QNAP Enterprise-class NAS Series:

ES1640dc v2, ES1640dc

QNAP Enterprise-class JBOD Series:

EJ1600 v2, EJ1600

Hardware User Manual

Version 7.0

Thank you for choosing QNAP products! This user manual provides description of the hardware of the ES NAS and relevant guideline of certain functions. Please read carefully and strictly adhere to the instructions of the manual.

This user manual is applicable to the following ES NAS models:

ES1640dc v2 and ES1640dc

This user manual is applicable to the following EJ JBOD models:

EJ1600 v2 and EJ1600

NOTE:

- The "ES NAS" is hereafter referred to as "NAS" or "ES NAS".
- The product you purchased may not support certain functions dedicated to specific models.
- All features, functionality, and other product specifications are subject to change without prior notice or obligation.
- Information presented is subject to change without notice.
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Note:

- Back up your system periodically to avoid any potential data loss. QNAP disclaims any responsibility of all sorts of data loss or recovery.
- Should you return any components of the ES NAS package for refund or maintenance, make sure they are carefully packed for shipping. Any form of damages due to improper packaging will not be compensated.

Regulatory Notice

FCC Notice

The QNAP NAS complies with different FCC compliance classes. Please refer to Appendix C for details. Once the class of the device is determined, refer to the following corresponding statement.

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FCC Class A Notice

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Modifications: Any modifications made to this device that are not approved by QNAP Systems, Inc. may void the authority granted to the user by the FCC to operate this equipment.

C E
CE NOTICE

The QNAP NAS complies with different CE compliance classes. Please refer to Appendix C for details.

Symbols in this document

⚠️ Warning	This icon indicates the instructions must be strictly followed. Failure to do so could result in injury to human body or death.
❗ Caution	This icon indicates the action may lead to disk clearance or loss OR failure to follow the instructions could result in data damage, disk damage, or product damage.

Table of Contents

Safety Warnings

1. The ES NAS can operate normally in temperatures of 0ºC–40ºC (32ºF -104ºF) and relative humidity of 5%–95%. Please make sure the environment is well-ventilated.
2. The power cord and devices connected to the ES NAS must provide correct supply voltage (770W, 100-240 V@50/60Hz).
3. Do not place the ES NAS in direct sunlight or near chemicals. Make sure the temperature and humidity of the environment are in optimized level.
4. Unplug the power cord and all connected cables before cleaning. Wipe the ES NAS with a dry towel. Do not use chemical or aerosol to clean the ES NAS.
5. Do not place any objects on the ES NAS for the server's normal operation and to avoid overheat.
6. Use the flat head screws in the product package to lock the hard disks in the ES NAS when installing hard disks for proper operation.
7. Do not place the ES NAS near any liquid.
8. Do not place the ES NAS on any uneven surface to avoid falling off and damage.
9. Make sure the voltage is correct in the location where the ES NAS is installed. Contact the distributor or the local power supply company for the information.
10. Do not place any object on the power cord.
11. Do not attempt to repair the ES NAS in any occasions. Improper disassembly of the product may expose the users to electric shock or other risks. For any enquiries, please contact the distributor.
12. The ES NAS models should only be installed in the server room and maintained by the authorized server manager or IT administrator. The server room is locked by key or keycard access and only certified staff is allowed to enter the server room.

⚠️ **Warning:**

- Danger of explosion if battery is incorrectly replaced. Replace only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.
- Do NOT touch the fan inside the system to avoid serious injuries.

Chapter 1. Introduction to QNAP ES NAS series

The Enterprise Storage NAS (ES NAS) series offers robust functionality, exceptional reliability, and availability with the familiar ease of storage management shared by all of QNAP NAS product lines.

The ES NAS series consists of two new major products: the ES1640dc v2 and the ES1640dc. Both of these models are ideal for mid- to large-scale network storage systems.

The ES NAS chassis adopts the industry standard 19 inch high-density enclosure design. The chassis supports 16 drives, saving physical space and lowering the energy consumption required for system cooling in data center environments.

The new ES NAS series has a high availability and serviceability architecture that supports two redundant Storage Controllers and two power supply units. In addition, the EJ1600 v2 and EJ1600 expansion enclosures allow for the growth of the storage system up to a 128 drive maximum using the ES NAS's SAS drive expansion. These expansion units also have high availability features, including dual power supplies and redundant cross loop connections to a base ES NAS. The new ES NAS series provides a number of new capabilities that distinguish them from other enterprise-class NAS. The enhancements are:

- To deliver reliable performance and advanced data services, the ES NAS series combines enterprise-grade hardware and a storage-optimized, enterprise operating system (QES) based on ZFS.

- The dual storage controllers are powered by Intel® Xeon® E5 series processors that deliver unprecedented computing power to run multiple workloads and management tasks concurrently in addition to advanced data services.

- The two active storage controllers work as a cluster, backing up one another so that a single controller can take over the storage resources owned by the other controller in the event of a controller failure.

- Non-disruptive firmware upgrades: Enables controller firmware upgrades with no interruption to data access.

- Cache configurations are available ranging from 1 drive up to 16 drives (full-SSD drive set) system cache.

- Data writes are protected by maintaining a copy in the battery-backed cache unit (comprising DRAM, an mSATA / M.2 SSD module, and a battery backup unit) until the data is written to the HDDs.

- Storage Pool Striping (across different expansion units) provides a mechanism to aggregates hard drives into a bigger storage space with the ability to support multiple RAID groups across different expansion enclosures. (Note that all RAID groups must have the same RAID type.)

Storage Pool Striping helps maximize performance by reducing hot spots in arrays and provides better data safety.

- RAID-TP (Triple parity) provides enhanced redundancy and protection in the event of three simultaneous disk failures.

- Triple Mirroring writes data simultaneously to three separate HDDs so if two-thirds of the HDDs fail in the same RAID group, no data will be lost.

- Support for OpenStack enables integration with the OpenStack cloud environment. After the driver is installed on the OpenStack Cinder nodes, block storage resources can be allocated by the Cinder nodes.

Data safety and encryption

Combined with the world-class business resiliency and encryption features, the ES NAS series provides a unique combination of high availability, performance, and security. QES built-in support for shared folder and LUN encryption ensures critical business-sensitive data is protected. In addition, WORM (Write Once Read Many) functionality protects data from being tampered at a shared-folder level.

Chapter 2. Hardware Specifications

> **⚠ Caution:** Modifying the hardware, software, or firmware of the QNAP products will void the warranty. QNAP is not responsible for any form of damage or loss of data caused by modifying the QNAP products. Users should bear their own risks of all sorts of possible data loss or system instabilities due to changing the hardware parts, modifying the default system firmware or installing any unauthorized third party applications on QNAP products.

Model No.	ES1640dc v2	ES1640dc
Form Factor	3U, Rackmount	
Processor	Intel Xeon E5-2420 v2 (2.2GHz, 6 core, 15MB L3, 80W TDP)	
Memory (x 2 for every system)	ES1640dc-v2-E5-160G: Per controller (2 controllers per system): DDR3 ECC RDIMM 32GB x 2 (total of 64GB) 16GB x 1 (NVRAM) ES1640dc-v2-E5-96G: Per controller (2 controllers per system): DDR3 ECC RDIMM 16GB x 2 (total of 32GB) 16GB x 1 (NVRAM)	ES1640dc Per controller (2 controllers per system): DDR3 ECC RDIMM 16GB x 2 (total of 32GB) 16GB x 1 (NVRAM)
Number of Disk Drives	16 x 2.5"/3.5" HDD Tray is lockable	16 x 2.5"/3.5"
HDD Interface	SAS 12Gb/s; backward-compatible to SAS 6Gb/s	SAS 6Gb/s
JBOD Expansion connectors (x 2 for every system)	Two mini-SAS 12Gb/s ports (SFF-8644)	Two mini-SAS 6Gb/s ports (SFF-8088)
Battery-Backed Write Cache (x 2 for every system)	M.2 2280 for NVRAM (SATA signal)	mSATA for NVRAM

10GbE LAN Port (x 2 for every system)	Four SFP+ (Intel XL710-AM1)	Two RJ45 (Intel X540-BT2)
PCIe expansion slots (x 2 for every system)	PCIe Slot x8 (Gen3 x8): Pre-installed with a LAN-10G2T-X550 NIC (2 x 10GbE RJ45 ports), replaceable with a 40GbE NIC PCIe Slot x4 (Gen2 x4): Pre-installed with a dual-port Mini-SAS adapter	PCIe Slot x8 (Gen2 x8): Reserved for 40GbE or 10GbE LAN card PCIe Slot x4 (Gen2 x4): Reserved for dual path Mini-SAS
Fan module (x 2 for every system)	Field-replaceable fan module (60*60*38mm, 16000 RPM/12v/2.8A x 3)	
Power Supply	770W 1+1, 100-240V@50/60Hz (hot-swappable, redundant)	
Temperature	0° C to 40 ºC	
Relative Humidity	5 % to 95 %	
Dimensions (mm)	618 (Depth) x 446.2 (Width) x 132 (Height), excluding the handles	
Weight (Net)	26.75kg	

Expansion Enclosures

Expansion Model	EJ1600 v2	EJ1600
Form Factor	3U, Rackmount	3U, Rackmount
Number of Disk Drives	16 x 2.5"/3.5" HDD Tray is lockable	16 x 2.5"/3.5"
HDD Interface	SAS 12Gb/s (backward-compatible to SAS 6Gb/s)	SAS 6Gb/s
JBOD expansion connector (x 2 for every system)	Two mini-SAS 12Gb/s ports (SFF-8644) One mini-SAS 12Gb/s port reserved	Two mini-SAS 6Gb/s ports (SFF-8088)
Fan module (x 2 for every system)	Field-replaceable fan module (60*60*38mm, 16000 RPM/12v/2.8A x 3)	Field-replaceable fan module (60*60*38mm, 16000 RPM/12v/2.8A x 3)
Power Supply	450W 100-240V@50/60Hz (hot-swappable, redundant)	450W 100-240V@50/60Hz (hot-swappable, redundant)
Temperature	0°C to 40 °C	0°C to 40 °C
Relative Humidity	5 % to 95 %	5 % to 95 %

Dimensions (mm)	618 (Depth) x 446.2 (Width) x 132 (Height), excluding the handles	618 (Depth) x 446.2 (Width) x 132 (Height), excluding the handles
Weight (Net)	24.11kg	24.11kg
All product specifications are subject to change without prior notice.		

Chapter 3. System Components

Front Panel Features

The power button, Power/Status LED indicators and LCD status display are conveniently located at the front panel for easy access.

