

# IBM DS8000 High-Performance Flash Enclosure Gen2

(DS8000 R9.1)

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Storage



## IBM DS8000 High-Performance Flash Enclosure Gen2

The IBM® DS8000® High-Performance Flash Enclosure Gen2 (HPFE Gen2) is a 2U storage enclosure that is installed in pairs in DS8900F and DS8880 models.

The HPFE Gen2 pair provides two 2U storage enclosures with associated RAID controllers and cabling. This combination of components forms a high-performance, fully redundant flash storage array.

The HPFE Gen2 pair contains the following hardware components:

- ▶ Two 2U 24-slot Serial Attached SCSI (SAS) flash drive enclosures
- ▶ 16, 32, or 48 encryption-capable 2.5-inch flash drives
- ▶ Each enclosure of the pair contains the following components:
  - Two SAS expander modules with two SAS ports each
  - Two power supplies with integrated cooling fans
  - One midplane or backplane for plugging components that allows maintenance of flash drives, expander modules, and power supplies

Installed with the HPFE Gen2 pair are a pair of flash RAID adapters configured for redundant access to the flash enclosures. Each RAID adapter supports concurrent maintenance and includes the following components:

- ▶ High-Performance ASIC RAID engine
- ▶ Four SAS ports and cables connected to the four SAS expander modules, providing fully-redundant access from each RAID adapter to both of the flash enclosures
- ▶ PCIe Gen3 x8 connectivity to the processor nodes via the I/O enclosures

The HPFE Gen2 is only available in DS8900F and DS8880 models. This product guide discusses DS8900F models 993, 994, 996, and DS8880 models 983, 984, 985, 986, and 988.

First-generation DS8880 models 980, 981, and 982 are not discussed in this product guide.

Figure 1 Shows the High-Performance Flash Enclosure Gen2, front view.



Figure 1 High-Performance Flash Enclosure Gen2 (front view)

# High-Performance Flash Enclosure Gen2 highlights

HPFE Gen2 includes features and capabilities, as characterized in the following list:

- ▶ As implemented in the DS8880, the HPFEs Gen2 are directly attached to the PCIe Gen3 fabric with flash RAID adapters, enabling increased bandwidth compared to Fibre Channel attached standard drive enclosures.
- ▶ Flash drives are enterprise class storage devices that are targeted at I/O-intensive workload applications that can benefit from a high level of fast-access storage.
- ▶ Flash drives offer a number of potential benefits over spinning drives, including higher IOPS, lower power consumption, less heat generation, and lower acoustical noise.
- ▶ Compared to the fibre-attached flash drives (SSDs) installed in the standard drive enclosures of DS8880 and earlier models, flash drives in HPFE Gen-2 offer even higher throughput using the flash RAID adapters, which have a direct PCIe Gen3 connectivity to the processor complexes.
- ▶ High-performance flash drives are classed as *Flash Tier 0*. Available Flash Tier 0 drive capacities include the following options:
  - 800 GB
  - 1.6 TB
  - 3.2 TB
- ▶ High-capacity flash drives are classed as *Flash Tier 1* or *Flash Tier 2*. Available Flash Tier 1 or Flash Tier 2 drives capacities include the following options:
  - 1.92 TB (Flash Tier 2) (not available for DS8886/DS8888)
  - 3.84 TB (Flash Tier 1)
  - 7.68 TB (Flash Tier 2)
  - 15.36 TB (Flash Tier 2)
- ▶ Flash drives in the HPFE Gen2 support full drive encryption (FDE).
- ▶ Each HPFE Gen2 pair contains up to 48 flash drives allowing up to 153.6 TB of raw capacity based on the 3.2 TB high-performance flash drives or a 737.28 TB raw capacity based on the 15.36 TB high-capacity flash drives.
- ▶ Up to 8 HPFE Gen2 pairs per DS8950F with one expansion enclosure or up to 16 HPFE Gen2 pairs in the DS8888F with two expansion racks give you an impressive total of 11,796.48 TB of raw flash capacity.
- ▶ The IBM Easy Tier® intra-tiering auto-rebalance (micro-tiering) feature is used to distribute the workload among traditional flash drives (SSDs) and *Flash Tier 0, 1, and 2* flash drives according to their IOPS capacity within the storage tier.
- ▶ *Smart Rebuild* for HPFE Gen2 is a function of the R9 firmware that is designed to help reduce the possibility of secondary failures and data loss of RAID arrays. *Smart Rebuild* predictive failures of a Flash Drives and starts cloning the data while the drive is still online, eliminating the need of a RAID rebuild. It is available only for a RAID 6 array. *Smart Rebuild* for flash drives in the DS8900F uses the same algorithm as for the standard drives in the DS8880.

