THEORY OF OPERATION SECTION

Contents

1. Storage System Overview

Section 1 describes the overview of the storage systems.

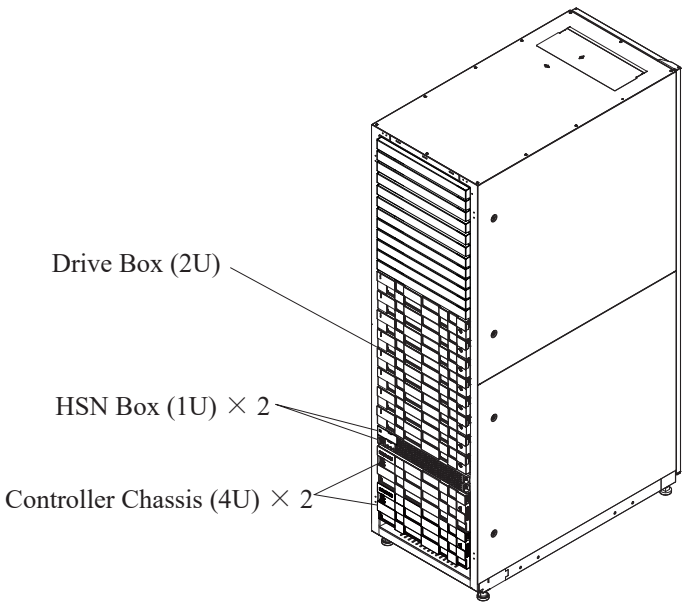
1.1 External View of Hardware

The DKC910I storage system is mounted in 19-inch racks and composed of the Controller Chassis (CBXs), HSN Boxes (HSNBXs), and Drive Boxes. The Controller Chassis contains the Controller Boards that control drives. The HSN Box (HSNBX) contains Interconnect Switches (ISWs) that connect multiple Controller Boards, and the dedicated PC for maintenance (SVP). The Drive Box contains drives.
The Controller Chassis is 4U high, the HSN Box is 1U high, and the Drive Box is 2U high.
There are the following types of Drive Boxes: DBS2 and DBN in which 2.5-inch SFF drives are installed, DBL in which 3.5-inch LFF drives are installed, and DBF3 in which FMDs (Flash Module Drives) are installed.
A set of Drive Boxes is referred to as Disk Unit (DKU). The DKU composed of four DBS2s is referred to as SBX, the DKU composed of eight DBLs is referred to as UBX, the DKU composed of four DBF3s is referred to as FBX, and the DKU composed of four DBNs is referred to as NBX.
The storage system operates by connecting multiple Controller Chassis to HSN Boxes. The following configurations are available:

- Two HSN Boxes and two CBXs
- Two HSN Boxes and four CBXs
- Two HSN Boxes and six CBXs

The maximum number of SBXs that can be installed per two CBXs is eight, while the maximum number of UBXs/FBXs that can be installed per two CBXs is four. Up to eight DKUs (the total number of SBXs, UBXs, and FBXs) can be installed per two CBXs.
NBX cannot be used with SBX, UBX, or FBX. Only one NBX can be installed per two CBXs.
An external view of a storage system configuration example is shown below.

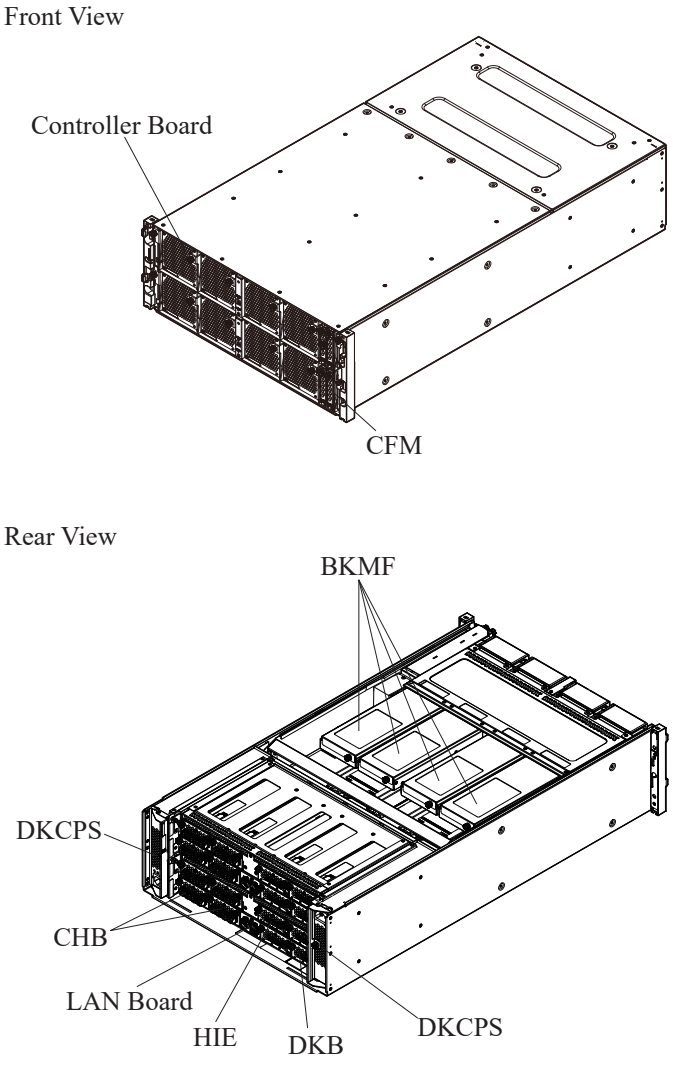
Figure 1-1 Storage System Configuration Example (Two CBXs)



1.2 Hardware Component

1. Controller Chassis (CBX)
   The Controller Chassis (CBX) contains the Controller Boards (CTLs), Disk Boards (DKBs), Channel Boards (CHBs), Interconnect Channel Boards (HIEs), LAN Boards, Power Supplies (DKCPSs), Cache Flash Memories (CFMs), and Backup Modules (BKMFs) in which batteries and fans are installed.
   DKBs are required for the connection between the Controller Chassis (CBX) and the Disk Unit (DKU). Eight or more DKBs must be installed per VSP 5500/VSP 5500H storage system. The installation number of DKBs per VSP 5100/VSP 5100H storage system is four, and the number cannot be increased. However, DKBs are not required for the drive-less configuration that does not contain DKU.
   Up to eight CHBs can be installed per CBX for VSP 5500/VSP 5500H, and up to four for VSP 5100/VSP 5100H. Two or more CHBs must be installed per storage system.

Figure 1-2 Controller Chassis



(1) Controller Boards (CTL)

The Cache Memories (DIMMs), Cache Flash Memories (CFMs), and Backup Modules (BKMFs) are installed in the Controller Board.

Figure 1-3 Controller Board

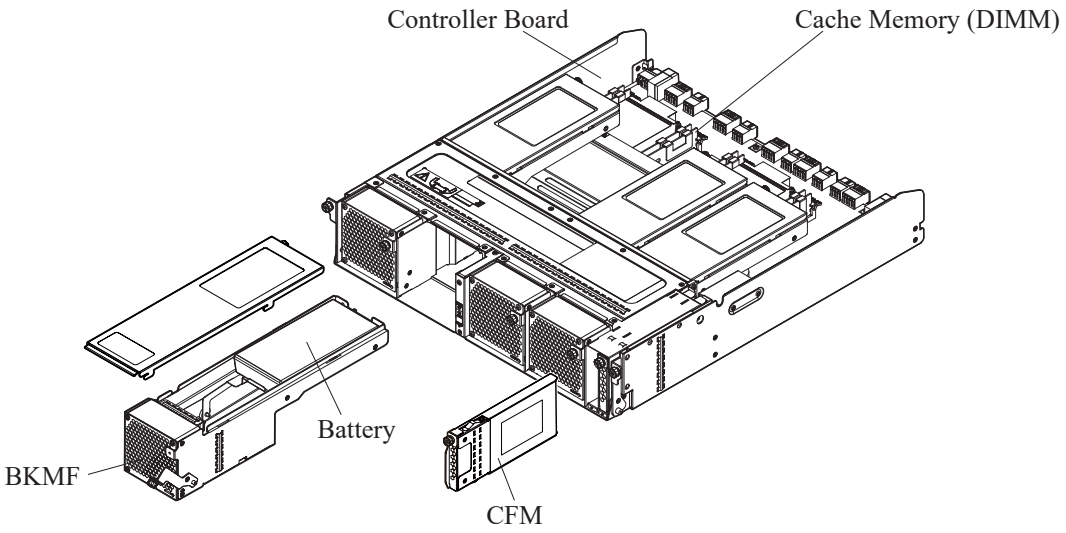


Table 1-1 Controller Boards Specifications

Item		Specifications
Necessary number of CTLs per Controller Chassis	VSP 5500/VSP 5500H	2
	VSP 5100/VSP 5100H	1
Number of DIMM slot		8
Cache Memory Capacity		128 GiB to 512 GiB

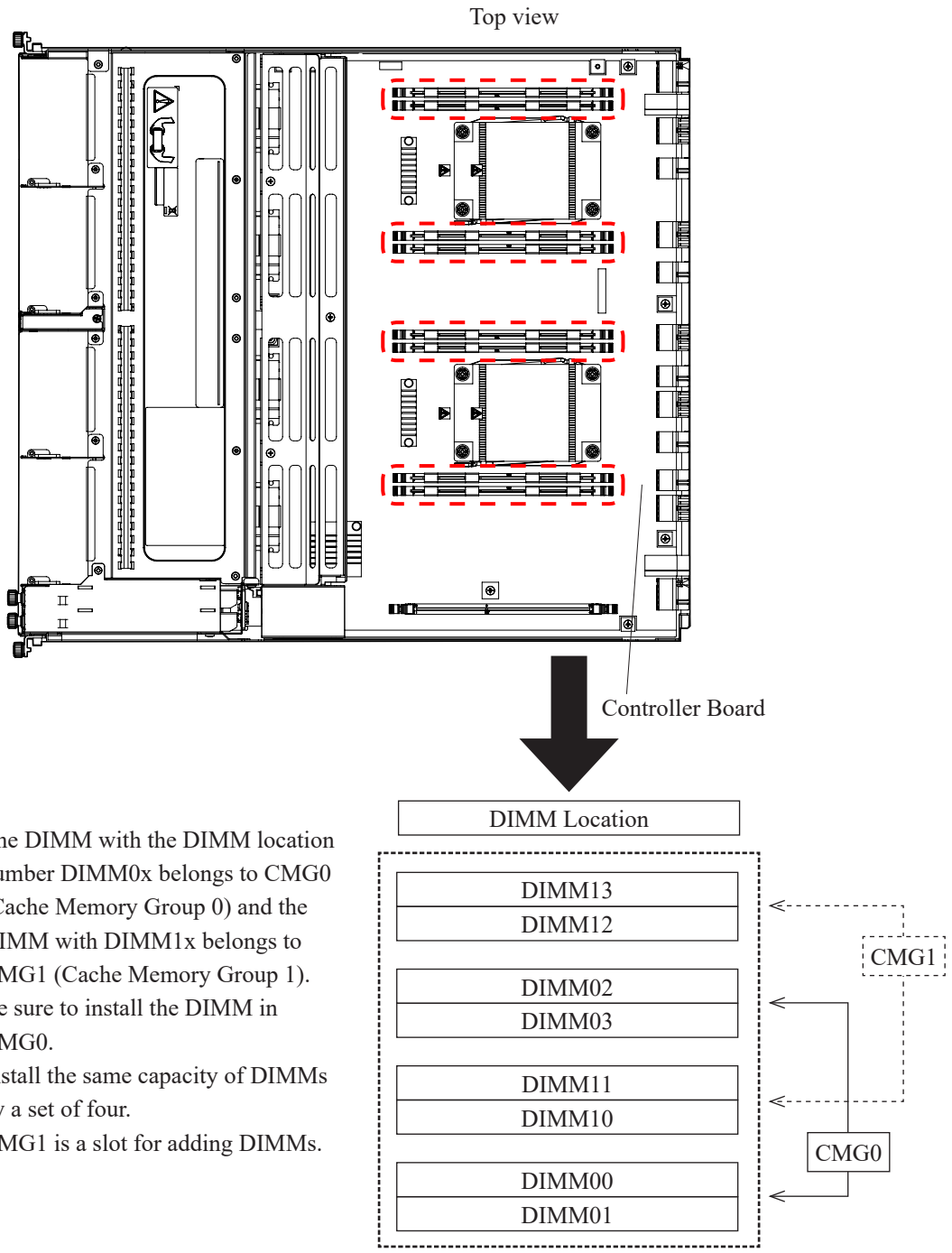
(2) Cache Memory (DIMM)

The DIMMs shown in the following table can be used.

Table 1-2 Cache Memory Specifications

Capacity	Component	Model Number
32 GiB	32 GiB DIMM × 1	DW-F850-CM32G
64 GiB	64 GiB DIMM × 1	DW-F850-CM64GL

Figure 1-4 Top of Controller Board



- The DIMM with the DIMM location number DIMM0x belongs to CMG0 (Cache Memory Group 0) and the DIMM with DIMM1x belongs to CMG1 (Cache Memory Group 1).
- Be sure to install the DIMM in CMG0.
- Install the same capacity of DIMMs by a set of four.
- CMG1 is a slot for adding DIMMs.

(3) Cache Flash Memory (CFM)

The Cache Flash Memory (CFM) is the memory to back up cache memory data when a power failure occurs

Up to two CFMs can be installed per CTL.

When DIMMs are installed in CMG1, the additional CFM must be installed in CFM-x11/x21.

There are four types of CFMs: BM35, BM45, BM3E and BM4E. The CFM that can be installed varies depending on the DIMM type as follows:

32 GiB DIMM capacity: BM35 or BM3E

64 GiB DIMM capacity: BM45 or BM4E

NOTE :
- It is necessary to match the type (model name) of CFM-x10/x20 and CFM-x11/x21 (addition side).
  When adding Cache Memories, check the model name of CFM-x10/x20 and add the same model.
- When replacing Cache Flash Memories, it is necessary to match the type (model name) defined in the configuration information.
  Example: When the configuration information is defined as BM35, replacing to BM45, BM3E or BM4E is impossible.

(4) Battery

The battery for the data saving is installed on each Controller Chassis.

- When the power failure continues for more than 20 milliseconds, the Storage System uses power from the batteries to back up the Cache Memory data and the Storage System configuration data onto the Cache Flash Memory.
- Environmentally friendly nickel hydride battery is used for the Storage System.

(5) Disk Board (DKB)

The Disk Board (DKB) controls data transfer between the Drive and Cache Memory. The DKB supporting the encryption and the DKB not supporting the encryption are available. The two types cannot be mixed in a storage system.

Table 1-3 Disk Board Specifications

Model Number		DKC-F910I-BS12G	DKC-F910I-BS12GE
Interface		SAS	
Number of PCB		1	1
Necessary number of PCB per Controller Chassis (CBX)	VSP 5500/ VSP 5500H	4	4
	VSP 5100/ VSP 5100H	2	2
Data Encryption		Not Supported	Supported
Performance of SAS Port		12 Gbps	12 Gbps

Model Number		DKC-F910I-BN8G
Interface		NVMe (PCIe)
Number of PCB		1
Necessary number of PCB per Controller Chassis (CBX)	VSP 5500/ VSP 5500H	4
	VSP 5100/ VSP 5100H	2
Data Encryption		Not Supported
Performance of NVMe Port		8 Gbps

Table 1-4 Number of Installed DKBs and SAS Ports / NVMe Ports by CBX Configuration

Item	VSP 5100/ VSP 5100H	VSP 5500/VSP 5500H		
	2 CBX (2CBX-2CTL Configuration)	2 CBX	4 CBX	6 CBX
Number of DKB/ DKBN	2 piece/CTL (4 piece/system)	2 piece/CTL (8 piece/system)	2 piece/CTL (8, 16 piece/system)	2 piece/CTL (8, 16, 24 piece/ system)
Number of SAS Port	8 port/system	16 port/system	16, 32 port/system	16, 32, 48 port/ system
Number of NVMe Port	8 port/system	16 port/system	16, 32 port/system	16, 32, 48 port/ system

The drive-less configuration that does not require DKBs is also supported.

(6) Channel Board (CHB)

The Channel Board controls data transfer between the upper host and the Cache Memory.
It supports the following CHBs.
The same type CHBs must be installed in sets of two, one CHB for each CBX of a CBX pair.

Table 1-5 Types CHB

Type	Option Name
32 G 4Port FC	DKC-F910I-4HF32R
10 G 2Port iSCSI (Optic)	DKC-F910I-2HS10S
16G 4Port Mainframe Fibre	DKC-F910I-4MS16
16G 4Port Mainframe Fibre	DKC-F910I-4ML16

The number of installable CHBs is shown below.

Table 1-6 The Number of Installable CHBs

Item	VSP 5100/ VSP 5100H	VSP 5500/VSP 5500H		
	2 CBX (2CBX-2CTL Configuration)	2 CBX	4 CBX	6 CBX
Minimum installable number	2 piece (1 piece/CTL)			
Maximum installable number	8 piece/system (4 piece/CTL)	16 piece/system (4 piece/CTL)	32 piece/system (4 piece/CTL)	48 piece/system (4 piece/CTL)

The CHB for Fibre Channel connection can correspond to Shortwave or Longwave by port unit by selecting a transceiver to be installed in each port.
Note that a port of each CHB installs a transceiver for Shortwave as standard.
When changing to a Longwave supported port, addition of SFP for Longwave is required.

Table 1-7 Maximum cable length (Fibre Channel, Shortwave)

Item	Maximum cable length		
Data Transfer Rate	OM2 (50/125 µm multi-mode fibre)	OM3 (50/125 µm laser optimized multi-mode fibre)	OM4 (50/125 µm laser optimized multi-mode fibre)
400 MB/s	150 m	380 m	400 m
800 MB/s	50 m	150 m	190 m
1600 MB/s	35 m	100 m	125 m
3200 MB/s	20 m	70 m	100 m

Table 1-8 Maximum cable length (iSCSI, Shortwave)

Item	Maximum cable length		
Data Transfer Rate	OM2 (50/125µm multi-mode fibre	OM3 (50/125µm laser optimized multi-mode fibre)	OM4 (50/125µm laser optimized multi-mode fibre)
1000 MB/s	82 m	300 m	550 m

Table 1-9 Maximum cable length (FICON, Shortwave)

Item	Maximum cable length		
Data Transfer Rate	OM2 (50/125µm multi-mode fibre	OM3 (50/125µm laser optimized multi-mode fibre)	OM4 (50/125µm laser optimized multi-mode fibre)
400 MB/s	150 m	380 m	400 m
800 MB/s	50 m	150 m	190 m
1600 MB/s	35 m	100 m	125 m

(7) Interconnect Channel Board (HIE)

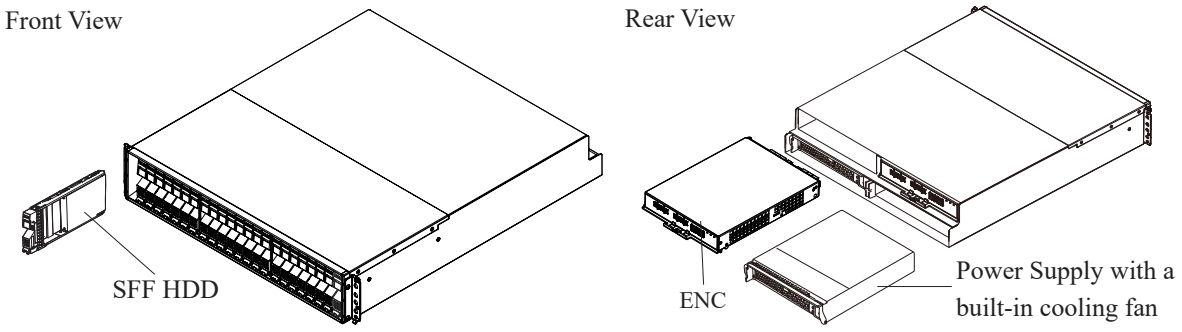
The Interconnect Chanel Board (HIE) is a channel board to connect the CBX and the HSN Box. As with the CHBs and DKBs, the HIEs are installed in the slots on the rear side of the CBX.

2. Drive Box

(1) Drive Box (DBS2)

The Drive Box (DBS2) is a chassis to install the 2.5-inch Disk Drives and the 2.5-inch Flash Drives, and consists of two ENCs and two Power Supplies with a built-in cooling fan.

Figure 1-5 Drive Box (DBS2)



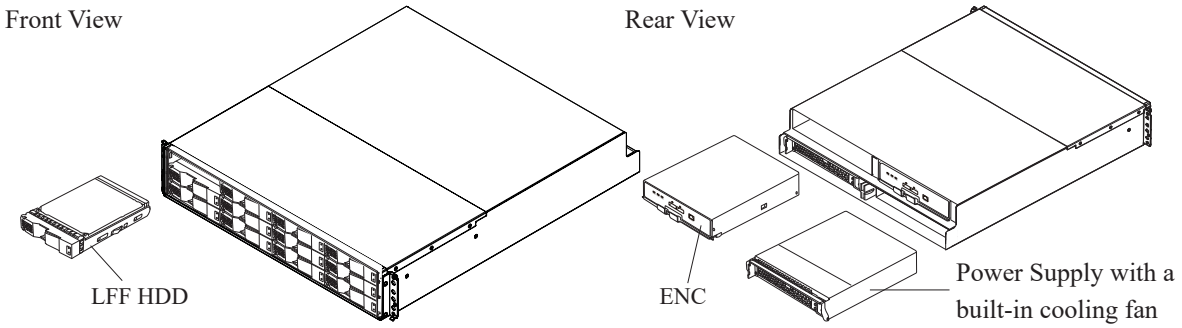
24 SFF HDDs can be installed.

ENC and Power Supply take a duplex configuration.

(2) Drive Box (DBL)

The Drive Box (DBL) is a chassis to install the 3.5-inch Disk Drives and consists of two ENCs and two Power Supplies with a built-in cooling fan.

Figure 1-6 Drive Box (DBL)



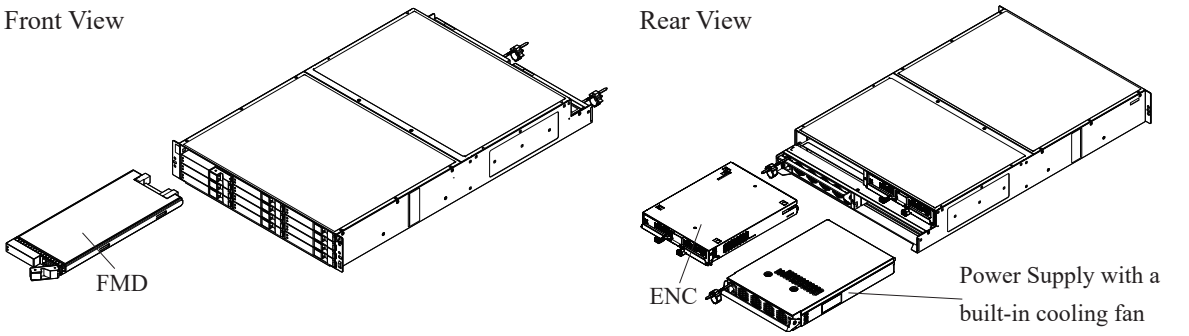
12 LFF HDDs can be installed.

