for IOM B.</p>   |

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.

Replace cables one at a time and make sure that you wait at least 70 seconds between disconnecting a cable and connecting a new one.

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

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:

| Controller<br>Switch Port | Initiator<br>Target Port | Initiator Side<br>TPGN | Switch Port | Target Side |
|---------------------------|--------------------------|------------------------|-------------|-------------|
| -----                     | -----                    | -----                  | -----       | -----       |
| stor-8080-1               | 1a                       | -                      |             | -           |
| -                         | -                        |                        |             |             |
| stor-8080-1               | 0d                       | -                      |             | -           |
| -                         | -                        |                        |             |             |
| stor-8080-2               | 1a                       | -                      |             | -           |
| -                         | -                        |                        |             |             |
| stor-8080-2               | 0d                       | -                      |             | -           |
| -                         | -                        |                        |             |             |

Errors:

```

-----
-

```

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 reenale 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.

## Move or transport DS460C shelves

If in the future, you move DS460C shelves to a different part of the data center or transport the shelves to a different location, you need to remove the drives from the drive drawers to avoid possible damage to the drive drawers and drives.

- If when you installed DS460C shelves as part of your shelf hot-add, you saved the drive packaging materials, use these to repackage the drives before moving them.

If you did not save the packaging materials, you should place drives on cushioned surfaces or use alternate cushioned packaging. Never stack drives on top of each other.

- Before handling drives, wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling a drive.

- You should take steps to handle drives carefully:
  - Always use two hands when removing, installing, or carrying a drive to support its weight.



Do not place hands on the drive boards exposed on the underside of the drive carrier.

- Be careful not to bump drives against other surfaces.
- Drives should be kept away from magnetic devices.



Magnetic fields can destroy all data on a drive and cause irreparable damage to the drive circuitry.

## Hot-add IOM12/IOM12B shelves to a stack of IOM6 shelves

When additional storage is needed, you can hot-add IOM12/IOM12B shelves (SAS



shelves with IOM12/IOM12B modules) to a stack of IOM6 shelves (SAS shelves with IOM6 modules), meaning you can mix a stack.

## Requirements for a hot-add

Your HA pair, single-controller or stretch MetroCluster configuration (system) must meet certain requirements before hot-adding IOM12/IOM12B shelves to a stack of IOM6 shelves.



For bridge-attached MetroCluster configurations, see [Requirements for a hot-add in bridge-attached MetroCluster configurations](#).

- Your system and version of ONTAP must support a mix of IOM6 shelves and IOM12/IOM12B shelves in the same stack (a mixed stack).

You can verify support by using one of the following methods:

- Enter the `run local sysconfig` command, at the admin prompt of either controller.

If the SAS2/SAS3 Mixed Stack Support field does not appear in the output or has a value of none, then your system does not support mixed stacks.

If anything else appears in the SAS2/SAS3 Mixed Stack Support field, such as all or bridge-attached, then your system does support mixed stacks.

- Go to Hardware Universe and navigate to your platform information.

[NetApp Hardware Universe](#)

- If you are adding a shelf to a MetroCluster configuration, the configuration must meet all requirements in the MetroCluster Installation and Configuration Guides.

[MetroCluster IP Installation and Configuration Guide](#)

[ONTAP 9 Stretch MetroCluster Installation and Configuration Guide](#)

[ONTAP 9 Fabric-attached MetroCluster Installation and Configuration Guide](#)

- The stack of IOM6 shelves, to which you are hot-adding an IOM12 shelf, must be cabled with SAS copper cables (for all shelf-to-shelf and controller-to-stack connections).

SAS optical cables are not supported in a mixed stack.



If the IOM6 shelf stack is cabled with any SAS optical cables, you cannot hot-add an IOM12 shelf. Contact your NetApp sales representative.

- Your system must have less than the maximum number of drives supported, by at least the number of drives capable of being installed in the IOM12 shelves you are hot-adding.

You cannot have exceeded the maximum number of drives supported for your system after hot-adding IOM12/IOM12B shelves.

[NetApp Hardware Universe](#)

- Your system cannot have any SAS cabling error messages.

You must correct any cabling errors using the corrective actions provided by the error messages.

[NetApp Downloads: Config Advisor](#)

- You must have ordered and received the IOM12/IOM12B shelves and appropriate number and types of SAS copper cables.

IOM12 shelves use mini-SAS HD connectors. IOM6 shelves use QSFP connectors.

## Requirements for a hot-add in bridge-attached MetroCluster configurations

If you are hot-adding IOM12/IOM12B shelves to a stack of IOM6 shelves that is attached using a pair of ATTO FibreBridge bridges in a MetroCluster configuration, the system must meet certain requirements.

- If bridge SAS ports are available in the current configuration, you should add the IOM12 shelves as a separate stack.

Use all bridge ports before mixing IOM12/IOM12B and IOM6 modules in a stack.

- Your system and version of ONTAP must support a mix of IOM6 shelves and IOM12/IOM12B shelves in the same stack (a mixed stack).

You can verify support by using one of the following methods:

- Enter the `run local sysconfig` command at the admin prompt of either controller.

If the SAS2/SAS3 Mixed Stack Support field does not appear in the output or has a value of none, then your system does not support mixed stacks.

If anything else appears in the SAS2/SAS3 Mixed Stack Support field, such as all or bridge-attached, then your system does support mixed stacks.

- Go to Hardware Universe and navigate to your platform information.

[NetApp Hardware Universe](#)

- The configuration must meet all requirements in the MetroCluster Installation and Configuration Guides.

[Installing and Configuring a Stretch MetroCluster Configuration](#)

[Installing and Configuring a fabric-attached MetroCluster Configuration](#)

- The stack of IOM6 shelves, to which you are hot-adding an IOM12/IOM12B shelf, must be cabled with SAS copper cables (for all shelf-to-shelf and controller-to-stack connections).

SAS optical cables are not supported in a mixed stack.



If the IOM6 shelf stack is cabled with any SAS optical cables, you cannot hot-add an IOM12/IOM12B shelf. Contact your NetApp sales representative.

- Your configuration must have less than the maximum number of drives supported for a bridge port.
- You must have ordered and received the IOM12/IOM12B shelves and appropriate number and types of SAS copper cables.

IOM12/IOM12B shelves use mini-SAS HD connectors. IOM6 shelves use QSFP connectors.

- The bridge must be running firmware version 3.16/4.16 and later.

## Considerations for a hot-add

You should familiarize yourself with aspects and best practices about this procedure before hot-adding IOM12/IOM12B shelves to a stack of IOM6 shelves.

### General considerations

- It is highly recommended that the IOM12/IOM12B shelves you are hot-adding are running firmware version 0260 or later, before you cable them to your system.

Having a supported version of shelf firmware protects against storage stack access issues if you cabled the hot-added shelf to the stack incorrectly.

After you download the IOM12/IOM12B shelf firmware to your shelves, verify the firmware version is 0260 or later by entering the `storage shelf show -module` command at the console of either controller.

- 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).

- You can use this procedure to hot-add disk shelves that were hot-removed within the same MetroCluster system if the affected shelf has mirrored aggregates.
- After you have cabled a hot-added shelf, ONTAP recognizes the shelf:
  - Drive ownership is assigned if automatic drive assignment is enabled.
  - Shelf (IOM) firmware and drive firmware should be updated automatically, if needed.



Firmware updates can take up to 30 minutes.

### Best practice considerations

- **Best practice:** The best practice is to have current versions of shelf (IOM) firmware and drive firmware on your system before hot-adding a shelf.

[NetApp Downloads: Disk Shelf Firmware](#)

[NetApp Downloads: Disk Drive Firmware](#)



Do not revert firmware to a version that does not support your shelf and its components.

- **Best practice:** The best practice is to have the current version of the Disk Qualification Package (DQP) installed before hot-adding a shelf.

Having the current version of the DQP installed allows your system to recognize and use newly qualified drives. This avoids system event messages about having noncurrent drive information and prevention of drive partitioning because drives are not recognized. The DQP also notifies you of noncurrent drive firmware.

#### [NetApp Downloads: Disk Qualification Package](#)

- **Best practice:** The best practice is to run Active IQ Config Advisor before and after hot-adding a shelf.

Running Active IQ Config Advisor before hot-adding a shelf provides a snapshot of the existing SAS connectivity, verifies shelf (IOM) firmware versions, and allows you to verify a shelf ID already in use on your system. Running Active IQ Config Advisor after hot-adding a shelf allows you to verify shelves are cabled correctly and that shelf IDs are unique within your system.

#### [NetApp Downloads: Config Advisor](#)

- **Best practice:** The best practice is to have in-band ACP (IBACP) running on your system.
  - For systems in which IBAP is running, IBACP is automatically enabled on hot-added IOM12 shelves.
  - For systems in which out-of-band ACP is enabled, ACP capabilities are not available on IOM12 shelves.

You should migrate to IBACP and remove the out-of-band ACP cabling.

- If your system is not running IBACP, and your system meets the requirements for IBACP, you can migrate your system to IBACP before hot-adding an IOM12 shelf.

#### [Instructions for migrating to IBACP](#)



The migration instructions provide the system requirements for IBACP.

## Prepare to manually assign drive ownership for a hot-add

If you are manually assigning drive ownership for the IOM12 shelves you are hot-adding, then you need to disable automatic drive assignment if it is enabled.

### Before you begin

You must have met the system requirements.

#### [Requirements for a hot-add](#)

#### [Requirements for a hot-add in bridge-attached MetroCluster configurations](#)

### About this task

If you have an HA pair, you need to manually assign drive ownership if drives in the shelf will be owned by both controller modules.

### Steps

1. Verify whether automatic drive assignment is enabled: `storage disk option show`

If you have an HA pair, you can enter the command on either controller module.

If automatic drive assignment is enabled, the output shows `on` in the “Auto Assign” column (for each

controller module).

2. If automatic drive assignment is enabled, disable it: `storage disk option modify -node node_name -autoassign off`

If you have an HA pair or two-node MetroCluster configuration, you must disable automatic drive assignment on both controller modules.

