QSAN Official Document

NVMe-of JBOF Connection Guide

Best Practice

May 2026

ANNOUNCEMENT

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PREFACE

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- Via Telephone: +886-2-77206355
- (Service hours: 09:30 - 18:00, Monday - Friday, UTC+8)
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- Via Email: support@qsan.com

Information, Tip, and Caution

This document uses the following symbols to draw attention to important safety and operational information.

INFORMATION

INFORMATION provides useful knowledge, definition, or terminology for reference.

TIP

TIP provides helpful suggestions for performing tasks more effectively.

CAUTION

CAUTION indicates that failure to take a specified action could result in damage to the system.

1. OVERVIEW

This document provides technical instructions for connecting NVMe-oF JBOF (Just a Bunch of Flash) with QSAN storage.

1.1. Introduction to NVMe-oF JBOF

The QSAN XE5 is an NVMe-oF JBOF fabric attached storage that provides high-density all-NVMe flash array and supports NVMe-oF connectivity, designed for performance-oriented enterprise environments. With flash-based architecture, the system delivers consistent low-latency response and high throughput, enabling efficient data access for AI workloads, database systems, and other data-intensive applications. XE5 series supports form factors as follows:

- SFF (Small Form Factor): 26-bay 19” rack mount 2U chassis.

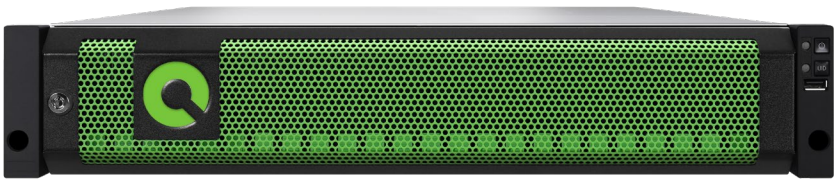

Figure 1-1 XE5 Series Form Factor

The following tables provide detailed information about all XE5 series models arranged by connectivity ports.

Table 1-1 XE5 Series Models

MODEL NAME	CONTROLLER TYPE	FORM FACTOR, BAY COUNT, RACK UNIT
XE5326D-400G	Dual Controller with 4 x 100 GbE LAN port	SFF 26-bay 2U Chassis
XE5326S-200G	Single Controller with 2 x 100 GbE LAN port	SFF 26-bay 2U Chassis

XE5326D-200G	Dual Controller with 8 x 25 GbE LAN port	SFF 26-bay 2U Chassis
XE5326S-100G	Single Controller with 4 x 25 GbE LAN port	SFF 26-bay 2U Chassis
XE5326D-100G	Dual Controller with 4 x 25 GbE LAN port	SFF 26-bay 2U Chassis
XE5326S-50G	Single Controller with 2 x 25 GbE LAN port	SFF 26-bay 2U Chassis
XE5326D-80G	Dual Controller with 8 x 10 GbE LAN port	SFF 26-bay 2U Chassis
XE5326S-40G	Single Controller with 4 x 10 GbE LAN port	SFF 26-bay 2U Chassis

1.2. Apply Models

The XE5 series can be used as an expansion unit for the following models.

Block Storage

- **XF5 Series**: XF5226D-12C, XF5226S-12C
- **XF4 Series**: XF4226D-8C, XF4226S-8C, XF4226D-4C, XF4226S-4C
- **XF3 Series**: XF3212D-4C, XF3212S-4C

Unified Storage

- **XN5 Series**: XN5226D-12C, XN5226S-12C
- **XN4 Series**: XN4226D-8C, XN4226S-8C, XN4226D-4C, XN4226S-4C
- **XN3 Series**: XN3212D-4C, XN3212S-4C

- **XCubeNXT 8100 Series**: XN8126D, XN8126S, XN8124D, XN8124S, XN8116D, XN8116S, XN8112D, XN8112S
- **XCubeNXT 5100 Series**: XN5126D, XN5126S, XN5124D, XN5124S, XN5116D, XN5116S, XN5112D, XN5112S

1.3. Transportation Protocols

The XE5 platform uses **NVMe-oF** (TCP/RoCE) as the transport protocol between storage and expansion units. This platform employs a high-density NVMe SSD design, supports parallel I/O processing, and maintains stable throughput under high loads. With **NVIDIA® GPUDirect** Storage support, XE5 ensures stable performance and minimizes the impact on response time for applications requiring continuous data access.