ES1640dc v2:
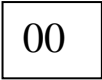
ES1640dc:

Note: Refer to the next section for detailed descriptions on these features.

Front Panel LEDs and Buttons

Item	Description	LED Color	Status
1	Power on button		System power on button. To force shut down the ES NAS, press and hold it for about 10 seconds (or after hearing a long beep, which indicates the system is performing power-down procedure). Release the button after hearing a long beep.
2	System Power LED	Blue	On = System power on

|			Off = System power off
	⊖		
3	Status ○ ⌷	Green Red	Green =The system is operating normally. Red = One or more of the following conditions exist: • There are system errors or warnings (e.g. degraded RAID mode, memory failure, fan/power supply failure, system/disk temperature too high, storage pool reaching threshold value) recorded in system logs of the QES to notify system administrators. Correct errors to reset the LED to green. • The system is performing takeover. [*] • The power supply unit has been unplugged.
4	LCD status display 00		The two-digit number represents various states of device booting process. The left and right digits represent the left Storage Controller (SCB) and the right Storage Controller (SCA) respectively. (Please refer to the High Availability app of the QES for viewing the components and their denoted names). No-Display: BIOS booting 1: Device detecting 2: Network settings 3: System settings 4: Services start 5: System self-testing 8: System initializing 0: System ready
5	HDD Status LEDs (upper)	Green Red	Green On = Drive is actively online Slow flashing = The "Locate" command which helps identify the drive is executed in the Storage Manager on the QES Red = Error/Damage Off = No HDD present
5	HDD Activity LEDs (lower)	Green	On/Slow flashing = No Drive activity Flashing = High activity on the drive or drive is being configured as part of an array **Caution**: Do not replace a drive without bring it offline first in the QES. You may replace a drive online only when it is part of an array that has been configured for fault tolerance and a predictive failure alert is received from the QES. For more information, refer to the software user

|			manual.
* The dual active-active controller system enables a single controller to take over the pool disk resources owned by the other controller in the event of a controller failure. Takeovers can be initiated manually or be set up with the automatic system failover protection (please refer to the software user manual).			

Rear Panel Features

The rear panel consists of two Storage Controllers, both including I/O expansion slots, Ethernet ports, USB connectors, onboard mini-SAS ports, a SAS HBA, the Storage Controller power-on button, a reset button, the system management port and the BBU.
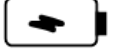
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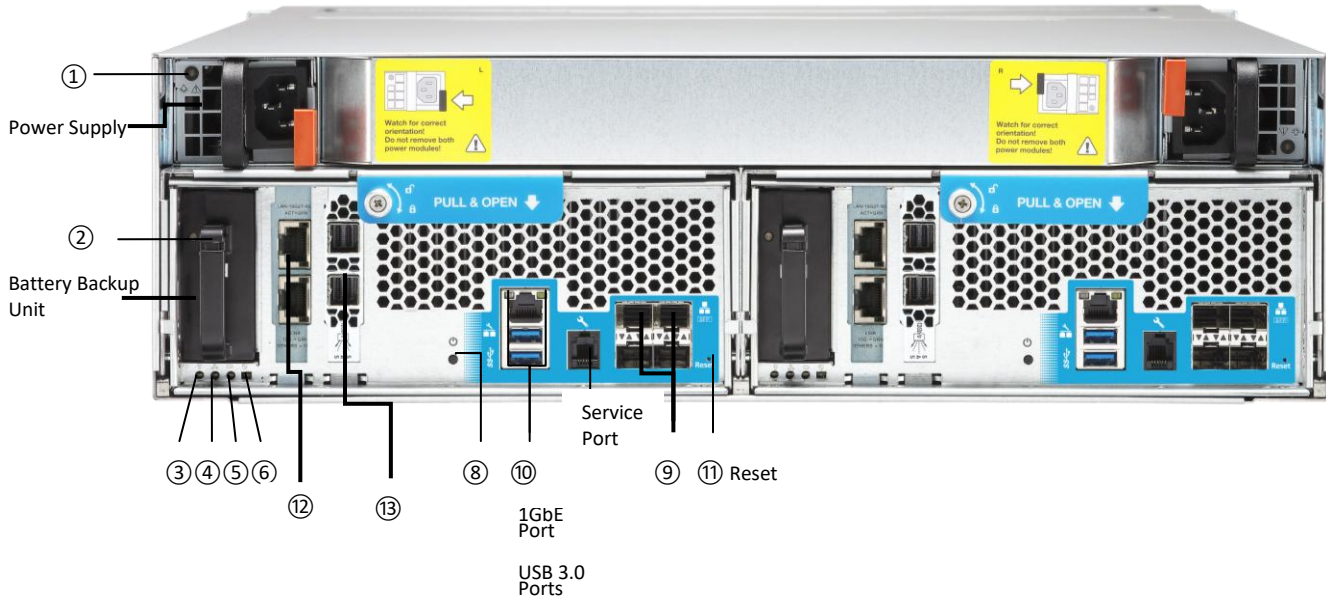
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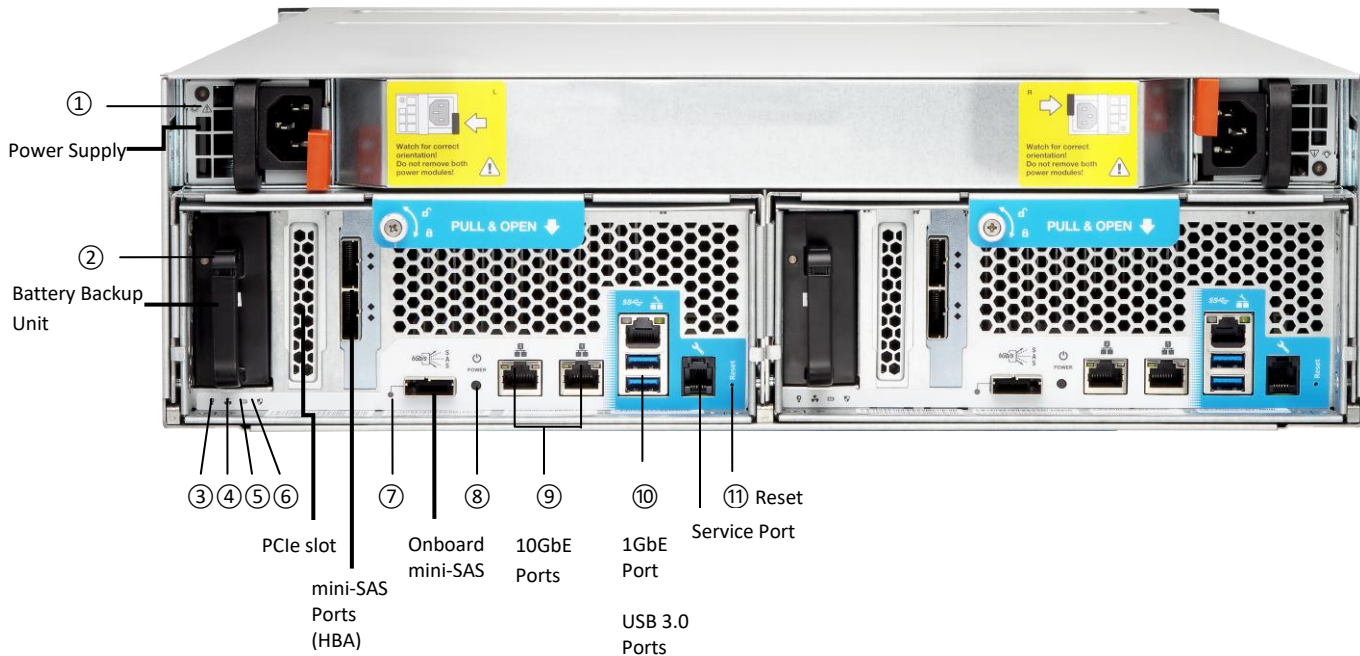
Note: USB 3.0 Ports are for development and debug only.

Rear Panel LEDs and Buttons

Item	Description	LED Color	Status
1	Power supply LED	Green Orange	On = Power turned on and power supply functioning properly Flashing green= System off Flashing orange= AC power cord is unplugged Off = One or more of the following conditions exist: • AC power unavailable • Power supply failed • Power supply exceeded current limit
2	BBU LED (on the battery module)	Green Red Orange	Green = Normal Flashing Green = Copying data to the NVRAM Red = Damage Orange= Charging/learning Off = Not correctly attached to the ES NAS
3	Status	Green Orange	Off = The system is powered off. Green = The system is operating normally. Flashing green = The system is booting.
4	Fan	Green Orange	Green = The fan is operating normally. Orange = Damage/error Off = Not detecting any fans
5	BBU LED (on the Storage Controller)	Green Orange	Green = Normal Orange = Error/Damage Off = One or more of the following conditions exist: •The Storage Controller is not powered on •The system cannot detect the BBU
6	High Availability LED	Green Orange	Green = Active state Flashing orange = performing takeover* or undergoing giveback** Orange = The Storage Controller has taken over from the other Storage Controller. Off = One or more of the following conditions exist: • The Storage Controller has failed over to the other Storage Controller. • The Storage Controller is not powered on.
7	Onboard mini-SAS Port LED	Green Red	Off = No link Green = Network link Flashing = Network activity Red = Error/damage
8	Power-on Button		The Power-on button of the Storage Controller. To shut down the Storage Controller, press and hold it

			for about 5 seconds. It provides the same function as the Power on and Shut Down function in the High Availability app on QES.
9 (Left)	10 Gigabit Ethernet RJ-45 Ports LAN1/LAN2 Speed LED	Green Orange Off	Green = 10 GbE connection Orange = 1 GbE connection Off = 100Mbps connection
9 (Right)	10 Gigabit Ethernet RJ-45 Ports LAN1/LAN2 link/activity LED	Green	Off = No link Green = Network link Flashing = Network activity
9 (Left for Model ES1640dc v2)	10 Gigabit Ethernet SFP+ LAN1/LAN2/LAN3/LAN4 Speed LED	Green Orange Off	Green = 10 GbE connection Orange = 1 GbE connection
9 (Right for Model ES1640dc v2)	10 Gigabit Ethernet SFP+ LAN1/LAN2/LAN3/LAN4 link/activity LED	Green Off	Off = No link Green = Network link Flashing = Network activity
10 (Left)	Management Port Link/activity LED	Green Off	Off = No link Green = Network link Flashing = Network activity
10 (Right)	Management Port Speed LED	Green Orange	Orange = 1 GbE connection Green = 100Mbpsconnection
11	Reset		System reset button for rebooting the Storage Controller without turning off the system power.
12 (Model ES1640dc v2)	PCIe Gen3 x8 Slot		LAN-10G2T-X550 NIC for 2 x 10GbE (RJ45) Port
13 (Model ES1640dc v2)	PCIe Gen2 x4 Slot		Dual path Mini-SAS (SFF-8644) expansion card on board
* The dual active-active controller system enables a controller to take over the pool disk resources and access the data upon the failure of the other controller. Takeovers can be initiated manually or be set up with the automatic system failover protection (please refer to the software user manual). **Storage Controller A (or B) has taken over the system. Storage Controller B (or A) has been recovered and it is ready to resume data service. Giveback can be initiated manually or be set up with automatic failback after system recovers (please refer to the software user manual).			