## Install shelves for a hot-add

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

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.



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, although the drives are packaged separately, which makes the shelf lighter, an empty DS460C shelf still weighs approximately 132 lb (60kg); therefore, exercise the following caution when moving a shelf.



It is recommended that you use a mechanized lift or four people using the lift handles to safely move an empty DS460C shelf.

Your DS460C shipment was packaged with four detachable lift handles (two for each side). To use the lift handles, you install them by inserting the tabs of the handles into the slots in the side of the shelf and pushing up until they click into place. Then, as you slide the disk shelf onto the rails, you detach one set of handles at a time using the thumb latch. The following illustration shows how to attach a lift handle.



3. Reinstall any power supplies and IOMs you removed prior to installing your disk shelf into the rack.
4. If you are installing a DS460C disk shelf, install the drives into the drive drawers; otherwise, go to the next step.



Always wear an ESD wrist strap grounded to an unpainted surface on your storage enclosure chassis to prevent static discharges.

If a wrist strap is unavailable, touch an unpainted surface on your storage enclosure chassis before handling the disk drive.

If you purchased a partially populated shelf, meaning that the shelf has less than the 60 drives it supports, for each drawer, install the drives as follows:

- Install the first four drives into the front slots (0, 3, 6, and 9).



**Risk of equipment malfunction:** To allow for proper air flow and prevent overheating, always install the first four drives into the front slots (0, 3, 6, and 9).

- For the remaining drives, evenly distribute them across each drawer.

The following illustration shows how the drives are numbered from 0 to 11 in each drive drawer within the shelf.



- a. Open the top drawer of the shelf.
- b. Remove a drive from its ESD bag.
- 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.



1

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.





**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.
- j. Attach the front bezel.
  - 1. If you are adding multiple disk shelves, repeat the previous steps for each disk shelf you are installing.
  - 2. Connect the power supplies for each disk shelf:
- k. 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.
- l. Turn on the power supplies for each disk shelf and wait for the disk drives to spin up.
  - 1. Set the shelf ID for each shelf you are hot-adding to an ID that is unique within the HA pair or single-controller configuration.

A valid shelf ID is 00 through 99. It is recommended that you set the shelf IDs so that IOM6 shelves use lower numbers (1 - 9) and IOM12 shelves use higher numbers (10 and greater).

If you have a platform model with onboard storage, shelf IDs must be unique across the internal shelf and externally attached shelves. It is recommended that you set the internal shelf to 0. In MetroCluster IP configurations, only the external shelf names apply, and therefore the shelf names do not need to be unique.

- m. If needed, verify shelf IDs already in use by running Active IQ Config Advisor.

#### [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.

- n. Access the shelf ID button behind the left end cap.
- o. 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.
- p. Press the button to advance the number until you reach the desired number.
- q. Repeat substeps c and d for the second number.
- r. Exit the programming mode by pressing and holding the button until the second number stops blinking, which can take up to three seconds.

- s. Power cycle the shelf to make the shelf ID take effect.

You must turn off both power switches, wait 10 seconds, and then turn them back on to complete the power cycle.

- t. Repeat substeps b through g for each shelf you are hot-adding.

## Cable shelves for a hot-add

How you cable an IOM12/IOM12B shelf to a stack of IOM6 shelves depends on whether the IOM12 shelf is the initial IOM12/IOM12B shelf, meaning no other IOM12 shelf exists in the stack, or whether it is an additional IOM12/IOM12B shelf to an existing mixed stack, meaning one or more IOM12/IOM12B shelves already exists in the stack. It also depends on whether the stack has multipath HA, multipath, single-path HA, or single-path connectivity.

### Before you begin

- You must have met the system requirements.

[Requirements for a hot-add](#)

- You must have completed the preparation procedure, if applicable.

[Prepare to manually assign drive ownership for a hot-add](#)

- You must have installed the shelves, powered them on, and set the shelf IDs.

[Install shelves for a hot-add](#)

### About this task

- You always hot-add IOM12/IOM12B shelves to the logical last shelf in a stack to maintain a single speed transition within the stack.

By hot-adding IOM12/IOM12B shelves to the logical last shelf in a stack, the IOM6 shelves remain grouped together and the IOM12/IOM12B shelves remain grouped together so that there is a single speed transition between the two groups of shelves.

For example:

- In an HA pair, a single speed transition within a stack having two IOM6 shelves and two IOM12/IOM12B shelves is depicted as:

```
Controller <-> IOM6 <-> IOM6 <---> IOM12IOM12B <-> IOM12/IOM12B <->
Controller
```

- In an HA pair with onboard IOM12E storage, a single speed transition within a stack having two IOM12 shelves and two IOM6 shelves is depicted as:

```
IOM12E 0b <-> IOM12/IOM12B <-> IOM12/IOM12B <---> IOM6 <-> IOM6 <->
IOM12E 0a
```

The onboard storage port 0b is the port from the internal storage (expander) and because it connects to the hot-added IOM12/IOM12B shelf (the last shelf in the stack), the group of IOM12/IOM12B shelves is kept together and a single transition is maintained through the stack and onboard IOM12E storage.

- Only a single speed transition is supported in a mixed stack. You cannot have additional speed transitions. For example, you cannot have two speed transitions within a stack, which is depicted as:

```
Controller <-> IOM6 <-> IOM6 <---> IOM12/IOM12B <-> IOM12/IOM12B <--->
IOM6 <-> Controller
```

- You can hot-add IOM6 shelves to a mixed stack. However, you must hot-add them to the side of the stack with the IOM6 shelves (existing group of IOM6 shelves) in order to maintain the single speed transition in the stack.
- You cable IOM12/IOM12B shelves by connecting the SAS ports on the IOM A path first, and then repeat the cabling steps for the IOM B path, as applicable to your stack connectivity.



In a MetroCluster configuration, you cannot use the IOM B path.

- The initial IOM12/IOM12B shelf (the IOM12 shelf connecting to the logical last IOM6 shelf) always connects to the IOM6 shelf circle ports (not square ports).
- The SAS cable connectors are keyed; when oriented correctly into a SAS port, the connector clicks into place.

For 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.

- You can reference the following illustration for cabling IOM12/IOM12B shelves to an IOM6 shelf stack in a configuration that is not using FC-to-SAS bridges.

This illustration is specific to a stack with multipath HA connectivity; however, the cabling concept can be applied to stacks with multipath, single-path HA, single-path connectivity, and stretch MetroCluster configurations.

## Hot-adding IOM12 shelves to an IOM6 shelf stack



- You can reference the following illustration for cabling IOM12/IOM12B shelves to an IOM6 shelf stack in a bridge-attached MetroCluster configuration.

## Hot-adding IOM12 shelves to an IOM6 shelf stack in a bridge-attached configuration



### Steps

1. Physically identify the logical last shelf in the stack.

Depending on your platform model and stack connectivity (multipath HA, multipath, single-path HA, or single-path), the logical last shelf is the shelf having controller-to-stack connections from controller SAS ports B and D, or it is the shelf having no connections to any controllers (because the controller-to-stack connectivity is to the logical top of the stack, through the controller SAS ports A and C).

2. If the IOM12/IOM12B shelf you are hot-adding is the initial IOM12/IOM12B shelf being added to the IOM6 stack, meaning no other IOM12/IOM12B shelf exists in the IOM6 shelf stack, complete the applicable substeps.



Make sure that you wait at least 70 seconds between disconnecting a cable and reconnecting it, and when you are replacing a cable for another one.

Otherwise, go to step 3.

| If your IOM6 stack connectivity is...  | Then...  |
|--|--|
| <p>Multipath HA or multipath, or single-path HA with controller connectivity to the logical last shelf (including stretch MetroCluster configurations)</p> | <ol style="list-style-type: none"> <li>a. Disconnect the controller-to-stack cable from the last IOM6 shelf IOM A circle port to the controller or bridge.<br/><br/> <p>Make note of the controller port.</p> <p>Put the cable aside. It is no longer needed.</p> <p>Otherwise; go to substep e.</p> </li> <li>b. Cable the shelf-to-shelf connection between the last IOM6 shelf IOM A circle port (from substep a) to the new IOM12/IOM12B shelf IOM A port 1.<br/><br/> <p>Use a SAS copper QSFP-to-Mini-SAS HD cable.</p> </li> <li>c. If you are hot-adding another IOM12/IOM12B shelf, cable the shelf-to-shelf connection between the IOM12/IOM12B shelf IOM A port 3, of the shelf you just cabled, and the next IOM12/IOM12B shelf IOM A port 1.<br/><br/> <p>Use a SAS copper Mini-SAS HD-to-Mini-SAS HD cable.</p> <p>Otherwise, go to the next substep.</p> </li> <li>d. Reestablish the controller-to-stack connection by cabling the same port on the controller or bridge (in substep a) to the new last IOM12 shelf IOM A port 3.<br/><br/> <p>Use a SAS copper QSFP-to-Mini-SAS HD cable or Mini-SAS HD-to-Mini-SAS HD cable, as appropriate for the port type on the controller.</p> </li> <li>e. Repeat substeps a through d for IOM B.<br/><br/> <p>Otherwise, go to step 4.</p> </li> </ol> |

| If your IOM6 stack connectivity is...                        | Then...   |
|--|---|
| Bridge-attached connectivity in a MetroCluster configuration | <p>a. Disconnect the bottom bridge-to-stack cable from the last IOM6 shelf IOM A circle port to the bridge.</p> <p>Make note of the bridge port.</p> <p>Put the cable aside. It is no longer needed.</p> <p>Otherwise; go to substep e.</p> <p>b. Cable the shelf-to-shelf connection between the last IOM6 shelf IOM A circle port (from substep a) to the new IOM12 shelf IOM A port 1.</p> <p>Use a SAS copper QSFP-to-Mini-SAS HD cable.</p> <p>c. If you are hot-adding another IOM12/IOM12B shelf, cable the shelf-to-shelf connection between the IOM12/IOM12B shelf IOM A port 3, of the shelf you just cabled, and the next IOM12/IOM12B shelf IOM A port 1.</p> <p>Use a SAS copper Mini-SAS HD-to-Mini-SAS HD cable.</p> <p>Otherwise, go to the next substep.</p> <p>d. Repeat substeps b and c to cable the shelf-to-shelf connections for IOM B.</p> <p>e. Reestablish the bottom bridge-to-stack connection by cabling the same port on the bridge (in substep a) to the new last IOM12 shelf IOM A port 3.</p> <p>Use a SAS copper QSFP-to-Mini-SAS HD cable or Mini-SAS HD-to-Mini-SAS HD cable, as appropriate for the port type on the controller.</p> <p>f. Go to step 4.</p> |

| If your IOM6 stack connectivity is...   | Then...  |
|---|--|
| Single-path HA or single-path with no controller connectivity to the logical last shelf | <p>a. Cable the shelf-to-shelf connection between the last IOM6 shelf IOM A circle port and the new IOM12/IOM12B shelf IOM A port 1.</p> <p>Use a SAS copper QSFP-to-Mini-SAS HD cable.</p> <p>b. Repeat the above substep for IOM B.</p> <p>c. If you are hot-adding another IOM12/IOM12B shelf, repeat substeps a and b.</p> <p>Otherwise, go to step 4.</p> |