1.4. NVMe-oF JBOF Selection Guide

The XE5 series offers a variety of models to choose from. We recommend selecting the appropriate bandwidth based on your storage needs. For example, if you plan to extend a dual-controller storage head to NVMe-oF JBOF using 100GbE (4 x 25 GbE LAN port), you can choose the XE5326D-100G (dual controller with 4 x 25 GbE LAN port) as the expansion unit.

TIP

Choosing an NVMe-oF JBOF with the same extended bandwidth will yield the greatest benefits.

2. Deployment Types and Cabling

This chapter describes the deployment options and cabling configurations for QSAN storage connecting to expansion units. The storage system can be deployed to host servers using either Fibre Channel or Ethernet connections to build a high-performance storage environment. For capacity expansion, the system supports connections to XE5 series expansion enclosures.

2.1. Deployment Types

The expansion unit supports following deployment types.

One NVMe-oF JBOF with Four Paths

The following diagram shows the connection of a dual-controller storage system and expansion units. The double-protected data connection ensures data consistency in the event of a single-path host connection failure.

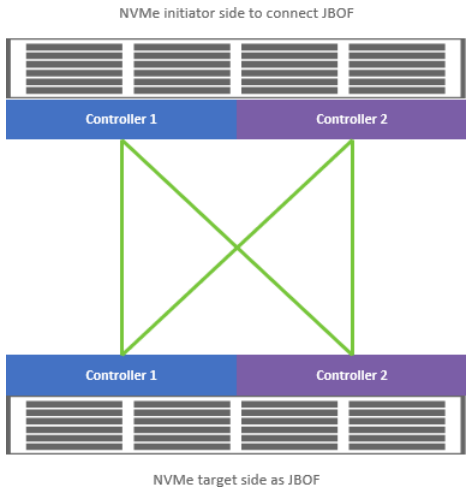

Figure 2-1 Four-Path Deployment Type

Step details are described below.

1. Connect the cable from QSAN CTRL 1 LAN port 1 to JBOF CTRL 1 LAN port 1.
2. Connect the cable from QSAN CTRL 1 LAN port 2 to JBOF CTRL 2 LAN port 1.
3. Connect the cable from QSAN CTRL 2 LAN port 1 to JBOF CTRL 1 LAN port 2.

4. Connect the cable from QSAN CTRL 2 LAN port 2 to JBOF CTRL 2 LAN port 2.

In a four-path deployment, in addition to the two paths from the storage heads to the expansion units, there are two additional paths for cross-connection redundancy between the controllers. In this deployment, a high-performance and fully redundant structure is provided. The conditions for the disk drive are the same as dual-path deployment.

INFORMATION

The four-path topology is applicable to the XF5 / XF4 / XF3 and XN5 / XN4 / XN3 series.

One NVMe-oF JBOF with Two Paths

The following figure illustrates the connections of a dual-controller storage system and expansion units. MPIO (Multipath Input/Output) configuration is designed to provide HA (High Availability) data connections to ensure data consistency in the event of a single path host connection failure.