Storage Controllers

With the dual-controller configuration, the controller on the left is Storage Controller A (SCA) and the right is Storage B (SCB), as named in the QES, when viewed from the rear of the system. The dual-controller configuration offers redundant access to disk storage. In the case of a controller or an I/O path failure, the redundant controller will continue to provide access to disk drives.

Each storage controller features a BBU, one SAS host bus adapter (pre-installed in one of the PCIe slot), one PCIe expansion slot, an onboard mini-SAS port, power-on button, two 10 Gigabit Ethernet ports, one system management port, two USB 3.0 ports, one service port, and a reset button.

Redundant Power Supply

The power supply module is a 770 Watt switching power supply (Input: 100-127V~/10A, 50-60Hz; 200-240V~/5A, 50-60Hz). The ES NAS has two identical power supply modules for power redundancy. If either power supply fails, the other module will keep the system running until it can be replaced.

Note: Refer to Rear Panel LEDs and Buttons for power supply LED description.

PCIe expansion adaptors

The ES NAS adopts point-to-point, high-speed PCI Express (PCIe) Gen2 (x4) and Gen3 (x8) for I/O expansions. The system can support one additional PCIe (Gen3 x8) attachment. The one with Gen2 (x4) is pre-installed with a SAS host bus adapter.

Onboard mini-SAS ports

Two onboard mini Serial Attached SCSI (SAS) ports provide point-to-point 6Gb/s data (or 12Gb/s depending on the model) transmission to other storage devices.

SAS Host Bus Adapter (HBA)

In addition to the above external Serial Attached SCSI (SAS) host attachment port built into the Storage Controller, a pre-installed SAS HBA provides two additional mini-SAS ports for direct attachment to the expansion units. The SAS HBA supports either 12Gb/s or 6Gb/s transmission speed depending on the models. (ES1640dc v2 comes with 12Gb/s SAS HBA whereas ES1640dc comes with 6Gb/s SAS HBA.)

Battery Backup Units (BBU)

The battery is 10.8V 2200mAH.

The cache of QES NAS Storage is protected by a battery against power loss. The BBU provides power to Battery-Backed Write Cache. The battery provides power if the data in the cache needs to be written to the mSATA memory card if power is disrupted. In the instance when only one BBU fails, the working BBU will protect the operation of write cache on both Storage Controllers. If both BBU fail at the same time, the system will switch to write-through cache mode. You can schedule the BBU learning cycle in the QES; for more information, please refer to the software user manual.

10GbE networking

4 x SFP+ (Intel® XL710-AM1) for Model ES1640dc v2 **or 2 x RJ45 (Intel® X540-BT2) for Model ES1640dc**

The ES NAS series is architected and validated with Intel® Xeon® processor E5 v2. The Ethernet ports based on the Intel XL710 or X540 Ethernet controller implement hardware optimizations and off-loads for exceptional performance. The network configuration of the QES supports Jumbo frame, port trunking and VLAN settings for you to optimize performance and security in an IP SAN environment.

40GbE networking can be easily achieved with the installation of network cards via the PCIe expansion (PCIe Gen3 x8).

On the ES1640dc v2, the PCIe slot is pre-installed with a LAN-10G2T-X550 network card that offers two 10GbE RJ45 ports. Users can replace it with a dual-port QSFP+ 40GbE NIC to provide massive data transmission potential and to simplify network cabling.

USB 3.0 Ports

USB 3.0 Ports are for development and debug only.

Storage Features

Disk drives and Disk Enclosures

The QES NAS storage system supports two redundant Storage Controllers with the latest SAS 12Gb/s or 6Gb/s HDD interface (ES1640dc v2 comes with 12Gb/s SAS HDD interface whereas ES1640dc comes with 6Gb/s HDD interface) in 16 drive configuration, which can be expanded to a maximum of 128 drives with the expansion units. The system supports all-SSD drive set within an enclosure. The drives are numbered 1 - 16 sequentially starting from the bottom left to the top right.

When creating a storage pool, you must assign the ownership of this storage pool to either of the two Storage Controllers (SCA or SCB) of the ES NAS system. LUNs can be distributed between the two controllers to achieve optimized performance of the whole system. In addition to load balancing, the dual active/active controller architecture provides system failover protection that enables automatic transfer of storage resources from one controller to the other in case of failure events such as JBOD or data service network connection failures.

Solid-state drives (SSDs)

The system can accommodate superfast solid-state drives, and traditional spinning disk drives such as SAS and NL-SAS drives. However, SSDs are the best choice for I/O intensive workload and they can be used for cache acceleration in QES. Cache configurations are available ranging from 1 drive up to 16 drives (full-SSD drive set) system cache. If you plan to install SSDs as partial drive set, please populate the bottom 4 drives (Drive 1~4) slots since these drives will be the system drives.

RAID implementation

RAID implementation improves data storage reliability and performance.

Redundant Array of Independent Disks (RAID) is comprised of many disks to form a disk array. The purpose of RAID implementation is to provide fault tolerance and improvements to storage reliability and data service performance. When one or multiple disks of an array fail, data can be recovered from the other disks in the array. The supported RAID types depend on the storage operation system and the number of disks available.

Refer to the table below for explanations on RAID types:

RAID Type	Description
Single Disk	A single, stand-alone RAID group can be set up for your NAS. However, this setup does not provide any redundancy protection. So, in the event that a disk is corrupted or otherwise damaged, all data on that disk will be lost.
RAID 0 Striping	A striping RAID group combines two or more disks into one large, logic al disk. It offers the fastest disk ac cess performance but no data redundancy protection in the event of disk failure or damage. The disk capacity is the sum of all disks. Disk striping is usually used to maximize disk capacity or to accelerate disk access speed. Please note that RAID 0 configuration is not recommended for storing sensitive data.
RAID 1 Mirroring	Disk Mirroring protects your data by automatic ally mirroring the contents of one disk to the second disk in the mirrored pair. It provides protection in the event of a single disk failure. The storage capacity is equal to the capacity of the smallest single disk, as the second disk drive is used to back up the first disk drive. RAID 1 configuration is suitable for storing sensitive data on a corporate or personal level.
RAID 5	RAID 5 configurations are ideal for organizations running databases and other transaction-based applications that require storage efficiency and data protection. A minimum of 3 hard disks are required to create a RAID 5 group. The total capacity of the RAID 5 group is equal to the size of the disk with the smallest capacity in the array times the number of (hard disk – 1). It is recommended (though not required) that only hard drives of the same brand and capacity are used to establish the most efficient hard drive capacity. In addition, if your system contains four disk drives, it is possible to use three drives to implement a RAID 5 data array with the fourth drive kept as a spare disk. In this configuration, the system will automatically use the spare disk to rebuild the array in the event of a physic al disk failure. A RAID 5 configuration can survive one disk failure without losing any system functionality. When a disk fails in RAID 5, the storage pool will operate in the "degraded mode". There is no more data protection at this stage, and all the data will be lost if the unit suffers a second disk failure. A failed disk should be immediately replaced. Users can choose to install a new disk after turning off the server or hot-swap the new disk while the server is running. The status of the storage pool will change to "rebuilding" after installing a new disk. Your storage pool will return to a normal status once the rebuilding process is complete.
RAID 6	RAID 6 is ideal for critic al data protection needs. To create a RAID 6 group, a minimum of 4 hard disks are required. The total capacity of a RAID 6 group is equal

	to the size of the disk with the smallest capacity in the array times the number of (hard disks – 2). It is recommended (though not required) to use identical hard drives to establish the most efficient hard drive capacity. RAID 6 can survive 2 disk failures and the system can still operate properly.
RAID 10	RAID 10 is a combination of RAID 1 (mirroring) and RAID 0 (striping), without parity. RAID 10 is a stripe across a number of disks to provide fault tolerance and high speed data transfer. The storage capacity of a RAID 10 group is equal to the size of the disk with the smallest capacity in the array times (the number of hard disks in the array/2). It is recommended that only hard disk drives of the same brand and capacity are used to create a RAID 10 group. RAID 10 is suitable for high volume transaction applications, such as a database, that require high performance and fault tolerance. A maximum of 2 failed disks from up to one drive.
RAID 50	RAID 50 is a combination of RAID 5 (distributed parity) and RAID 0 (striping). It is recommended for applications that require high fault tolerance, capacity, and random access performance. RAID 50 requires a minimum of 6 drives and can overcome up to one drive failure in each RAID 5 array. The total storage capacity of a RAID 50 array is the sum of its RAID 5 arrays. The total capacity of a RAID 5 group is equal to the size of the disk with the smallest capacity in the array times the number of (hard disk – 1). It is recommended (though not required) that only hard drives of the same brand and capacity are used to establish the most efficient hard drive capacity.
RAID 60	RAID 60 is a combination of RAID 6 (distributed double parity) and RAID 0 (striping). It offers higher fault tolerance than RAID 50, but uses an extra drive per set for parity. RAID 60 requires a minimum of 8 drives and can overcome up to two drive failures in each RAID 6 array. The total storage capacity of a RAID 60 array is the sum of its RAID 6 arrays. The total capacity of a RAID 6 group is equal to the size of the disk with the smallest capacity in the array times the number of (hard disks – 2). It is recommended (though not required) that only hard drives of the same brand and capacity are used to establish the most efficient hard drive capacity.
Triple Mirror	Triple mirror aims to solve RAID 1 data loss risk if both the primary and mirror drive fails or if there is a non-recoverable read error. Triple mirror writes data simultaneously to three separate HDDs so if two HDDs, the system still has access to data with no degradation in performance even as the drives are rebuilt. The advantage is performance; the disadvantage is far less usable capacity.
RAID-TP	RAID TP (disk striping with triple distributed parities) is similar to RAID 5 and 6. It stripes data across drives, but calculates for three parities that are written to three

	Basic system reset (1 beep)	Advanced system reset (2 beeps)
System		
All ES models	3 sec	10 sec

individual disks. RAID-TP uses three independent equations to calculate each individual parity that enables reconstruction of data when three disks and /or blocks fail at the same time. RAID-TP can add an extra level of redundancy to help protect your data. RAID-TP requires a minimum of 4 drives.