3. If the IOM12/IOM12B shelf you are hot-adding is an additional IOM12/IOM12B shelf to an existing mixed stack, meaning one or more IOM12/IOM12B shelves already exists in the stack, complete the applicable substeps.



Make sure that you wait at least 70 seconds between disconnecting a cable and reconnecting it, and if you are replacing a cable for a longer one.



| If your mixed stack connectivity is...  | Then...  |
|---|--|
| <p>Multipath HA or multipath, or single-path HA with controller connectivity to the logical last shelf, or bridge-attached connectivity in a MetroCluster configuration</p> | <ol style="list-style-type: none"> <li>Move the controller-to-stack cable from the last IOM12/IOM12B shelf IOM A port 3 to the same port on the new last IOM12/IOM12B shelf.</li> <li>If you are hot-adding one IOM12/IOM12B shelf, cable the shelf-to-shelf connection between the old last IOM12/IOM12B shelf IOM A port 3 to the new last IOM12/IOM12B shelf IOM A port 1.<br/><br/>Use a SAS copper Mini-SAS HD-to-Mini-SAS HD cable.<br/><br/>Otherwise, go to the next substep.</li> <li>If you are hot-adding more than one IOM12/IOM12B shelf, cable the shelf-to-shelf connection between the old last IOM12/IOM12B shelf IOM A port 3 and the next IOM12/IOM12B shelf IOM A port 1, and then repeat this for any additional IOM12/IOM12B shelves.<br/><br/>Use additional SAS copper Mini-SAS HD-to-Mini-SAS HD cables.<br/><br/>Otherwise, go to the next substep.</li> <li>Repeat substeps a through c for IOM B.<br/><br/>Otherwise, go to step 4.</li> </ol> |
| <p>Bridge-attached connectivity in a MetroCluster configuration</p>   | <ol style="list-style-type: none"> <li>Move the bottom bridge-to-stack cable from the old last IOM12/IOM12B shelf to the same port on the new last IOM12/IOM12B shelf.</li> <li>Cable the shelf-to-shelf connection between the old last IOM12/IOM12B shelf IOM A port 3 and the next IOM12/IOM12B shelf IOM A port 1, and then repeat this for any additional IOM12/IOM12B shelves.<br/><br/>Use a SAS copper Mini-SAS HD-to-Mini-SAS HD cable.</li> <li>Cable the shelf-to-shelf connection between the old last IOM12/IOM12B shelf IOM B port 3 and the next IOM12/IOM12B shelf IOM B port 1, and then repeat this for any additional IOM12/IOM12B shelves.</li> <li>Go to step 4.</li> </ol>   |

| If your mixed stack connectivity is...  | Then...   |
|---|---|
| Single-path HA or single-path with no controller connectivity to the logical last shelf | <p>a. Cable the shelf-to-shelf connection between the last IOM12/IOM12B shelf IOM A port 3 and the new last IOM12/IOM12B shelf IOM A port 1.</p> <p>Use a SAS copper Mini-SAS HD-to-Mini-SAS HD cable.</p> <p>b. Repeat the above substep for IOM B.</p> <p>c. If you are hot-adding another IOM12/IOM12B shelf, repeat substeps a and b.</p> <p>Otherwise, go to step 4.</p> |

4. Verify that the SAS connections are cabled correctly.

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

[NetApp Downloads: Config Advisor](#)

5. If you disabled automatic drive assignment as part of the preparation for this procedure, you need to manually assign drive ownership and then re-enable automatic drive assignment, if needed.

Otherwise, you are done with this procedure.

[Complete the hot-add](#)



All MetroCluster configurations require manual drive assignment.

## Complete the hot-add

If you disabled automatic drive assignment as part of the preparation for hot-adding the IOM12/IOM12B shelves to the stack of IOM6 shelves, you need to manually assign drive ownership and then reenable automatic drive assignment if needed.

### Before you begin

You must have already cabled your shelf as instructed for your system.

[Cable shelves for a hot-add](#)

### Steps

1. Display all unowned drives: `storage disk show -container-type unassigned`

If you have an HA pair, you can enter the command on either controller module.

2. Assign each drive: `storage disk assign -disk disk_name -owner owner_name`

If you have an HA pair, you can enter the command on either controller module.

You can use the wild card character to assign more than one drive at once.

3. Reenable automatic drive assignment if needed: `storage disk option modify -node node_name -autoassign on`

If you have an HA pair, you must reenable automatic drive assignment on both controller modules.

## Change a shelf ID - shelves with IOM12/IOM12B modules

You can change a shelf ID in a system when ONTAP is not yet running or when hot-adding a shelf prior to it being cabled to the system. You can also change a shelf ID when ONTAP is up and running (controller modules are available to serve data) and all drives in the shelf are unowned, spares, or part of offlined aggregate(s).

### Before you begin

- If ONTAP is up and running (controller modules are available to serve data), you must have verified that all drives in the shelf are unowned, spares, or part of offlined aggregate(s).

You can verify the state of the drives by using the `storage disk show -shelf shelf_number` command. Output in the Container Type column should display spare or broken if it is a failed drive. Additionally, the Container Name and Owner columns should have a dash.

- You can verify shelf IDs already in use in your system by running Active IQ 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.

- You must power cycle a shelf in order for the shelf ID to take effect.

The amount of time you wait before turning the power back on depends on the state of ONTAP, as described later in this procedure.

### 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.



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.

You must turn off both power switches, wait the appropriate amount of time, and then turn them back on to complete the power cycle.

- If ONTAP is not yet running or you are hot-adding a shelf (that has not yet been cabled to the system), wait at least 10 seconds.
- If ONTAP is running (controllers are available to serve data), and all disk drives in the shelf are unowned, spares, or part of offlined aggregate(s), wait at least 70 seconds.

This time allows ONTAP to properly delete the old shelf address and update the copy of the new shelf address.

9. Replace the left end cap.
10. Repeat steps 1 through 9 for each additional disk shelf.
11. 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 Active IQ 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.

## SAS cabling rules, worksheets, and examples

### SAS cabling rules, worksheets, and examples overview - shelves with IOM12/IOM12B modules

To help you cable your SAS drive shelves with IOM12/IOM12B modules to your storage system, you can use any of the available SAS cabling rules, worksheets, and examples content as needed.

#### SAS cabling rules

- [Configurations](#)
- [Controller slot numbering](#)
- [Shelf-to-shelf connections](#)
- [Controller-to-stack connections](#)
- [Mini-SAS HD SAS optical cables](#)

## Cabling worksheets and examples

- [Common multipath HA configurations](#)
- [AFF and FAS platforms with onboard storage](#)
- [Quad-path HA configurations](#)

## Cabling worksheet templates

- [Multipathed connectivity](#)
- [Quad-pathed connectivity](#)
- [How to read a worksheet for multipathed connectivity](#)
- [How to read a worksheet for quad-pathed connectivity](#)

## SAS cabling rules - shelves with IOM12/IOM12B modules

Disk shelves with IOM12/IOM12B 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.



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/IOM12B, 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/IOM12B 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:
  - AFF A200, AFF A220, FAS2600 series and FAS2700HA pair configurations (with external disk shelves) can be cabled as single-path HA configurations to support connectivity to an external SAS tape backup device.
  - AFF A200, AFF A220, FAS2600 series and FAS2700HA 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.

- FAS2600 series single-controller configurations do not support quad-path connectivity.

## Controller slot numbering rules

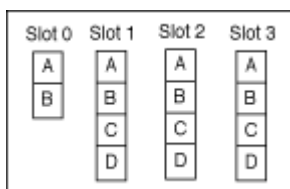
For the purpose of applying cabling rules across all supported HA pairs and single-controller configurations, a controller slot numbering convention is used.

- 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.