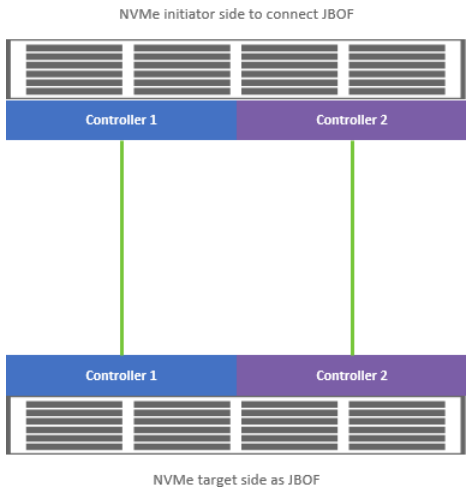

Figure 2-2 Two-Path Deployment Type

Step details are described below.

1. Connect the cable from QSAN CTRL 1 LAN port 1 to JBOF CTRL 1 LAN port 1.
2. Connect the cable from QSAN CTRL 2 LAN port 1 to JBOF CTRL 2 LAN port 1.

In a dual-path deployment, two paths connect from the storage head to the expansion unit. In this deployment, both controllers in the system are used. Basic dual-domain fault tolerance is provided, and the disk drives must support dual-path I/O (dual-port NVMe interface).

Without Redundant Path

The following figure shows a dual-controller storage system connected to an expansion unit; the second figure shows a dual-controller storage system connected to an expansion unit but experiencing failure.

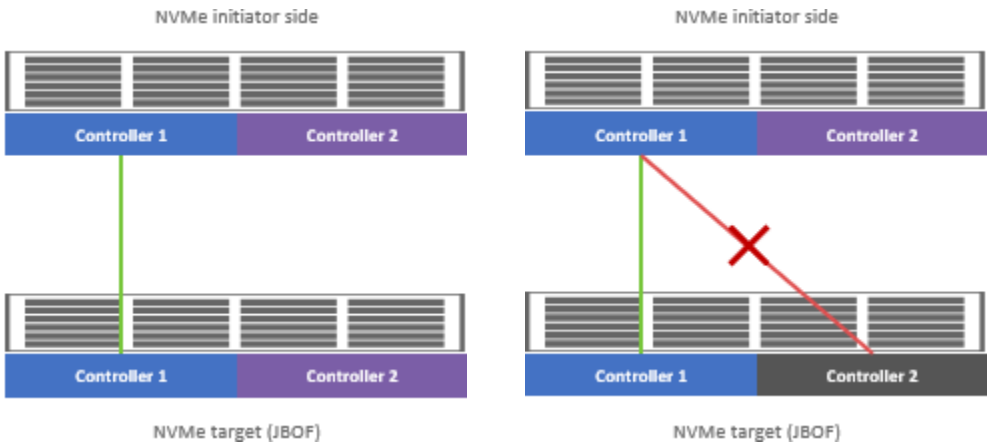

Figure 2-3 Without Redundant Path Deployment Type

In a single-path deployment, one path connects from the storage head to the expansion unit. In this deployment, only one controller in the enclosure is used. In dual-controller storage, single-channel degradation is provided, and data can be accessed. Without redundant path, the storage head cannot access the expansion unit if one controller fails.

With Redundant Path

The following figure illustrates the connections of a dual-controller storage system and expansion units. MPIO (Multipath Input/Output) configuration is designed to provide HA (High Availability) data connections to ensure data consistency in the event of a single path host connection failure.