Reset Button Behavior

Reset button: Press to reset the system settings.

Basic system reset (3 sec)

Press the reset button for 3 seconds, a beep sound will be heard. The System administration password will be reset to default.

Advanced system reset (10 sec)

Press the reset button for 10 seconds; you will hear two beeps at the third and the tenth seconds. The settings such as the users and user groups previously created will be cleared. The ES NAS will reset all the system settings to default as it would by using the web-based system reset in "Control Panel" > "System Settings" > "Backup / Restore" > "Restore to Factory Default" > "Reinitialize NAS". *However*, resetting the ES NAS by holding the button, the data on the ES NAS *will not* be deleted.

Management port

The management is provided by Intel® 82579 Gigabit Ethernet controller. The management port allows you to connect to the QES desktop of the ES NAS. The default ES NAS management website is 169.254.100.100:8080. If the ES NAS has been configured to use DHCP, you can use the QNAP Qfinder Pro to check the IP address of the ES NAS. Make sure the ES NAS and the computer that runs the QNAP Qfinder Pro are connected to the same subnet. The system requires that the management IP addresses are configured on both controllers and that the controllers' management ports are connected to the management network. This should be a separate LAN or a VLAN because you should not use the production LAN or VLAN for management network traffic. To configure the management port IP Address, please refer to the software user manual. In case that one Storage Controller fails, you can enable takeover function from the High Availability app in QES to manage the system through the management port of the other Storage Controller with the same IP address. For more information, please see the software user manual.

Service port

Note: The service port is the main point for hardware installation, configuration, and maintenance activities and it should only be used by QNAP technical support personnel or when you are instructed by QNAP technical support.

The service port is an RS-232 port with RJ-11 connector. Please use the appropriate cable/adapter (i.e.RJ-11 to DB9/DB9 to USB or RJ-11 to USB) to connect this port with your computer. The pin-outs are defined as the following:
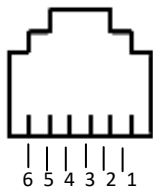
| Pin No.	Signal	Description
1	Rx1	Receive Data of UART1
2	Tx1	Transmit Data of UART1
3	GND	Ground
4	Rx2	Receive Data of UART2
5	Tx2	Transmit Data of UART2
6	GND	Ground

Configure the baud rate and character format of the PC or terminal to match these console port default characteristics:

- 115200 baud rate

- 8 data bits

- 1 stop bit

- No parity

- Flow control: XON/XOFF

- Default username/*password*: admin/*admin*.

Connecting Expansion Units

The ES NAS Series offers the expansion enclosures for expanding the storage space beyond the original drive number offered by the base ES NAS. There are two models of expansions to choose from: the EJ1600 v2 and the EJ1600. These expansions connect to the ES NAS system through the 12 or 6 Gbps SAS expansion ports (depending on the base enclosure model) on the Storage Controller.

The following figure is an example of the storage system ES1640dc v2 and expansion enclosure EJ1600 v2:
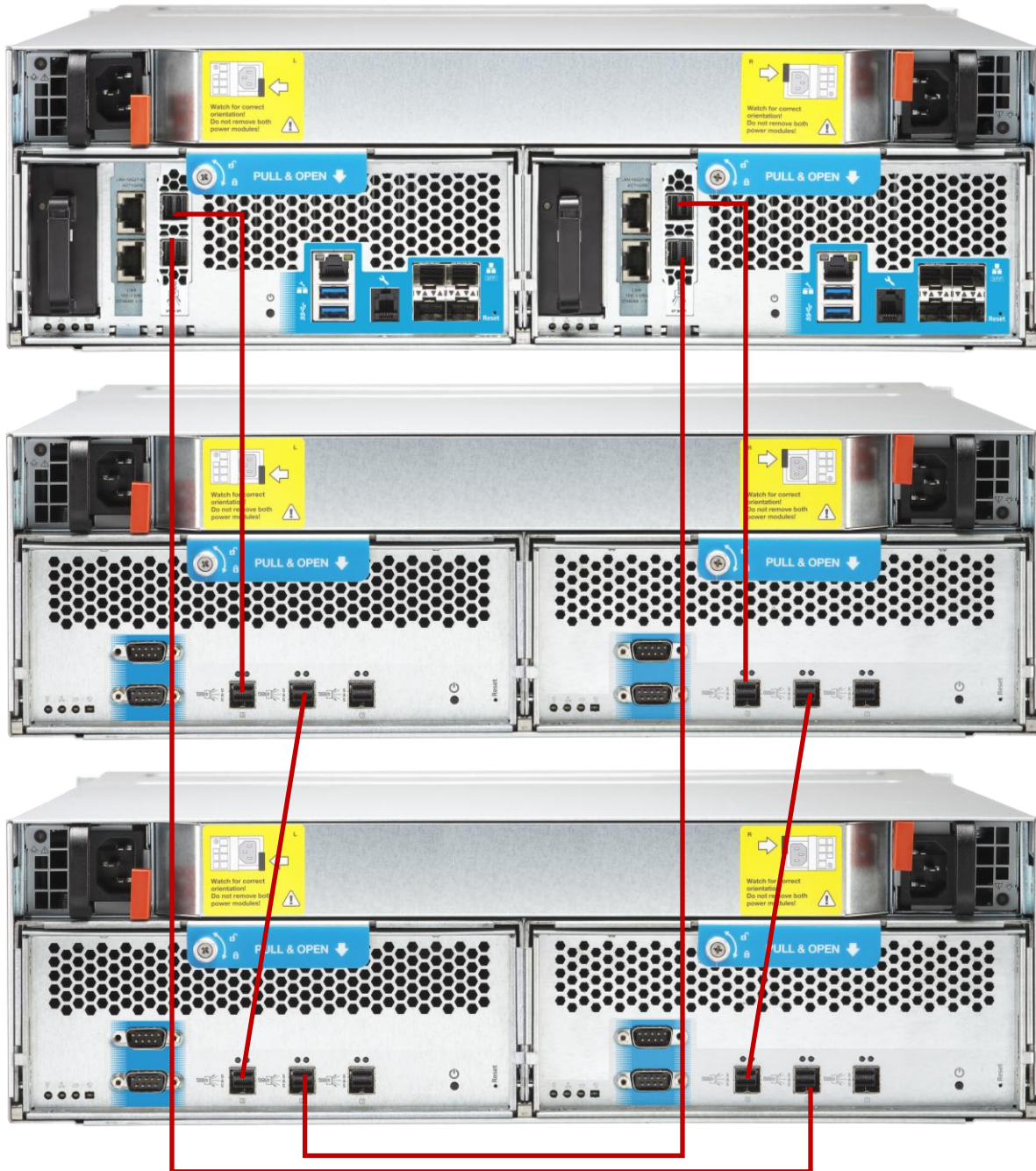
The following figure is an example of the storage system ES1640dc and expansion enclosure EJ1600:

Expansion

IN PORT   OUT PORT

Expansion

IN PORT   OUT PORT
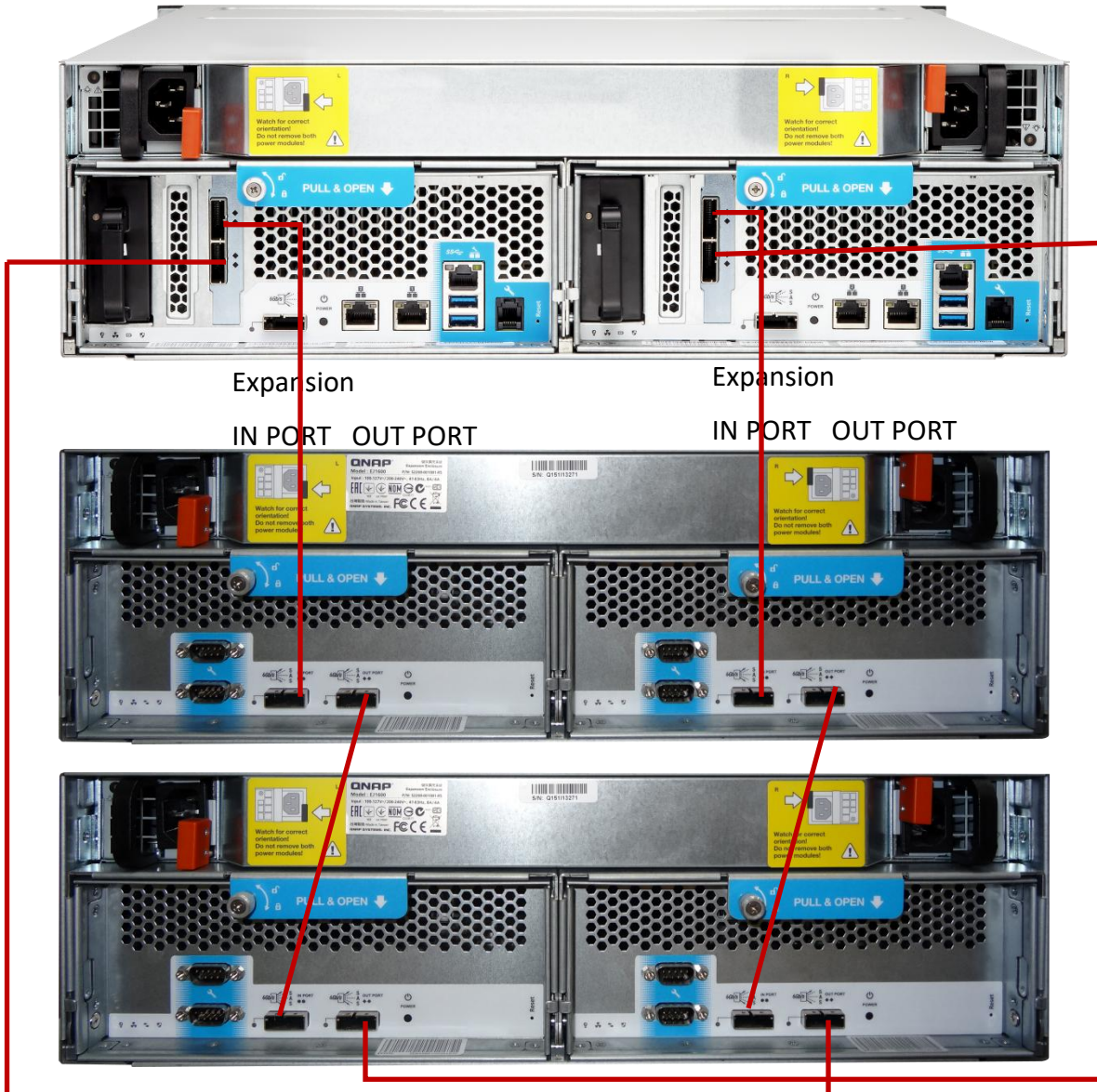
As shown in the above figure, the cabling method used to connect expansion units creates a redundant-cross loop configuration. This provides the expansion units with redundant paths to the base ES NAS. Moreover, system failover protection includes protection of JBOD connection failure to provide an extra layer of protection. (Please refer to the High Availability app of QES.) With these two protection methods, when one or multiple paths to the ES NAS disconnect, the expansion units are still able to communicate with the base ES NAS.