In this document, slots and the slot ports are depicted as follows:



## Shelf-to-shelf connection rules

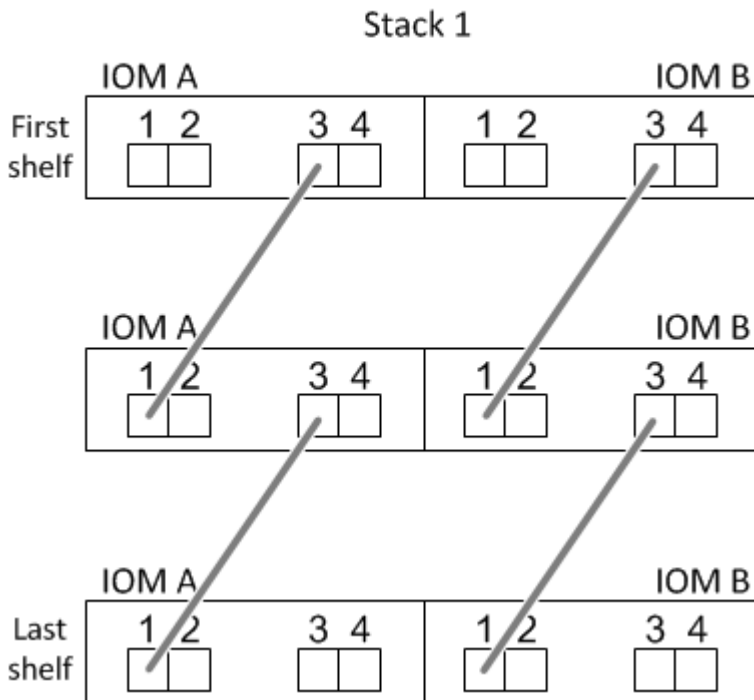
When you have more than one disk shelf in a stack of disk shelves, they connect to each other through each SAS domain (IOM A and IOM B) using the applicable “standard” or “double-wide” shelf-to-shelf cabling. Your use of “standard” or “double-wide” shelf-to-shelf cabling depends on the configuration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

### Standard shelf-to-shelf connectivity



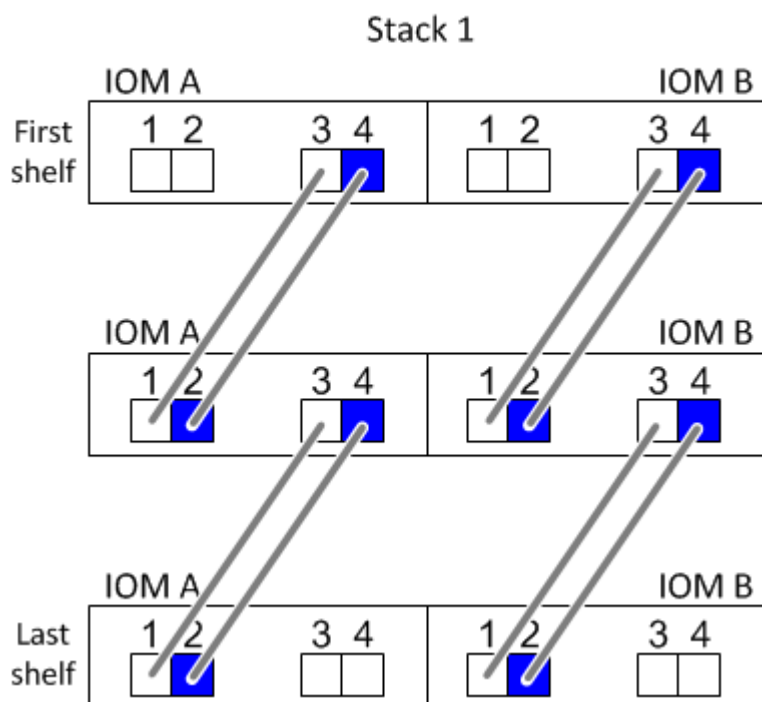
### Double-wide shelf-to-shelf connectivity

- 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.)

## Double-wide shelf-to-shelf connectivity



### 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 AFF A200, AFF A220, FAS2600 series and FAS2700 system 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 AFF A200, AFF A220, 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.



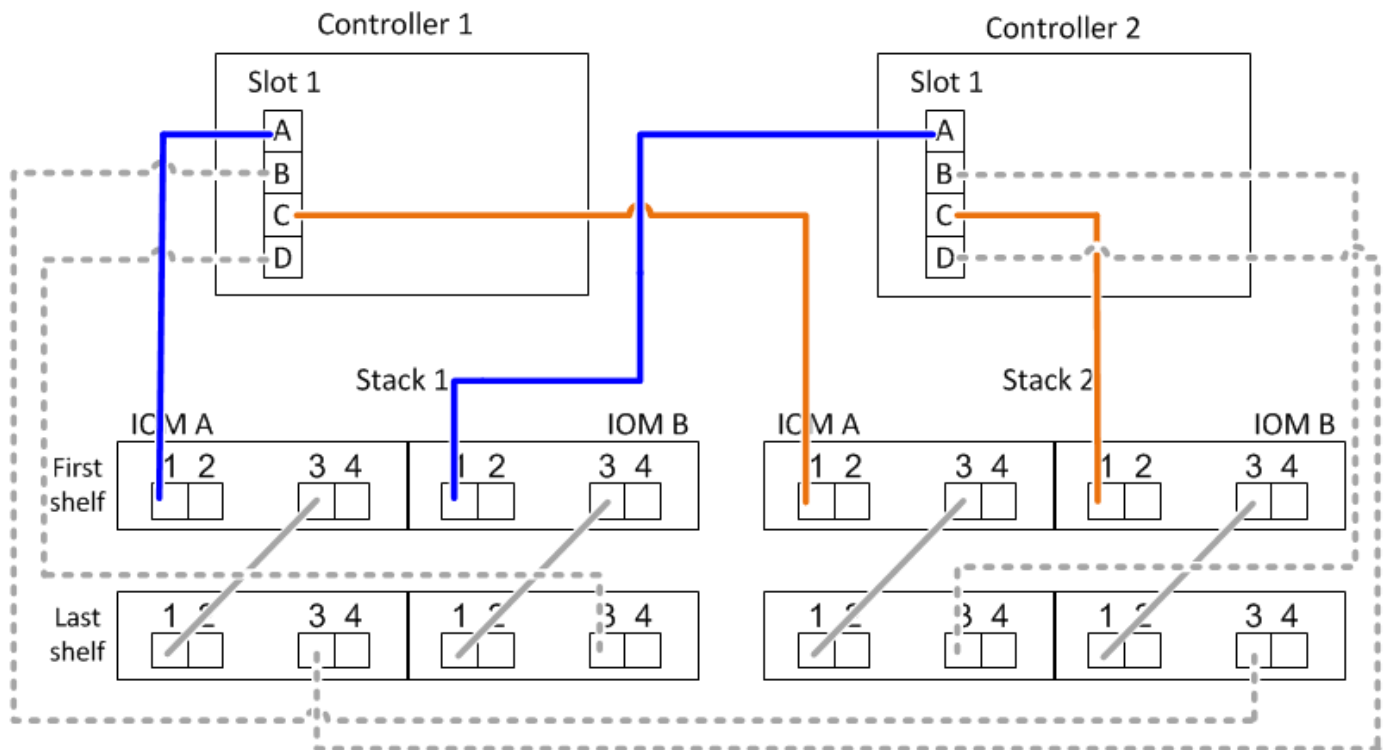
- A and C ports always connect to disk shelf IOM ports 1 and 2.

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.

### Port A and C connections (in a multipath HA configuration)



### Controller B and D port connection rules (for non AFF A200, AFF A220, 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.

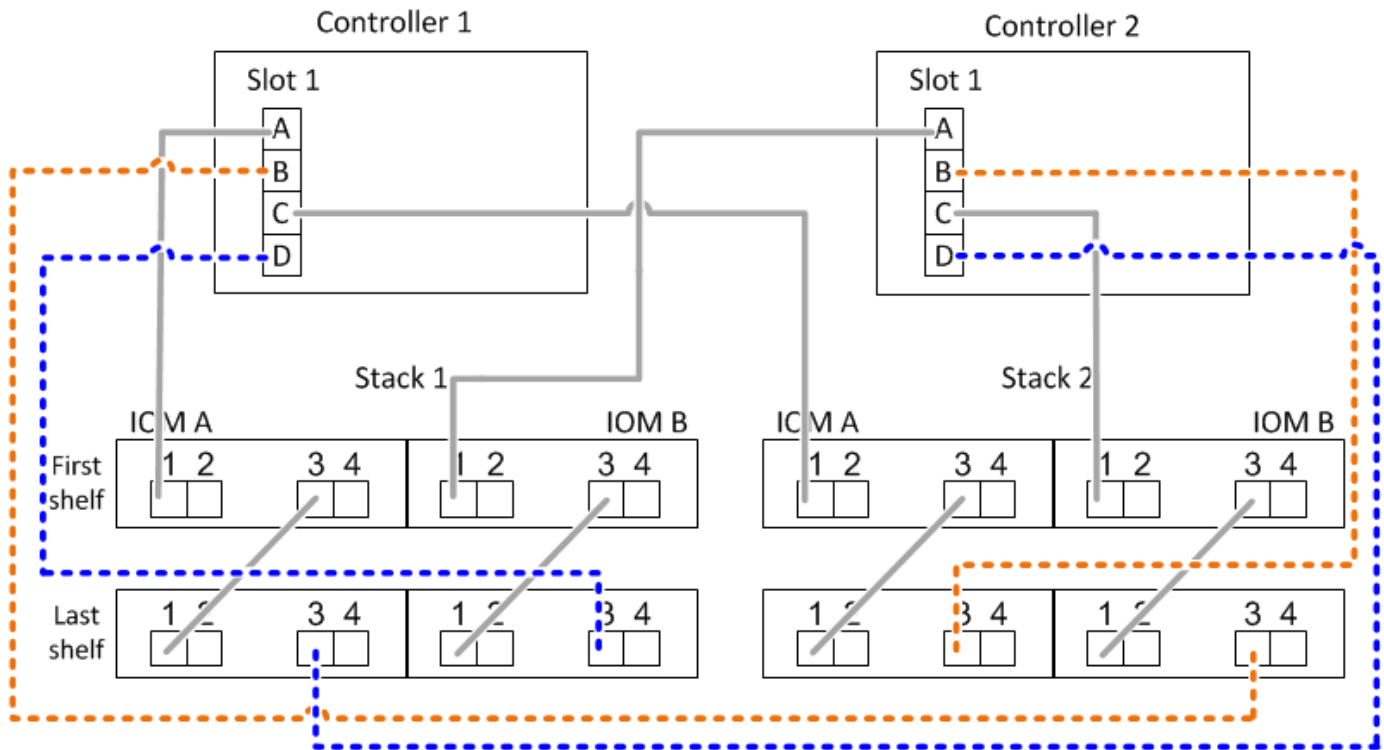
IOM port 4 is only used for quad-path HA and quad-path configurations.