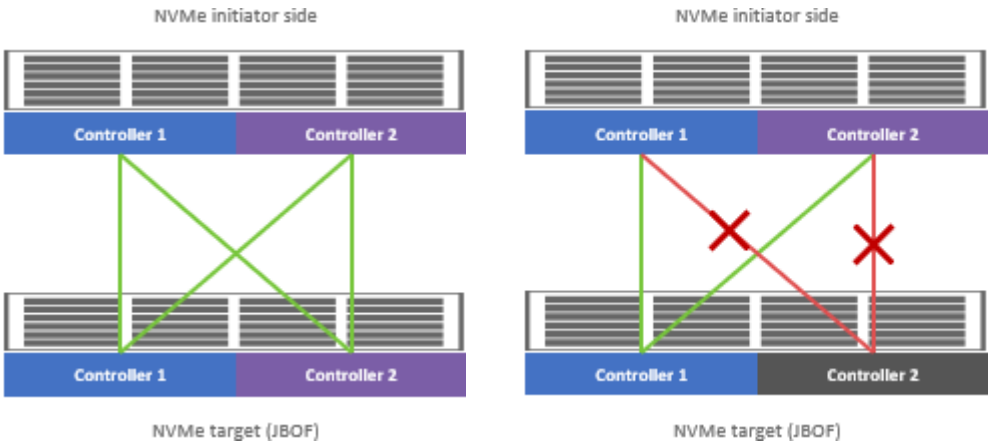

Figure 2-4 With Redundant Path Deployment Type

In a dual-path deployment for each controller, four paths connect from the storage head to the expansion unit. In this deployment, both controllers in the system are used. With redundant path, storage head can still access the expansion unit even if one controller fails.

Multiple NVMe-oF JBOF Deployment

QSAN storage supports up to 4 NVMe-oF JBOF expansions. If deploying multiple expansion units, it is recommended to purchase an **NVMe fabric switch** to connect the storage devices and JBOFs.

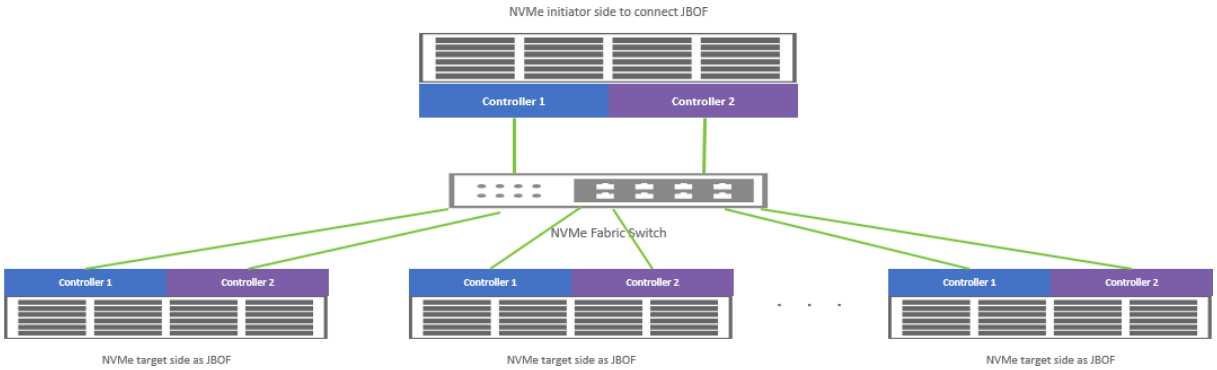

Figure 2-5 Multiple NVMe-oF JBOF Deployment Type

INFORMATION

The maximum number of connecting to XE5026 expansion units is 4.

2.2. System Behavior

The following describes the situation of the QSAN storage system.

Table 2-1 Storage Status Connected to the Expansion Unit

ITEM	TWO CABLES	ONLY ONE CABLE LEFT	FOUR CABLES
Connection Context	One per controller, corresponding to JBOF CTRL1 and CTRL2	Single controller or one line failure	Head CTRL1 and CTRL2 have two cables each, cross-connected to JBOF CTRL1 and CTRL2
XF5 / XF4 / XF3 Series	Basic dual-path redundant configuration: two connections provide fault tolerance and load sharing.	Degraded mode: Loss of redundancy, but still accessible. JBOF performance slightly degraded, and the Event log displays "Path Degraded".	High-performance configuration: Dual controllers with dual-channel cross-connection provide higher I/O bandwidth and stability.
XN5 / XN4 / XN3 Series			
XCubeNXT Series	Standard dual-controller architecture: Dual-path fault-tolerant design ensures continued operation even if any path fails.	Degraded but operational: The system enters Degraded state, but the Pool and Disk is still fully accessible.	High-performance configuration: It improves performance and load balancing.