The following procedure describes the steps required to attach an expansion enclosure to a base ES NAS.

1. Connect either of the mini-SAS ports of the SAS HBA on Storage Controller A in the ES NAS and the (SAS) *IN PORT* on the left controller in the expansion enclosure with a mini-SAS cable.

2. (Repeat the above step for Storage Controller B) Connect either of the mini-SAS ports of the SAS HBA on Storage Controller B in the ES NAS and the (SAS) *IN PORT* on the right controller in the expansion enclosure with a mini-SAS cable.

3. (For connecting more expansion units) If there are more expansion enclosures to be connected, connect the (SAS) *OUT PORT* on the left controller in the expansion enclosure to the (SAS) *IN PORT* on the left controller in the next expansion enclosure with a mini-SAS cable. Repeat this step with the right controllers in both expansion enclosures.

4. (For connecting the last expansion unit) Connect one end of the mini-SAS cable to the OUT port on the left controller in the last expansion enclosure and the other end of the mini-SAS cable to the mini-SAS expansion port on *Storage Controller B* of the ES NAS (cross-connect to the other Storage Controller of the ES NAS).

5. (Repeat the above step for the other Storage Controller) Connect one end of the SAS cable to the OUT port on the right controller in the last expansion enclosure and the other end of the mini-SAS cable to the mini-SAS expansion port on *Storage Controller A* of the ES NAS (cross-connect to the other Storage Controller of the ES NAS).

6. Connect the power cables to the new expansion enclosures and power on the expansion enclosures.

Note:

1. If the ES NAS is not powered on, it is recommended to power-on the expansion units first and then power-on the ES NAS.

2. To connect a mini-SAS cable, insert the mini-SAS connector into a mini-SAS port. Make sure that it locks into place. To remove a mini-SAS cable, put one finger into the hole on the finger tab on the mini-SAS connector and pull on the tab to release the lock.

3. Use mini-SAS SFF-8088 to SFF-8088 cable to attach ES1640dc with EJ1600. And use mini-SAS SFF-8644 to SFF-8644 cable to attach ES1640dc v2 with EJ1600 v2. To attach ES1640dc v2 with EJ1600 use mini-SAS SFF-8644 to SFF-8088 cable.

Expansion Units Features

Just like the ES NAS system, the power button, Power/Status LED indicators and LCD status display are conveniently located at the front panel on the EJ expansion units for easy access.

EJ1600 v2:

EJ1600:

Front Panel LEDs and Buttons

Item	Description	LED Color	Status
1	Power on button		System power on button
2	System Power LED	Blue	On = System power on Off = System power off
3	Status	Green Red	Green =The system is operating normally. Red = The Power Supply Unit has been unplugged.

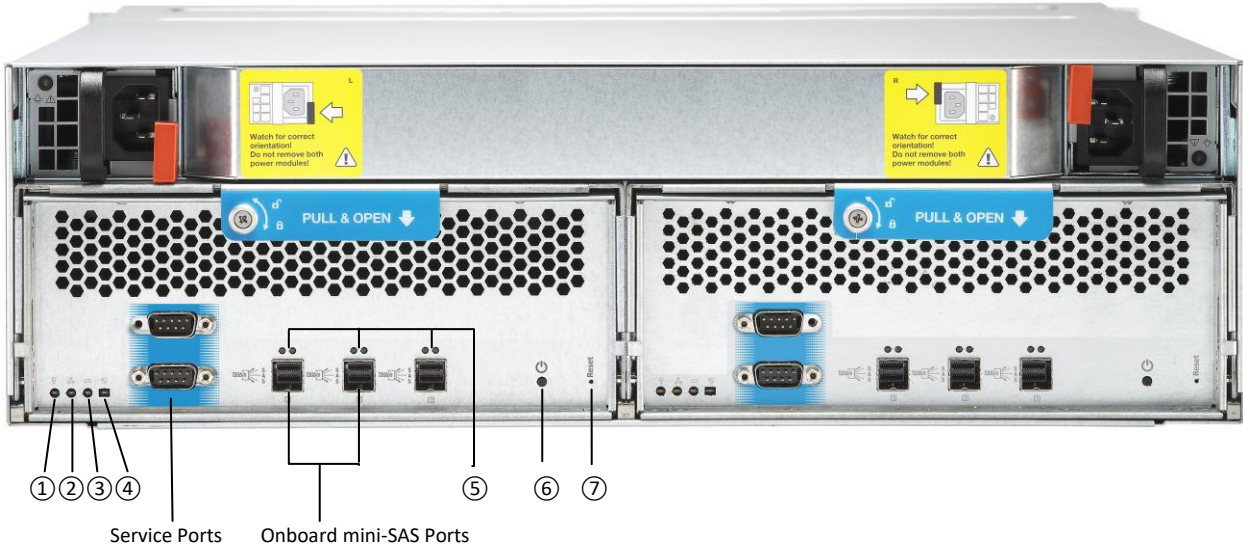| 4	LCD status display 01		The two-digit number represents the expansion unit number. It corresponds to the REXP# in the Storage Manager of the QES.

Enclosure IDs

Each expansion enclosure has an ID number associated with it. The ID allows each enclosure to be identified properly to the ES NAS system. Each enclosure must use a unique value. The Storage Manager of the QES uses the Enclosure IDs to identify each expansion enclosure.
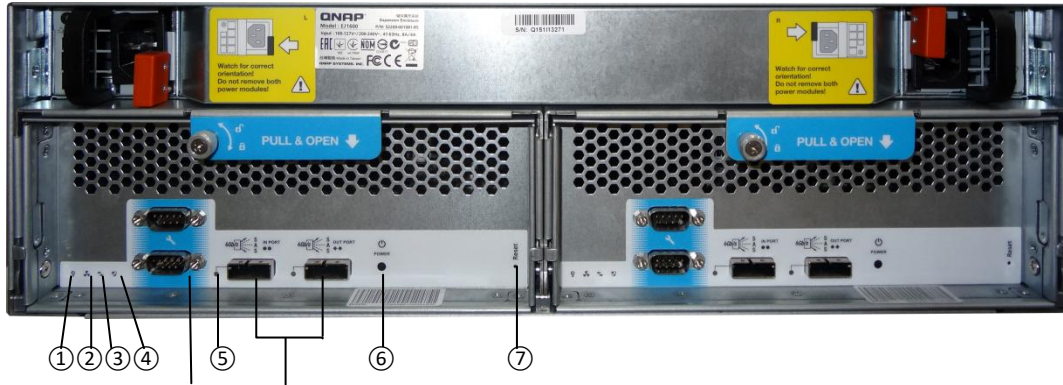
For both enclosure models EJ1600 v2 and EJ1600, the enclosure ID is indicated by a two-digit LCD status display located on the front panel. The QES automatically sets the enclosure ID number as the REXP#. There are no switches on the expansion enclosures to manually set the enclosure ID. To reinitialize or reorder the expansion units, use the "Reinitialize Enclosure ID" function of the QES. For more information, please refer to the software user manual.

Rear Panel LEDs and Buttons

EJ1600 v2:

Service Ports   Onboard mini-SAS Ports

EJ1600:

Service Ports   Onboard mini-SAS Ports

Rear Panel LEDs and Buttons

1	Status	Green Orange	Off = The system is powered off. Green = The system is operating normally. Flashing green = The system is booting.
2	Fan	Green Orange	Green = The fan is operating normally. Orange = There is an error or the fan is damaged. Off = The system cannot detect any fans.
3	Connection Status	Green Orange	Green = The expansion unit is operating normally and is connected to the NAS using dual-path configuration. Orange = The NAS detects the expansion unit, but it is not connected using dual-path configuration. Off = One or more of the following conditions exist: • The expansion unit is powered off. • The system cannot detect the expansion unit.
4	High Availability LED	Green Orange	Green = Active Orange = The expansion controller has taken over from the other expansion controller. Off = One or more of the following conditions exist: • The expansion controller has failed over to the other controller. • The expansion controller is powered off.
5	Onboard SAS Port LED	Green Red	Off = No link Green = Network link Flashing = Network activity Red = Error/damage
6	Power On Button		The power on button of the expansion controller. To power off the expansion controller, press and hold the button for 5 seconds.*
7	Reset Button		The expansion controller reset button
* QES does not provide the power on and off function for the expansion units.			

Onboard mini-SAS ports

Two onboard mini Serial Attached SCSI (SAS) ports provide direct attachment to the base ES NAS enclosure with 6Gb/s data transmission (or 12Gb/s depending on the expansion enclosure model).

Disk drives and Disk Enclosures

**The ES NAS system and the expansion units**

The system can accommodate superfast solid-state drives, and traditional spinning disk drives such as SAS and NL-SAS drives. However, SSDs are the best choice for I/O intensive workload and they can be used for cache acceleration in QES. Cache configurations are available ranging from 1 drives up to 16 drives (full-SSD drive set) of the base ES NAS.

Service port of expansion units

Note: The service port is the main point for hardware installation, configuration, and maintenance activities and it should only be used by QNAP technical support personnel or when you are instructed by QNAP technical support.

The service port of the expansion unit is an RS-232 port with DB-9 (or DE-9) connector. The pin-outs are defined as the following:
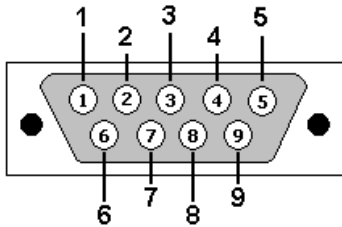
Pin No.	Signal	Description
1	NC	No Connection
2	Rx	Receive Data
3	Tx	Transmit Data
4	NC	No connection
5	GND	Ground
6	NC	No Connection
7	NC	No Connection
8	NC	No Connection
9	NC	No Connection

Figure: Service Port (DB-9) Pin-outs

Configure the baud rate and character format of the PC or terminal to match these console port default characteristics:

- 115200 baud rate

- 8 data bits

- 1 stop bit

- No parity

- Flow control: XON/XOFF

- Default username/*password*: admin/*admin*.