## High-Performance Flash Enclosure Gen2 components

The following section describes the components of the HPFE Gen2 enclosure.

### Flash drives

The HPFE Gen2 pair provides two 2U flash enclosures. The HPFE Gen2 is available with a choices of drive sets. The following drives are available:

- ▶ 2.5-inch Flash Tier 0 drives
  - 800 GB
  - 1.6 TB
  - 3.2 TB
- ▶ 2.5-inch Flash Tier 1 drives
  - 3.84 TB
- ▶ 2.5-inch Flash Tier 2 drives
  - 1.92 TB (not available for DS8886/DS8888)
  - 7.68 TB
  - 15.36 TB

**Note:** Intermix of high performance Flash Tier 0 drives with high capacity Flash Tier 1 and Flash Tier 2 drives is not supported in a HPFE G2 pair.  
All flash drives in a HPFE Gen2 pair are Full Drive Encryption (FDE) capable.

### Flash drive sets

Flash drives are ordered in sets of 16. The HPFE Gen2 pair can contain 16, 32, or 48 flash drives (1, 2, or 3 drive sets). Half the drive set is installed in each enclosure of the pair. Figure 2 shows the HPFE Gen2 flash drive set install order. Flash drives and fillers are installed from the front of the enclosure.

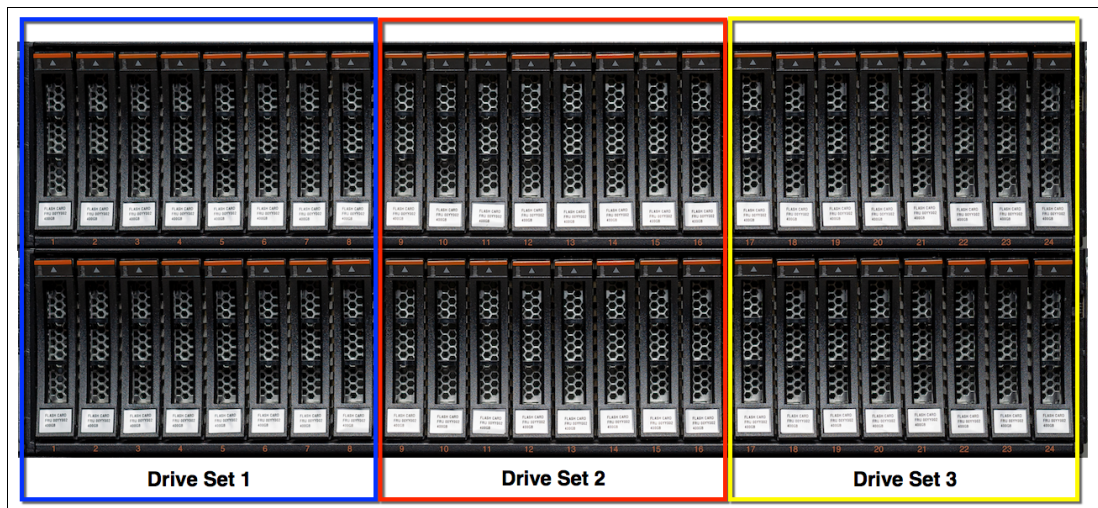


Figure 2 Flash drive set install order

Intermix of different drive set capacity within a HPFE Gen2 enclosure pair is only supported within the same drive family. This means that intermix of Flash Tier 0 drives (High-performance flash) in the same HPFE Gen2 pair is supported. Alternatively, intermix of Flash Tier 1 or Flash Tier 2 drives (High Capacity flash) in the same HPFE G2 pair is supported. Any intermix of drive capacity within an HPFE G2 pair requires an RPQ.