System Behavior Summary

1. **Two Cables Deployment:** Under normal circumstances, both paths are available, and I/O traffic is distributed using the MPIO /NMP (Network Multipathing) Round-Robin

mechanism. If either path is disconnected, the system automatically fails over, ensuring uninterrupted operation.

2. **Only One Cable Left:** The JBOF will not be offline; MPIO will automatically switch to a single path. It is recommended to repair it as soon as possible to restore full fault tolerance.
3. **Four Cables:** This ensures full JBOF fault tolerance and zero-disruption operation.

2.3. Expansion Configuration Rules

The diagram below shows the connection of the XF5 / XF4 / XN5 / XN4 series with the most expansion units.

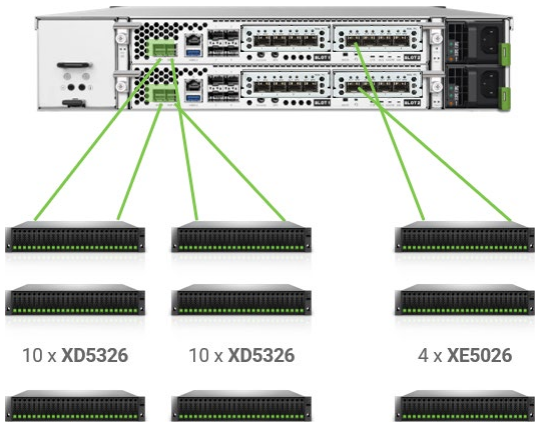

Figure 2-6 Connection of XF5 / XF4 / XN5 / XN4 Series

The following table lists the configuration rules for the storage system and expansion enclosures. Before deploying your system, you can refer to the table below to understand the maximum number of expansion cabinets and hard drives.

Table 2-2 XF5 / XF4 / XN5 / XN4 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (SAS HDD 26 TB, SAS SSD 30.72 TB, NVME SSD 61.44 TB)
XF5 / XF4 Series XN5 / XN4 Series (2U 26-bay, SFF)	XD5312 (2U 12-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (NVMe SSD) + 20 x 12 (SAS HDD) + 4 x 26 (NVMe SSD) = 370	14,227 TB
	XD5316 (2U 16-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (NVMe SSD) + 20 x 16 (SAS HDD) + 4 x 26 (NVMe SSD) = 450	16,307 TB
	XD5324 (2U 24-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (NVMe SSD) + 20 x 24 (SAS HDD) + 4 x 26 (NVMe SSD) = 610	20,467 TB
	XD5326 (2U 26-bay, SFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (NVMe SSD) + 20 x 26 (SAS SSD) + 4 x 26 (NVMe SSD) = 650	23,961 TB
	XD5378 (4U 78-bay, LFF) XE5026 (2U 26-bay, SFF)	4 (SAS JBOD) + 4 (JBOF)= 8	26 (NVMe SSD) + 4 x 78 (SAS HDD) + 4 x 26 (NVMe SSD) = 442	16,099 TB

INFORMATION

The maximum number of connecting to XD5378 expansion units is 4.

The diagram below shows the connection of the XF3 / XN3 series with the most expansion units.

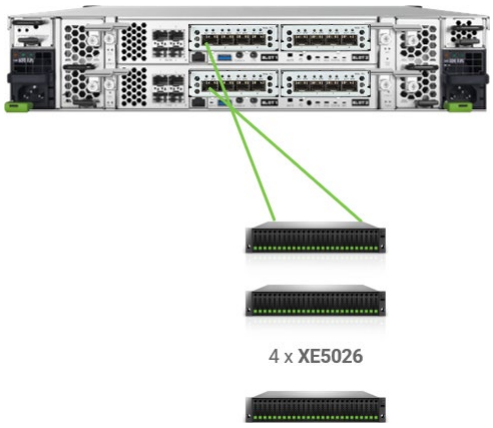

Figure 2-7 Connection of XF3 / XN3 Series

The following table lists the configuration rules for the storage system and expansion enclosures.