Chapter 4. Service and Maintenance

Note: This chapter is intended for qualified IT personnel and IT administrators. QNAP assumes you are a qualified IT technician.

Safety Considerations

Before performing service procedures, review all the safety information.

To prevent damaging the device, be aware of the warnings below. A discharge of static electricity from finders or electric conductors may damage system boards or other static-sensitive devices. This damage may result in shorter life expectancy of the device.

WARNING: To prevent electrostatic damage:

Avoid hand contact by transporting and storing products in static-safe containers.

Place parts on a grounded surface before removing them from their containers.

Avoid touching pins, leads, or circuitry.

Always be properly grounded when touching a static-sensitive component or assembly.

WARNING: To reduce the risk of electric shock and damage to equipment:

Do not disable the power cord grounding plug.

Ensure the electrical outlet and the device plug are easily accessible at all times.

Unplug the power cord from the power supply to disconnect power from the equipment.

WARNING: To reduce the risk of personal injury from hot surfaces, ensure the drives and the internal system components have cooled before touching them.

Preparation Procedures

To access some components and perform certain service procedures, you must perform one or more of the following procedures:

- You must use the locking feature of the rack rails to support the ES NAS and gain access to internal components if your rack provides one.
- Power down the system

If you must remove a system from a rack or a non-hot-plug component from a system, power down the system. Please refer to the next section for more details on powering down the system.

- Power down the system
- If the rack environment or the ES NAS location is hard for performing maintenance service, remove the ES NAS from the rack. Reverse rack mounting procedure to remove the ES NAS from the rack. Please refer to the next chapter: *Quick-Deploy Rack kit installation* for details.

Powering Down the ES NAS

WARNING: To reduce the risk of personal injury, electric shock, or damage to the device, remove the power cord to completely remove power from the ES NAS. The front panel Power-On button does not completely shut off system power.

IMPORTANT: If installing a hot-plug device, it is not necessary to power down the ES NAS. Use the following procedure to completely remove the power:

1. Back up the system data.

2. Shut down the system with the shut-down function from QES as instructed by the Software User Manual.

3. The system power LED on the front of the system should be off now.

4. Disconnect the power cords.

The system is now without power.

Replacing the battery backup unit (BBU)
Batteries can be replaced only when the LED indicates that they have failed, or by the QES's warning of possibility of failure.

Each Storage Controller contains one battery backup unit (BBU). To remove the BBU:

Note: If the battery module is installed, be sure the battery LED on the battery module is not blinking. If the battery LED (refer to Rear Panel LEDs and Buttons in *Chapter 3: System Components*) is blinking, the battery module is backing up data. Wait until the LED stops blinking before continuing with the procedure.

1. Release the lock by pressing the battery module's handle. Remove the battery module by sliding it out from the Storage Controller.
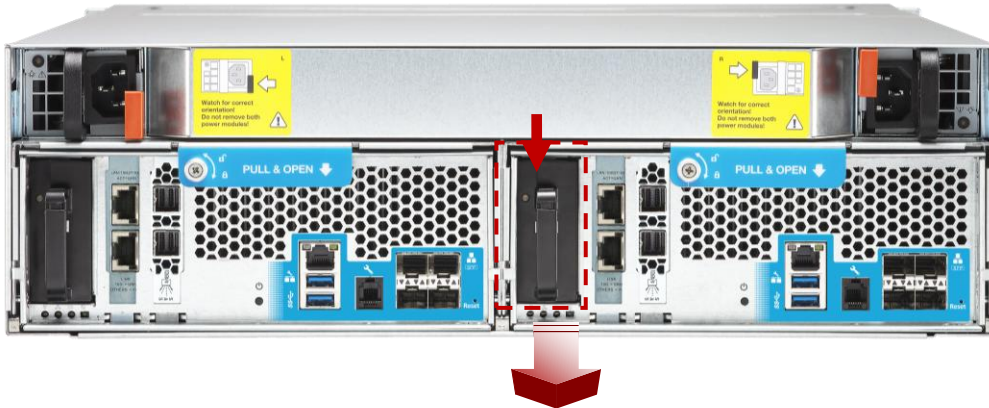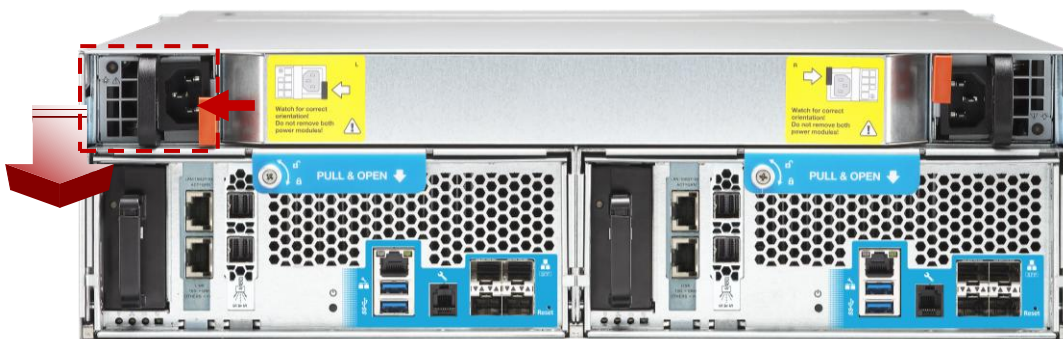
To replace the component, reverse the removal procedure.

Replacing hot-plug power supply

The system comes with two hot-plug power supplies (770W). These PSUs are capable of redundant power supply; when one of them fails, the other will provide power to the entire system.

To remove a hot-plug power supply:

1. Determine how many hot-plug power supplies are installed:

    - -If only one hot-plug power supply is installed, power down and remove the power cord from the ES NAS Disconnect the power cord from the power supply.
    - -If more than one hot-plug power supply is installed, continue with the next step.

2. Unplug the AC power cord.

3. Press the red latch next to the handle to unlock it.

4. Slide the power supply out of the power supply bay.

To replace the component, reverse the removal procedure. Observe the following warning.

 Warning: To reduce the risk of electric shock or damage to the equipment, do not connect the power cord to the power supply until the power supply is installed to the device.

Replacing hot-plug SAS HDDs

Warning:

Do not remove the bottom 4 HDDs as they are used to install or configure the operating system.

To avoid data loss, please back up all data on the hard drives.

To remove a HDD:

1. First bring the storage pool that comprises this HDD that you would like to remove or replace offline. For more information, please refer to the Storage Manager app in software manual.


2. Press to unlock the drive.

3. Remove the hard drive.

To replace the HDD, install the HDD drive on the tray with screws.
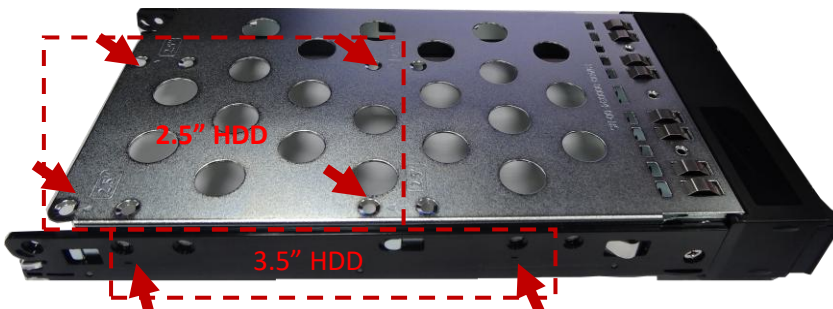
Replacing field-replaceable fan modules

To remove a fan:

1. Shut down the respective Storage Controller that contains this fan either from QES (refer to the High Availability app in software manual) or by pressing the power button on the Storage Controller's back panel.

2. Remove the Storage Controller from the system by loosening the thumb screws on the Storage Controller.

3. Remove the fan module.
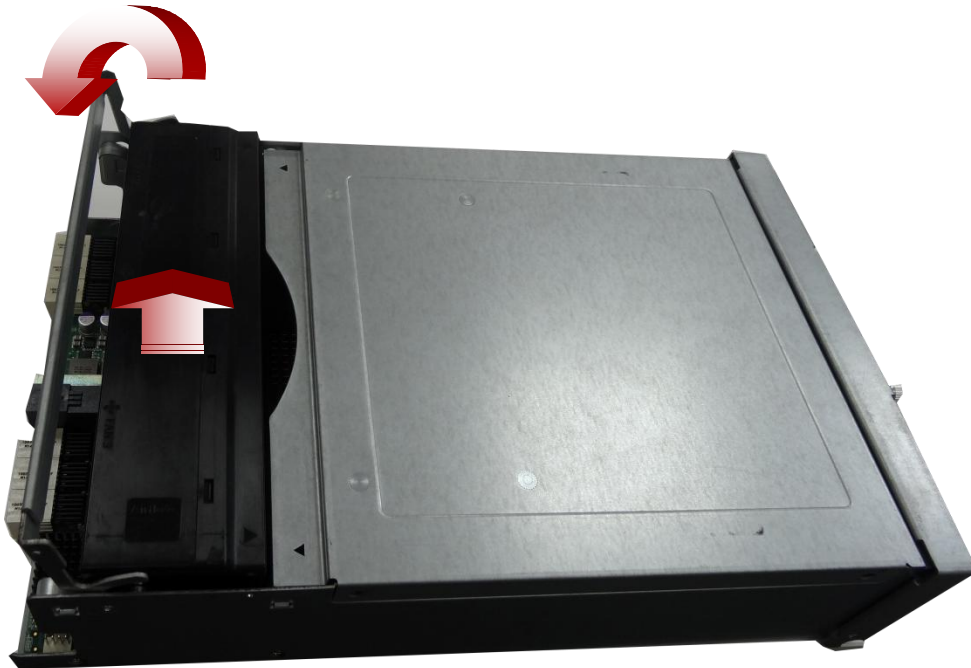
To replace the fan module, reverse the removal steps and push the handle (please do not press down the fan module) to be sure it is seated properly.

Installing expansion cards

To install a PCIe expansion card:

1. Shutdown the respective Storage Controller on which you would like to install an expansion card from QES (refer to the High Availability app in software manual) or by pressing the power button on the Storage Controller (back panel).