ENC and Power Supply take a duplex configuration.

(3) Drive Box (DBF3)

The Drive Box (DBF3) is a chassis to install the FMDs (Flash Module Drives) and consists of two ENCs and two Power Supplies with a built-in cooling fan.

Figure 1-7 Drive Box (DBF3)



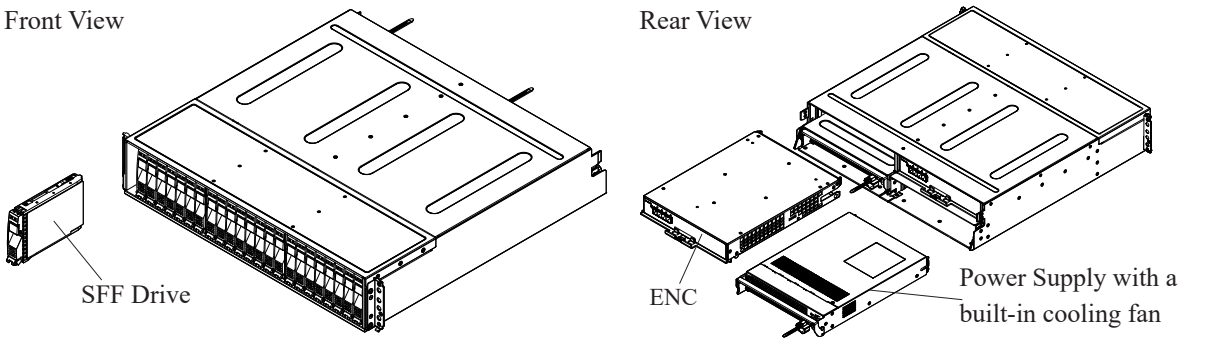
12 FMDs can be installed.

ENC and Power Supply take a duplex configration.

(4) Drive Box (DBN)

The Drive Box (DBN) is a chassis to install the 2.5-inch NVMe-interface Flash Drives, and consists of two ENCs and two Power Supplies with a built-in cooling fan.

Figure 1-8 Drive Box (DBN)

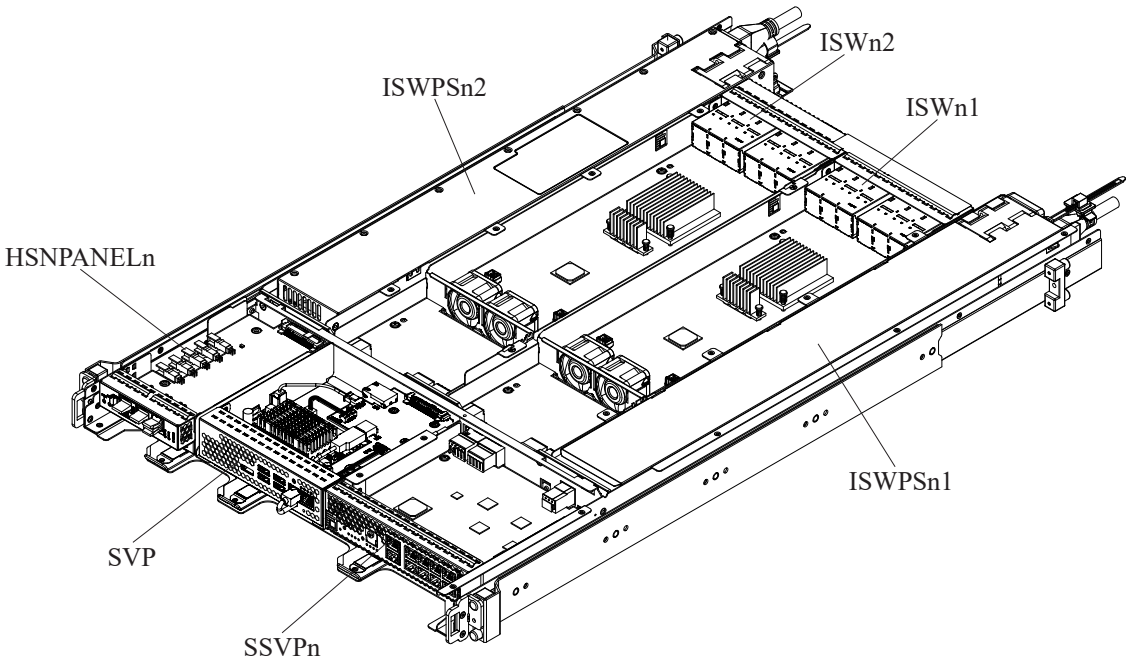


24 SFF Drives can be installed.

ENC and Power Supply take a duplex configuration.

3. HSN Box (HSNBX)
   The HSN Box (HSNBX) is a chassis composed of an SVP, an SSVP, an Operation Panel (HSNPANEL), two Interconnect Switches (ISWs), and two Power Supplies (ISWPSs), and connects and controls each Controller Chassis (CBX).

Figure 1-9 HSN Box (HSNBX)



General view of HSNBX-n

(1) Service Processor (SVP)

The Service Processor (SVP) is mainly used for setting and modification of the storage system configuration, acquisition of the device availability statistical information, and maintenance.
The redundant SVP configuration can be build by installing two SVPs. The primary SVP is Master SVP, and the secondary SVP is Standby SVP. When the primary SVP fails, the secondary SVP is automatically switched into operation with approximately 3 minutes of switching time, and operates as Master SVP. In the event of a SVP failure, employing the redundant SVP configuration can prevent the outage of the failure monitoring function or the like of the storage system.
The Maintenance PC with exact specification must be prepared and connects with SVP, to implement the installation or maintenance of the storage system, because the exclusive SVP for DKC910I has neither a display nor a keyboard. A power supply for the Maintenance PC also must be prepared near the SVP.

Table 1-10 SVP Specifications

Item	Specifications
OS	Windows® 10 IoT Enterprise 2019 LTSC 64bit
LAN	2 × GbE LAN
USB	USB 3.0 × 4 ports

Table 1-11 Specification of Maintenance PC

Item	Specifications
OS	Windows 7 / Windows 8 / Windows 10
Disk Drive	Available hard disk space: 500 MB or more
Display	1024 × 768 (XGA) or higher-resolution 1280 × 1024 (SXGA) Recommendation
DVD Drive	Need
LAN	Ethernet 1000Base-T / 10Base-T / 100Base-T
USB	Need
Tool to view Maintenance Manual	Acrobat Reader, Web browser

4. Disk Drive, Flash Drive and Flash Module Drive
   The Disk Drives, Flash Drives and Flash Module Drives supported by DKC910I are shown below.

Table 1-12 Disk Drive, Flash Drive and Flash Module Drive Support Type

Group	I/F	Size (inch)	Maximum Transfer Rate (Gbps)	Revolution Speed (min^{-1}) or Flash Memory Type	Capacity
Disk Drive (HDD)	SAS	2.5 (SFF)	12	10,000	2.4 TB
	SAS	3.5 (LFF)	12	7,200	10 TB, 14 TB
Flash Drive (SAS SSD)	SAS	2.5 (SFF)	12	MLC/TLC	960 GB, 1.9 TB, 3.8 TB, 7.6 TB, 15 TB, 30 TB
Flash Module Drive (FMD)	SAS	—	12	MLC/TLC	7 TB, 14 TB
Flash Drive (NVMe SSD)	NVMe	2.5 (SFF)	8	TLC	1.9 TB, 3.8 TB, 7.6 TB, 15.3 TB

Table 1-13 LFF Disk Drive Specifications

Item		DKC-F810I-10RH9M	DKC-F810I-14RH9M
Disk Drive Model Name	Seagate	DKS2K-H10RSS	DKS2K-H14RSS
	HGST	DKR2H-H10RSS	—
User Capacity		9790.36 GB	13706.50 GB
Revolution speed (min^{-1})		7,200	7,200

Table 1-14 SFF Disk Drive Specifications

Item		DKC-F810I-2R4JGM
Disk Drive Model Name	Seagate	DKS5K-J2R4SS
	HGST	—
User Capacity		2305.58 GB
Revolution speed (min^{-1})		10,000

Table 1-15 SFF Flash Drive Specifications

Item		DKC-F810I-960MGM	DKC-F810I-1T9MGM	DKC-F810I-3R8MGM
Flash Drive Model Name	Toshiba	SLB5F-M960SD/ SLB5G-M960SS	SLB5I-M1T9SS	SLB5F-M3R8SS/ SLB5G-M3R8SS
	HGST	—	—	SLR5E-M3R8SS/ SLR5F-M3R8SS
	Samsung	—	—	SLM5A-M3R8SS
User Capacity		945.23 GB	1890.46 GB	3780.92 GB
Form Factor		2.5 inch	2.5 inch	2.5 inch

Item		DKC-F810I-7R6MGM	DKC-F810I-15RMGM	DKC-F810I-30RMGM
Flash Drive Model Name	Toshiba	SLB5G-M7R6SS	SLB5H-M15RSS	—
	HGST	SLR5E-M7R6SS/ SLR5F-M7R6SS	—	—
	Samsung	SLM5A-M7R6SS	—	SLM5A-M30RSS
User Capacity		7561.85 GB	15048 GB	30095 GB
Form Factor		2.5 inch	2.5 inch	2.5 inch

Table 1-16 Flash Module Drive Specifications

Item	DKC-F810I-7R0FP	DKC-F810I-14RFP
Flash Module Drive Model Name	NFHAF-Q6R4SS/ NFHAH-Q6R4SS/ NFHAJ-Q6R4SS/ NFHAK-Q6R4SS/ NFHAL-Q6R4SS NFHAM-Q6R4SS	NFHAF-Q13RSS/ NFHAH-Q13RSS/ NFHAJ-Q13RSS/ NFHAK-Q13RSS NFHAM-Q13RSS
User Capacity	7036.87 GB	14073.74 GB
Form Factor	—	—

Table 1-17 NVMe SFF Flash Drive Specifications

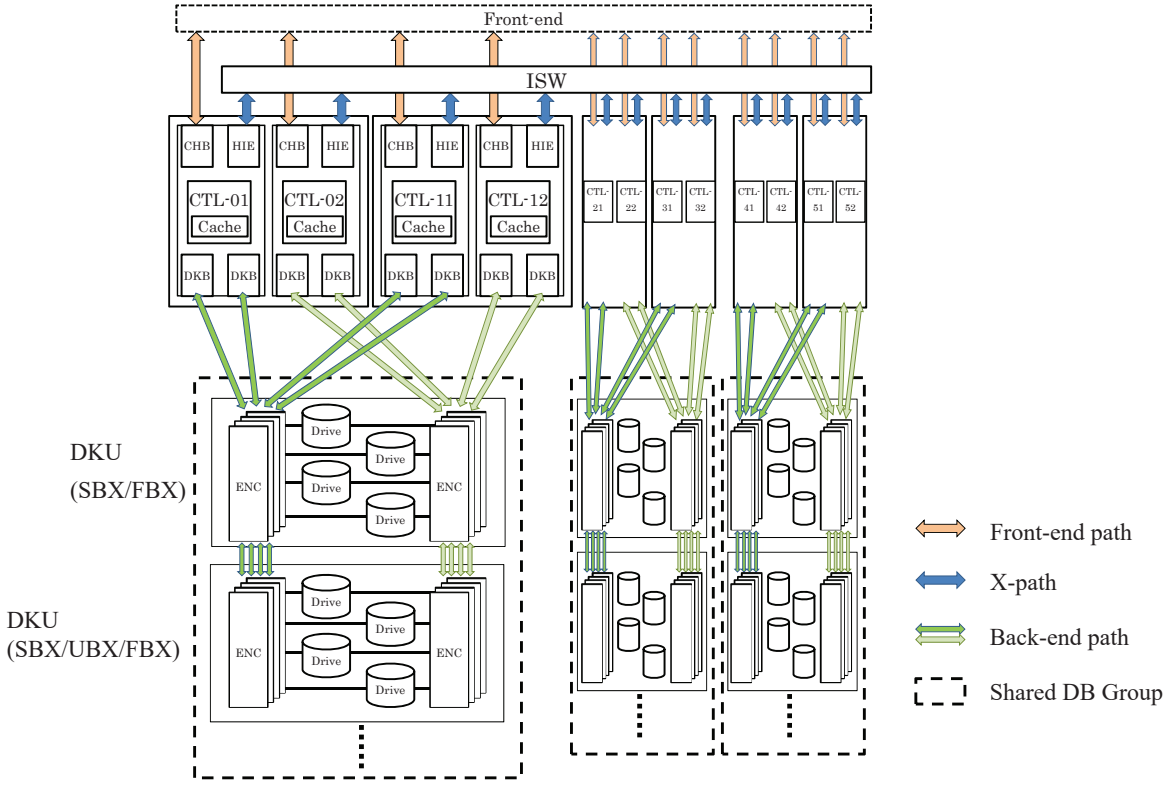
Item		DKC-F910I-1R9RVM	DKC-F910I-3R8RVM	DKC-F910I-7R6RVM
Flash Drive Model Name	HGST	SNR5A-R1R9NC	SNR5A-R3R8NC	SNR5A-R7R6NC
	Toshiba	SNB5A-R1R9NC	SNB5A-R3R8NC	SNB5A-R7R6NC
	Intel	—	—	—
User Capacity		1890.46 GB	3780.92 GB	7561.85 GB
Form Factor		2.5 inch	2.5 inch	2.5 inch

Item		DKC-F910I-15RRVM
Flash Drive Model Name	HGST	—
	Toshiba	SNB5A-R15RNC
	Intel	SNN5A-R15RNC
User Capacity		15048.49 GB
Form Factor		2.5 inch

1.3 Hardware Architecture

- Controller Chassis (CBX) connection patterns
  The basic configuration of the storage system is two Controller Chassis (CBXs), which is referred to as “a CBX pair”, connected to two HSN Boxes (HSNBXs). In addition, the configuration consisting of two CBX pairs (four CBXs) connected to two HSNBXs and the configuration consisting of three CBX pairs (six CBXs) connected to two HSNBXs are available. VSP 5500/VSP 5500H supports up to 3 CBX pairs configuration, and each CBX contains two Controller Boards. VSP 5100/VSP 5100H supports only 1 CBX pair configuration, and each CBX contains one Controller Board.
- Interconnect
  The CBXs and the HSNBXs are connected through the Interconnect Channel Boards (HIEs) installed in the Controller Boards (CTLs) and the Interconnect Switches (ISWs) installed in the HSNBXs by using cables. All CTLs are connected each other through ISWs.
  Up to 12 CTLs can be connected to an ISW. Each fixed port on the ISW is used to connect to each port location on HIEs. The paths between the CTLs and the ISW are referred to as X-paths, and the connection cables are referred to as X-path cables.
- Backend connection
  The Drive Box connections are configured per CBX pair. A set of Drive Boxes of a DKU cannot be separately connected to different CBX pairs. The DKU that is directly connected to a CBX pair must be the SBX composed of four DBS2s, the FBX composed of four DBF3s, or the NBX composed of four DBNs. Each CTL installed in a CBX pair connects to four DBS2s in the SBX, four DBF3s in the FBX or four DBNs in the NBX.
  DKU other than NBX can be connected to another DKU. A set of Drive Boxes of a DKU cannot be separately connected to different DKUs connected to different CBX pairs. Therefore, one CTL can access all drives connected to the same CBX pair. The group of Drive Boxes that a CBX pair can access is referred to as Shared DB Group. The logical configuration of the storage system is shown below.

Figure 1-10 Hardware Logical Configuration Diagram



[Notes on Drive Box connection]

There are three types of Drive Boxes: DBS2, DBL, DBF3, and DBN. All Drive Boxes that compose a DKU are installed at a time (four DBS2s/DBF3s/DBNs or eight DBLs).

Only SBX (DBS2 × 4), FBX (DBF3 × 4), or NBX (DBN × 4) can be directly connected to DKCs. UBX (DBL × 8) must be connected to SBX, FBX, or UBX. All DKBs in DKCs are connected to SBX, FBX, or NBX.

UBX can be used by connecting it to the SBX/FBX connected to DKCs to secure the path availability. Each CTL in DKCs can access all drives.

- DBS2 (for 2.5-inch drives)
  Up to 24 2.5-inch drives can be installed. One DB number is assigned to a set of 12 drives. Two consecutive DB numbers are assigned to a DBS2.
- DBL (for 3.5-inch drives)
  Up to 12 3.5-inch drives can be installed. One DB number is assigned to a DBL.
- DBF3 (for FMD)
  Up to 12 FMDs (Flash Module Drives) can be installed. One DB number is assigned to a set of 6 drives. Two consecutive DB numbers are assigned to a DBF3.
- DBN (for 2.5-inch drives) (NVMe interface)
  Up to 24 2.5-inch NVMe-interface drives can be installed. One DB number is assigned to a set of 12 drives. Two consecutive DB numbers are assigned to a DBN.

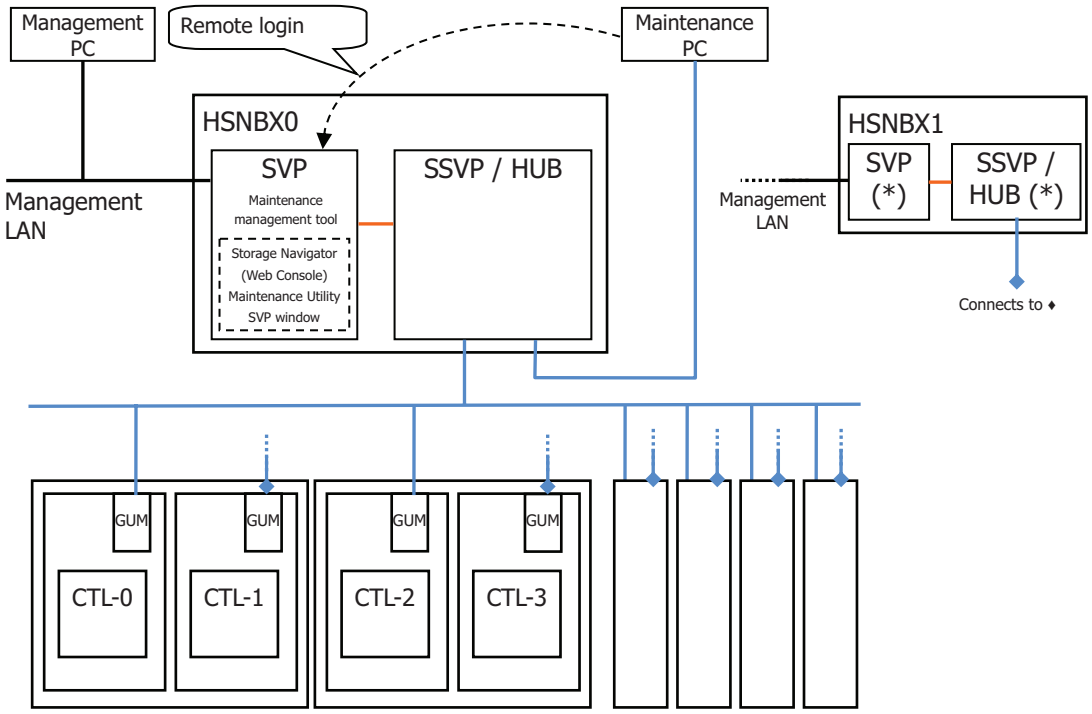
1.4 Network Topology

The DKC910I storage system is designed based on the star network topology where the SVP and each Controller Chassis (DKC) are connected through LAN so that maintenance operation can be performed from the SVP. The center of the star network is the SSVP installed in the HSN Box, which has the hub function and SVP monitoring function.
A management PC of a customer is connected to the PUBLIC LAN port on the SVP. The SVP provides the GUI function for Web browsers, and a customer can set the storage system configuration information and check the storage system status by accessing the SVP from the management PC through a Web browser.
The Maintenance PC is connected to the LAN port on the HSN Box. A maintenance person remotely logs in to the SVP from the Maintenance PC to perform maintenance work using maintenance management tools (Web Console, SVP window, and Maintenance Utility).

GUM:
GUM is a communication port that can be physically accessed from a management LAN port. When the storage system is not turned on but electricity is supplied to Controller Chassis, the GUM can be accessed through GUI or CLI. When the storage system is turned on, the GUM operates by sharing information with micro-programs.

The network diagram is shown below.

Figure 1-11 Network Diagram (VSP 5500/VSP 5500H)



*: The SVP and SSVP in the HSNBX1 are optional components.

For VSP 5100/VSP 5100H consisting of only CTL-1 and CTL-3, unlike the above figure, GUM in CTL-3 needs to be connected to SSVP in HSNBX0. Furthermore, the maintenance LAN ports (not illustrated in the above figure) on CTL-0 and CTL-3 need to be directly connected with each other by using a LAN cable. When the optional SSVP is installed in HSNBX1, GUM in CTL-3 needs to be connected to the optional SSVP in HSNBX1.

1.4.1 Management Software

Hitachi Device Manager - Storage navigator (hereinafter referred to as Storage Navigator) and Web Console that contains menus dedicated for maintenance personnel in addition to the Storage Navigator functions are GUI for managing and operating the storage system. A system administrator accesses Storage Navigator through a Web browser to operate the storage system using GUI. A maintenance person accesses Web Console to operate the storage system.

The following is a summary of the management software.

- Storage Navigator (Web Console)
  Storage management software used for storage system hardware management (setting configuration information, defining logical devices, and displaying the statuses) and performance management (tuning). A system administrator accesses Storage Navigator from a PC connected to LAN through a Web browser to perform management operations for the storage system. A maintenance person remotely logs in to the SVP and performs Web Console operations equivalent to Storage Navigator operations.

1.4.2 Maintenance Software

Web Console, SVP window, and Maintenance Utility are used for storage system maintenance, micro-program exchange, and so on.

The following are summaries of each software.

- Web Console
  Storage management software used for storage system hardware management (setting configuration information, defining logical devices, and displaying the statuses) and performance management (tuning). Web Console can be used also for maintenance work. A remote login to the SVP is required for accessing Web Console.

- SVP window
  Used for status check, collection of dumps and logs, network settings, micro-program exchange, and so on. The SVP window is started from Web Console. Maintenance Utility is started from SVP window.

- Maintenance Utility
  Web application for storage system failure monitoring, replacement work, and so on. Maintenance Utility is embedded in the GUM (Gateway for Unified Management) controller installed in the Controller Chassis. Installation is not necessary. Maintenance Utility is started from the SVP window.