Table 2-3 XF3 / XN3 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (NVME SSD 61.44 TB)
XF3 / XN3 Series (2U 12-bay, LFF)	XE5026 (2U 26-bay, SFF)	4 (JBOF)	12 (NVMe SSD) + 4 x 26 (NVMe SSD) = 116	7,127 TB

The diagram below shows the connection of the XCubeNXT series with the most expansion units.

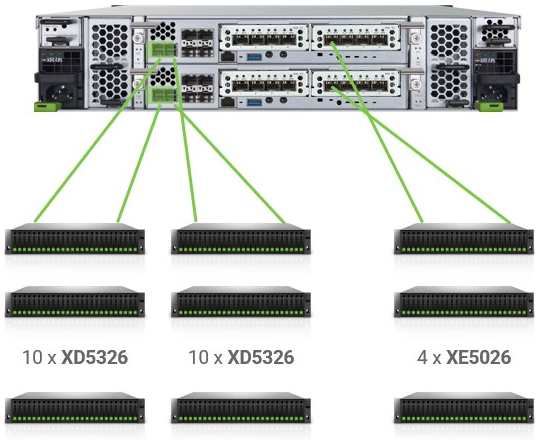

Figure 2-8 Connection of XCubeNXT Series

Table 2-4 XN8112 / XN5112 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (SAS HDD 26 TB, SAS SSD 30.72 TB, NVME SSD 61.44 TB)
XN8112 / XN5112 (2U 12-bay, LFF)	XD5312 (2U 12-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	12 (SAS HDD) + 20 x 12 (SAS HDD) + 4 x 26 (NVMe SSD) = 356	12,941 TB
	XD5316 (2U 16-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	12 (SAS HDD) + 20 x 16 (SAS HDD) + 4 x 26 (NVMe SSD) = 436	15,021 TB
	XD5324 (2U 24-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	12 (SAS HDD) + 20 x 24 (SAS HDD) + 4 x 26 (NVMe SSD) = 596	19,181 TB
	XD5326 (2U 26-bay, SFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	12 (SAS HDD) + 20 x 26 (SAS SSD) + 4 x 26 (NVMe SSD) = 636	22,676 TB
	XD5378 (4U 78-bay, LFF) XE5026 (2U 26-bay, SFF)	4 (SAS JBOD) + 4 (JBOF)= 8	12 (SAS HDD) + 4 x 78 (SAS HDD) + 4 x 26 (NVMe SSD) = 428	14,813 TB

Table 2-5 XN8116 / XN5116 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (SAS HDD 26 TB, SAS SSD 30.72 TB, NVME SSD 61.44 TB)
XN8116 / XN5116 (3U 16-bay, LFF)	XD5312 (2U 12-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	16 (SAS HDD) + 20 x 12 (SAS HDD) + 4 x 26 (NVMe SSD) = 360	13,045 TB
	XD5316 (2U 16-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	16 (SAS HDD) + 20 x 16 (SAS HDD) + 4 x 26 (NVMe SSD) = 440	15,125 TB
	XD5324 (2U 24-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	16 (SAS HDD) + 20 x 24 (SAS HDD) + 4 x 26 (NVMe SSD) = 600	19,285 TB
	XD5326 (2U 26-bay, SFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	16 (SAS HDD) + 20 x 26 (SAS SSD) + 4 x 26 (NVMe SSD) = 640	22,780 TB
	XD5378 (4U 78-bay, LFF) XE5026 (2U 26-bay, SFF)	4 (SAS JBOD) + 4 (JBOF)= 8	16 (SAS HDD) + 4 x 78 (SAS HDD) + 4 x 26 (NVMe SSD) = 432	14,917 TB