- 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 B and D connections (in a multipath HA configuration)



### Port pair connection rules (for non AFF A200, AFF A220, 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:
  - 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

- 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

- 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: ~~1a~~, 2b, 3b, 1d, 2d, 3d, 1b

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

- d. 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.



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, ~~2a/3b~~, 3a/1d, ~~1c/2d~~, 2c/3d, ~~3c/1b~~



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](#)

[Controller-to-stack cabling worksheet template for quad-pathed connectivity](#)

#### **AFF A200, AFF A220, FAS2600 series and FAS2700 controller 0b and 0a port connection rules to external disk shelves**

The AFF A200, AFF A220, FAS2600 series and FAS2700 systems 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.

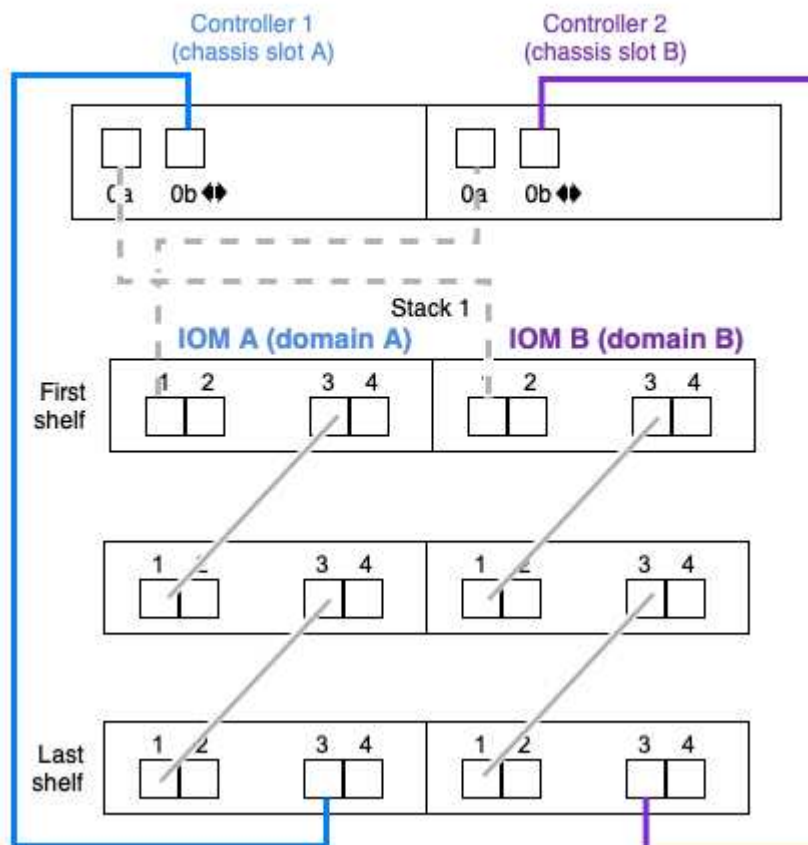


If you do not connect the 0b port to the correct domain (cross-connect domains), you expose your system to resiliency issues that prevent you from performing nondisruptive procedures safely.

- 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 connect 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 connect to disk shelf IOM port 1.

The following illustration highlights internal storage port (0b) domain connectivity for a AFF A200, AFF A220, FAS2600 series and FAS2700 multipath HA configuration:

**AFF A200, AFF A220, FAS2600, and FAS2700 series  
internal storage port (0b) domain connectivity**



## 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.

If you are using a mix of SAS copper cables and SAS optical cables, the following rules apply:

- 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 worksheets and cabling examples for common multipath HA configurations - shelves with IOM12/IOM12B modules

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 [SAS cabling rules](#) 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 [How to read a worksheet to cable controller-to-stack connections for multipathed connectivity](#).
- 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.

| Controller-to-Stack Cable Type Key  |  |
|---|--|
| Cable Type  | Description  |
|  | <ul style="list-style-type: none"> <li>▪ Connects controller <b>A</b> and <b>C</b> ports to the logical <b>first</b> disk shelf in a stack</li> <li>▪ The <b>primary</b> path from a controller to a stack</li> </ul>  |
|  | <ul style="list-style-type: none"> <li>▪ Connects controller <b>B</b> and <b>D</b> ports to the logical <b>last</b> disk shelf in a stack</li> <li>▪ The <b>secondary</b> path from a controller to a stack</li> </ul> |

- 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.

| Controller-to-Stack Cable Color Key   |            |                |                                       |
|---|------------|----------------|---------------------------------------|
| Cable Color   |            | Connects to... | From...                               |
|  | Dark blue  | Stack 1        | Each controller by a unique port pair |
|  | Orange     | Stack 2        |                                       |
|  | Green      | Stack 3        |                                       |
|  | Light blue | Stack 4        |                                       |

- 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:

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |    |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|----|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |   |   |   |   |
|  |             |                          |     |      | 1          | 2  | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |   |   |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a         | 1c |   |   |   |   |
|  | 2           | First                    | B   | 1    |            |    |   |   |   |   |
| B and D  |             |                          |     |      | 1b         | 1d |   |   |   |   |
|  | 1           | Last                     | B   | 3    | 1d         | 1b |   |   |   |   |
|  | 2           | Last                     | A   | 3    |            |    |   |   |   |   |

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:

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |    |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|----|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |   |   |   |   |
|  |             |                          |     |      | 1          | 2  | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |   |   |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a         | 1c |   |   |   |   |
|  | 2           | First                    | B   | 1    |            |    |   |   |   |   |
| B and D  |             |                          |     |      | 1b         | 1d |   |   |   |   |
|  | 1           | Last                     | B   | 3    | 1d         | 1b |   |   |   |   |
|  | 2           | Last                     | A   | 3    |            |    |   |   |   |   |

### Multipath HA configuration



#### 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).



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.



| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |    |    |    |   |   |
|--|-------------|--------------------------|-----|------|------------|----|----|----|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |    |    |   |   |
|  |             |                          |     |      | 1          | 2  | 3  | 4  | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |    |    |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a         | 2a | 1c | 2c |   |   |
|  | 2           | First                    | B   | 1    |            |    |    |    |   |   |
| B and D  |             |                          |     |      | 1b         | 2b | 1d | 2d |   |   |
|  | 1           | Last                     | B   | 3    | 2b         | 1d | 2d | 1b |   |   |
|  | 2           | Last                     | A   | 3    |            |    |    |    |   |   |

Controller



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



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

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |     |     |    |   |   |
|--|-------------|--------------------------|-----|------|------------|-----|-----|----|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |     |     |    |   |   |
|  |             |                          |     |      | 1          | 3 2 | 2 3 | 4  | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |     |     |    |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a         | 2a  | 1c  | 2c |   |   |
|  | 2           | First                    | B   | 1    |            |     |     |    |   |   |
| B and D  |             |                          |     |      | 1b         | 2b  | 1d  | 2d |   |   |
|  | 1           | Last                     | B   | 3    | 2b         | 1d  | 2d  | 1b |   |   |
|  | 2           | Last                     | A   | 3    |            |     |     |    |   |   |

## Multipath HA configuration



**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:

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |    |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|----|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |   |   |   |   |
|  |             |                          |     |      | 1          | 2  | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |   |   |   |   |
| A and C  | 1           | First                    | A   | 1    | 0a         | 0c |   |   |   |   |
|  | 2           | First                    | B   | 1    |            |    |   |   |   |   |
| B and D  |             |                          |     |      | 0b         | 0d |   |   |   |   |
|  | 1           | Last                     | B   | 3    | 0d         | 0b |   |   |   |   |
|  | 2           | Last                     | A   | 3    |            |    |   |   |   |   |

### Multipath HA configuration



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 |             |                          |     |      |            |    |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|----|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |   |   |   |   |
|  |             |                          |     |      | 1          | 2  | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |   |   |   |   |
| A and C  | 1           | First                    | A   | 1    | 0a         | 0c |   |   |   |   |
|  | 2           | First                    | B   | 1    |            |    |   |   |   |   |
| B and D  |             |                          |     |      | 0b         | 0d |   |   |   |   |
|  | 1           | Last                     | B   | 3    | 0d         | 0b |   |   |   |   |
|  | 2           | Last                     | A   | 3    |            |    |   |   |   |   |

### 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).



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.

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |            |    |    |    |   |   |
|--|-------------|--------------------------|-----|------|------------|----|----|----|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |    |    |   |   |
|  |             |                          |     |      | 1          | 2  | 3  | 4  | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |    |    |   |   |
| A and C  | 1           | First                    | A   | 1    | 0a         | 1a | 0c | 1c |   |   |
|  | 2           | First                    | B   | 1    |            |    |    |    |   |   |
| B and D  |             |                          |     |      | 0b         | 1b | 0d | 1d |   |   |
|  | 1           | Last                     | B   | 3    | 1b         | 0d | 1d | 0b |   |   |
|  | 2           | Last                     | A   | 3    |            |    |    |    |   |   |