1.5 Storage System Function Overview

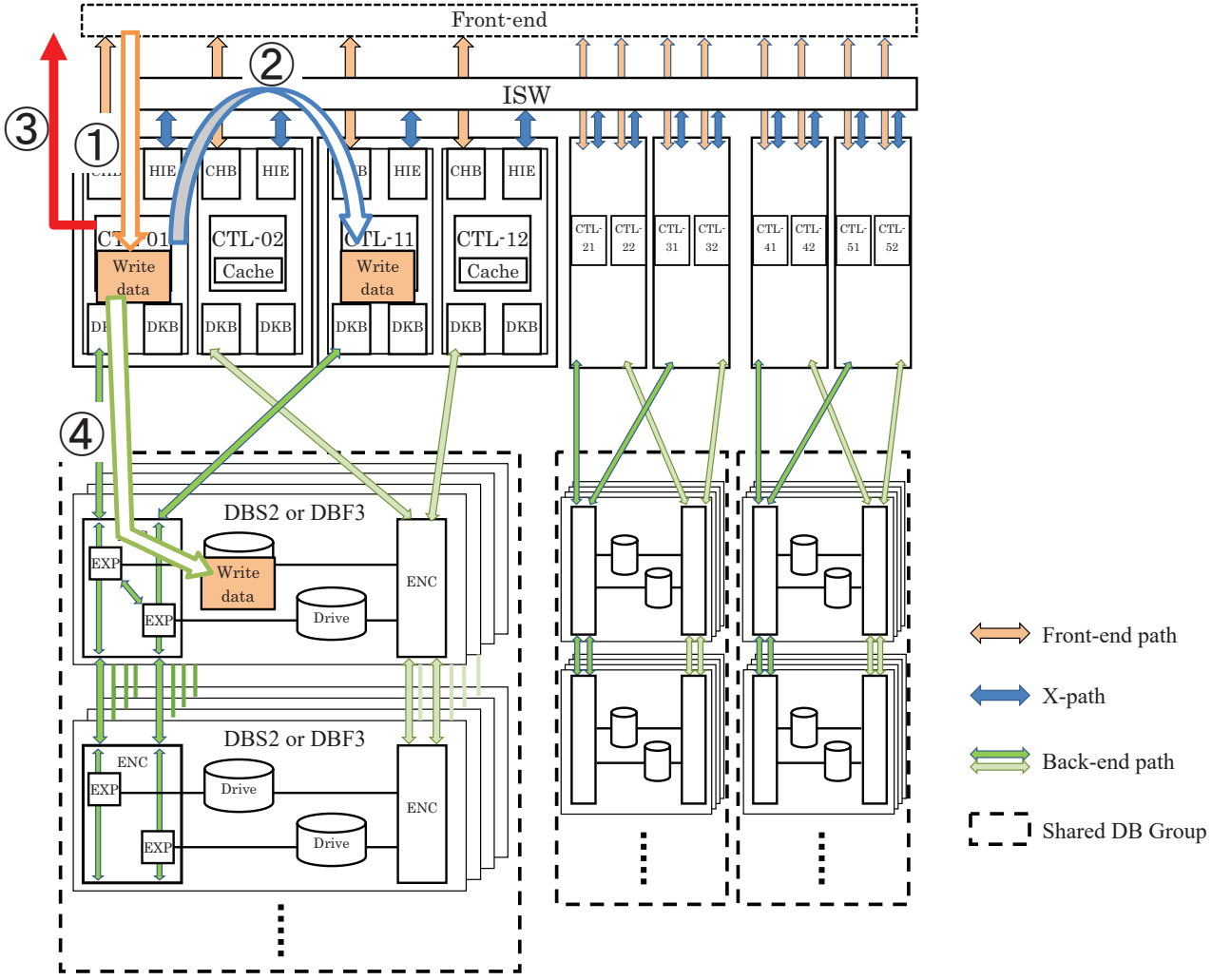
1.5.1 Basic Functions

The storage system redundant configuration shown below allows the storage system to continue I/O even when a failure occurs.

NOTE: SAS-interface DKUs are illustrated in the following diagrams. However, the same operations are applied also when the NVMe-interface DKU is installed.

1. Cache redundancy and destage
   Cache memory in CTL has a space to temporarily store the data sent to and from the front end.
   (1) When a write request is received from a server, the data is temporarily stored in cache memory.
   (2) The data is duplicated in cache memory in another CTL.
   (3) When the data duplication is completed, the write completion is reported to the server.
   (4) After the write completion report, the data in cache memory is stored in drives.
   Thus, the storage system ensures quick response to servers and enhanced fault tolerance.

Figure 1-12 Write Data Flow

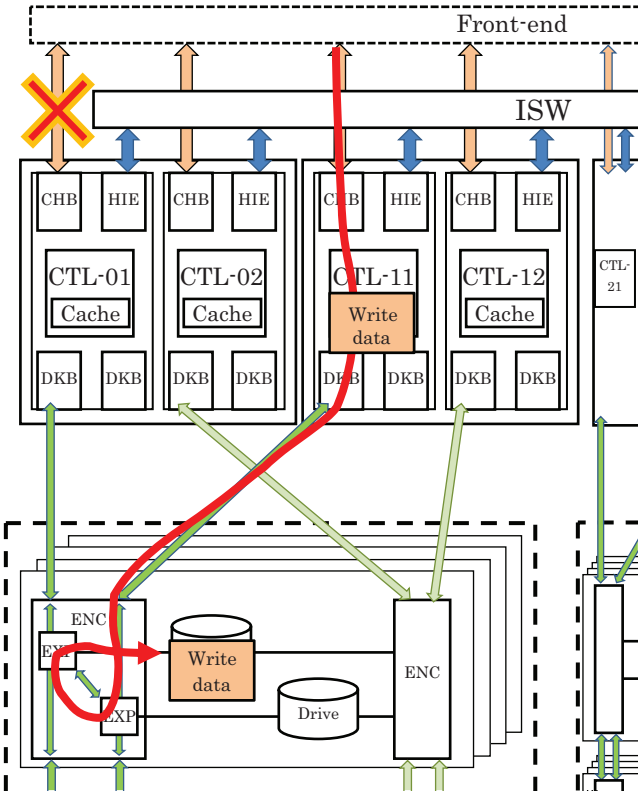


NOTE: CTLs installed in VSP 5100/VSP 5100H are only CTL-01 and CTL-12.
Therefore, unlike the above figure, the cache redundancy for VSP 5100/VSP 5100H is configured in CTL-01 and CTL-12.

2. Two separate cache areas
   A CBX pair has two separate cache memory areas so that write data can be duplicated.
   If a failure occurs in cache memory or a CTL, data is immediately copied to cache memory on another CTL for duplication.

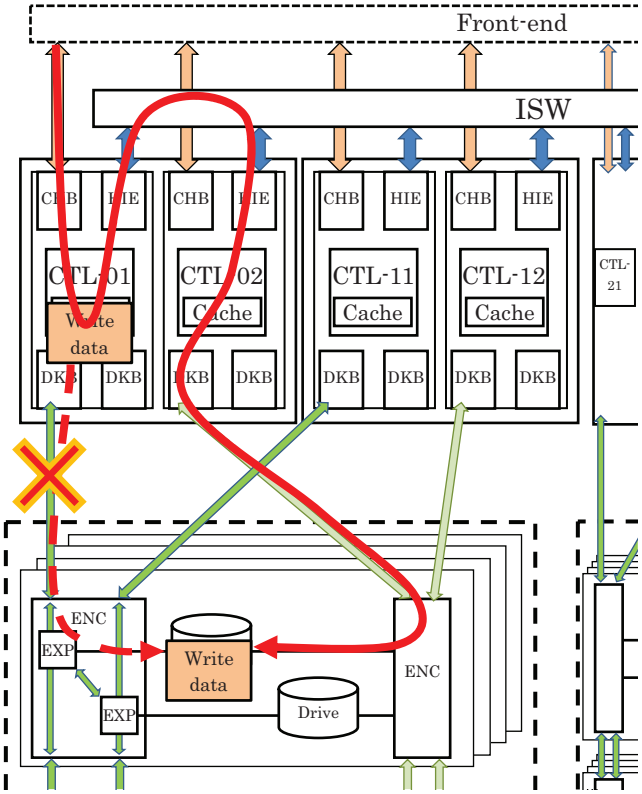
3. Alternate path (front end)
   Alternate paths to servers can be set.
   For VSP 5500/VSP 5500H, an alternate path can be set for the other CTL of a CTL pair in a CBX pair. Paired CTLs are CTLs installed in the same locations in CBXs in a pair. In the figure below, CTL pairs are the pair of CTL-01 and CTL-11 and the pair of CTL-02 and CTL-12. For VSP 5100/VSP 5100H, CTL-01 and CTL-12 are paired because installed CTLs are only CTL-01 and CTL-12.
   Setting an alternate path allows the storage system to continue I/O from and to a server even when a front end path failure occurs.

Figure 1-13 Front End Alternate Path



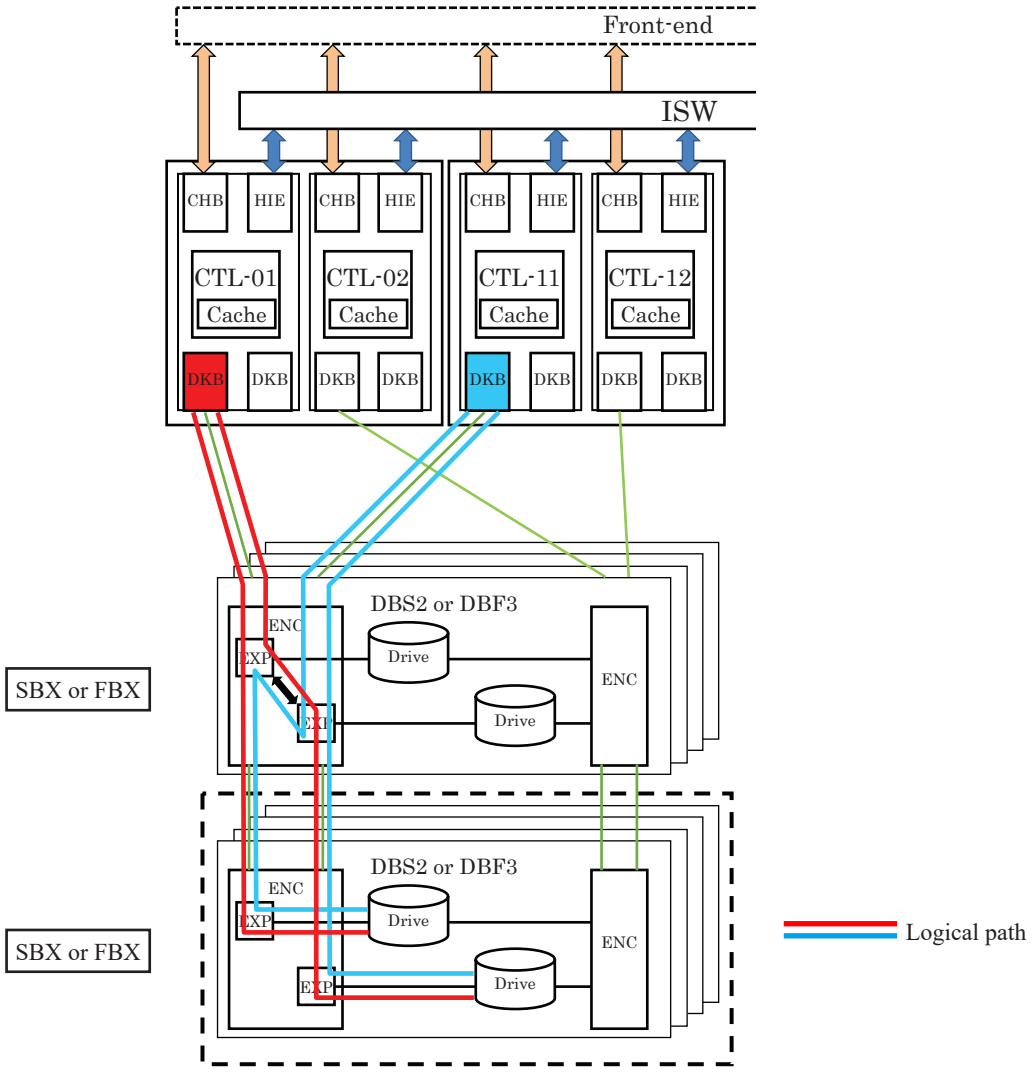
4. Alternate path (back end)
   In the back end connection, alternate paths are set so that each CTL in a CBX pair can access the same drives.
   Even if a failure occurs in a backend path when cache data is stored in drives, an alternate path substitutes the backend path to continue access to drives.

Figure 1-14 Back End Alternate Path



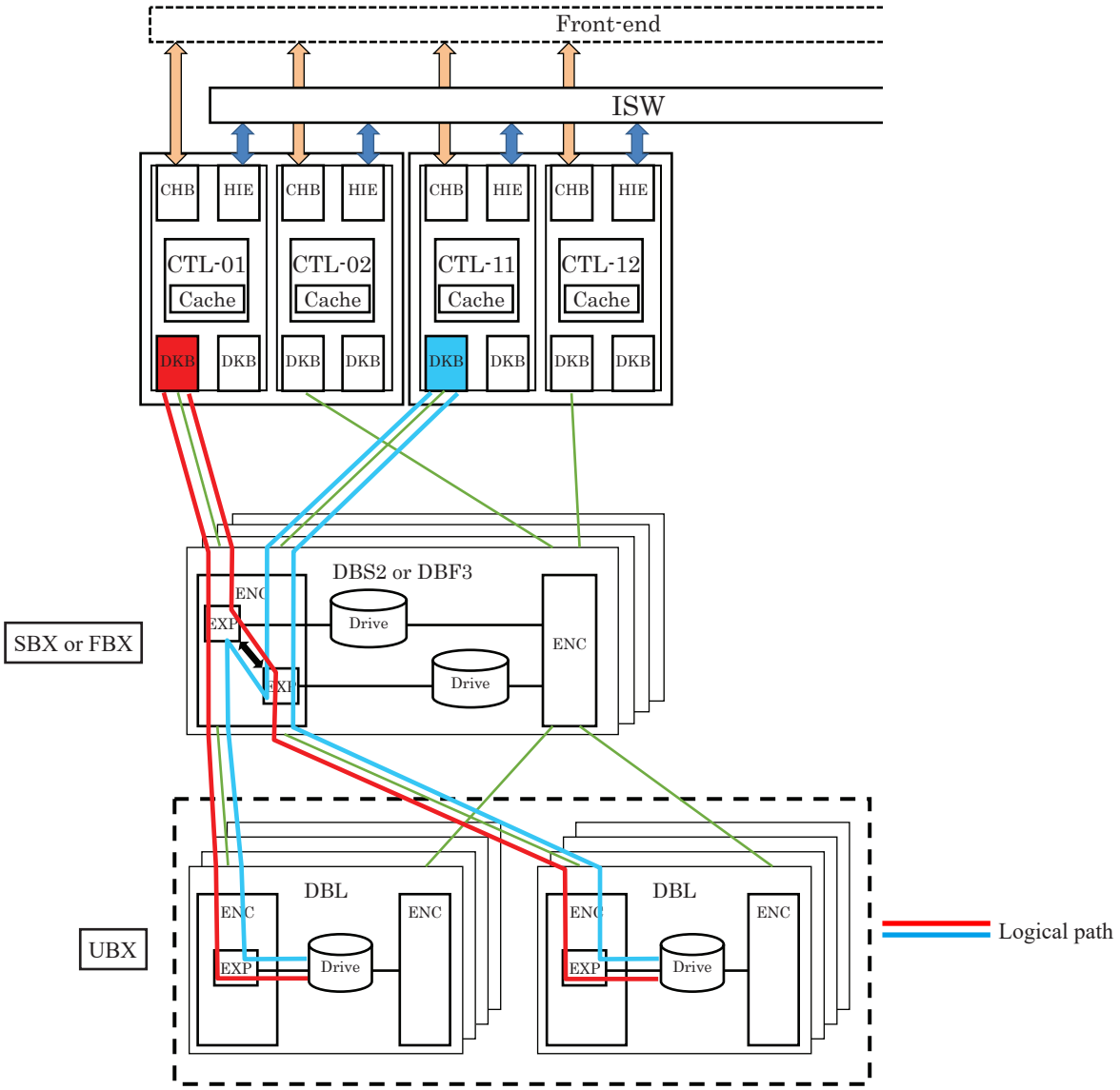
The ENC for DBS2 (SBX), DBF3 (FBX), and DBN (NBX) has two EXP routes, and the EXP routes in the ENC are connected each other. Two DKBs in a CBX pair are connected to one ENC by four logical paths. Even if one DKB is blocked, I/O can be continued by the other DKB because one ENC is connected to two DKBs.
The following is the logical path diagram when SBX or FBX is connected to SBX or FBX.
For NBX, a CBX pair can be connected to one Disk Unit (DKU) only, but cannot be connected to other DKUs. Four logical paths are created by connecting the EXP routes as shown in the figure for SBX and FBX.

Figure 1-15 Logical Paths When SBX or FBX Is Connected to SBX or FBX



UBX needs to be connected to SBX or FBX. Each ENC of DBL (UBX) is equipped with one EXP route, so two DBLs need to be connected to one DBS2 or DBF3.
The following is the logical path diagram when UBX is connected to SBX or FBX.

Figure 1-16 Logical Paths When UBX is connected to SBX or FBX



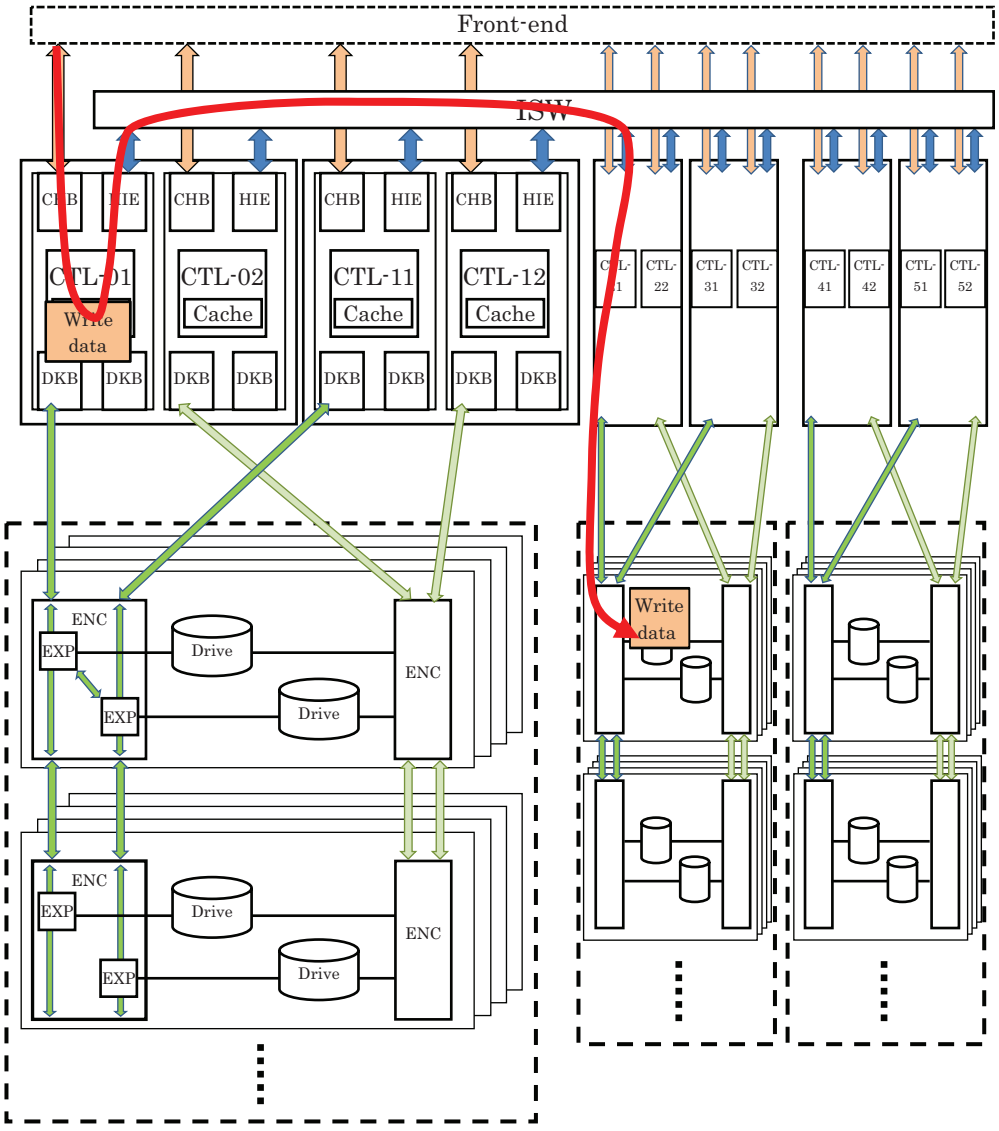
5. I/O among multiple nodes

All CTLs are connected each other through ISW in HSN Box.

Even when the drives to be accessed are not in the Shared DB Group connected to the DKB in the CTL that receives I/O requests from a server, the drives in the other Shared DB Groups can be accessed through ISW.

When a failure occurs in the CTL that receives I/O requests, the storage system can continue I/O to or from a server by using another CTL. When a failure occurs in the CTL that performs drive I/O, the storage system can continue drive I/O by using another CTL that shares the same Shared DB Group.

Figure 1-17 Drive Access through ISW



1.5.2 Redundant Design

- Power supply redundancy
  Controller Box (CBX), Drive Box, and HSN Box are equipped with two power supplies to have power system redundancy. Even if one power supply fails, the other power supply supplies power to all components in the chassis to continue to operate. Two power supplies must be connected to different electricity supply equipment.

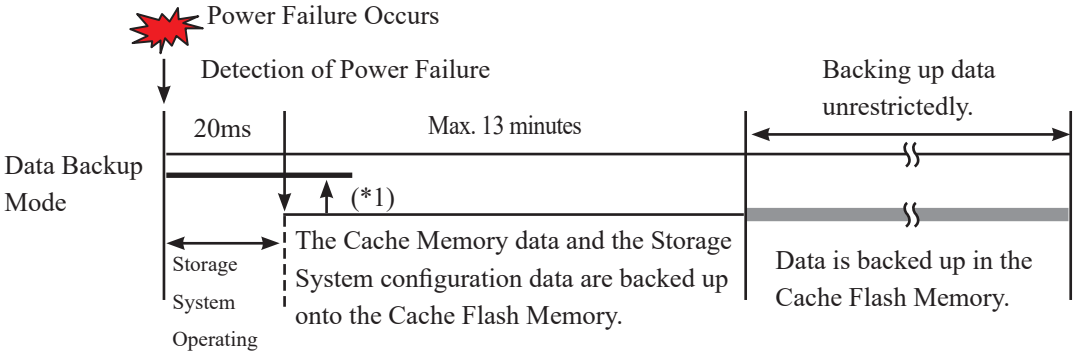
- Drive redundancy
  RAID configurations composed of multiple drives prevent data from being lost in case of a drive failure. RAID configurations can be kept even when a drive failure occurs, by installing spare drives in which data is restored.