Table 2-6 XN8124 / XN5124 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (SAS HDD 26 TB, SAS SSD 30.72 TB, NVME SSD 61.44 TB)
XN8124 / XN5124 (4U 24-bay, LFF)	XD5312 (2U 12-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	24 (SAS HDD) + 20 x 12 (SAS HDD) + 4 x 26 (NVMe SSD) = 368	13,253 TB
	XD5316 (2U 16-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	24 (SAS HDD) + 20 x 16 (SAS HDD) + 4 x 26 (NVMe SSD) = 448	15,333 TB
	XD5324 (2U 24-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	24 (SAS HDD) + 20 x 24 (SAS HDD) + 4 x 26 (NVMe SSD) = 608	19,493 TB
	XD5326 (2U 26-bay, SFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	24 (SAS HDD) + 20 x 26 (SAS SSD) + 4 x 26 (NVMe SSD) = 648	22,988 TB
	XD5378 (4U 78-bay, LFF) XE5026 (2U 26-bay, SFF)	4 (SAS JBOD) + 4 (JBOF)= 8	24 (SAS HDD) + 4 x 78 (SAS HDD) + 4 x 26 (NVMe SSD) = 440	15,125 TB

Table 2-7 XN8126 / XN5126 Expansion Configuration Rules

STORAGE MODELS	EXPANSION UNIT	MAX. NUMBER OF EXPANSION UNIT	MAX. NUMBER OF DISK DRIVE	MAX. RAW CAPACITY (SAS HDD 26 TB, SAS SSD 30.72 TB, NVME SSD 61.44 TB)
XN8126 / XN5126 (2U 26-bay, SFF)	XD5312 (2U 12-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (SAS SSD) + 20 x 12 (SAS HDD) + 4 x 26 (NVMe SSD) = 370	13,428 TB
	XD5316 (2U 16-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (SAS SSD) + 20 x 16 (SAS HDD) + 4 x 26 (NVMe SSD) = 450	15,508 TB
	XD5324 (2U 24-bay, LFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (SAS SSD) + 20 x 24 (SAS HDD) + 4 x 26 (NVMe SSD) = 610	19,668 TB
	XD5326 (2U 26-bay, SFF) XE5026 (2U 26-bay, SFF)	20 (SAS JBOD) + 4 (JBOF)= 24	26 (SAS SSD) + 20 x 26 (SAS SSD) + 4 x 26 (NVMe SSD) = 650	23,162 TB
	XD5378 (4U 78-bay, LFF) XE5026 (2U 26-bay, SFF)	4 (SAS JBOD) + 4 (JBOF)= 8	26 (SAS SSD) + 4 x 78 (SAS HDD) + 4 x 26 (NVMe SSD) = 442	15,300 TB

INFORMATION

The maximum number of connecting to XD5378 expansion units is 4.

3. CONCLUSION

When expanding your storage environment, connecting XE5 series expansion enclosures allows for seamless scalability, enhancing storage capacity while maintaining high performance. By adhering to these best practices for cabling and configuration, users can effectively expand their storage environment, providing additional storage space without compromising on system reliability or performance.

4. APPENDIX

4.1. Apply To

Please refer to Chapter 1.2, Apply Models for supported models.

XEVO 3 firmware 3.2.1 and later

QSM 4 firmware 4.2.1 and later

4.2. Reference

Product Page

- Block Storage
  - XF5 Series
  - XF4 Series
  - XF3 Series
  - XEVO Storage Manager
- Unified Storage
  - XN5 Series
  - XN4 Series
  - XN3 Series
  - XCubeNXT 8100 Series
  - XCubeNXT 5100 Series
  - QSM Storage Manager
- Fabric Attached Storage
  - XE5 Series
- Storage Utility
  - XInsight Central Management

Document

- Hardware Manual
- XEVO 3 Software Manual
- QSM 4 Software Manual
- SAS JBOD Connection Guide