Controller



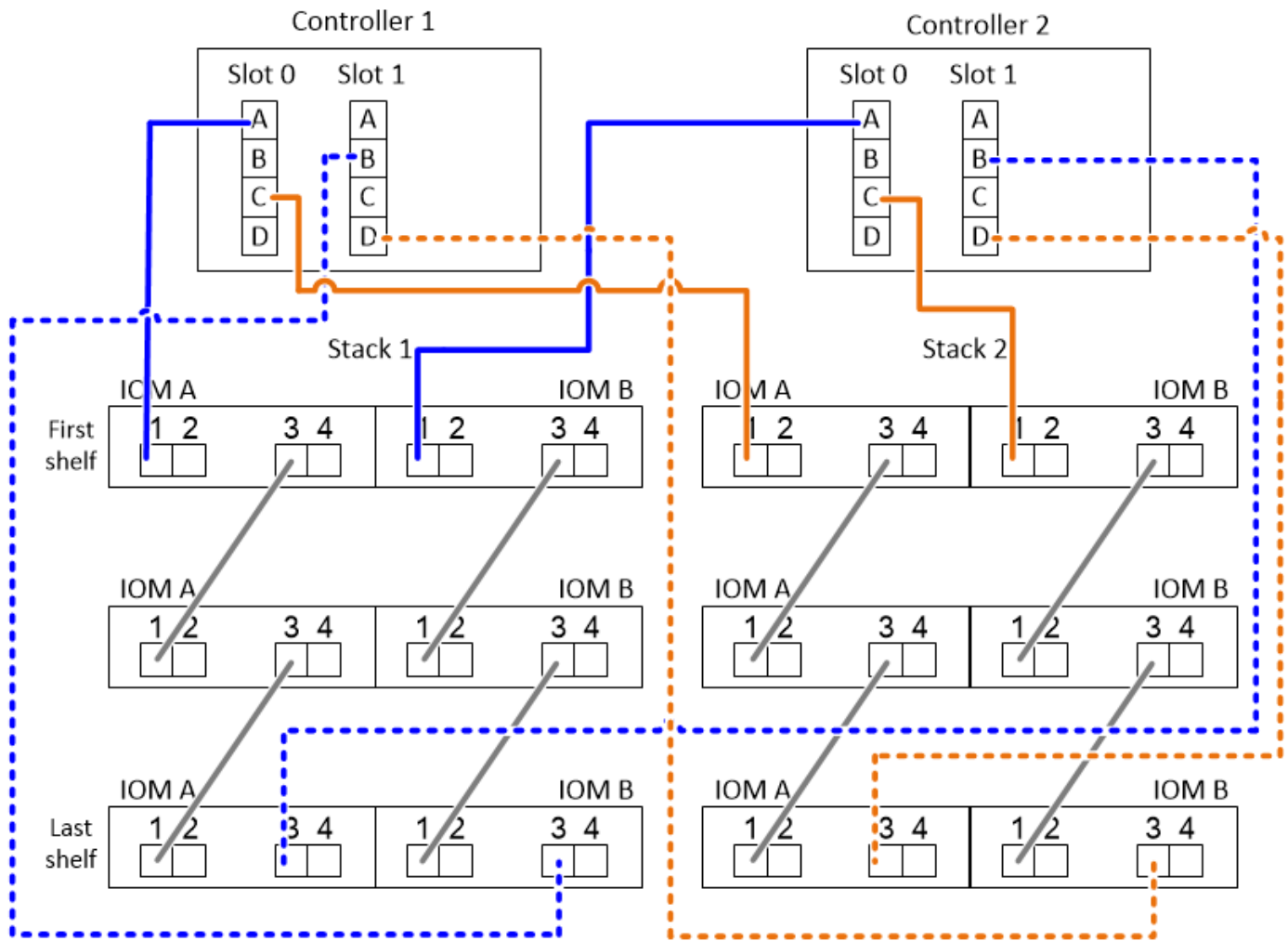
The following worksheet and cabling example shows port pairs being skipped to use every other one in the list: 0a/1b and 0c/1d.



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

| Controller-to-Stack Cabling Worksheet for Multipathed Connectivity |             |                          |     |      |               |               |               |               |   |   |
|--|-------------|--------------------------|-----|------|---------------|---------------|---------------|---------------|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks        |               |               |               |   |   |
|  |             |                          |     |      | 1             | 3 2           | 2 3           | 4             | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs    |               |               |               |   |   |
| A and C  | 1           | First                    | A   | 1    | 0a            | 1a            | 0c            | 1c            |   |   |
|  | 2           | First                    | B   | 1    |               |               |               |               |   |   |
| B and D  |             |                          |     |      | <del>0b</del> | <del>1b</del> | <del>0d</del> | <del>1d</del> |   |   |
|  | 1           | Last                     | B   | 3    | 1b            | 0d            | 1d            | 0b            |   |   |
|  | 2           | Last                     | A   | 3    |               |               |               |               |   |   |

## Multipath HA configuration



### Controller-to-stack cabling worksheets and cabling examples for AFF and FAS platforms with onboard storage - shelves with IOM12/IOM12B modules

You can use the completed controller-to-stack cabling worksheets and cabling examples to cable AFF and FAS platforms with onboard storage, such as but not limited to AFF A200, AFF A220, FAS2600 series and FAS2700 platforms. This information does not apply to FAS25XX platforms.

- If needed, you can refer to [SAS cabling rules](#) for information about supported configurations, shelf-to-shelf connectivity, and controller-to-shelf connectivity.
- Cabling examples show controller-to-stack cables as solid or dashed to distinguish controller 0b port connections from controller 0a port connections.

| Controller-to-stack cable type key: AFF and FAS platforms with onboard storage (except FAS25XX) |  |
|---|--|
| Cable Type  | Description  |
|                | <ul style="list-style-type: none"> <li>Connects controller <b>0b</b> port to the logical <b>last</b> disk shelf in the stack</li> <li>The <b>primary</b> path from a controller to the stack</li> <li>The internal storage connection</li> </ul> |
|                | <ul style="list-style-type: none"> <li>Connects controller <b>0a</b> port to the logical <b>first</b> disk shelf in the stack</li> <li>The <b>secondary</b> path from a controller to the stack</li> <li>The internal HBA connection</li> </ul>  |

- 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).

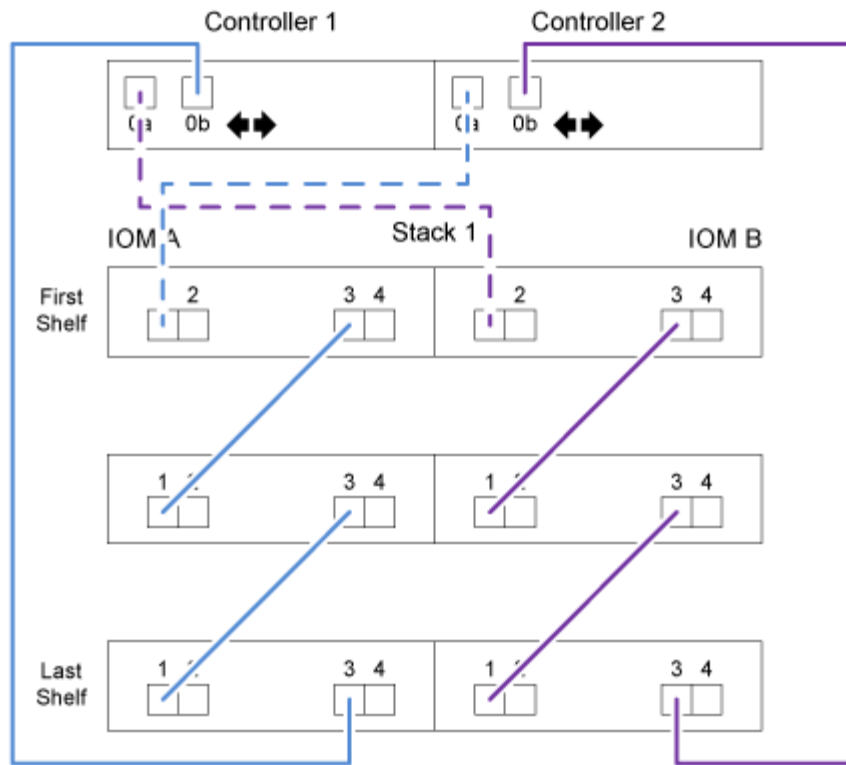
| Cable color key: AFF and FAS platforms with onboard storage (except FAS25XX)      |            |                  |
|---|------------|------------------|
| Cable Color   |            | Connects...      |
|  | Light blue | IOM A (domain A) |
|  | Purple     | IOM B (domain B) |

### AFF and FAS platforms with onboard storage in a multipath HA configuration with one multi-shelf stack

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

| Controller-to-stack cabling worksheet: AFF and FAS platforms with onboard storage (except FAS25XX) |             |                          |     |      |            |   |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|---|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |   |   |   |   |   |
|  |             |                          |     |      | 1          | 2 | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |   |   |   |   |   |
| A and C  | 1           | First                    | B   | 1    | 0a         |   |   |   |   |   |
|  | 2           | First                    | A   | 1    |            |   |   |   |   |   |
| B and D  | 1           | Last                     | A   | 3    | 0b         |   |   |   |   |   |
|  | 2           | Last                     | B   | 3    |            |   |   |   |   |   |

AFF and FAS platforms with onboard storage (except FAS25XX)  
Multipath HA Configuration



### 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.

| Controller-to-Stack Cabling Worksheet (FAS2600 series) |              |                          |              |              |        |            |   |   |   |   |
|--|--------------|--------------------------|--------------|--------------|--------|------------|---|---|---|---|
| Controller SAS ports                                   | Controllers  | Cable to disk shelf IOMs |              |              | Stacks |            |   |   |   |   |
|  |              |                          |              |              | 1      | 2          | 3 | 4 | 5 | 6 |
|  |              | Shelf                    | IOM          | Port         |        | Port pairs |   |   |   |   |
| A and C  | 1            | First                    | B            | 1            | 0a     |            |   |   |   |   |
|  | <del>2</del> | <del>First</del>         | <del>A</del> | <del>1</del> |        |            |   |   |   |   |
| B and D  | 1            | Last                     | A            | 3            | 0b     |            |   |   |   |   |
|  | <del>2</del> | <del>Last</del>          | <del>B</del> | <del>3</del> |        |            |   |   |   |   |