- SVP redundancy
  Installing the SVP in each of two HSN Boxes provides redundant access to the maintenance and management tools. One SVP operates as Master SVP, and the other SVP operates as Standby SVP. When the Master SVP fails, the Standby SVP automatically substitutes the Master SVP.
  A redundant SVP to be installed in HSNBX-1 is not standard equipment but an optional component.

- X-path redundancy
  Connecting two HSNBXs (four ISWs) and CBXs (HIEs) with X-path cables in mesh topology makes the communication among Controller Boards have redundancy.
  Even if a failure occurs in an X-path cable or HSNBX (ISW), the storage system can continue to operate.

- Data protection in case of power failure
  Cache Flash Memories and Batteries are installed in each Controller Box (CBX). When power is not supplied due to a failure in a power supply or power outage, the Cache Flash Memories back up the cache memory data and the Batteries supply power to enable the backup processing. If a power outage lasts 20 milliseconds or more, the Batteries supply power to the Controller Board and the cache memory data and storage system configuration information are copied to Cache Flash Memories.

Figure 1-18 Data Backup Process



*1: The data backup processing is continued when the power outage is restored while the data is being backed up.

See below for more specifications related to power outage.

1. Battery lifetime

   The battery lifetime is affected by the battery temperature. The battery temperature changes depending on the intake temperature and installation altitude of the storage system, the configuration and operation of the Controller Chassis, charge-discharge count, and individual differences of batteries. Therefore, the battery lifetime varies in the range between three and five years.

   The battery lifetime (estimated value) in the standard environment is shown below.

Storage System Intake Temperature	Lifetime (Estimated Value)
Up to 24 degrees Celsius	5 years
Up to 30 degrees Celsius	5 years
Up to 34 degrees Celsius	4 years
Up to 40 degrees Celsius	3 years

2. Relation between Battery Charge Level and System Startup Action

No.	Power Status	Battery Charge Level	System Startup Action
1	PS ON	<Case1> There is at least one battery that is charged less than 30% in each the CTL group A and the CTL group B (*3).	The system does not start up until all batteries in CTLs in the group A or all batteries in CTLs in the group B are charged 30% or more. (It takes a maximum of 90 minutes (*2).) (*1)
2		<Case2> There is at least one battery that is charged less than 50% in each the CTL group A and the CTL group B (*3) (in the case other than <Case 1>).	The SIM that shows the lack of battery charge is reported and the system starts up. I/O is processed by write through until all batteries in CTLs in the group A or all batteries in CTLs in the group B are charged 50% or more. (It takes a maximum of 60 minutes (*2).)
3		<Case3> Other than <Case 1> or <Case 2> (All batteries in CTLs in the group A or all batteries in CTLs in the group B (*3) are charged 50% or more.)	The system starts up normally. If the condition changed from <Case 2> to <Case 3> during startup, the SIM that shows the completion of battery charge is reported.

*1: Action when System Option Mode 837 is off (default setting).
*2: Battery charge time: 4.5 hours to charge from 0% to 100%.
*3: Group A: CTL-0x, CTL-2x, and CTL-4x
Group B: CTL-1x, CTL-3x, and CTL-5x

3. Relation between Power Status and SM/CM Data Backup Methods

No.	Power Status		SM/CM Data Backup Methods	Data Restore Methods during Restart
1	PS OFF (planned power off)		SM data (including CM directory information) is stored in CFM before PS OFF is completed. If PIN data exists, all the CM data including PIN data is also stored.	SM data is restored from CFM. If CM data was stored, CM data is also restored from CFM.
2	When power outage occurs	Instant power outage	If power is recovered in a moment, SM/CM data remains in memory and is not stored in CFM.	SM/CM data in memory is used.
3		Power outage while the system is in operation	All the SM/CM data is stored in CFM. However, if a power outage occurs after the system starts up in the condition of <Case 2> and before the battery charge level of <Case 3> is restored, only SM data is stored (see "2. Relation between Battery Charge Level and System Startup Action").	All the SM/CM data is restored from CFM. If CM data was not stored, only CM data is volatilized and the system starts up.
4		Power outage while the system is starting up	Data storing in CFM is not done. (The latest backup data that was successfully stored remains.)	The data that was stored in the latest power off operation or power outage is restored from CFM.

4. Action When CFM Error Occurs

No.	DKC Status	Description of Error	Action When Error Occurs
1	In operation	CFM error or data comparing error was detected at the time of CFM health check (*1).	• CFM Failure SIMRC = 30750x (Environmental error: CFM Failure) is output.
2	Planed power off or power outage	CFM error was detected, and moreover, retry failed four times during data storing. • Data storing error is managed in a per module group (MG) basis and is classified into data storing error only in the MG concerned and data storing error in all the MG depending on the location of the failed memory.	• DKC power off process is executed. • Blockage occurs in Controller Board or CMG in Controller Board depending on the location of the failed memory.
3	When powered on -1 (In the case that data storing was successfully done in No.2)	CFM error or protection cord (*2) error occurred during data restoring.	• Blockage occurs in Controller Board or CMG in Controller Board depending on the location of the failed memory. • If the failed memory is in CMG0, the Controller Board concerned becomes blocked. If the failed memory is in CMG1, the CACHE concerned is volatilized and the system starts up. If the Controller Board forming the cache redundant configuration with the Controller Board that contains the failed CFM is in the normal status, the data is not lost.
4	When powered on -2 (In the case that data storing failed in No.2)	—	• Blockage occurs in Controller Board or CMG in Controller Board depending on the location of data storing error. (Same as described in No.2.)

*1: CFM health check: Function that executes the test of read and write of a certain amount of data at specified intervals to CFM while the DKC is in operation.

*2: Protection code: The protection code (CRC) is generated and saved onto CFM at the time of data storing in CFM and is checked at the time of data restoring.

NOTE: CFM handles only the data in the Controller Board in which it is installed.

5. Notes during Planned Power Off (PS OFF)

Removing the Controller Board when the system is off and the breakers on the PDU are on may result in <Case1> of (1) because of the lack of battery charge.

Therefore, to remove the board and the battery, replace them when the system is on, or remove them after the breakers on the PDU are powered off.

1.5.3 Impact of Each Failure Part on Storage System

For the impact of each failure part on the storage system, see “Impact of failures” in Chapter 2 of “Hitachi Virtual Storage Platform 5000 Series Systems configuration guideline”.

2. Hardware Specifications

2.1 Storage System Specifications

Table 1-1 shows the storage system specifications.

Table 2-1 Storage System Specifications

Item			Specifications			
			VSP 5500, 5500H (6CBX)	VSP 5500, 5500H (4CBX)	VSP 5500, 5500H (2CBX)	VSP 5100, 5100H (2CBX, 2CTL)
System	Number of 2.5" Drives	Minimum	0			
		Maximum	2,304	1,536	768	768
	Number of 3.5" Drives (*1)	Minimum	0			
		Maximum	1,152	768	384	384
	Number of Flash Module Drives	Minimum	0			
		Maximum	576	384	192	192
	Number of NVMe Drives	Minimum	0			
		Maximum	288	192	96	96
	RAID Level		RAID6/RAID5/RAID1 (*9)			
	RAID Group Configuration	RAID6	6D+2P, 14D+2P			
		RAID5	3D+1P, 7D+1P			
		RAID1	2D+2D			
	Maximum Number of Spare Disk Drives		192 (*2)	128 (*2)	64 (*2)	64 (*2)
	Maximum Number of Volumes		65,280			
	Maximum Storage System Capacity (Physical Capacity)	30 TB 2.5" SAS SSD used	61.5 PiB	41.0 PiB	20.5 PiB	20.5 PiB
		15.3 TB 2.5" NVMe SSD used	3.9 PiB	2.6 PiB	1.3 PiB	1.3 PiB
	Maximum External Configuration		255 PiB			
	Maximum Number of DBs	DBS2/DBL	96	64	32	32
		DBF3	48	32	16	16
		DBN	12	8	4	4
Memory	Cache Memory Capacity		1.536 GiB to 6,144 GiB	1,024 GiB to 4,096 GiB	512 GiB to 2,048 GiB	256 GiB to 1,024 GiB
	Cache Flash Memory Type		BM35/BM45/BM3E/BM4E			

(To be continued)

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Item			Specifications			
			VSP 5500, 5500H (6CBX)	VSP 5500, 5500H (4CBX)	VSP 5500, 5500H (2CBX)	VSP 5100, 5100H (2CBX, 2CTL)
Storage I/F	DKC-DB Interface		SAS/Dual Port			
			NVMe/Dual Port			
	Transfer Rate	SAS Interface	12 Gbps			
		NVMe (PCIe) Interface	8 Gbps			
	Number of DKB		24/16/8/0	16/8/0	8/0	4/0
Device I/F	Support Channel Type	Open System	Fibre Channel Short Wave/ Fibre Channel Long Wave (*3)/ iSCSI (Optic)			
		Mainframe	Fibre Channel Short Wave/ Fibre Channel Long Wave			
	Transfer Rate	Fibre Channel	Open System : 4/8/16/32 Gbps Mainframe : 4/8/16 Gbps			
		iSCSI (Optic)	10 Gbps			
	Maximum Number of CHB		48	32	16	8
Acoustic Level LpAm (*4) (*5) (*6) (*7) (*8)	Operating	CBX	LpAm 60 dB, LwA 6.6 Bel			
		HSNBX	LpAm 60 dB, LwA 6.6 Bel			
		DBS2	LpAm 60 dB, LwA 6.4 Bel			
		DBL	LpAm 60 dB, LwA 6.4 Bel			
		DBF3	LpAm 60 dB, LwA 6.0 Bel			
		DBN	LpAm 60 dB, LwA 6.4 Bel			
	Standby	CBX	LpAm 55 dB			
		HSNBX	LpAm 55 dB			
		DBS2	LpAm 55 dB			
		DBL	LpAm 55 dB			
		DBF3	LpAm 55 dB			
		DBN	LpAm 55 dB			

(To be continued)

(Continued from preceding page)

Item		Specifications			
		VSP 5500, 5500H (6CBX)	VSP 5500, 5500H (4CBX)	VSP 5500, 5500H (2CBX)	VSP 5100, 5100H (2CBX, 2CTL)
Non-disruptive Maintenance	Control PCB, SVP, ISW	Supported			
	Cache Memory	Supported			
	Cache Flash Memory	Supported			
	Power Supply, Fan	Supported			
	Micro-program	Supported			
	Disk Drive, Flash Drive, Flash Module Drive	Supported			

*1: 3.5” drives are supported only by VSP 5500H and VSP 5100H.

*2: Available as spare or data Disks.

*3: By the replacing SFP transceiver of the fibre port on the Channel Board to SFP for Longwave, the port can be used for the Longwave.

*4: Acoustic level value of each single chassis.

*5: [LpAm] is the mean A-weighted emission sound pressure level that is measured at the 1-meter bystander positions under the following conditions in accordance with ISO7779 and the value is declared based on ISO9296.
In a normal installation area (data center/general office), the storage system is surrounded by different elements from the following measuring conditions according to ISO, such as noise sources other than the storage system (other devices) , the walls and ceilings that reflect the sound. Therefore, the values described in the table do not guarantee the acoustic level in the actual installation area.
- Measurement environment: In a semi-anechoic room whose ambient temperature is 23 degrees C ± 2 degrees C
- Device installation position: The Controller Chassis is at the bottom of the rack and the Drive Box is at a height of 1.5 meters in the rack
- Measurement position: 1 meter away from the front, rear, left, or right side of the storage system and 1.5 meters high (at four points)
- Measurement value: Energy average value of the four points mentioned above (front, rear, left, and right)

*6: [LpAm] varies between 45 dB and 63 dB according to the ambient temperature, drive configuration, and operating status. The maximum could be 67 dB during maintenance procedure for failed ENC or Power Supply.

*7: The maximum power level could be 8.0 Bel according to the ambient temperature, HDD type, and operating status.

*8: It is recommended to install the storage system in a computer room in a data center and the like. It is possible to install the storage system in a general office, however, take measures against noise as required.
When you replace the old Hitachi storage system with the new one in a general office, especially note the following:
The cooling fans in the storage system are downsized to enhance the high density of the storage system. As a result, the rotation number of the fan is increased than before to maintain the cooling performance. Therefore, the rate of the noise occupied by high-frequency content is high.

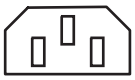
*9: RAID1 supported by these storage systems is commonly referred to as RAID1+0. RAID1+0 mirrors blocks across two drives and then creates a striped set across multiple drive pairs.
In this manual, the above RAID level is referred to as “RAID1”.

2.2 Power Specifications

2.2.1 Storage System Current

DKC910I input current are shown as each Power Supply.

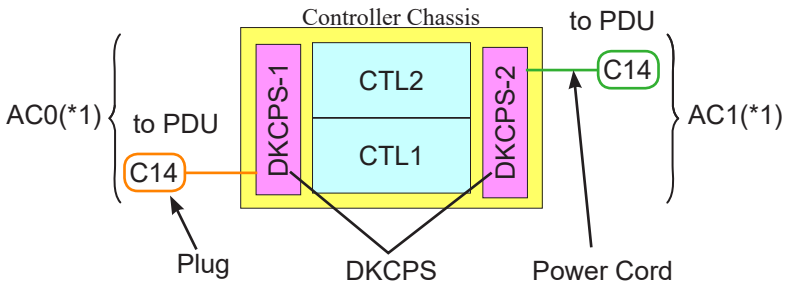
Table 2-2 Input Power Specifications

Item	Input Power	Inrush Current (Rating) (*1)		Leakage Current	Inrush Current			Power Cord Plug Type
		When one PS is operating	When two PSs are operating		1st (0-p)	2nd (0-p)	1st (0-p) Time (-25%)	
DKCPS (CBX)	Single phase, AC200V to AC240V	7.2 A	3.6 A	1.75 mA	30 A	30 A	25 ms	
DBPS (DBS2)		3.2 A	1.6 A	1.75 mA	30 A	30 A	25 ms	
DBPS (DBL)		2.0 A	1.0 A	1.75 mA	35 A	30 A	25 ms	
DBPS (DBF3)		3.1 A	1.55 A	1.75 mA	20 A	15 A	80 ms	
DBPS (DBN)		4.0 A	2.0 A	1.75 mA	24 A	18 A	25 ms	
ISWPS (HSNBX)		1.2 A	0.6 A	1.75 mA	30 A	30 A	25 ms	

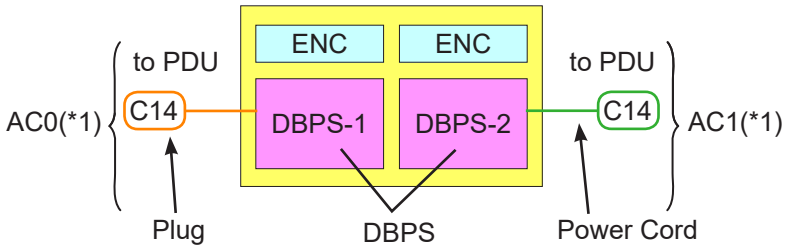
*1: When two power supplies are operating, each power supply provides about half of the required power for the storage system. When only one of the two power supplies is operating, the power supply provides all required power for the storage system. Therefore, use the power supplies that meet the rated input current for when one power supply is operating.

Figure 2-1 Power Supply Locations

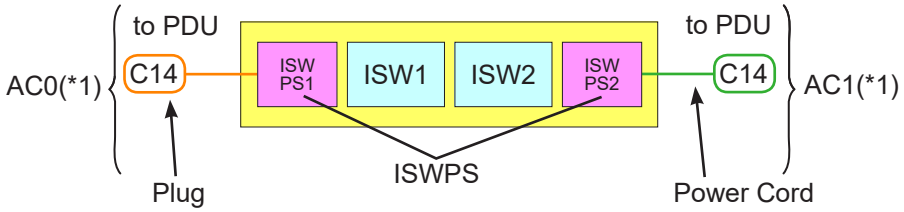
1. Controller Chassis



2. Drive Box



3. HSN Box (HSNBX)



*1: It is necessary to separate AC0 and AC1 for AC redundant.

2.2.2 Input Voltage and Frequency

The following shows the electric power system specifications for feeding to the Storage System.

1. Input Voltage and Frequency
   The following shows the input voltage and frequency to be supported.

   • CBX/HSNBX/DBS2/DBL/DBF3/DBN

Input Voltage	Voltage Tolerance	Frequency	Wire Connection
200V to 240V	+10% or -11%	50Hz ± 2Hz 60Hz ± 2Hz	1 Phase 2 Wire + Ground

This unit does not apply to IT Power System.

2. Circuit Breakers and PDU
   • Use PDU with the standard plug.
   • If PDU is provided with connecting type B plug, use PDU with circuit breaker of 20 (16) A or less, or install circuit breaker of 20 (16) A in the power supply.

2.3 Environmental Specifications

The environmental specifications are shown in the following table.

1. Environmental Conditions

Table 2-3 Usage Environment Conditions

Item	Condition		
	Operating (*1) (*8)		
Model Name	CBX	DBS2/DBL/DBF3/DBN	HSNBX
Temperature range (ºC)	10 to 35	10 to 35	10 to 35
Relative humidity (%) (*4)	8 to 80	8 to 80	8 to 80
Maximum wet-bulb temperature (ºC)	29	29	29
Temperature gradient (ºC/hour)	10	10	10
Dust (mg/m3)	0.15 or less	0.15 or less	0.15 or less
Gaseous contaminants (*6)	G1 classification levels		
Altitude (m) (Ambient temperature)	(*7) ~ 3,050 (10 ºC ~ 28 ºC) ~ 950 (10 ºC ~ 35 ºC)	(*7) ~3,050 (10 ºC ~28 ºC) ~ 950 (10 ºC ~ 35 ºC)	(*7) ~ 3,050 (10 ºC ~ 28 ºC) ~ 950 (10 ºC ~ 35 ºC)
Noise Level (Recommended)	90 dB or less (*5)		

Item	Condition		
	Non-Operating (*2)		
Model Name	CBX	DBS2/DBL/DBF3/DBN	HSNBX
Temperature range (ºC)	-10 to 50	-10 to 50	-10 to 50
Relative humidity (%) (*4)	8 to 90	8 to 90	8 to 90
Maximum wet-bulb temperature (ºC)	29	29	29
Temperature gradient (ºC/hour)	10	10	10
Dust (mg/m^3)	—	—	—
Gaseous contaminants (*6)	G1 classification levels		
Altitude (m)	-60 to 12,000	-60 to 12,000	-60 to 12,000

Item	Condition		
	Transportation, Storage (*3)		
Model Name	CBX	DBS2/DBL/DBF3/DBN	HSNBX
Temperature range (ºC)	-30 to 60	-30 to 60	-30 to 60
Relative humidity (%) (*4)	5 to 95	5 to 95	5 to 95
Maximum wet-bulb temperature (ºC)	29	29	29
Temperature gradient (ºC/hour)	10	10	10
Dust (mg/m^3)	—	—	—
Gaseous contaminants (*6)	—		
Altitude (m)	-60 to 12,000	-60 to 12,000	-60 to 12,000

*1: Environmental conditions of operation should be completed before switch on a system.
*2: “Non-operation” includes conditions of both packing and unpacking.
*3: Transportation and storage should be conducted in the packing of initial shipping.
*4: No dew condensation.
*5: Fire suppression systems and acoustic noise:
Some data center inert gas fire suppression systems when activated release gas from pressurized cylinders that moves through the pipes at very high velocity. The gas exits through multiple nozzles in the data center. The release through the nozzles could generate high-level acoustic noise. Similarly, pneumatic sirens could also generate high-level acoustic noise. These acoustic noises may cause vibrations to the hard disk drives in the storage systems resulting in I/O errors, performance degradation in and to some extent damage to the hard disk drives. Hard disk drives (HDD) noise level tolerance may vary among different models, designs, capacities and manufactures. The acoustic noise level of 90dB or less in the operating environment table represents the current operating environment guidelines in which Hitachi storage systems are designed and manufactured for reliable operation when placed 2 meters from the source of the noise.
Hitachi does not test storage systems and hard disk drives for compatibility with fire suppression systems and pneumatic sirens. Hitachi also does not provide recommendations or claim compatibility with any fire suppression systems and pneumatic sirens. Customer is responsible to follow their local or national regulations.
To prevent unnecessary I/O error or damages to the hard disk drives in the storage systems, Hitachi recommends the following options:
(1) Install noise-reducing baffles to mitigate the noise to the hard disk drives in the storage systems.
(2) Consult the fire suppression system manufacturers on noise reduction nozzles to reduce the acoustic noise to protect the hard disk drives in the storage systems.
(3) Locate the storage system as far as possible from noise sources such as emergency sirens.
(4) If it can be safely done without risk of personal injury, shut down the storage systems to avoid data loss and damages to the hard disk drives in the storage systems.
DAMAGE TO HARD DISK DRIVES FROM FIRE SUPPRESSION SYSTEMS OR PNEUMATIC SIRENS WILL VOID THE HARD DISK DRIVE WARRANTY.

*6: See ANSI/ISA-71.04-2013 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

*7: Meets the highest allowable temperature conditions and complies with ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) 2011 Thermal Guidelines Class A2. The maximum value of the ambient temperature and the altitude is from 35 degrees C at an altitude of 950 meters (3000 feet) to 28 degrees C at an altitude of 3050 meters (10000 feet). The allowable ambient temperature is decreased by 1 degree C for every 300-meter increase in altitude above 950 meters.

*8: The system monitors the intake temperature and the internal temperature of the Controller and the Power Supply. It executes the following operations in accordance with the temperatures.

(1) Controller Chassis (DKC)

- If the use environment temperature rises to 43 degrees C or higher, or drops to 5 degrees or lower, the external temperature warning (SIM-RC = af11xx) is notified.
- If the use environment temperature rises to 50 degrees C or higher, the external temperature alarm (SIM-RC = af12xx) is notified.
- If the temperature of the CPU exceeds its operation guarantee value, the MP temperature abnormality warning (SIM-RC = af10xx) is notified.

<Automatic stop caused by abnormal temperature>

Controller Boards are divided into two groups (Group A and Group B) as shown below. When one or more Controller Boards in each group detect the external temperature alarm or the MP temperature abnormality warning, the power-off processing (planned stop) is automatically executed.