2. Remove the Storage Controller from the system by loosening the thumb screws on the Storage Controller.
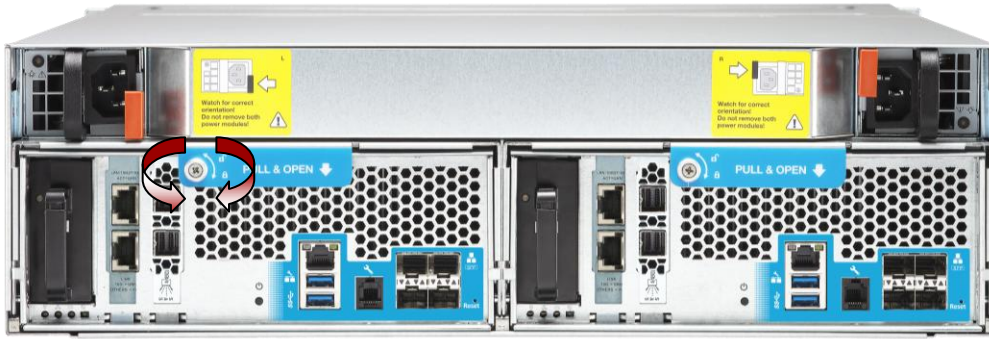
3. Take off the top cover of the Storage Controller by uninstalling the screws (3 at the top, 2 at each side).
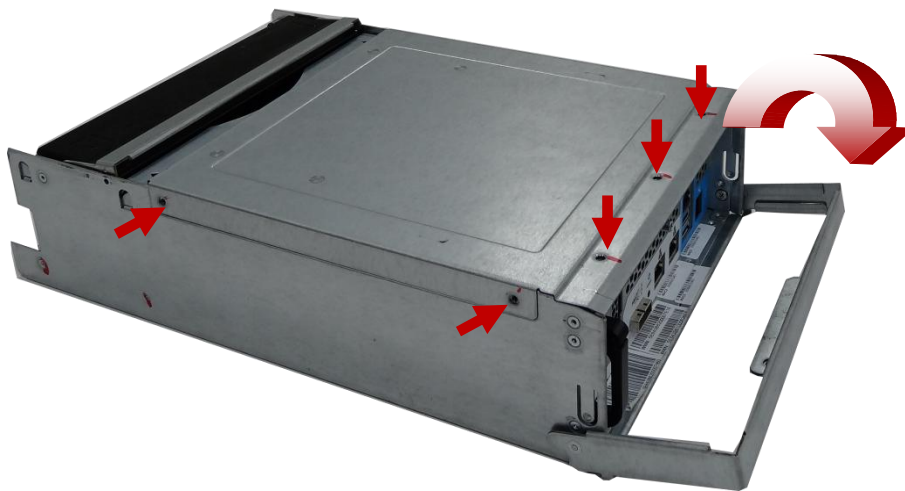
4. Remove the screw that secures the metal bracket to the chassis then remove the metal bracket.

5. Align and insert the expansion card into the PCIe slot.

6. Replace the screw of the metal bracket to secure the card to the chassis.

Note: When removing or inserting the Storage Controller, please use the handle of the Storage Controller to ensure proper handling of the Storage Controller. Always lock the Storage Controller to make sure that it is seated in place after installing it to the system.
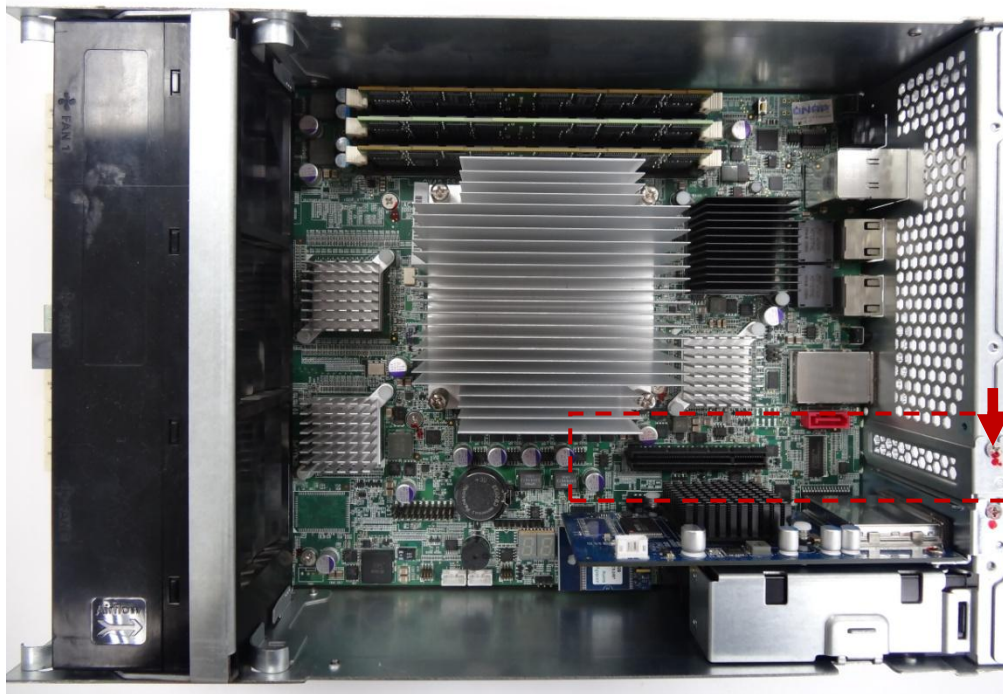
Installing DIMMs

To install a DIMM:

1. Shutdown the respective Storage Controller on which the DIMMs are installed from QES (refer to the High Availability app in software manual) or by pressing the power button on the Storage Controller (Refer to Rear Panel LEDs and Buttons in *Chapter 3*: *System Components*).

2. Remove the Storage Controller from the system by loosening the thumb screws on the Storage Controller.
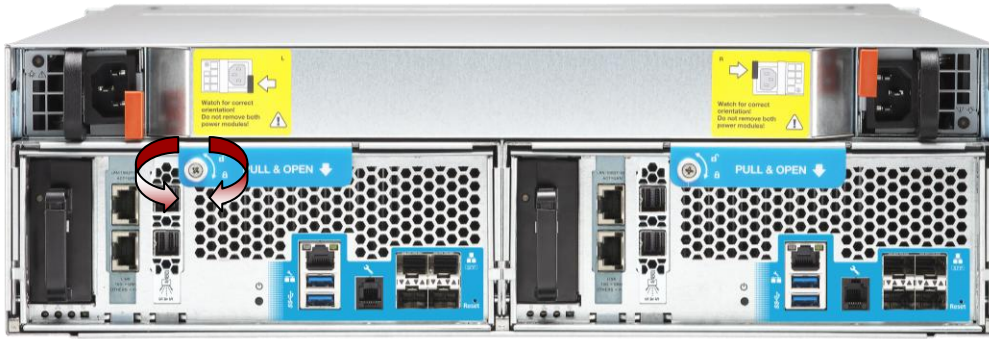
3. Take off the top cover of the Storage Controller by uninstalling the screws (3 at the top, 2 at each side).
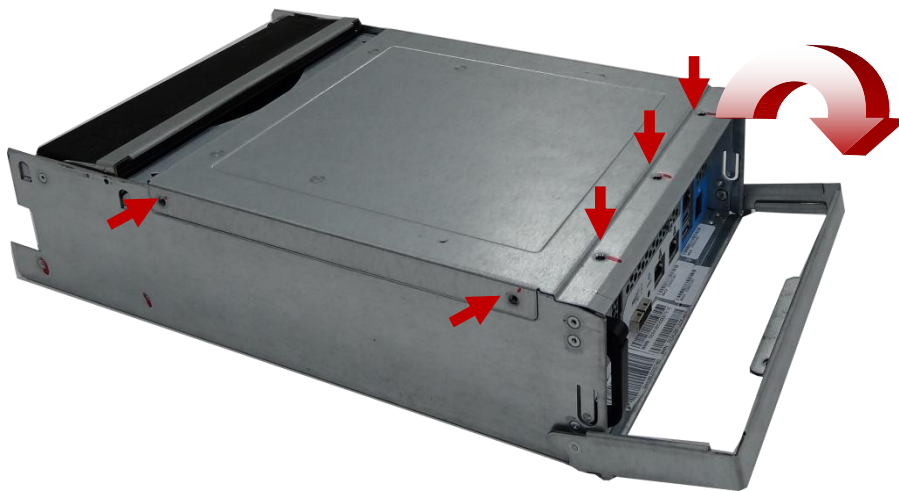
4. Insert the DIMMs.
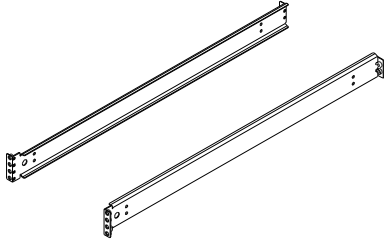
Note: To replace or upgrade a system component, refer to the QNAP website for a list of optional accessories that have been validated with the ES NAS series.

Chapter 5. Quick-Deploy Rack kit Installation Instructions

Overview

This chapter details instructions for installing QNAP rack rails into square-hole racks for the 3U ES NAS. These quick rails automatically latch into the square holes of racks and greatly reduce installation time.

Kit contents

Item	Figure
Two mounting rails (left and right) **NOTE**: This rail will fit a rack between 24" and 36" deep.	
Two cage nuts	
Six Phillips Screw	

Caution

Electrostatic discharge (ESD) can damage electronic components. Perform proper grounding practices before beginning any installation procedure.

Caution

Always plan the rack installation so that the heaviest item is on the bottom of the rack. Install the heaviest item first, and continue to populate the rack from the bottom to the top.

Warning

Ensure that the rack is level and stable before working on the rack. Ensure that the rack is level and stable before working on the rack. Be sure the leveling jacks (feet) extend to the floor and that the full weight of the rack rests firmly on the floor.

![Warning icon] **Warning**

Ensure that the rack has anti-tip measures in place. Such measures may include floor-bolting and anti-tip feet specified by the rack manufacturer and applicable codes.

![Warning icon] **Warning**

To reduce the risk of personal injury or damage to the equipment, at least two people are required to lift the ES NAS during installation or removal.

Mounting the Device

Position left and right rack rails at the desired 'U' position in the rack (step 1 in Figure 1).

Important

When installing the rack rails, be sure they are oriented Front Left and Front Right, as indicated on the rails.

Note: The rails can be adjusted to fit the rack.