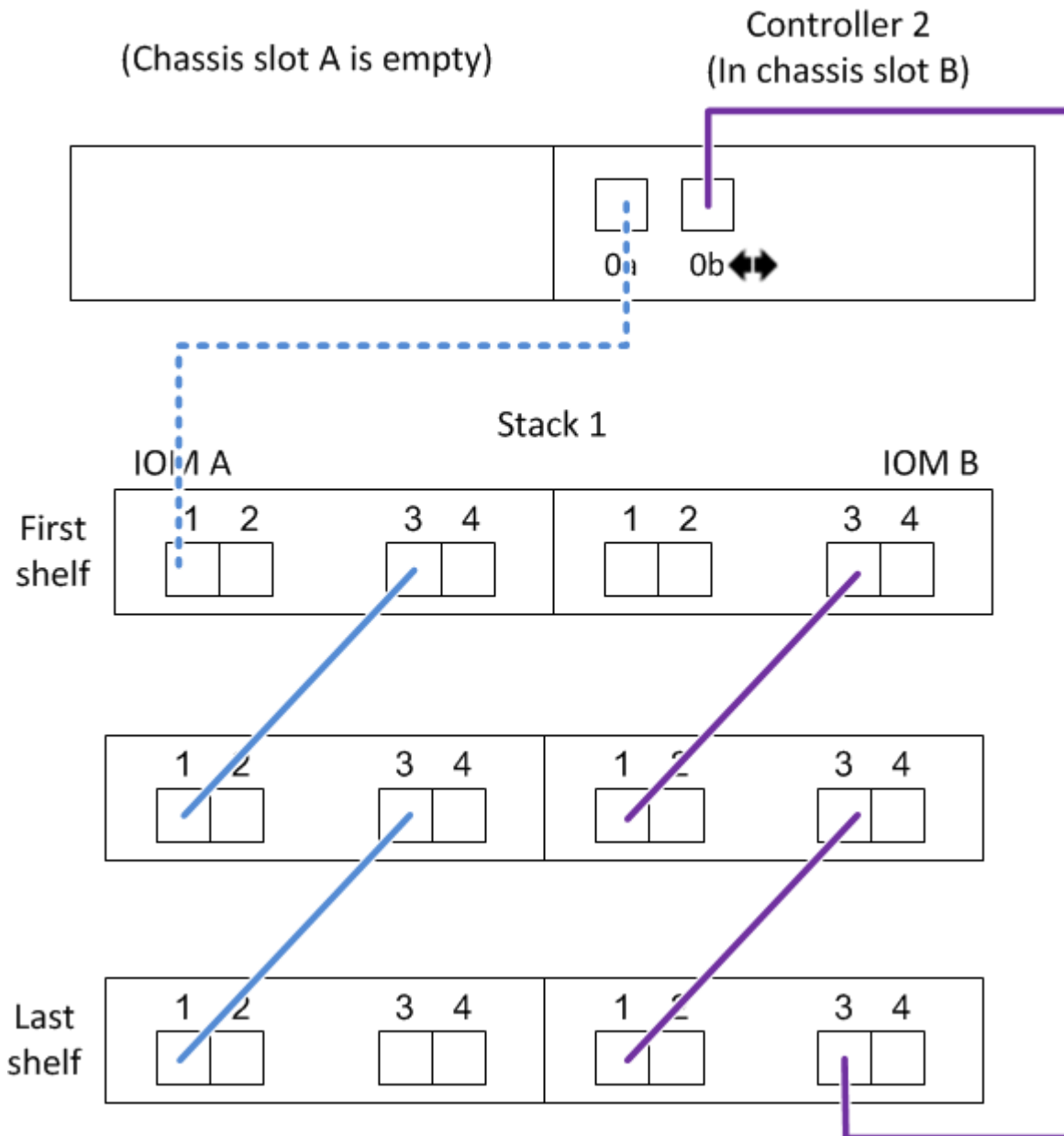
## FAS2600 series multipath configuration



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.

| Controller-to-Stack Cabling Worksheet (FAS2600 series) |              |                          |              |              |            |   |   |   |   |   |
|--|--------------|--------------------------|--------------|--------------|------------|---|---|---|---|---|
| Controller SAS ports                                   | Controllers  | Cable to disk shelf IOMs |              |              | Stacks     |   |   |   |   |   |
|  |              |                          |              |              | 1          | 2 | 3 | 4 | 5 | 6 |
|  |              | Shelf                    | IOM          | Port         | Port pairs |   |   |   |   |   |
| A and C  | 1            | First                    | B            | 1            | 0a         |   |   |   |   |   |
|  | <del>2</del> | <del>First</del>         | <del>A</del> | <del>1</del> |            |   |   |   |   |   |
| B and D  | 1            | Last                     | A            | 3            | 0b         |   |   |   |   |   |
|  | <del>2</del> | <del>Last</del>          | <del>B</del> | <del>3</del> |            |   |   |   |   |   |



## FAS2600 series multipath configuration







## Controller-to-stack cabling worksheet and cabling example for a quad-path HA configuration with two quad-port SAS HBAs - shelves with IOM12/IOM12B modules

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 [SAS cabling rules](#) 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 [How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity](#).
- 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.

| Controller-to-Stack Cable Type Key  |  |
|---|--|
| Cable Type  | Description  |
|  | <ul style="list-style-type: none"> <li>▪ Connects controller <b>A</b> and <b>C</b> ports to the logical <b>first</b> disk shelf in a stack</li> <li>▪ The <b>primary</b> path from a controller to a stack</li> </ul>  |
|  | <ul style="list-style-type: none"> <li>▪ Connects controller <b>B</b> and <b>D</b> ports to the logical <b>last</b> disk shelf in a stack</li> <li>▪ The <b>secondary</b> path from a controller to a stack</li> </ul> |

- 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.

| Controller-to-Stack Cable Color Key   |           |                |                                       |
|---|-----------|----------------|---------------------------------------|
| Cable Color   |           | Connects to... | From...                               |
|  | Dark blue | Stack 1        | Each controller by a unique port pair |
|  |           |                |                                       |
|  | Orange    | Stack 2        | Each controller by a unique port pair |
|  |           |                |                                       |

- 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.

| Controller-to-Stack Quad-Pathed Connectivity Key         |             |  |  |
|--|-------------|--|--|
| Quad-pathed connectivity consists of two sets of cabling |             | Shown by color-coded ports on controllers and IOMs   | Description  |
| Set 1  | Multipathed | No color   | Ports (on controllers and IOMs) cabled with multipathed connectivity are shown without a color.  |
| Set 2  | Quad-pathed | The cable color associated with the applicable stack | Ports (on controllers and IOMs) cabled with quad-pathed connectivity are the same color as the cables connecting the stack, as shown in the "Controller-to-Stack Cable Color Key". |

- 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 stack2.

| Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |             |                          |     |             |             |            |    |    |    |
|--|-------------|--------------------------|-----|-------------|-------------|------------|----|----|----|
| 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           |            |    |    |    |
| B and D  |             |                          |     |             |             | 1b         | 2b | 1d | 2d |
|  | 1           | Last                     | B   | 3           | 4           | 2b         | 1d | 2d | 1b |
|  | 2           | Last                     | A   | 3           | 4           |            |    |    |    |

## Quad-path HA configuration



### Controller-to-stack cabling worksheet template for multipathed connectivity - shelves with IOM12/IOM12B modules

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/IOM12B 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 an AFF A200, AFF A220, FAS2600 series or FAS2700 system. If you have one of these configurations, use the following:

[Controller-to-stack cabling worksheets and cabling examples for common AFF A200, AFF A220, FAS2600 series and FAS2700 configurations](#)

#### 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/IOM12B 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](#) 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 [How to read a worksheet to cable controller-to-stack connections for multipathed connectivity](#)

| Controller-to-Stack Cabling Worksheet Multipathed Connectivity |             |                          |     |      |            |   |   |   |   |   |
|--|-------------|--------------------------|-----|------|------------|---|---|---|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |   |   |   |   |   |
|  |             |                          |     |      | 1          | 2 | 3 | 4 | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |   |   |   |   |   |
| A and C  | 1           | First                    | A   | 1    |            |   |   |   |   |   |
|  | 2           | First                    | B   | 1    |            |   |   |   |   |   |
| B and D  |             |                          |     |      |            |   |   |   |   |   |
|  | 1           | Last                     | B   | 3    |            |   |   |   |   |   |
|  | 2           | Last                     | A   | 3    |            |   |   |   |   |   |

## 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).

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).

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.

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 stack3, and port pair 2c/1b is cabled to stack 4.

| Controller-to-Stack Cabling Worksheet for Multipath Connectivity |             |                          |     |      |               |               |               |               |   |   |
|--|-------------|--------------------------|-----|------|---------------|---------------|---------------|---------------|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks        |               |               |               |   |   |
|  |             |                          |     |      | 1             | 2             | 3             | 4             | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs    |               |               |               |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a            | 2a            | 1c            | 2c            |   |   |
|  | 2           | First                    | B   | 1    |               |               |               |               |   |   |
| B and D  |             |                          |     |      | <del>1b</del> | <del>2b</del> | <del>1d</del> | <del>2d</del> |   |   |
|  | 1           | Last                     | B   | 3    | 2b            | 1d            | 2d            | 1b            |   |   |
|  | 2           | Last                     | A   | 3    |               |               |               |               |   |   |

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 2c/1b is cabled to stack 4.



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 Worksheet Multipathed Connectivity |             |                          |     |      |               |               |               |               |   |   |
|--|-------------|--------------------------|-----|------|---------------|---------------|---------------|---------------|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks        |               |               |               |   |   |
|  |             |                          |     |      | 1             | 3 2           | 2 3           | 4             | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs    |               |               |               |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a            | 2a            | 1c            | 2c            |   |   |
|  | 2           | First                    | B   | 1    |               |               |               |               |   |   |
| B and D  |             |                          |     |      | <del>1b</del> | <del>2b</del> | <del>1d</del> | <del>2d</del> |   |   |
|  | 1           | Last                     | B   | 3    | 2b            | 1d            | 2d            | 1b            |   |   |
|  | 2           | Last                     | A   | 3    |               |               |               |               |   |   |

You can use your completed worksheet to cable your system.