Group A: Controller Boards in DKC-0, DKC-2, and DKC-4

Group B: Controller Boards in DKC-1, DKC-3, and DKC-5

(2) DBS2

- If the internal temperature of the Power Supply rises to 65 degrees C or higher, the DB external temperature warning (SIM-RC = af7000) is notified.
- If the internal temperature of the Power Supply rises to 75 degrees C or higher, the DB external temperature alarm (SIM-RC = af7100) is notified.

(3) DBL

- If the internal temperature of the Power Supply rises to 55 degrees C or higher, the DB external temperature warning (SIM-RC = af7000) is notified.
- If the internal temperature of the Power Supply rises to 64.5 degrees C or higher, the DB external temperature alarm (SIM-RC = af7100) is notified.

(4) DBF3
- If the internal temperature of the Power Supply rises to 68 degrees C or higher, the DB external temperature warning (SIM-RC = af7000) is notified.
- If the internal temperature of the Power Supply rises to 78 degrees C or higher, the DB external temperature alarm (SIM-RC = af7100) is notified.

(5) DBN
- If the internal temperature of the Power Supply rises to 65 degrees C or higher, the DB external temperature warning (SIM-RC = af7000) is notified.
- If the internal temperature of the Power Supply rises to 75 degrees C or higher, the DB external temperature alarm (SIM-RC = af7100) is notified.

(6) HSNBX
- If the use environment temperature rises to 50 degrees C or higher, the HSNBX ambient temperature warning (SIM-RC = afb0xx) is notified.

2. Mechanical Environmental Conditions
It is recommended to install the storage system in a computer room in a data center and the like, where the effects of train vibration and continuous vibration of air conditioner outdoor units are almost eliminated. The equipment for earthquake resistance or seismic isolation might be required at a customer site so that the mechanical environmental conditions are met.

Table 2-4 Mechanical Environmental Conditions

Item	In operating	In non-operating
Guaranteed value to vibration (*1) (*2)	0.25 Grms, 5-500 Hz	0.6 Grms, 3-500 Hz
Guaranteed value to impact (*2)	—	5 G, 11 ms, half sine, three-axis direction, 10 G, 6 ms, half sine, three-axis direction and 10 G, 11 ms, half sine, falling direction

*1: Vibration that is constantly applied to the storage system due to construction works and so on
*2: Guaranteed value for each chassis of the storage system. If the vibration or impact exceeding the specified value is imposed, the acceleration value to which the storage system is subjected to needs to be reduced to the specified value or lower by the equipment for earthquake resistance or seismic isolation so that the storage system can operate continuously. For general 19-inch racks, the lateral vibration amplitude tends to be larger at the upper installation location. Therefore, it is recommend to install the chassis in order from the bottom of the rack without making a vacant space, If the rack frame and storage system are moved while the storage system is operating, the operation is not guaranteed.

2.4 FC Interface Specifications

2.4.1 FC Interface Specification Values

The following table shows signal power level (dBm) of SFPs used for the storage system in a normal state.

Table 2-5 Signal Power Level of SFPs

(Unit：dBm)

SFP type	Model number	When used at 8 Gbps	When used at 16 Gbps	When used at 32 Gbps
Long Wave 16G	DKC-F810I-1PL16	-8.4 or more	-5.0 or more	—
Short Wave 16G	DKC-F810I-1PS16	-8.2 or more	-7.8 or more	—
Short Wave 32G	DKC-F810I-1PS32	-8.2 or more	-7.8 or more	-6.2 or more

2.4.2 FC Port WWN

The Port-WWN that is calculated automatically for each FC port from the Serial Number is described in the table below. Use this value of the table to find the target FC port when analyzing FC-SW log.

Port-WWN								
Byte	7	6	5	4	3	2	1	0
Value	50	06	0E	80	Y8	NN	NN	PP

Vendor ID	50060E80	Vendor unique value; this will always be here.
Serial Number	Y8	If array SN is in the range of 0-65535, then Y = 0. If array SN is in the range of 65536-99999, then Y = 1.
	NNNN	This is the HEX equivalent (simple conversion) of the array 5-digit serial number. e.g. 10152 = x27A8; Y value will equal 0. e.g. 74320 = x2250; Y value will equal 1.
WWN Port#	PP	This is the value as defined by the port the WWN represents. The correspondence between port locations and WWN port# is shown in Table 2-6.

Table 2-6 WWN Port # Corresponding to Port Locations

DKC	CHB Location	Port Location	WWN Port# (HEX)	CHB Location	Port Location	WWN Port# (HEX)
DKC-0	1A	1A	00	2A	1B	01
		3A	20		3B	21
		5A	40		5B	41
		7A	60		7B	61
	1B	1C	02	2B	1D	03
		3C	22		3D	23
		5C	42		5D	43
		7C	62		7D	63
	1E	1E	04	2E	1F	05
		3E	24		3F	25
		5E	44		5F	45
		7E	64		7F	65
	1F	1G	06	2F	1H	07
		3G	26		3H	27
		5G	46		5H	47
		7G	66		7H	67
DKC-1	1A	2A	10	2A	2B	11
		4A	30		4B	31
		6A	50		6B	51
		8A	70		8B	71
	1B	2C	12	2B	2D	13
		4C	32		4D	33
		6C	52		6D	53
		8C	72		8D	73
	1E	2E	14	2E	2F	15
		4E	34		4F	35
		6E	54		6F	55
		8E	74		8F	75
	1F	2G	16	2F	2H	17
		4G	36		4H	37
		6G	56		6H	57
		8G	76		8H	77

(To be continued)

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DKC	CHB Location	Port Location	WWN Port# (HEX)	CHB Location	Port Location	WWN Port# (HEX)
DKC-2	1A	1J	08	2A	1K	09
		3J	28		3K	29
		5J	48		5K	49
		7J	68		7K	69
	1B	1L	0A	2B	1M	0B
		3L	2A		3M	2B
		5L	4A		5M	4B
		7L	6A		7M	6B
	1E	1N	0C	2E	1P	0D
		3N	2C		3P	2D
		5N	4C		5P	4D
		7N	6C		7P	6D
	1F	1Q	0E	2F	1R	0F
		3Q	2E		3R	2F
		5Q	4E		5R	4F
		7Q	6E		7R	6F
DKC-3	1A	2J	18	2A	2K	19
		4J	38		4K	39
		6J	58		6K	59
		8J	78		8K	79
	1B	2L	1A	2B	2M	1B
		4L	3A		4M	3B
		6L	5A		6M	5B
		8L	7A		8M	7B
	1E	2N	1C	2E	2P	1D
		4N	3C		4P	3D
		6N	5C		6P	5D
		8N	7C		8P	7D
	1F	2Q	1E	2F	2R	1F
		4Q	3E		4R	3F
		6Q	5E		6R	5F
		8Q	7E		8R	7F

(To be continued)

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DKC	CHB Location	Port Location	WWN Port# (HEX)	CHB Location	Port Location	WWN Port# (HEX)
DKC-4	1A	9A	80	2A	9B	81
		BA	A0		BB	A1
		DA	C0		DB	C1
		FA	E0		FB	E1
	1B	9C	82	2B	9D	83
		BC	A2		BD	A3
		DC	C2		DD	C3
		FC	E2		FD	E3
	1E	9E	84	2E	9F	85
		BE	A4		BF	A5
		DE	C4		DF	C5
		FE	E4		FF	E5
	1F	9G	86	2F	9H	87
		BG	A6		BH	A7
		DG	C6		DH	C7
		FG	E6		FH	E7
DKC-5	1A	AA	90	2A	AB	91
		CA	B0		CB	B1
		EA	D0		EB	D1
		GA	F0		GB	F1
	1B	AC	92	2B	AD	93
		CC	B2		CD	B3
		EC	D2		ED	D3
		GC	F2		GD	F3
	1E	AE	94	2E	AF	95
		CE	B4		CF	B5
		EE	D4		EF	D5
		GE	F4		GF	F5
	1F	AG	96	2F	AH	97
		CG	B6		CH	B7
		EG	D6		EH	D7
		GG	F6		GH	F7

3. Software Specifications

3.1 Micro-program and Program Product

Software can be categorized into two basic types: micro-program and program product (PP). The micro-program is the essential software for controlling the DKC910I storage system while the PPs provide a variety of storage system functions to customers. Customers can select a suitable PP software package, in which same kinds of PPs are packed together, according to their needs.

A host can read and write the data on the storage system by installing PPs in addition to the micro-program. PPs also allow customers to handle volumes of external storage systems virtually on the DKC910I storage system, copy volumes, and make use of various features. For the list of PPs, see THEORY03-03-10.

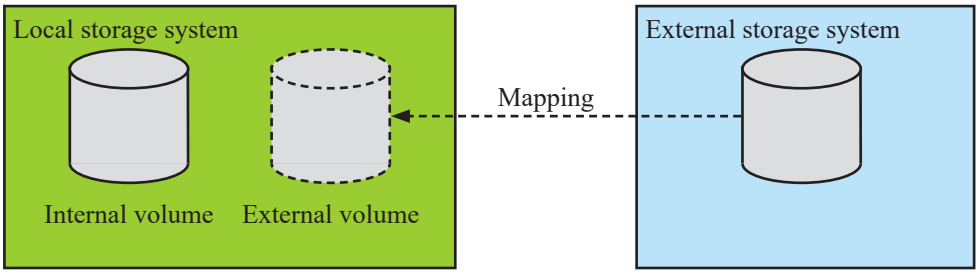
Upgrades of the micro-program versions are performed by a maintenance person. Micro-program upgrades are automatically applied to all DKCs. Therefore, a maintenance person does not need to upgrade the micro-program for each DKC.
PPs chosen by a customer are installed in the storage system before shipment. If the customer wants to add PPs, the customer or system administrator needs to install the license keys for the PPs. The license keys are applied to the whole storage system.

3.2 Logical Components Defined by Software

Logical components defined by software are shown below. The following is the basic terminology.

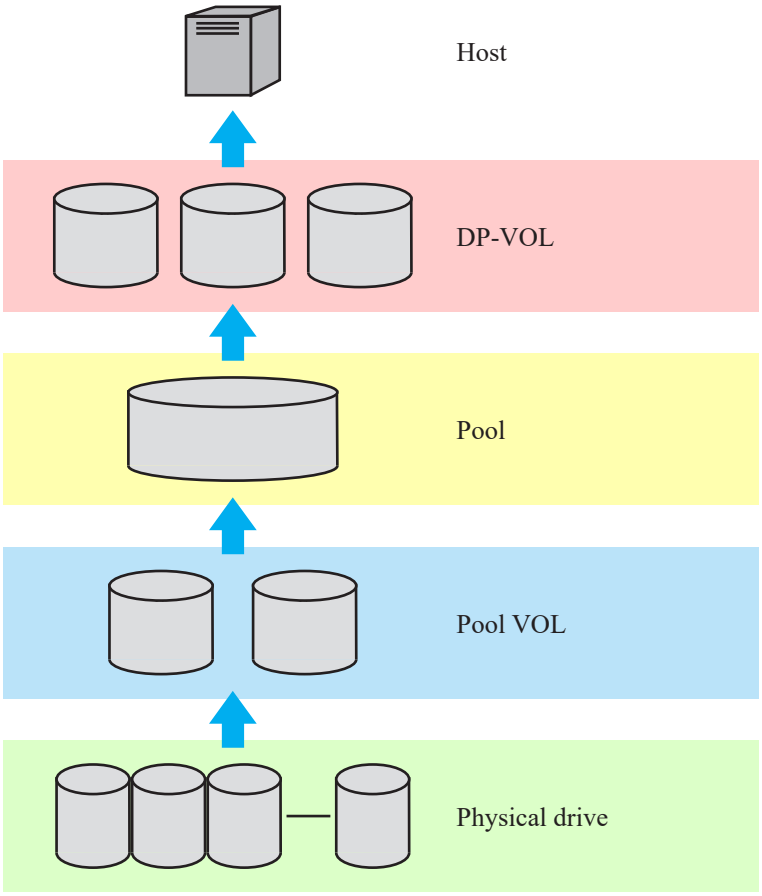
1. Logical components related to volumes
   - Logical volume or LDEV (Logical Device)
     Data is distributed and stored in multiple drives in a RAID configuration to provide high redundancy. The data storage area across the multiples drives is referred to as “logical volume” or “logical device (LDEV)”. In this manual, “volume” is sometimes used instead.

   - Internal volume and external volume
     An internal volume is a logical volume located in the local storage system.
     An external volume is a logical volume which is mapped from a volume located in another storage system (external storage system) to the local storage system.

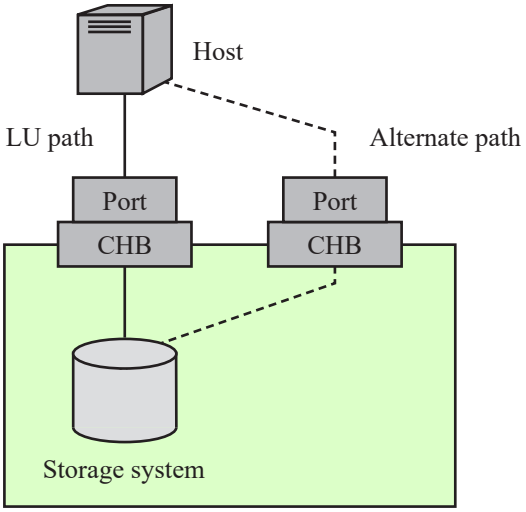


- DP-VOL, virtual volume, pool, and pool VOL
  A DP-VOL (Dynamic Provisioning Volume) is a virtually created volume that has a larger capacity than a physical capacity. In this manual, DP-VOL is sometimes referred to as “virtual volume”.
  The volume capacity is virtualized by allocating actual area from a pool according to write requests to a DP-VOL by a host.

  A pool VOL is a logical volume comprised of multiple drives and is a component of a pool.
  A pool is a virtual area composed of one or more pool VOLs. A pool capacity can be expanded by adding pool VOLs to the pool. Creating DP-VOLs from a pool allows you to allocate volumes to a host without considering physical drives.



2. Logical components related to host connection
   - LU path and alternate path
     An HBA for a host and a CHB for the storage system are connected though Fibre Channel. A data I/O path between a host and a port on a CHB for the storage system is referred to as “LU path” or “LUN path”. Another LU path defined in case of a failure in the data I/O path is referred to as “alternate path”. A port on another CHB must be assigned to an alternate path.



   - Host group
     A group of hosts that are connected to the same port of the storage system and operate on the same platform is referred to as “host group”. To connect a host to the storage system, register the host to a host group, associate the host group to a port, and then allocate logical volumes to the combination of the host group and the port.

3. Logical components related to cache
   - Shared memory
     The shared memory is the memory that logically exists in the cache memory. The abbreviation for the shared memory, “SM”, is also used in this manual. The common information of the storage system, the cache management information (directory), and so on are stored in the shared memory. The capacity of a pool and virtual volume that can be created, and so on vary depending on the capacity of the shared memory. To add the shared memory capacity, set the shared memory function.

   - CLPR
     The cache memory can be logically divided. Each cache partition after the division is referred to as “CLPR”. Allocating CLPRs to DP-VOLs and parity groups prevents a host from occupying a large part of the cache memory.

4. Logical components related to replication
   - Pair, primary volume, and secondary volume

     A combination of an original volume and the copy of the volume is called “pair”. An original volume is referred to as “primary volume” or “P-VOL”, and the copy of the volume is referred to as “secondary volume” or “S-VOL”.

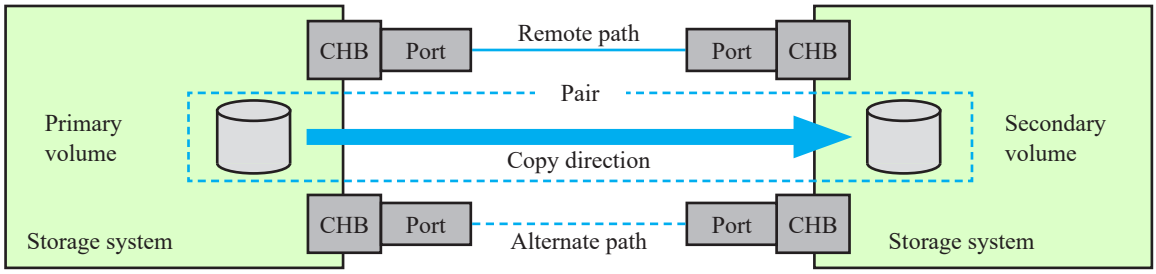
     Copying a volume is creating a pair. When you create a pair, data in a primary volume is copied to a secondary volume (initial copy). After the initial copy, data written to the primary volume is copied to the secondary volume (update copy), and the secondary volume data always coincides with the primary volume data in the pair. You can split and resynchronize a created pair. If you split a pair, the update of the primary volume is not applied to the secondary volume, but the pair is kept. If you resynchronize a split pair, the secondary volume data coincides with the primary volume data.

     Location of a secondary volume, copy method, and copy timing differ depending on program products (PP). Sometimes, a PP name is added to “pair” (for example, “TrueCopy pair (TC pair)” and “Universal Replicator pair (UR pair)”).

   - Port, remote path, alternate path

     When a primary volume and a secondary volume are located in different storage systems, the storage systems are connected through ports.

     A data I/O path between the ports is referred to as “remote path”. Another remote path defined in case of a failure in the data I/O path is referred to as “alternate path”. A port on another CHB must be assigned to an alternate path.



3.3 Program Product (PP) List

The following tables lilts usable PPs on the DKC910I storage system. For details of PPs, refer to the corresponding User Guides.

A: Available, N/A: Not available

PP	Abbreviation	Supported Platform		User Guide
		Open System	Mainframe	
Dynamic Provisioning Dynamic Provisioning for Mainframe	DP, HDP	A	A	Provisioning Guide for Open Systems Provisioning Guide for Mainframe Systems
dedupe and compression	-	A	N/A	
Dynamic Tiering Dynamic Tiering for Mainframe	DT, HDT	A	A	
active flash active flash for mainframe	-	A	A	
Resource Partition Manager	-	A	A	
Data Retention Utility	DRU	A	N/A	
Volume Retention Manager	VRM	N/A	A	
Virtual LUN Virtual LVI	VLL	A	A	
LUN Manager	LUNM	A	N/A	
Thin Image	TI	A	N/A	Thin Image User Guide
Universal Volume Manager	UVM	A	A	Universal Volume Manager User Guide
Virtual Partition Manager	VPM	A	A	Performance Guide (Performance Monitor, Server Priority Manager)
Performance Monitor	-	A	A	
Server Priority Manager	SPM	A	N/A	
Compatible PAV	PAV	N/A	A	Hitachi Compatible PAV User Guide
Volume Migration	VM	A	A	Hitachi Volume Migration User Guide
SNMP Agent	-	A	A	SNMP Agent User Guide
Audit Log	-	A	A	Audit Log User Guide
Encryption License Key	-	A	A	Encryption License Key User Guide
Volume Shredder	-	A	A	Hitachi Volume Shredder User Guide
ShadowImage ShadowImage for Mainframe	SI SI-MF	A	A	ShadowImage User Guide ShadowImage for Mainframe User Guide

(To be continued)

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A: Available, N/A: Not available

PP	Abbreviation	Supported Platform		User Guide
		Open System	Mainframe	
Compatible FlashCopy® V2 Compatible Software for IBM® FlashCopy® SE	FlashCopy	N/A	A	Hitachi Compatible FlashCopy® User Guide
TrueCopy TrueCopy for Mainframe	TC TC-MF	A	A	Hitachi TrueCopy® User Guide Hitachi TrueCopy® for Mainframe User Guide
Universal Replicator Universal Replicator for Mainframe	UR UR-MF	A	A	Hitachi Universal Replicator User Guide Hitachi Universal Replicator for Mainframe User Guide
global-active device	GAD	A	N/A	Global-Active Device User Guide
Compatible XRC	XRC	N/A	A	Compatible XRC User Guide

4. Maintenance Work

4.1 Overview of Maintenance Work

Maintenance work of the storage system includes addition and removal of optional components, preventive replacement of installed components, change of setting information, and micro-program update, as well as troubleshooting. Maintenance work can be performed while the storage system is operating.

Troubleshooting must be started as soon as a failure notification from a customer or a report from the remote monitoring system is received. A maintenance person isolates a failed part by analyzing the notification or report, and then performs recovery actions according to the troubleshooting workflow. Recovery actions for some types of failures might need to be performed by a customer.
Maintenance work other than troubleshooting is performed upon a request from the Technical Support Division.

If a failure occurs, the system must be quickly restored from the failure. The storage system that features a redundant configuration can operate even after a failure occurs, but the redundancy becomes incomplete. If another failure occurs in a part operating in a normal state before the storage system is restored, a system down might be caused.

4.2 Maintenance Management Tools for Maintenance Person and Their Usage

The following maintenance management tools installed in the SVP are used for maintenance work of the storage system. The tools are operated by remotely connecting to the SVP.