Push the release tab to hang the hooks of the rails onto the rack holes and release the tab to snap the rails into place. Secure the back end of the rails to the back rack columns by using the screws provided (Step 2 in Figure 1).
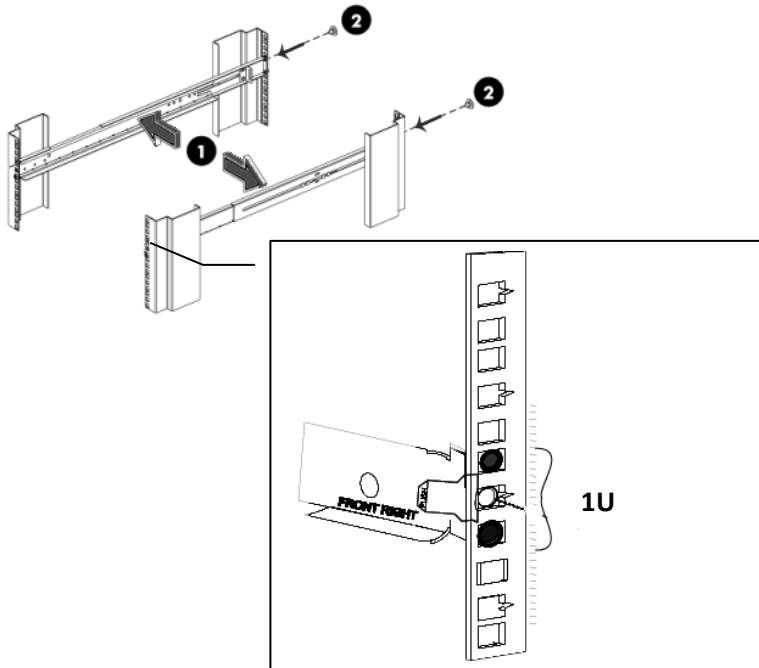
Figure 1: Attach the rails to the rack columns

Place the cage nuts 6 holes (or 2U space from the centerline of the rail) above and snapt it into the square holes of the front columns. Theses cage nuts will be used to attach the ES NAS to the rack later (Figure 2).
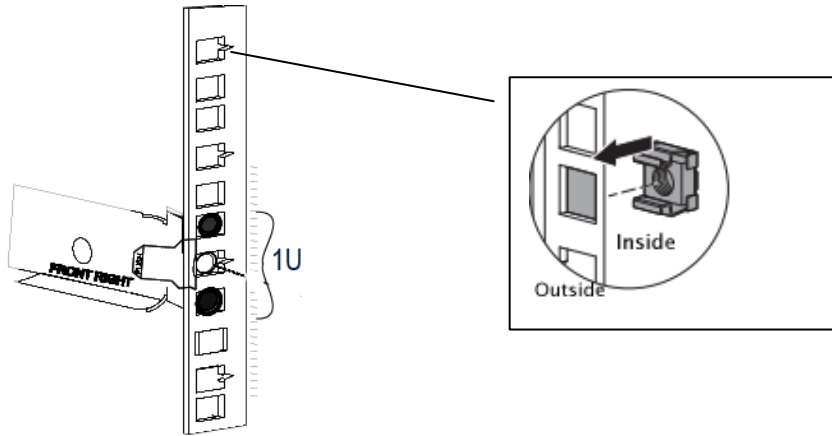
Figure 2: Attach the cage nuts to the rack columns

Slide the ES NAS into position on the rails (Figures 3).
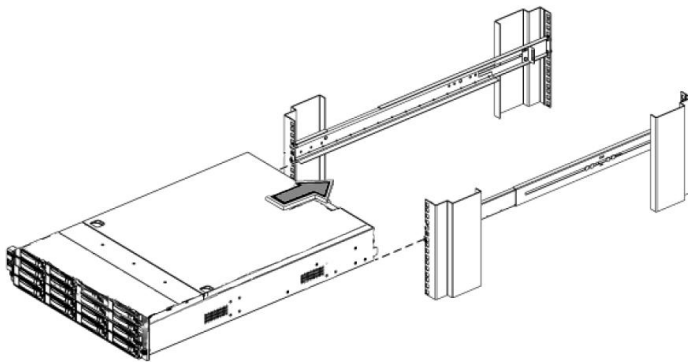
Figure 3: Insert the device into the rack

Secure the device and the front end of the rails to the front rack columns by using the screws provided (Step 1 in Figure 4). The bottom hole can be installed with only screws where as the upper hole (the centerline of 2U space above or 6 holes above) should be installed with the cage nuts (Step 3). Place the LED cap onto the device (Step 2 in Figure 4). (You might want to do this after powering on your system since the power-on button will not be accessible after the cap is attached.)

45

Figure 4: Attach the screws

Appendix A: Multipathing Support for High Availability

ES NAS support connections from multiple hosts with multiple-port configurations in an iSCSI storage area networking (SAN) environment and utilizes standard Ethernet infrastructure. This allows connectivity of a host computer running a Windows server-class operating system with integrated Multipath I/O (MPIO) support.

Multipath solutions employ a redundant network infrastructure to create interconnecting paths between the server, network and storage device. The alternative paths of the redundant network infrastructure allows for continued access in the event that one or more of these network devices fail.

Each Storage Controller should be connected using such redundant network infrastructure to ensure uninterrupted access to storage. The following diagram is an example of how the configuration should be implemented.

Follow these guidelines when configuring iSCSI connections:

- Do not configure any two Ethernet interfaces on the same subnet. Each Ethernet interface must be on a separate subnet.

- The QES only allows fixed IP address configuration for Ethernet ports designated for data services.

- Isolate iSCSI network traffic from other network traffic by using VLANs or separate network equipment.
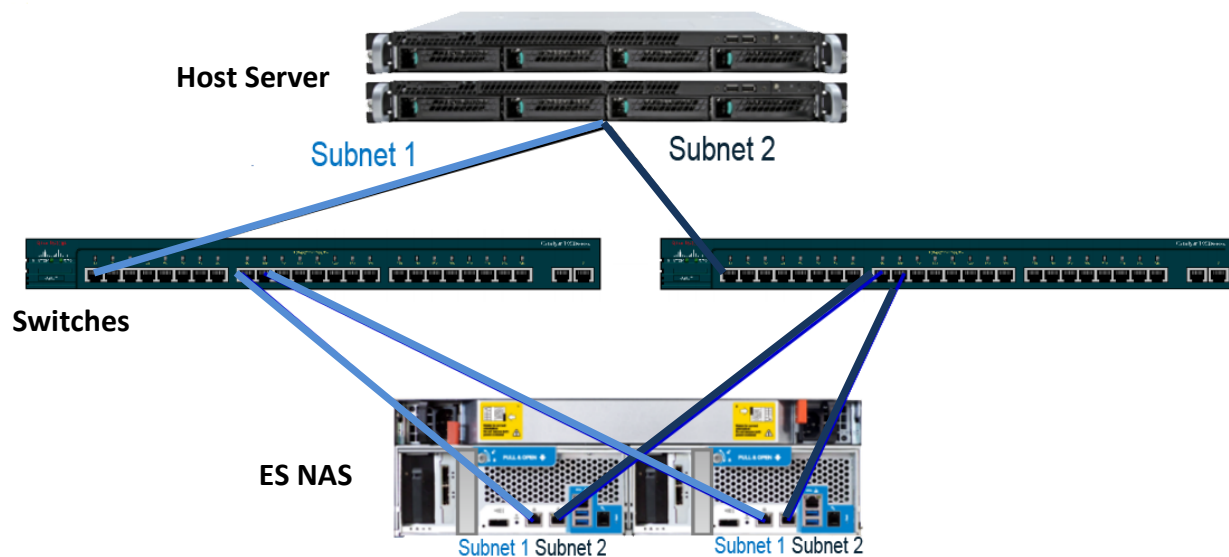
Using this configuration with MPIO, each network port on the host server will be able to see both controllers and use alternate paths to communicate with the ES NAS.

Appendix B: Beep alarm

The beep alarm can be disabled in "Control Panel" > "System Settings" > "Hardware"> "Buzzer".

Beep	Times	Description
Short beep (0.5 Sec)	1	1) The ES NAS/SAN is starting up 2) The ES NAS/SAN is being shut down (software shutdown) 3) The user presses the reset button to reset the ES NAS/SAN 4) The ES NAS is performing giveback.
Short beep (0.5 Sec)	2	The ES NAS is performing takeover.
Short beep (0.5 Sec)	3	The system firmware has been updated
Short beep (0.5 sec)	3, every 5 min	1) The system fan is out of function 2) Heart beat lost connection
Long beep (1.5 Sec)	2	1) The disk volume is going to be full 2) The disk volume has reached its full capacity 3) The hard drives on the ES NAS/SAN are in degraded mode 4) BBU/power supply plug-out 5) JBOD lost
	1	1) The ES NAS/SAN is turned off by force shutdown (hardware shutdown) 2) The ES NAS/SAN has been turned on successfully and is ready

Appendix C. Product Compliance Class

NAS Models	FCC	CE
ES1640dc v2	Class A	Class A
ES1640dc	Class A	Class A

Technical Support

QNAP provides dedicated online support and customer service via instant messenger.

Online Support: http://helpdesk.qnap.com/

Forum: http://forum.qnap.com

Technical Support in the USA and Canada:

Online Support: http://helpdesk.qnap.com/

TEL: +1-909-595-2782 #3

Address: 168 University Parkway, Pomona CA 91768

Service Hours: 08:00-17:00 (GMT- 08:00 Pacific Time, Monday to Friday)

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To "modify" a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a "modified version" of the earlier work or a work "based on" the earlier work.

A "covered work" means either the unmodified Program or a work based on the Program.

To "propagate" a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To "convey" a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

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1. Source Code.

The "source code" for a work means the preferred form of the work for making modifications to it. "Object code" means any non-source form of a work.

A "Standard Interface" means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The "System Libraries" of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A "Major Component", in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The "Corresponding Source" for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

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the compilation and its resulting copyright are not used to limit the access or legal rights of
the compilation's users beyond what the individual works permit. Inclusion of a covered work in an
aggregate does not cause this License to apply to the other parts of the aggregate.

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You may convey a covered work in object code form under the terms of sections 4 and 5, provided that
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a) Convey the object code in, or embodied in, a physical product (including a physical distribution
medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily
used for software interchange.

b) Convey the object code in, or embodied in, a physical product (including a physical distribution
medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer
spare parts or customer support for that product model, to give anyone who possesses the object code
either (1) a copy of the Corresponding Source for all the software in the product that is covered by this
License, on a durable physical medium customarily used for software interchange, for a price no more

than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

c) Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and non-commercially, and only if you received the object code with such an offer, in accord with subsection 6b.

d) Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.

e) Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

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