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

| Controller-to-Stack Cabling Worksheet Multipathed Connectivity |             |                          |     |      |            |    |    |    |   |   |
|--|-------------|--------------------------|-----|------|------------|----|----|----|---|---|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |    |    |    |   |   |
|  |             |                          |     |      | 1          | 2  | 3  | 4  | 5 | 6 |
|  |             | Shelf                    | IOM | Port | Port pairs |    |    |    |   |   |
| A and C  | 1           | First                    | A   | 1    | 1a         | 2a | 1c | 2c |   |   |
|  | 2           | First                    | B   | 1    |            |    |    |    |   |   |
| B and D  |             |                          |     |      | 1b         | 2b | 1d | 2d |   |   |
|  | 1           | Last                     | B   | 3    | 2b         | 1d | 2d | 1b |   |   |
|  | 2           | Last                     | A   | 3    |            |    |    |    |   |   |

You can use your completed worksheet to cable your system.

## Controller-to-stack cabling worksheet template for quad-pathed connectivity - shelves with IOM1/IOM12B2 modules

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/IOM12B 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.

A configuration with two quad-port SAS HBAs and two stacks of disk shelves with IOM12/IOM12B modules is used for the worksheet examples.

- 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”.

The second set of cabling is referred to as “quad-pathed” because completing this set of cabling gives you the quad-pathed connectivity from a controller to a stack in an HA pair or single-controller configuration.

- 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.

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. Stack 1 is associated with the color blue; stack 2 is associated with the color orange.

- If needed, you can refer to [SAS cabling rules](#) 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 [How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity](#).

| Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |             |                          |     |             |             |        |   |  |  |
|--|-------------|--------------------------|-----|-------------|-------------|--------|---|--|--|
| Controller SAS ports   | Controllers | Cable to disk shelf IOMs |     |             |             | Stacks |   |  |  |
|  |             | Shelf                    | IOM | Port        |             | 1      | 2 |  |  |
|  |             |                          |     | Multipathed | Quad-pathed |        |   |  |  |
| A and C  | 1           | First                    | A   | 1           | 2           |        |   |  |  |
|  | 2           | First                    | B   | 1           | 2           |        |   |  |  |
| B and D  |             |                          |     |             |             |        |   |  |  |
|  | 1           | Last                     | B   | 3           | 4           |        |   |  |  |
|  | 2           | Last                     | A   | 3           | 4           |        |   |  |  |

### 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).

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).

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.

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.

| Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |             |                          |     |             |             |            |    |    |    |
|--|-------------|--------------------------|-----|-------------|-------------|------------|----|----|----|
| 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           |            |    |    |    |
| B and D  |             |                          |     |             |             | 1b         | 2b | 1d | 2d |
|  | 1           | Last                     | B   | 3           | 4           | 2b         | 1d | 2d | 1b |
|  | 2           | Last                     | A   | 3           | 4           |            |    |    |    |

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.

| Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |             |                          |     |             |             |            |    |    |    |
|--|-------------|--------------------------|-----|-------------|-------------|------------|----|----|----|
| 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           |            |    |    |    |
| B and D  |             |                          |     |             |             | 1b         | 2b | 1d | 2d |
|  | 1           | Last                     | B   | 3           | 4           |            |    |    |    |
|  | 2           | Last                     | A   | 3           | 4           | 2b         | 1d | 2d | 1b |

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-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |              |                          |              |              |              |            |    |    |    |
|--|--------------|--------------------------|--------------|--------------|--------------|------------|----|----|----|
| 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 |
|  | <del>2</del> | <del>First</del>         | <del>B</del> | <del>1</del> | <del>2</del> |            |    |    |    |
| B and D  |              |                          |              |              |              | 1b         | 2b | 1d | 2d |
|  | 1            | Last                     | B            | 3            | 4            | 2b         | 1d | 2d | 1b |
|  | <del>2</del> | <del>Last</del>          | <del>A</del> | <del>3</del> | <del>4</del> |            |    |    |    |

## How to read a worksheet to cable controller-to-stack connections for multipathed connectivity - shelves with IOM12/IOM12B modules

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/IOM12B modules for multipathed connectivity.

### Before you begin

Your HA pair or single-controller configuration cannot be an AFF A200, AFF A220, FAS2600 series or FAS2700 system. These systems use a unique worksheet:

[Controller-to-stack cabling worksheets and cabling examples for common AFF A200, AFF A220, FAS2600 series and FAS2700 configurations](#)

### 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/IOM12B modules. Port pairs are cabled by skipping every other port pair in the worksheet.



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 [SAS cabling rules](#) 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.

# Controller-to-Stack Cabling Worksheet Multipathed Connectivity

| Controller SAS ports | Controllers | Cable to disk shelf IOMs |     |      | Stacks     |     |     |    |   |   |
|----------------------|-------------|--------------------------|-----|------|------------|-----|-----|----|---|---|
|                      |             |                          |     |      | 1          | 3 2 | 2 3 | 4  | 5 | 6 |
|                      |             | Shelf                    | IOM | Port | Port pairs |     |     |    |   |   |
| A and C              | 1           | First                    | A   | 1    | 1a         | 2a  | 1c  | 2c |   |   |
|                      | 2           | First                    | B   | 1    |            |     |     |    |   |   |
| B and D              | 1           | Last                     | B   | 3    | 1b         | 2b  | 1d  | 2d |   |   |
|                      | 2           | Last                     | A   | 3    | 2b         | 1d  | 2d  | 1b |   |   |

## Multipath HA configuration



### 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.

## How to read a worksheet to cable controller-to-stack connections for quad-pathed connectivity - shelves with IOM12/IOM12B modules

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/IOM12B modules for quad-pathed connectivity.

### About this task

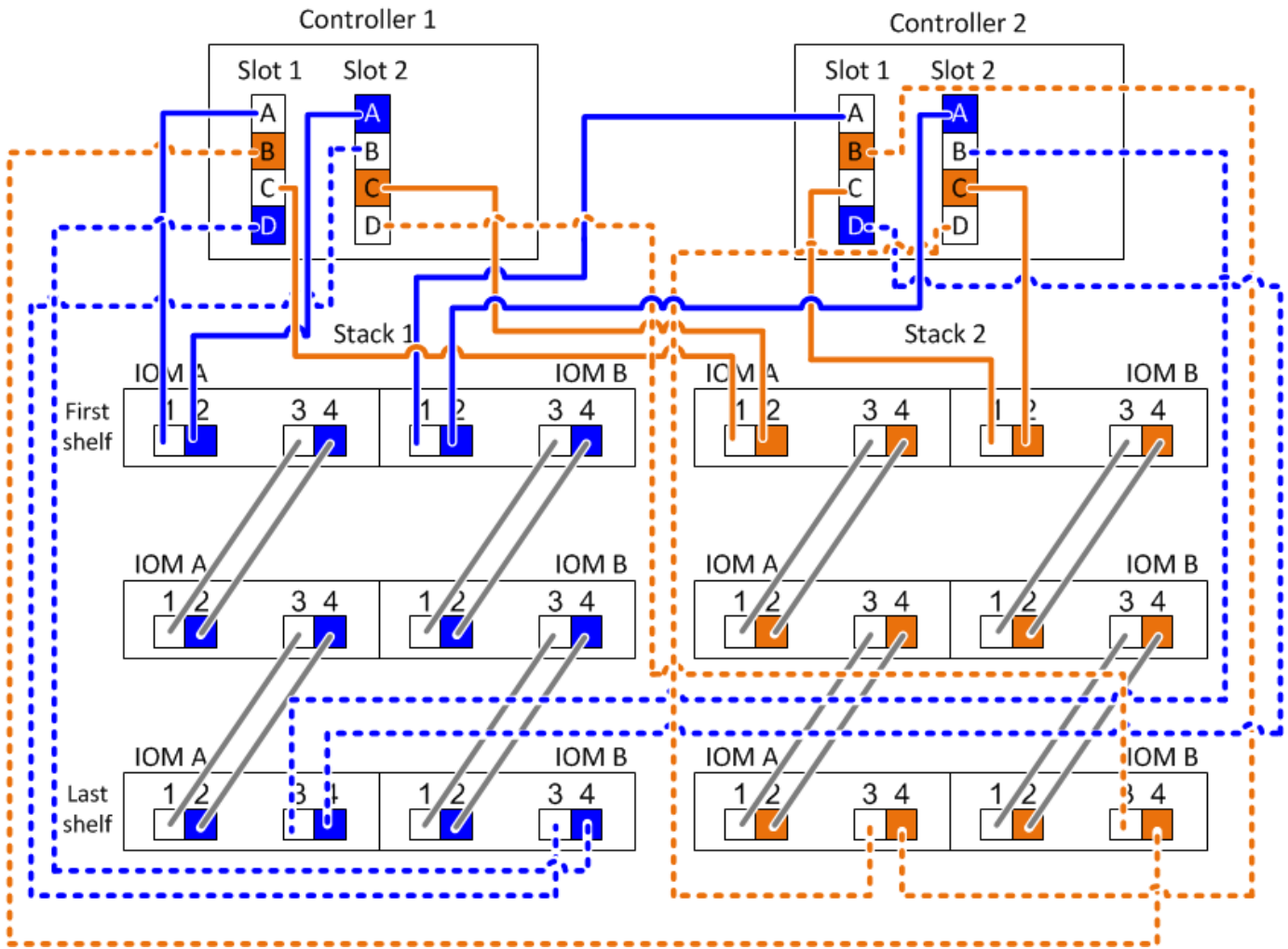
- This procedure references the following worksheet and cabling example to demonstrate how to read a worksheet to cable controller-to-stack connections.

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 [SAS cabling rules](#) for information about the controller slot numbering convention, shelf-to-shelf connectivity, and controller-to-shelf connectivity (including the use of port pairs).

| Controller-to-Stack Cabling Worksheet for Quad-Pathed Connectivity |             |                          |     |             |             |            |    |    |    |
|--|-------------|--------------------------|-----|-------------|-------------|------------|----|----|----|
| 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           |            |    |    |    |
| B and D  |             |                          |     |             |             | 1b         | 2b | 1d | 2d |
|  | 1           | Last                     | B   | 3           | 4           | 2b         | 1d | 2d | 1b |
|  | 2           | Last                     | A   | 3           | 4           |            |    |    |    |

## Quad-path HA configuration



### 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.

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