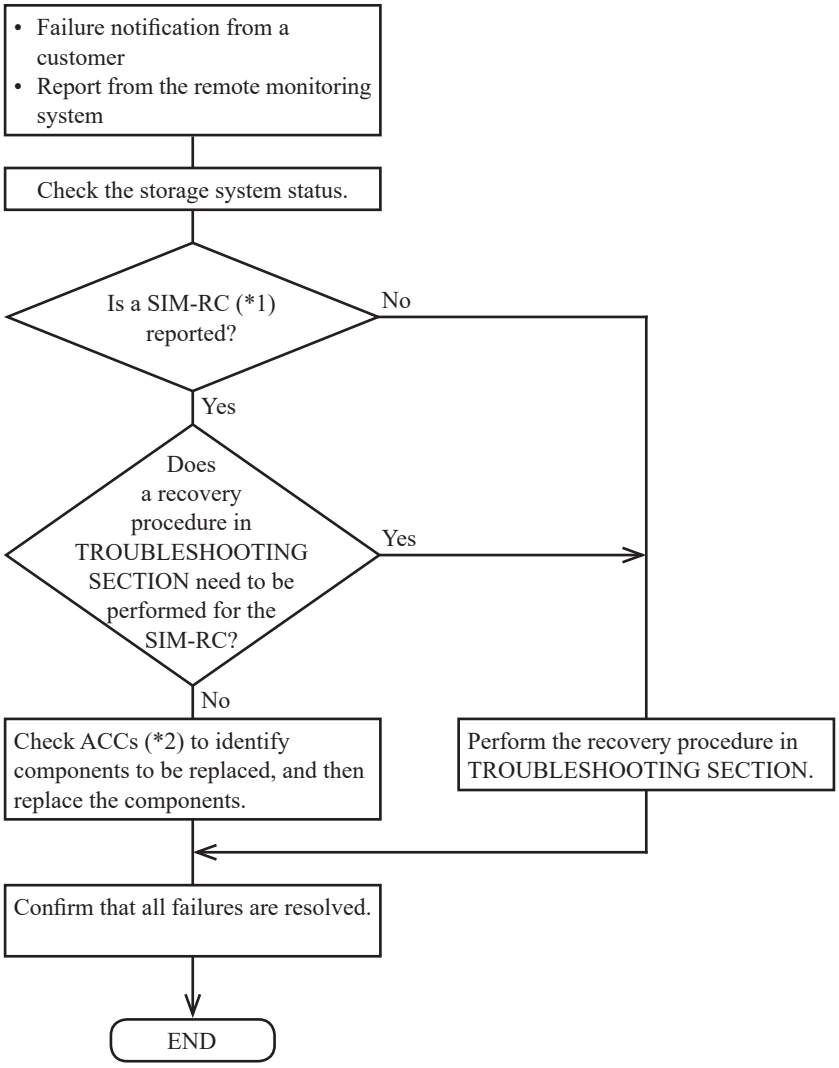
× : Usable — : Not usable

Tool Name	Usage	Maintenance Person	Customer
SVP Window	The SVP window is a GUI used for operations for the whole storage system. Main uses: Status check and various settings of the storage system Failure check according to SIM-RC and SSB log Dump collection Status check of volumes Version check of micro-program Micro-program update	×	—
Maintenance Utility	Maintenance Utility is a GUI used for operations for storage system components. Main uses: Status check of the storage system and each component Replacement of a failed component (*1) Addition and removal of optional components (*1)	×	—
Web Console / Storage Navigator	Storage Navigator is a GUI for customers which is used for setting and viewing the storage system configuration. Web Console is a GUI for maintenance persons which contains menus dedicated for them in addition to Storage Navigator functions. Maintenance persons use Web Console when creating parity groups, allocating spare drives, and so on, according to instructions in the maintenance manual.	×	×
Command Control Interface (CCI)	CCI is a CLI used for setting and viewing the storage system configuration. CCI is mainly used by customers, but sometimes used by maintenance persons for performing procedures described in the maintenance manual. Main uses: Initialization, restoration, deletion, and setting change of pools and volumes	×	×

*1: Maintenance Utility is used for the addition, removal, and replacement of components other than the SVP or SSVP. The SVP window is used for the addition, removal, and replacement of the SVP and SSVP.

4.3 Troubleshooting Workflow

When a failure notification from a customer or a report from the remote monitoring system is received, troubleshooting must be started. Troubleshooting workflows differ depending on failure types.
The following is a typical workflow. For details, see "1. Overview of TRBL" and "2. Isolation of Failed Part" in TROUBLESHOOTING SECTION.



*1: SIM-RC is a reference code that represents an error name, and is viewed in the SVP window.
*2: ACC is a code that indicates a location of a failed part, and is displayed with SIM-RC.

4.4 Important Precautions during Maintenance Work

Important precautions on the storage system maintenance work are shown below.

- Perform maintenance work when a customer is not changing a storage system configuration.
- Do not start Maintenance Utility by entering an IP address of a CTL in your browser's address bar.
- Maintenance work can be generally performed without stopping I/O. However, in some cases, depending on the failure, maintenance procedure, and configuration, I/O needs to be stopped. If the maintenance manual instructs you to stop I/O, ask your customer to stop I/O.
- A customer might change the password for the maintenance account of the storage system after the storage system is installed. Ask the customer about the password for the maintenance account of the storage system.
- Before collecting dumps, check that the loads on CTLs are not high. Dump collections, which are concurrently executed by all CTLs, impose a heavy load on the storage system.
- Color code labels for distinguishing connection destinations are attached to the connection cable between CBX and HSN Box. Colors presented in the maintenance manual might be different from actual colors. When performing maintenance work, be sure to check location numbers printed on the labels in addition to colors.

Precautions are described also in the beginning or middle of the maintenance procedures in the maintenance manual. When performing the maintenance procedures, be sure to read the precautions.

5. Drive Formatting

5.1 Logical Volume Formatting

5.1.1 Overviews

DKC can format two or more ECCs at the same time by providing HDDs and Flash Module Drive with the Logical Volume formatting function. However, when using the encryption function, the high-speed format is unusable.

Table 5-1 Flow of Format

Item No.	Item	Contents
1	Web Console operation	Specify a parity group and execute the LDEV format.
2	Display of execution status	The progress (%) is displayed in the “Task” window or in the summary of the “Parity Group” window and “LDEV” window.
3	Execution result	• Normal: Completed normally • Failed: Terminated abnormally
4	Recovery action when a failure occurs	Same as the conventional one. However, a retry is to be executed in units of ECC. (Because the Logical Volume formatting is terminated abnormally in units of ECC when a failure occurs in the HDD.)
5	Operation of the Web Console which is a high-speed Logical Volume formatting object	When the Logical Volume format for more than one ECCs is instructed, the high-speed processing is carried out(*1).
6	PS/OFF or powering off	The Logical Volume formatting is suspended. No automatic restart is executed.
7	Maintenance PC powering off during execution of an Logical Volume formatting	After the SVP is rebooted, the indication before the PC powering off is displayed in succession.
8	Execution of a high-speed Logical Volume format in the status that the spare is saved	ECC of HDD which the spare is saved fails the high-speed Logical Volume formatting, and changes to a low-speed format. (Because the low-speed formatting is executed after the high-speed format is completed, the format time becomes long.) After the high-speed Logical Volume formatting is completed, execute the copy back of HDD which the spare is saved from SIM log and restore it.

*1: Normal Format is used for ECC of SSD.

5.1.2 Estimation of Logical Volume Formatting Time

The standard formatting time of the high-speed LDEV format and the low-speed LDEV format for each Drive type is described below.
Note that the Storage System configuration at the time of this measurement is as shown below.

<Storage System Conditions at the Time of Format Measurement>
- Standard model (the number of DKB is one pair)
- Without I/O
- Perform the formatting for the single ECC
- Define the number of LDEVs (define a maximum number of 100GB LDEVs for the single ECC)
- Measurement emulation (OPEN-V and 3390-M.)

1. HDD
   The formatting times for HDD do not vary depending on the number of logical volumes, but instead vary depending on the capacity of HDD and the rotation speed of HDD.
   (1) High speed LDEV formatting
   The following table shows the standard formatting times.
   The formatting times are an estimation only. Results from real world use might vary depending on RAID groups and the drive type.

Table 5-2 High-speed format time estimation

(Unit : min)

HDD Capacity/rotation Speed	Standard Formatting Time (*3)		Monitoring Time (*1)
	OPEN-V	3390-M	
14 TB / 7.2 krpm	1265	1295	1945
10 TB / 7.2 krpm	950	980	1470
2.4 TB / 10 krpm	285	290	435

(2) Low speed LDEV formatting

The following table shows the standard formatting times.

Estimated low-speed LDEV formatting times per 1TB/1PG without I/O are shown (including the encryption). (*2) (*4).

Table 5-3 10 krpm

(Unit : min)

RAID Level		Standard Formatting Time (*3)	
		OPEN-V	3390-M
RAID1	2D+2D	105	130
RAID5	3D+1P	60	85
	7D+1P	30	35
RAID6	6D+2P	35	45
	14D+2P	20	20

Table 5-4 7.2 krpm

(Unit : min)

RAID Level		Standard Formatting Time (*3)	
		OPEN-V	3390-M
RAID1	2D+2D	175	200
RAID5	3D+1P	115	120
	7D+1P	55	50
RAID6	6D+2P	65	60
	14D+2P	30	25

2. SSD

SSD does not have the self LDEV formatting function.
Only the low-speed LDEV formatting can be performed.
Estimated formatting times per 1TB/1PG without I/O are shown (including the encryption). (*2) (*4).

Table 5-5 SSD format time estimation

(Unit : min)

RAID Level		Standard Formatting Time (*3)	
		OPEN-V	3390-M
RAID1	2D+2D	20	15
RAID5	3D+1P	15	10
	7D+1P	10	5
RAID6	6D+2P	10	5
	14D+2P	5	5

The formatting time becomes the same in 16 SSDs because the transmission of the format data does not arrive even at the limit of passing.

3. FMD

The formatting times for FMD do not vary depending on the number of logical volumes, but instead vary depending on the capacity of FMD.

(1) High speed LDEV formatting

The following table shows the standard formatting times.

The formatting times are an estimation only. Results from real world use might vary depending on RAID groups and the drive type.

Table 5-6 FMD High-speed format time estimation

(Unit : min)

FMD Capacity	Standard Formatting Time (*3)		Monitoring Time (*1)
	OPEN-V	3390-M	
7.0 TB (6.4 TiB)	1	68	6
14.0 TB (12.8 TiB)	1	50	6

(2) Low speed LDEV formatting

The following table shows the standard formatting times.

Estimated low-speed LDEV formatting times per 1TB/1PG without I/O are shown (including the encryption). (*2) (*4).

Table 5-7 FMD Low-speed format time estimation

(Unit : min)

RAID Level		Standard Formatting Time (*3)	
		OPEN-V	3390-M
RAID1	2D+2D	5	20
RAID5	3D+1P	5	15
	7D+1P	5	15
RAID6	6D+2P	5	15
	14D+2P	5	15

*1: After the standard formatting time has elapsed, the display on the Web Console shows 99% until it reaches to the monitoring time. Because Drive itself performs the format, and the progress rate to the total capacity is not understood, the ratio at the elapsed time from the format beginning to the Formatting time required is displayed.

*2: If there is an I/O operation, the minimum formatting time is over 6 times as long as the discrete value, depending on the I/O load.

*3: The formatting time varies according to the generation of the Drive in standard time distance.

NOTE: The formatting time when mixing the Drive types and the configurations described in "(1) High speed LDEV formatting" and "(2) Low speed LDEV formatting" divides into the following cases.

(a) When only the high speed formatting available Drives (1. HDD, 3. FMD) are mixed
The formatting time is the same as the formatting time of Drive types and configurations with the maximum standard time.

(b) When only the low speed formatting available Drives (2. SSD) are mixed
The formatting time is the same as the formatting time of Drive types and configurations with the maximum standard time.

(c) When the high speed formatting available Drives (1. HDD, 3. FMD) and the low speed formatting available Drives (2. SSD) are mixed

(1) The maximum standard time in the high speed formatting available Drive configuration is the maximum high speed formatting time.

(2) The maximum standard time in the low speed formatting available Drive configuration is the maximum low speed formatting time.

The formatting time is the sum of the above formatting time (1) and (2).

When the high speed formatting available Drives and the low speed formatting available Drives are mixed in one formatting process, the low speed formatting starts after the high speed formatting is completed. Even after the high speed formatting is completed, the logical volumes with the completed high speed formatting cannot be used until the low speed formatting is completed.

In all cases of (a), (b) and (c), the time required to start using the logical volumes takes longer than the case that the high speed formatting available Drives and the low speed formatting available Drives are not mixed.
Therefore, when formatting multiple Drive types and the configurations, we recommend dividing the formatting work and starting the work individually from a Drive type and a configuration with the shorter standard time.

*4: The time required to format the drive might be increased by up to approximately 20% in the DB on the rear stage in cascade connection.

5.2 Quick Format

5.2.1 Overviews

Quick Format provides the function to format in the background that allows the volumes to be usable without waiting for the completion of the formatting when starting the formatting function.
The support specifications are shown below.

Table 5-8 Quick Format Specifications

<table>
<tr><th>Item No.</th><th>Item</th><th>Contents</th></tr>
<tr><td>1</td><td>Support Drive HDD type</td><td>All drive types are supported.</td></tr>
<tr><td>2</td><td>Support emulation type</td><td>Quick Format can be performed on volumes of all emulation types.</td></tr>
<tr><td>3</td><td>Number of parity groups on which Quick Format can be performed</td><td>• Quick Format can be performed on multiple parity groups simultaneously. The number of those parity groups depends on the total of parity group entries.
The number of entries is an indicator for controlling the number of parity groups on which Quick Format can be performed. The number of parity group entries depends on the drive capacity configuring each parity group.
The entry count per parity group is shown in the table below.
<table>
<tr><th>Emulation type</th><th>Capacity of a component drive of a parity group</th><th>Entry count per parity group</th></tr>
<tr><td rowspan="2">OPEN-V</td><td>48 TB or less</td><td>1 entry</td></tr>
<tr><td>More than 48 TB</td><td>2 entries</td></tr>
<tr><td rowspan="2">3380-xx,
6586-xx</td><td>36 TB or less</td><td>1 entry</td></tr>
<tr><td>More than 36 TB</td><td>2 entries</td></tr>
<tr><td rowspan="2">3390-xx,
6588-xx</td><td>45 TB or less</td><td>1 entry</td></tr>
<tr><td>More than 45 TB</td><td>2 entries</td></tr>
</table>
• When the number of entries is 72 or less, the number of volumes on which Quick Format can be performed is not limited.
• In the case of four concatenations, the number of parity groups is four. In the case of two concatenations, the number of parity groups is two.</td></tr>
<tr><td>4</td><td>Combination with various P.P.</td><td>It is operable in combination with all P.P.</td></tr>
<tr><td>5</td><td>Formatting types</td><td>When performing a format from Web Console or CLI, you can select either Quick Format or the normal format.</td></tr>
<tr><td>6</td><td>Additional execution of Quick Format during its execution</td><td>Additional Quick Format can be executed during Quick Format execution. In this case, the total number of entries during Quick Format and those to be added is limited 72.</td></tr>
<tr><td>7</td><td>Preparing Quick Format</td><td>• When executing Quick Format, management information is created first. I/O access cannot be executed in the same way as the normal format in this period.
• Creating management information takes up to about one minute for one parity group, and up to about 36 minutes in case of 36 parity groups for the preparation. For M/F volumes, the above mentioned time and the time in Table 5-9 need to be summed up.</td></tr>
</table>

(To be continued)

(Continued from the preceding page)

Item No.	Item	Contents
8	Blocking and restoring the volume	• When the volume during Quick Format execution is blocked for maintenance, the status of the volume (during Quick Format execution) is stored in the Storage System. When the volume is restored afterwards, the volume status becomes "Normal (Quick Format)". Therefore, parity groups in which all volumes during Quick Format are blocked are included in the number of entries during Quick Format. The number of entries for additional Quick Format can be calculated with the following calculating formula: 72 - X - Y (Legend) X: The number of entries for parity groups during Quick Format. Y: The number of entries for parity groups in which all volumes during Quick Format are blocked.
9	Operation at the time of PS OFF/ON	After P/S ON, Quick Format restarts.
10	Restrictions	• Quick Format cannot be executed to the journal volume of Universal Replicator, external volume, and virtual volume. • Volume Migration and Quick Restore of ShadowImage cannot be executed to a volume during Quick Format. • When the parity group setting is the accelerated compression, Quick Format cannot be performed. (If performed, it terminates abnormally)

5.2.2 Volume Data Assurance during Quick Formatting

The Quick Formatting management table is kept on SM. This model can prevent the management table from volatilizing by backing up the SM to an SSD, and assures the data quality during Quick Formatting.

5.2.3 Control information format time of M/F VOL

In the case of M/F VOL, the control information at the terminal of each volume is initialized and then the volume status becomes usable. Therefore, it is required to wait for the format, as well as the conventional format, until completing the creation processing of control information. The time required at this time varies depending on the emulation type and the number of volumes as shown in the following table.

Table 5-9 Control Information Format Time of M/F VOL (Per 1K Volume)

Emulation type	Format time (minute)
3390-A	133
3390-M	34
3390-MA/MB/MC	28
3390-L	18
3390-LA/LB/LC	14
6588-L	18
6588-LA/LB/LC	14
3390-9	9
3390-9A/9B/9C	5
6588-9	9
6588-9A/9B/9C	5
Others	3

The above is the time required when formatting a 1K volume and it is proportional to the number of volumes.

5.2.4 Quick Formatting Time

Quick Format is executed in the background while I/O from and to the host is performed.
Therefore, the Quick Format time may vary significantly depending on the number of I/Os from and to the host or other conditions.
You can also calculate a rough estimation of the Quick Format time using the following formula.

Rough estimation of Quick Format time

- When executing Quick Format in the entire area of a parity group
  Format time = Format standard time (see Table 5-10, Table 5-11)
  × Format multiplying factor (see Table 5-12) × ↑ (The number of parity groups ÷ 8) ↑
- When executing Quick Format on some LDEVs in a parity group
  Format time = Format standard time (see Table 5-10, Table 5-11)
  × Format multiplying factor (see Table 5-12) × ↑ (The number of parity groups ÷ 8) ↑
  × (Capacity of LDEVs on which Quick Format is executed ÷ Capacity of a parity group)

NOTE: “ ↑ ”indicates roundup.

Table 5-10, Table 5-11 shows the Quick Format time when no I/O is performed in the entire area of a parity group.

Table 5-10 Quick Format Time (OPEN-V)

Drive type	Formatting time
H10R0 (7.2 krpm)	130 h
H14R0 (7.2 krpm)	184 h
J2R4 (10 krpm)	31 h
M960 (SAS SSD)	4 h
M1T9 (SAS SSD)	9 h
M3R8 (SAS SSD)	17 h
M7R6 (SAS SSD)	34 h
M15R (SAS SSD)	67 h
M30R (SAS SSD)	134 h
R1R9 (NVMe SSD)	9 h
R3R8 (NVMe SSD)	17 h
R7R6 (NVMe SSD)	34 h
R15R (NVMe SSD)	67 h
Q6R4 (FMD)	32 h
Q13R (FMD)	64 h

Table 5-11 Quick Format Time (Other than OPEN-V)

Drive type	Formatting time
H10R0 (7.2krpm)	149 h
H14R0 (7.2krpm)	209 h
J2R4 (10krpm)	35 h
M960 (SAS SSD)	5 h
M1T9 (SAS SSD)	10 h
M3R8 (SAS SSD)	20 h
M7R6 (SAS SSD)	40 h
M15R (SAS SSD)	79 h
M30R (SAS SSD)	158 h
R1R9 (NVMe SSD)	10 h
R3R8 (NVMe SSD)	20 h
R7R6 (NVMe SSD)	40 h
R15R (NVMe SSD)	79 h
Q6R4 (FMD)	37 h
Q13R (FMD)	74 h

Table 5-12 Format Multiplying Factor

RAID level	I/O	Multiplying factor
RAID1	No	0.5
	Yes	2.5
RAID5, RAID6	No	1.0
	Yes	5.0

- When Quick Format is executed to parity groups with different Drive capacities at the same time, calculate the time based on the parity group with the largest capacity.

5.2.5 Performance during Quick Format

Quick Format executes the formatting in background while executing I/O from HOST.
Therefore, it may influence the HOST performance.
The following table shows the proportion of the performance influence.
(However, this is only a rough standard, and it may change depending on the conditions.)

Table 5-13 Performance during Quick Format

I/O types	Performance when the ratio shows 100% at normal condition
Random read	80%
Random write to the unformatted area	20%
Random write to the formatted area	60%
Sequential read	90%
Sequential write	90%

5.2.6 Combination with Other Maintenance

Table 5-14 Combination with Other Maintenance

Item No.	Maintenance Operation	Operation during Quick Format
1	Drive copy / correction copy	The processing is possible as well as the normal volumes, but unformatted area is skipped.
2	LDEV Format (high-speed / low-speed)	The LDEV Format is executable for the volumes that Quick Format is not executed.
3	Volume maintenance block	It is possible to block the volumes instructed by Web Console or CLI for the volumes during Quick Format.
4	Volume forcible restore	If forcible restore is executed after the maintenance block, it returns to Quick Formatting.
5	Verify consistency check	Possible. However, the Verify consistency check for the unformatted area is skipped.
6	PDEV replacement	Possible as usual
7	PK replacement	Possible as usual

5.2.7 SIM Output When Quick Format Completed

After Quick Format is completed, SIM = 0x410100 is output when performing Quick Format. However, SIM is not output when Quick Format is performed by RAID Manager.

5.2.8 Coexistence of Drives

Table 5-15 shows permitted coexistence of RAID levels and HDD types respectively.

Table 5-15 Specifications for Coexistence of Elements

<table>
<tr><th>Item</th><th>Specifications</th><th>Remarks</th></tr>
<tr><td>Coexistence of RAID levels</td><td>RAID1 (2D+2D), RAID5 (3D+1P, 7D+1P), RAID6 (6D+2P, 14D+2P) can exist in the system.</td><td></td></tr>
<tr><td>Drive type</td><td>Different drive types can be mixed for each parity group.</td><td></td></tr>
<tr><td>Spare drive</td><td>When the following conditions 1 and 2 are met, the drives can be used as spare drives.
1. Capacity of the spare drives is the same as or larger than the drives in operation.
2. The type of the drives in operation and the type of the spare drives fulfill the following conditions.

<table><tr><th>Type of Drive in Operation</th><th>Type of Usable Spare Drive</th></tr><tr><td>HDD (7.2 krpm)</td><td>HDD (7.2 krpm)</td></tr><tr><td>HDD (10 krpm)</td><td>HDD (10 krpm)</td></tr><tr><td>SAS SSD</td><td>SAS SSD</td></tr><tr><td>NVMe SSD</td><td>NVMe SSD</td></tr><tr><td>FMD (QxRy)</td><td>FMD (QxRy)</td></tr></table>
NOTE: “x” and “y” are an arbitrary number. Some drives do not contain the number of “y” (e.g. Q13R).
The numbers (x, y) of Type of Drive in Operation need not be the same as those of Type of Usable Spare Drive.
For example, when the drives in operation are Q6R4, the drives of Q6R4, Q13R, etc. can be used as spare drives.</td><td></td></tr>
</table>

5.3 Notes on Maintenance during LDEV Format/Drive Copy Operations

This section describes whether maintenance operations can be performed when Dynamic Sparing, Correction Copy, Copy Back, Correction Access or LDEV Format is running or when data copying to a spare Disk is complete.

If Correction Copy runs due to a Drive failure or Dynamic Sparing runs due to preventive maintenance on large-capacity Disk Drives or Flash Drives, it may take long to copy data. In the case of low-speed LDEV Format performed due to volume addition, it may take time depending on the I/O frequency because host I/Os are prioritized. In such a case, it is recommended to perform operations, such as replacement, addition, and removal, after Dynamic Sparing, LDEV Format et cetera. is completed, based on the basic maintenance policy, but the following maintenance operations are available.

Maintenance operation		Storage System status					
		Dynamic Sparing	Correction Copy	Copy Back	Correction Access	Copied to spare Disk	LDEV Format
Replacement	CTL/CACHE	Possible (*16)	Possible (*16)	Possible (*16)	Possible (*1) (*14)	Possible	Impossible (*13)
	LANB	Possible (*16)	Possible (*16)	Possible (*16)	Possible (*1) (*14)	Possible	Impossible (*13)
	CHB	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	Power supply	Possible	Possible	Possible	Possible	Possible	Possible
	SVP	Possible	Possible	Possible	Possible	Possible	Possible
	SSVP	Possible	Possible	Possible	Possible	Possible	Possible
	ENC/SAS cable	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	DKB	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	PDEV	Possible (*6)	Possible (*6)	Possible (*6)	Possible (*1) (*14)	Possible	Possible (*4)
	CFM	Possible	Possible	Possible	Possible	Possible	Possible
	BKMF	Possible	Possible	Possible	Possible (*1)	Possible	Possible
	FAN (ISW)	Possible	Possible	Possible	Possible	Possible	Possible
	Battery	Possible	Possible	Possible	Possible (*1)	Possible	Possible
	SFP replacement	Possible	Possible	Possible	Possible	Possible	Possible
	HSNPANEL	Possible	Possible	Possible	Possible	Possible	Possible
	ISWPS	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	PCIADP	Possible	Possible	Possible	Possible	Possible	Possible
	PCICON	Possible	Possible	Possible	Possible	Possible	Possible
	LAN cable	Possible	Possible	Possible	Possible	Possible	Possible
	HIE	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	ISW	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	X-path	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)
	HSNBX chassis	Possible	Possible	Possible	Possible (*1) (*14)	Possible	Impossible (*13)

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Maintenance operation		Storage System status					
		Dynamic Sparing	Correction Copy	Copy Back	Correction Access	Copied to spare Disk	LDEV Format
Addition/ Removal	CACHE/SM	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible	Impossible (*13)
	CHB	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible	Impossible (*13)
	Power supply	Possible	Possible	Possible	Possible	Possible	Possible
	SVP	Possible	Possible	Possible	Possible	Possible	Possible
	SSVP	Possible	Possible	Possible	Possible	Possible	Possible
	DKB	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible	Impossible (*13)
	PDEV	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible (*2)	Impossible (*13)
	CFM	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible	Impossible (*13)
	SFP type change	Possible	Possible	Possible	Possible	Possible	Possible
	Parity Group	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible (*2)	Impossible (*13)
	Spare	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible (*2)	Impossible (*13)
	PCIADP	Possible	Possible	Possible	Possible	Possible	Possible
	PCICON	Possible	Possible	Possible	Possible	Possible	Possible
	Drive Box	Impossible (*12)	Impossible (*12)	Impossible (*12)	Possible (*1) (*14)	Possible (*2)	Impossible (*13)
Addition	Controller Chassis	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*18)
Removal		Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Impossible (*18)
Addition	Controller Board	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*17)	Impossible (*18)
Removal		Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Possible (*1) (*17)	Impossible (*18)
Micro-program exchange	Online	Possible (*3)	Possible (*3)	Possible (*3)	Possible (*1) (*14)	Possible (*1) (*3)	Impossible (*12)
	Offline	Impossible (*12)	Impossible (*12)	Impossible (*12)	Impossible (*14)	Possible	Impossible (*12)
	SVP only	Possible	Possible	Possible	Possible	Possible	Possible

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Maintenance operation		Storage System status					
		Dynamic Sparing	Correction Copy	Copy Back	Correction Access	Copied to spare Disk	LDEV Format
LDEV maintenance	Blockade	Possible (*5) (*7) (*15)	Possible (*5) (*7) (*15)	Possible (*5) (*7) (*15)	Possible (*5)	Possible	Possible (*7) (*15)
	Restore	Possible (*5) (*8) (*15)	Possible (*5) (*8) (*15)	Possible (*5) (*8) (*15)	Possible (*5)	Possible	Possible (*8) (*15)
	Format	Possible (*5)	Possible (*5)	Possible (*5)	Possible (*5) (*10) (*15)	Possible	Impossible (*9)
	Verify	Impossible (*7)	Impossible (*7)	Impossible (*7)	Possible (*11) (*15)	Possible	Impossible (*7)

*1: The operation is prevented with a message. However, the operation is made possible by checking the checkbox “Forcibly run without safety checks” and retrying the operation.

*2: It is impossible to remove a RAID group in which data is migrated to a spare Disk and the spare Disk.

*3: Micro-program exchange can be performed if HDD Micro-program exchange is not included.

*4: It is impossible when high-speed LDEV Format is running. When low-speed LDEV Format is running, it is possible to replace PDEV in a RAID group in which LDEV Format is not running.

*5: It is possible to perform LDEV maintenance for LDEV defined in a RAID group in which Dynamic Sparing, Correction Copy, Copy Back or Correction Access is not running.

*6:
- The operation is prevented with the message [03005-002095] when the RAID group to which the PDEV to be maintained belongs does not coincide with the RAID group in which Dynamic Sparing/Correction Copy/Copy Back is running.
- The operation is prevented with the message [30762-208159] when the RAID group to which the PDEV to be maintained belongs coincides with the RAID group in which Dynamic Sparing/Correction Copy/Copy Back is running. When the RAID level is RAID6, the operation might be prevented with the message [03005-002095] depending on the state of PDEVs other than the PDEV to be maintained.
  If the operation is prevented with the message [03005-002095], the operation is made possible by checking the checkbox “Forcibly run without safety checks” and retrying the operation. However, a different message might be displayed depending on the timing when the conditions that cause a prevention occur.

*7: It is prevented with message [03005-002095]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*8: It is prevented with message [03005-202002]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*9: It is prevented with message [03005-202001]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*10: It is prevented with message [03005-202005]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*11: It is prevented with message [03005-002011]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*12: It is prevented with message [30762-208159]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*13: It is prevented with message [30762-208158]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*14: It is prevented with message [33361-203503 : 33462-200046]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

*15: The operation is prevented with a message. However, the operation is made possible by checking the checkbox “Forcibly run without safety checks” and retrying the operation.

*16: For micro-program versions “90-01-41-xx/xx” and “90-01-61-xx/xx”, the operation is prevented with the message [30762-208159]. Even if “Forcibly run without safety checks” is selected, the operation is prevented.

*17: The operation is prevented with message [30762-208899] or [30762-208911].

*18: The operation is prevented with message [30762-208096]. However, a different message might be displayed depending on the occurrence timing of the state regarded as a prevention condition.

5.4 Verify (Parity Consistency Check)

When a parity inconsistency occurs for some reason, the Verify processing recovers parity consistency by forcibly matching the parity data to the current data that is assumed to be consistent.

5.5 PDEV Erase

5.5.1 Overview

When the specified system option (*1) is set, the DKC deletes the data of PDEV automatically in the case according Table 5-16.

*1: Please contact to T.S.D.

Table 5-16 Overview

No.	Item	Content
1	SVP Operation	Select system option from “Install”.
2	Status	DKC only reports on SIM of starting the function. The progress status is not displayed.
3	Result	DKC reports on SIM of normality or abnormal end.
4	Recovery procedure at failure	Re-Erase of PDEV that terminates abnormally is impossible. Please exchange it for new service parts.
5	PS off or B/K off	The Erase processing fails. It doesn’t restart after PS on.
6	How to stop the “PDEV Erase”	Please execute Replace from the Maintenance Utility and exchange PDEV that Erase wants to stop for new service parts.
7	Data Erase Pattern	Data Erase Pattern is zero data.

Table 5-17 PDEV Erase execution case

No.	Execution case
1	PDEV is blocked according to Drive Copy completion.

5.5.2 Rough Estimate of Erase Time

The Erase time is decided by capacity and the rotational speed of PDEV.
Time is indicated as follows. (Time is a standard and it might take the TOV)

Table 5-18 PDEV Erase completion expectation time

Type of PDEV	960 GB	1.9 TB	2.4 TB	3.8 TB	7.0 TB	7.6 TB	10 TB	14 TB
SAS (7.2 krpm)	–	–	–	–	–	–	945 min	1145 min
SAS (10 krpm)	–	–	190 min	–	–	–	–	–
Flash Drive	20 min	40 min	–	80 min	–	140 min	–	–
Flash Module Drive	–	–	–	–	1 min	–	–	1 min

Type of PDEV	15 TB	30 TB
SAS (7.2 krpm)	–	–
SAS (10 krpm)	–	–
Flash Drive	210 min	490 min
Flash Module Drive	–	–

Table 5-19 PDEV Erase TOV

Type of PDEV	960 GB	1.9 TB	2.4 TB	3.8 TB	7.0 TB	7.6 TB	10 TB	14 TB
SAS (7.2 krpm)	–	–	–	–	–	–	1920 min	2320 min
SAS (10 krpm)	–	–	410 min	–	–	–	–	–
Flash Drive	70 min	110 min	–	190 min	–	310 min	–	–
Flash Module Drive	–	–	–	–	9 min	–	–	9 min

Type of PDEV	15 TB	30 TB
SAS (7.2 krpm)	–	–
SAS (10 krpm)	–	–
Flash Drive	450 min	1010 min
Flash Module Drive	–	–

5.5.3 Influence in Combination with Other Maintenance Operation

The influence on the maintenance operation during executing PDEV Erase becomes as follows.

Table 5-20 PDEV Replace

No.	Object part	Influence	Countermeasure
1	Replace from Maintenance Utility as for PDEV that does PDEV Erase.	PDEV Erase terminates abnormally.	—
2	Replace from Maintenance Utility as for PDEV that does not PDEV Erase.	Nothing	—
3	User Replace	Please do not execute the user replacement during PDEV Erase.	Please execute it after completing PDEV Erase.

Table 5-21 DKB Replace

No.	Object part	Influence	Countermeasure
1	DKB connected with PDEV that is executed PDEV Erase	[SVP4198W] may be displayed. The DKB replacement might fail by [ONL2412E] when the password is entered. (*2)	<SIM4d8xxx/4d9xxx/4daxxx/4dbxxx about this PDEV is not reported> Please replace PDEV (to which Erase is done) to new service parts. (*1) The DKB replacement might fail by [ONL2412E] when the password is entered. (*2)
2	DKB other than the above	Nothing	Nothing

Table 5-22 I/F Board Replace/I/F Board Removal

No.	Object part	Influence	Countermeasure
1	I/F Board that is executed PDEV Erase	[SVP4198W] may be displayed. The I/F Board replacement might fail by [ONL2412E] when the password is entered. (*2)	<SIM4d8xxx/4d9xxx/4daxxx/4dbxxx about this PDEV is not reported> Please replace PDEV (to which Erase is done) to new service parts. (*1) The I/F Board replacement might fail by [ONL2412E] when the password is entered. (*2)
2	I/F Board other than the above	Nothing	Nothing

Table 5-23 ENC Replace

No.	Object part	Influence	Countermeasure
1	ENC connected with DKB connected with HDD that does PDEV Erase	[SVP4198W] may be displayed. The ENC replacement might fail by [ONL2788E] [ONL3395E] when the password is entered. (*2)	<SIM4d8xxx/4d9xxx/4daxxx/4dbxxx about this PDEV is not reported> Please replace PDEV (to which Erase is done) to new service parts. (*1) The ENC replacement might fail by [ONL2788E][ONL3395E] when the password is entered. (*2)
2	ENC other than the above	Nothing	Nothing

Table 5-24 PDEV Addition/Removal

No.	Object part	Influence	Countermeasure
1	ANY	Addition/Removal might fail by [SVP739W].	Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)

Table 5-25 Exchanging micro-program

No.	Object part	Influence	Countermeasure
1	DKC MAIN	[SVP0732W] may be displayed. Micro-program exchanging might fail by [SMT2433E], when the password is entered. (*2)	Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)
2	Drive	[SVP0732W] may be displayed. Micro-program exchanging might fail by [SMT2433E], when the password is entered. (*2)	Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)

Table 5-26 LDEV Format

No.	Object part	Influence	Countermeasure
1	ANY	There is a possibility that PATH-Inline fails. There is a possibility that the cable connection cannot be checked when the password is entered.	Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)

Table 5-27 PATH-Inline

No.	Object part	Influence	Countermeasure
1	DKB connected with PDEV that is executed PDEV Erase	There is a possibility of detecting the trouble by PATH-Inline.	Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)

Table 5-28 PS/OFF

No.	Object part	Influence	Countermeasure
1	ANY	PDEV Erase terminates abnormally.	<SIM4d8xxx/4d9xxx/4daxxx/4dbxxx about this PDEV is not reported> Please wait for the Erase completion or replace PDEV (to which Erase is done) to new service parts. (*1)

*1: When PDEV that stops PDEV Erase is installed into DKC again, it might fail by Spin-up failure.

*2: It is not likely to be able to maintain it when failing because of concerned MSG until PDEV Erase is completed or terminates abnormally.

5.5.4 Notes of Various Failures

Notes of the failure during PDEV Erase become as follows.

No.	Failure	Object part	Notice	Countermeasure
1	B/K OFF/ Black Out	Drive BOX (DB)	There is a possibility that PDEV Erase fails due to the failure.	Please replace PDEV of the Erase object to new service parts after PS on.
2		DKC	Because monitor JOB of Erase disappears, it is not possible to report on normality/ abnormal termination SIM of Erase.	Please replace PDEV of the Erase object to new service parts after PS on.
3	MP failure	I/F Board	[E/C 9470 is reported at the MP failure] JOB of the Erase monitor is reported on E/C 9470 when Abort is done due to the MP failure and completes processing. In this case, it is not possible to report on normality/abnormal termination SIM of Erase.	Please replace PDEV of the Erase object to new service parts after the recovery of MP failure.
4			[E/C 9470 is not reported at the MP failure] It becomes impossible to communicate with the Controller who is doing Erase due to the MP failure. In this case, it becomes TOV of monitor JOB with E/C 9450, and reports abnormal SIM.	Please replace PDEV to new service parts after judging the Erase success or failure after it waits while TOV of PDEV Erase after the recovery of MP.

6. Appendix A : Maintenance Associated with MF Products

6.1 Channel Commands

Command Overview

1. READ commands
   The read commands transfer the readout data from devices to channels.

2. WRITE commands
   The write commands write the transfer data from channels to devices.

3. SEARCH commands
   The search commands follow a control command and logically search for the target data.

4. CONTROL commands
   The control commands include the SEEK command that positions cylinder and head positions, the SET SECTOR command that executes latency time processing, the LOCATE RECORD command that specifies the operation of the ECKD command, the SET FILE MASK command that defines the permissible ranges for the WRITE and SEEK operations, and the DEFINE EXTENT command that defines the permissible ranges for the WRITE and SEEK operations and that defines the cache access mode.

5. SENSE commands
   The sense commands transfer sense bytes and device specifications.

6. PATH CONTROL commands
   The path control commands enable and disable the exclusive control of devices.

7. TEST I/O command
   The TEST I/O command transfers the specified device and its path state to a given channel in the form of DSBs.

8. SUBSYSTEM commands
   The subsystem commands include the commands and paths that specify the information for cache control to DKCs, and the commands that transfer the channel information and cache related information to channels.

Table 6-1 Command Summary (1/3)

Command Name			Command Code	
			Single Track	Multitrack
READ commands	READ INITIAL PROGRAM LOAD	(RD IPL)	02	–
	READ HOME ADDRESS	(RD HA)	1A	9A
	READ RECORD ZERO	(RD R0)	16	96
	READ COUNT,KEY,DATA	(RD CKD)	1E	9E
	READ KEY,DATA	(RD KD)	0E	8E
	READ DATA	(RD D)	06	86
	READ COUNT	(RD C)	12	92
	READ MULTIPLE COUNT,KEY AND DATA	(RD MCKD)	5E	–
	READ TRACK	(RD TRK)	DE	–
	READ SPECIAL HOME ADDRESS	(RD SP HA)	0A	–
WRITE commands	WRITE HOME ADDRESS	(WR HA)	19	–
	WRITE RECORD ZORO	(WR R0)	15	–
	WRITE COUNT,KEY,DATA	(WR CKD)	1D	–
	WRITE COUNT,KEY,DATA NEXT TRACK	(WR CKD NT)	9D	–
	ERASE	(ERS)	11	–
	WRITE KEY AND DATA	(WR KD)	0D	–
	WRITE UPDATE KEY AND DATA	(WR UP KD)	8D	–
	WRITE DATA	(WR D)	05	–
	WRITE UPDATE DATA	(WR UP D)	85	–
	WRITE SPECIAL HOME ADDRESS	(WR SP HA)	09	–
SEARCH commands	SEARCH HOME ADDRESS	(SCH HA EQ)	39	B9
	SEARCH ID EQUAL	(SCH ID EQ)	31	B1
	SEARCH ID HIGH	(SCH ID HI)	51	D1
	SEARCH ID HIGH OR EQUAL	(SCH ID HE)	71	F1
	SEARCH KEY EQUAL	(SCH KEY EQ)	29	A9
	SEARCH KEY HIGH	(SCH KEY HI)	49	C9
	SEARCH KEY HIGH OR EQUAL	(SCH KEYD HE)	69	E9

Table 6-2 Command Summary (2/3)

Command Name			Command Code	
			Single Track	Multitrack
CONTROL commands	DEFINE EXTENT	(DEF EXT)	63	–
	LOCATE RECORD	(LOCATE)	47	–
	LOCATE RECORD EXTENDED	(LOCATE EXT)	4B	–
	SEEK	(SK)	07	–
	SEEK CYLINDER	(SK CYL)	0B	–
	SEEK HEAD	(SK HD)	1B	–
	RECALIBRATE	(RECAL)	13	–
	SET SECTOR	(SET SECT)	23	–
	SET FILE MASK	(SET FM)	1F	–
	READ SECTOR	(RD SECT)	22	–
	SPACE COUNT	(SPC)	0F	–
	NO OPERATION	(NOP)	03	–
	RESTORE	(REST)	17	–
	DIAGNOSTIC CONTROL	(DIAG CTL)	F3	–
SENSE commands	SENSE	(SNS)	04	–
	READ AND RESET BUFFERED LOG	(RRBL)	A4	–
	SENSE IDENTIFICATION	(SNS ID)	E4	–
	READ DEVICE CHARACTERISTICS	(RD CHR)	64	–
	DIAGNOSTIC SENSE/READ	(DIAG SNS/RD)	C4	–
PATH CONTROL commands	DEVICE RESERVE	(RSV)	B4	–
	DEVICE RELEASE	(RLS)	94	–
	UNCONDITIONAL RESERVE	(UNCON RSV)	14	–
	SET PATH GROUP ID	(SET PI)	AF	–
	SENSE SET PATH GROUP ID	(SNS PI)	34	–
	SUSPEND MULTIPATH RECONNECTION	(SUSP MPR)	5B	–
	RESET ALLEGIANCE	(RST ALG)	44	–
	READ CONFIGURATION DATA	(RD CONF DATA)	FA	–
TST I/O	TEST I/O	(TIO)	00	–
TIC	TRANSFER IN CHANNEL	(TIC)	X8	–

Table 6-3 Command Summary (3/3)

Command Name			Command Code	
			Single Track	Multitrack
STORAGE SYSTEM commands	SET STORAGE SYSTEM MODE	(SET SUB MD)	87	–
	PERFORM STORAGE SYSTEM FUNCTION	(PERF SUB FUNC)	27	–
	READ STORAGE SYSTEM DATA	(RD SUB DATA)	3E	–
	SENSE STORAGE SYSTEM STATUS	(SNS SUB STS)	54	–
	READ MESSAGE ID	(RD MSG IDL)	4E	–

NOTE:
- Command Reject, format 0, and message 1 are issued for the commands that are not listed in this table.
- TEST I/O is a CPU instruction and cannot be specified directly. However, it appears as a command to the interface.
- TIC is a type of command but runs only on a channel. It will never be visible to the interface.

6.2 Comparison of Pair Status on SVP, Web Console, RAID Manager

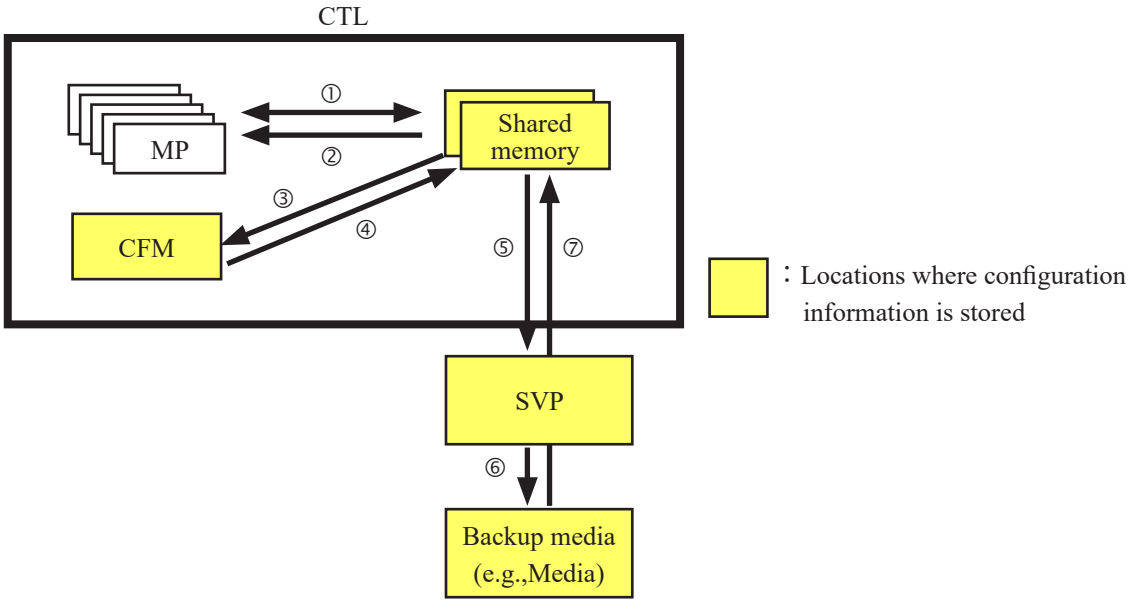
Table 6-4 Comparison of Pair Status on Storage Navigator, RAID Manager

No.	Event	Status on RAID Manager	Status on SVP, Web Console
1	Simplex Volume	P-VOL: SMPL S-VOL: SMPL	P-VOL: SMPL S-VOL: SMPL
2	Copying LU Volume Partly completed (SYNC only)	P-VOL: PDUB S-VOL: PDUB	P-VOL: PDUB S-VOL: PDUB
3	Copying Volume	P-VOL: COPY S-VOL: COPY	P-VOL: COPY S-VOL: COPY
4	Pair volume	P-VOL: PAIR S-VOL: PAIR	P-VOL: PAIR S-VOL: PAIR
5	Pairsplit operation to P-VOL	P-VOL: PSUS S-VOL: SSUS	P-VOL: PSUS (S-VOL by operator) S-VOL: PSUS (S-VOL by operator)/ SSUS
6	Pairsplit operation to S-VOL	P-VOL: PSUS S-VOL: PSUS	P-VOL: PSUS (S-VOL by operator) S-VOL: PSUS (S-VOL by operator)
7	Pairsplit -P operation (*1) (P-VOL failure, SYNC only)	P-VOL: PSUS S-VOL: SSUS	P-VOL: PSUS (P-VOL by operator) S-VOL: PSUS (by MCU)/SSUS
8	Pairsplit -R operation (*1)	P-VOL: PSUS S-VOL: SMPL	P-VOL: PSUS(Delete pair to RCU) S-VOL: SMPL
9	P-VOL Suspend (failure)	P-VOL: PSUE S-VOL: SSUS	P-VOL: PSUE (S-VOL failure) S-VOL: PSUE (S-VOL failure)/SSUS
10	S-VOL Suspend (failure)	P-VOL: PSUE S-VOL: PSUE	P-VOL: PSUE (S-VOL failure) S-VOL: PSUE (S-VOL failure)
11	PS ON failure	P-VOL: PSUE S-VOL: —	P-VOL: PSUE (MCU IMPL) S-VOL: —
12	Copy failure (P-VOL failure)	P-VOL: PSUE S-VOL: SSUS	P-VOL: PSUE (Initial copy failed) S-VOL: PSUE (Initial copy failed)/ SSUS
13	Copy failure (S-VOL failure)	P-VOL: PSUE S-VOL: PSUE	P-VOL: PSUE (Initial copy failed) S-VOL: PSUE (Initial copy failed)
14	RCU accepted the notification of MCU's P/S-OFF	P-VOL: — S-VOL: SSUS	P-VOL: — S-VOL: PSUE (MCU P/S OFF)/SSUS
15	MCU detected the failure of RCU	P-VOL: PSUE S-VOL: PSUE	P-VOL: PSUS (by RCU)/PSUE S-VOL: PSUE (S-VOL failure)

*1: Operation on RAID Manager

6.3 Locations where Configuration Information is Stored and Timing of Information Update

Locations where configuration information is stored and timing of information update is indicated.



No.	Locations	Update/Save/Load
①	MP ⇔ Shared memory	• The configuration information is updated due to the configuration change by operators for VOL creation, LUNM setting, and the like. • The configuration information is updated due to the change of resource allocation.
②	Shared memory → MP	If the storage system starts up when the shared memory is not volatile, the configuration information in the shared memory is loaded into MPs.
③	Shared memory → CFM	• When the storage system is powered off, the configuration information is saved into the CFM. • When the configuration information is updated, it is saved into the CFM by online configuration backup.
④	CFM → Shared memory	If the storage system starts up when the shared memory is volatile, the configuration information saved into the CFM in ③ is loaded into the shared memory.
⑤	Shared memory → SVP	When the configuration information is updated, the configuration information in the shared memory is saved into the SVP.
⑥	SVP → Backup media (e.g.,Media)	The configuration information in the shared memory is saved into the backup media, according to the operation settings for configuration information backup (Create Configuration Backup) in the SVP.
⑦	Backup media (e.g.,Media) → (SVP) → Shared memory	The configuration information saved in the backup media is loaded into the shared memory, according to the operation settings for Restoring Configuration Information in the SVP.

6.4 TPF

6.4.1 An outline of TPF

TPF is one of operating systems (OS) mainly used for airline on-line reservation systems (CRS/Computer Reservation System).
To correspond to TPF, DKC must support logical exclusive lock facility and extended cache facility.
The former is a function which is called MPLF (Multi-Path Lock Facility) and the latter is a function which is called RC (Record Cache).
A DKC which supports TPF has the MPLF and RC functions defined in RPQ#8B0178 in the IBM public manual: IBM3990 Transaction Processing Facility support RPQs (GA32-0134-03).

A DKC which corresponds to TPF implements a special version of microprogram which supports the MPLF and RC functions of TPF feature (RPQ#8B0178), described in the following IBM public manuals:

(1) IBM3990 Transaction Processing Facility support RPQs (GA32-0134-03)
(2) IBM3990 Storage Control Reference for Model 6 (GA32-0274-03)

1. Outline of MPLF

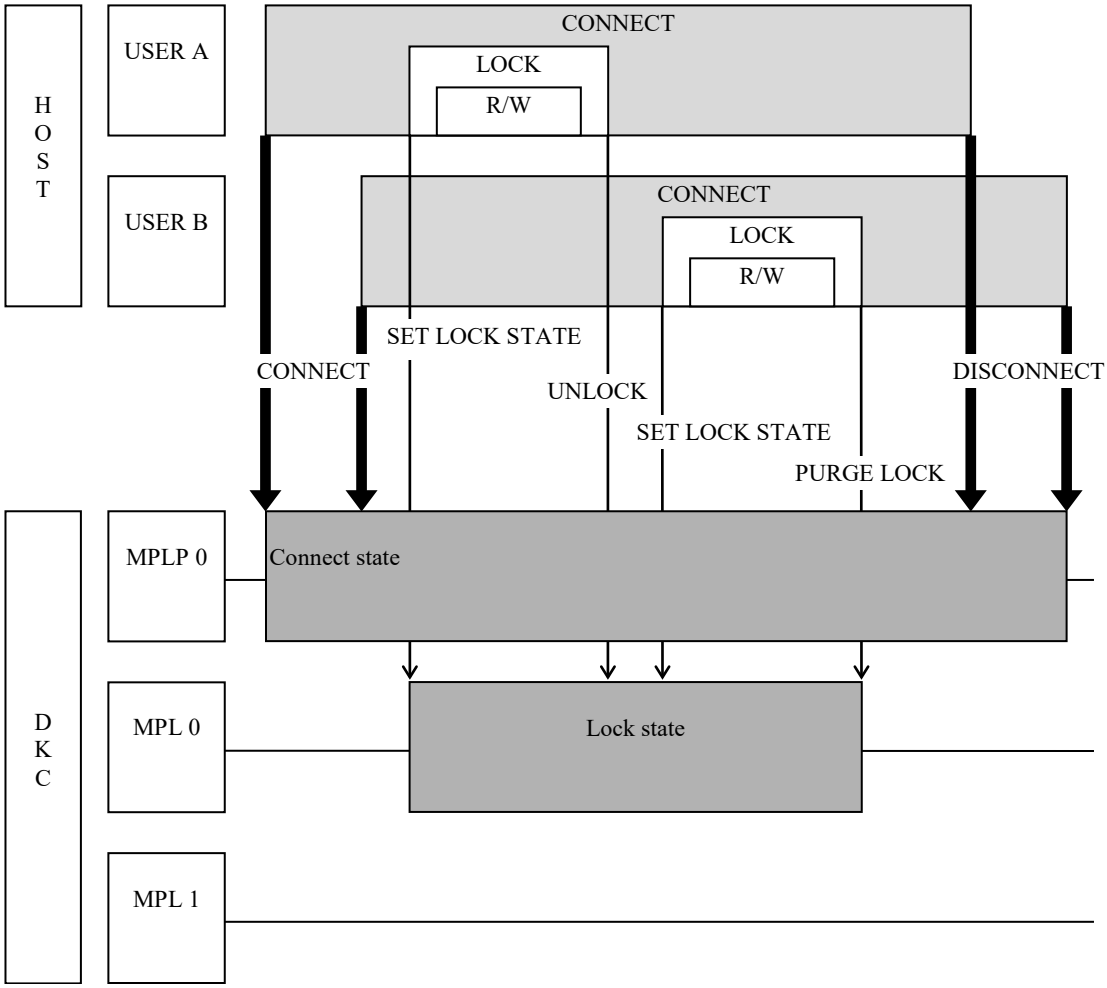
A host system can control concurrent use of resources by using logical locks of DKC. Logical locks are defined in shared resources of each logical CU in DKC. These shared resources are managed by MPL (Multi-Path Lock). Each MPL can have up to 16 types of lock statuses.

Figure 6-1 shows the overview of the I/O sequence with MPLF. A TPF host uses a unique MPLF user identifier. Up to 32 MPLF users can be connected to one logical CU.

In Figure 6-1, MPLF users are USER A and USER B. Each user specifies MPLP (Multi-Path Lock Partition) to use MPLF. MPLP is a logical partition that divides a group of MPLs which are divided for each logical CU. Up to eight MPLPs can be set. Two MPLPs are usually used: one MPLP is for transactions and the other for maintenance jobs. MPLP is specified by an MPLP identifier.

(1) Before starting an I/O sequence, each host performs the CONNECT processing to get permission to use MPLP. Only a user who is given permission by the processing can use the logical lock facility of MPLF.
(2) Each user performs the SET LOCK STATE processing by specifying a multi-path lock name (equivalent to a dataset name for which concurrent use is controlled) to get a logical lock.
(3) The user who gets a logical lock by the SET LOCK STATE processing performs the R/W processing for the specified multi-path lock name.
(4) The user who finishes the R/W processing performs the UNLOCK processing by specifying the multi-path lock name to release the logical lock. This processing enables DASD to be shared while maintaining the data consistency.
(5) The user who does not have to use each MPLP performs the DISCONNECT processing to give up permission to use each MPLP.

Figure 6-1 Overview of MPLF



2. Outline of RC

RC has the following two features:

(1) Record Mode Chain
(2) Record Caching

The following explains these features.

(1) Record Mode Chain

Record Mode Chain consists of the following 4 command chains:

(a) Mainline Processing (Read)
(b) Mainline Processing (Write)
(c) Capture
(d) Restore

To run Record Mode Chain, Record Mode needs to be allowed for each device by the command. If Record Mode is not allowed for the target device, the chain is processed as an I/O in the standard mode (non-TPF mode).

(2) Record Caching

When the host specifies Set Cache Allocation Parameters by a command, record caching is enabled in DKC.

6.4.2 TPF Support Requirement

1. OS
   TPF Ver.4.1./zTPF VER.1.1

2. Hardware
   The following table shows the storage system hardware specifications for TPF support.

Table 6-5 TPF Support Hardware Specification

Item	Description
Number of MODs	Max. 16,384/box
Number of LCUs/Box	Max. 64
Number of SSIDs/LCU	1
Cache/SM capacity	Refer to (INST(GE)03-04-10)
RAID level	1, 5 or 6
Emulation type (1) DKC (2) Device	 2107 3390-3/9/L/M
Number of host paths	Max. 32
Number or Multi-Path Locks	16,384/LCU (assigned to only 16LCUs) 4,096/LCU (assigned to 64LCUs)

6.4.3 TPF trouble shooting method

Basically TPF environment and MVS (as a standard operation system) are same in trouble shooting.

An example order is below:

(1) Collect system error information by Syslog, EREP, and so on.
(2) Collect DKC error information by SVP dump operation.
(3) Send the above data to T.S.D.

6.4.4 The differences of DASD-TPF (MPLF) vs DASD-MVS

1. Controlling concurrent use of data by MPLF

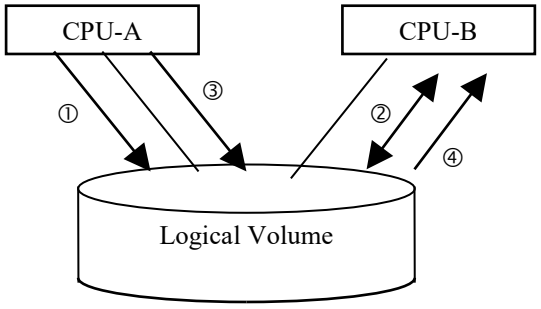
MVS environments

(1) Logical volume (device) is the unit of controlling concurrent use of data among multiple CPUs.
(2) "Device" is owned by one CPU during CPU processing (accessing), and "Device-busy" status is reported to another CPU's accesses.
(3) "Device-end" status is used to notify the waiting CPUs when the device becomes free.

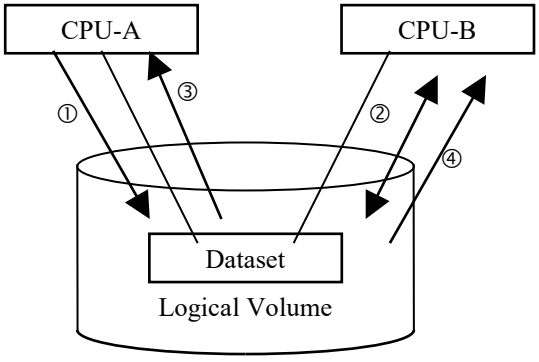
TPF environments

(1) A logical lock is the unit of exclusive control of data among multiple CPUs, in place of a logical volume (device) in MVS.
(2) Each logical lock can be accessed in parallel.
(3) When a CPU occupies a certain logical lock, DSB x4C/x0C is returned in response to a request for the logical lock by other CPU. DSB x4C indicates that the logical lock succeeded, and DSB x0C indicates that the logical lock failed (changing to the waiting for logical lock state).
(4) When the logical lock is released, it is given to the CPU that is changing to the waiting for logical lock state. "Attention" is reported to other waiting CPUs.

Figure 6-2 Differences between TPF DASD and MVS DASD



① Reserve/Read&Write Access by CPU-A (Successful).
② CPU-B's trial is rejected by Device-busy (Failed).
③ Terminate its process and release the volume.
④ Free (Device-end) will be sent.
CPU-B can use this volume.



① Set Lock/Read&Write process *1 by CPU-A (Successful).
② CPU-B's trial is rejected by Not-granted (failed).
③ Terminate with Unlock, by CPU-A.
④ Free (Attention) will be sent. *2.
CPU-B can use this Dataset.

*1: Typical CCW chain:
- Set lock State (x27/order(x30));
- Read Storage system Data (x3E);
- TIC (to be continued if granted)
- (ordinary CCW chain)

*2: This report's path/Address is usually different from above ②.

2. Path-group

   (1) The TPF system does not use a path-group composed of multiple paths.

3. Connect Path/Device

   (1) TPF system issues “Connect order” to define :
   - User registration to each logical CU and MPLP
   - MPL resource allocation to each logical CU and MPLP
   - Setting of paths and devices that report attentions

   (2) This order is code (x33) of Perform Storage system Function (x27) command.
   (3) CPU (channel) only has the capability to change this path and device definition.

4. Channel Re-drive function

   Function unique to the TPF channels, which makes a sub channel try the reconnection on the same path for a certain period of time when an I/O request is rejected because CU is busy

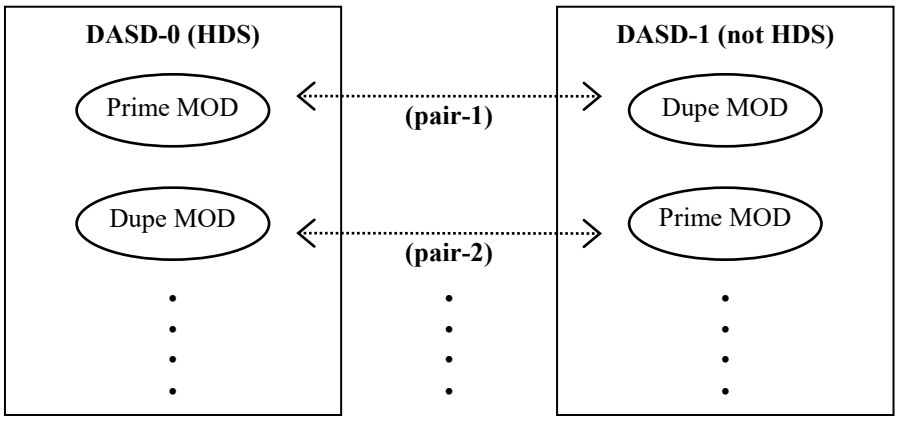
5. Fixed length record

   The TPF system uses fixed length records for faster update writes of records and for more efficient cache handling in reads of single records. In the online environment, the system usually operates at a hit rate of almost 100% for writes and a hit rate of 80% or higher for reads.

6. Prime/Dupe MODs pairs

(1) To improve Data-integrity of DASD, TPF system often makes the Data-duplications on different two DASD storage systems.
(2) The following figure shows one example of these pairs.
Prime MOD (module)s and Dupe MODs are always located on each side of storage system (spread to all storage systems).

Figure 6-3 Prime/Dupe MODs pairs



7. Data Copy procedures

The Copy procedures are taken for the following purposes:
(1) To make a pair (To copy data from Prime MOD to Dupe).
(2) To recover the failed data.

There are two ways to make a pair.
(1) AFC (All File Copy)
(2) AMOD (Alter Module)

6.4.5 Notices for TrueCopy for Mainframe-option setting

<SVP operation>

1. RCU Option
   We strongly recommend you to select “No” in the “PPRC support by host” column of the RCU Option window.
   We strongly recommend you to select the “Not Report” in the “Service SIM of Remote Copy” column of the RCU Option window.

2. Add Pair
   We strongly recommend you to select the “Copy to R-VOL” in the “CFW Data” column of the Add Pair window.

3. Suspend Pair
   We strongly recommend you to select the “Disable” in the “SSB (F/M = FB)” column of the Suspend Pair window.

<Host (TPF-OS) consideration>

When MVS is used, TC-MF requires customers to extend the I/O patrol time to prevent MIH reporting. This applies also to TPF. You need to discuss with your customer to find opportunity to extend the “Stalled Module Queue” timer. If you cannot extend the timer, you need to avoid the reporting by using split volumes of SI-MF, for example.

6.5 CHB/DKB - SASCTL#/PSW#, Port# Matrixes

Table 6-6 Relationship between CHB/DKB and SASCTL#/PSW#, Port# (1/3)

CBX Pair	Location	Channel Port#	SAS CTL#/ PSW#	SAS Port#/ NVMe Port#
CBX Pair 0	CHB-01A	00 ~ 03	-	-
	CHB-01B	04 ~ 07	-	-
	CHB-01E	08 ~ 0b	-	-
	CHB-01F	0c ~ 0f	-	-
	CHB-02A	10 ~ 13	-	-
	CHB-02B	14 ~ 17	-	-
	CHB-02E	18 ~ 1b	-	-
	CHB-02F	1c ~ 1f	-	-
	CHB-11A	20 ~ 23	-	-
	CHB-11B	24 ~ 27	-	-
	CHB-11E	28 ~ 2b	-	-
	CHB-11F	2c ~ 2f	-	-
	CHB-12A	30 ~ 33	-	-
	CHB-12B	34 ~ 37	-	-
	CHB-12E	38 ~ 3b	-	-
	CHB-12F	3c ~ 3f	-	-
	DKB-01D	-	01	02/03/12/13
	DKB-01H	-	00	00/01/10/11
	DKB-02D	-	03	06/07/16/17
	DKB-02H	-	02	04/05/14/15
	DKB-11D	-	05	0a/0b/1a/1b
	DKB-11H	-	04	08/09/18/19
	DKB-12D	-	07	0e/0f/1e/1f
	DKB-12H	-	06	0c/0d/1c/1d

Table 6-7 Relationship between CHB/DKB and SASCTL#/PSW#, Port# (2/3)

CBX Pair	Location	Channel Port#	SAS CTL#/ PSW#	SAS Port#/ NVMe Port#
CBX Pair 1	CHB-21A	40 ~ 43	-	-
	CHB-21B	44 ~ 47	-	-
	CHB-21E	48 ~ 4b	-	-
	CHB-21F	4c ~ 4f	-	-
	CHB-22A	50 ~ 53	-	-
	CHB-22B	54 ~ 57	-	-
	CHB-22E	58 ~ 5b	-	-
	CHB-22F	5c ~ 5f	-	-
	CHB-31A	60 ~ 63	-	-
	CHB-31B	64 ~ 67	-	-
	CHB-31E	68 ~ 6b	-	-
	CHB-31F	6c ~ 6f	-	-
	CHB-32A	70 ~ 73	-	-
	CHB-32B	74 ~ 77	-	-
	CHB-32E	78 ~ 7b	-	-
	CHB-32F	7c ~ 7f	-	-
	DKB-21D	-	09	22/23/32/33
	DKB-21H	-	08	20/21/30/31
	DKB-22D	-	0b	26/27/36/37
	DKB-22H	-	0a	24/25/34/35
	DKB-31D	-	0d	2a/2b/3a/3b
	DKB-31H	-	0c	28/29/38/39
	DKB-32D	-	0f	2e/2f/3e/3f
	DKB-32H	-	0e	2c/2d/3c/3d

Table 6-8 Relationship between CHB/DKB and SASCTL#/PSW#, Port# (3/3)

CBX Pair	Location	Channel Port#	SAS CTL#/ PSW#	SAS Port#/ NVMe Port#
CBX Pair 2	CHB-41A	80 ~ 83	-	-
	CHB-41B	84 ~ 87	-	-
	CHB-41E	88 ~ 8b	-	-
	CHB-41F	8c ~ 8f	-	-
	CHB-42A	90 ~ 93	-	-
	CHB-42B	94 ~ 97	-	-
	CHB-42E	98 ~ 9b	-	-
	CHB-42F	9c ~ 9f	-	-
	CHB-51A	a0 ~ a3	-	-
	CHB-51B	a4 ~ a7	-	-
	CHB-51E	a8 ~ ab	-	-
	CHB-51F	ac ~ af	-	-
	CHB-52A	b0 ~ b3	-	-
	CHB-52B	b4 ~ b7	-	-
	CHB-52E	b8 ~ bb	-	-
	CHB-52F	bc ~ bf	-	-
	DKB-41D	-	11	42/43/52/53
	DKB-41H	-	10	40/41/50/51
	DKB-42D	-	13	46/47/56/57
	DKB-42H	-	12	44/45/54/55
	DKB-51D	-	15	4a/4b/5a/5b
	DKB-51H	-	14	48/49/58/59
	DKB-52D	-	17	4e/4f/5e/5f
	DKB-52H	-	16	4c/4d/5c/5d

6.6 CTL/MPU - MPU#, MP# Matrixes

Table 6-9 Relationship between MP Unit ID,MP Location and MP#

DKC#	CTL Location	MPU Location	MPU#	MP Location	MP#
0	CTL01	MPU-010	0x00	MP010-00 ~ MP010-13	0x00 ~ 0x13
	CTL02	MPU-020	0x01	MP020-00 ~ MP020-13	0x14 ~ 0x27
1	CTL11	MPU-110	0x02	MP110-00 ~ MP110-13	0x28 ~ 0x3B
	CTL12	MPU-120	0x03	MP120-00 ~ MP120-13	0x3C ~ 0x4F
2	CTL21	MPU-210	0x04	MP210-00 ~ MP210-13	0x50 ~ 0x63
	CTL22	MPU-220	0x05	MP220-00 ~ MP220-13	0x64 ~ 0x77
3	CTL31	MPU-310	0x06	MP310-00 ~ MP310-13	0x78 ~ 0x8B
	CTL32	MPU-320	0x07	MP320-00 ~ MP320-13	0x8C ~ 0x9F
4	CTL41	MPU-410	0x08	MP410-00 ~ MP410-13	0xA0 ~ 0xB3
	CTL42	MPU-420	0x09	MP420-00 ~ MP420-13	0xB4 ~ 0xC7
5	CTL51	MPU-510	0x0A	MP510-00 ~ MP510-13	0xC8 ~ 0xDB
	CTL52	MPU-520	0x0B	MP520-00 ~ MP520-13	0xDC ~ 0xEF