**Note:** Intermix of High-performance (Tier 0) with High-capacity (Tier 1 and Tier 2) flash drives in the same HPFE Gen2 pair is not supported.

### **Storage-enclosure fillers**

Storage-enclosure fillers fill empty drive slots in the storage enclosures. The fillers ensure sufficient airflow across populated storage. For HPFE Gen2, one filler feature provides a set of 16 fillers (feature code 1699).

### **HPFE Gen2 flash drive features**

Table 1 lists the available feature codes for flash drive sets for HPFE Gen2.

*Table 1 Feature Codes for HPFE Gen2 flash drive sets*

<b>Feature code</b>	<b>Disk size</b>	<b>Drive type</b>	<b>RAID support</b>
1611	800 GB	Flash Tier 0	5, 6, 10
1612	1.6 TB	Flash Tier 0	6, 10 <sup>1,2</sup>
1613	3.2 TB	Flash Tier 0	6, 10 <sup>1,2</sup>
1622	1.92 TB	Flash Tier 2	6, 10 <sup>2</sup>
1623	3.84 TB	Flash Tier 1	6, 10 <sup>1,2</sup>
1624	7.68 TB	Flash Tier 2	6 <sup>1,2</sup>
1625	15.36 TB	Flash Tier 2	6 <sup>1,2</sup>
<p>Note:</p> <ol style="list-style-type: none"> <li>1. RAID 5 is not supported for drives larger than 1 TB, and requires a request for price quote (RPQ).</li> <li>2. RAID 6 is the default and preferred RAID type for all drives larger than 1 TB, and it is the only supported RAID type for 7.68 TB and 15.36 TB drives.</li> <li>3. Within a High-Performance Flash Enclosure Gen2 pair, no intermix of High-Performance Flash (Tier 0) with High-Capacity Flash (Tier 1 and Tier 2) is supported.</li> </ol>			

### **Arrays and spares**

Each HPFE Gen2 pair can contain up to six array sites. The first set of 16 flash drives creates two 8-flash drive array sites. RAID 6 arrays are created by default on each array site. RAID 5 is optional for flash drives smaller than 1 TB, but is not advised. RAID 10 is optional for all flash drive sizes, except for the 7.68 TB and 15.36 TB Flash Tier 2 drives.

During logical configuration, RAID 6 arrays and the required number of spares are created. Each HPFE Gen2 pair has two global spares, created from the first increment of 16 flash drives. The first two arrays to be created from these array sites are 5+P+Q. Subsequent RAID 6 arrays in the same HPFE Gen2 Pair will be 6+P+Q.

### **RAID capacities for HPFE Gen2 drive sets**

The default RAID type for all drives larger than 1 TB is RAID 6, and it is the only RAID type supported for 7.68 TB and 15.36 TB drives. RAID 5 is not supported for drives larger than 1 TB, and requires a request for price quote (RPQ).

Since DS8000 R8.3, a RAID intermix is also possible with one HPFE Gen2 pair.

### **Enclosure SAS expanders**

The enclosure also includes two redundant SAS expanders (also known as *Electronic Control Modules* or ECMs). They provide SAS connectivity from the flash RAID adapters to

the HPFE Gen2 enclosure. Enclosure SAS expanders and power supplies are installed from the rear of the enclosure.

### Enclosure power supplies

Each HPFE Gen2 has a pair of fully redundant power supply units (PSU). Each PSU has its own integrated fan.

Figure 3 is a rear view of the HPFE Gen2 enclosure showing the redundant SAS expanders and power supplies.

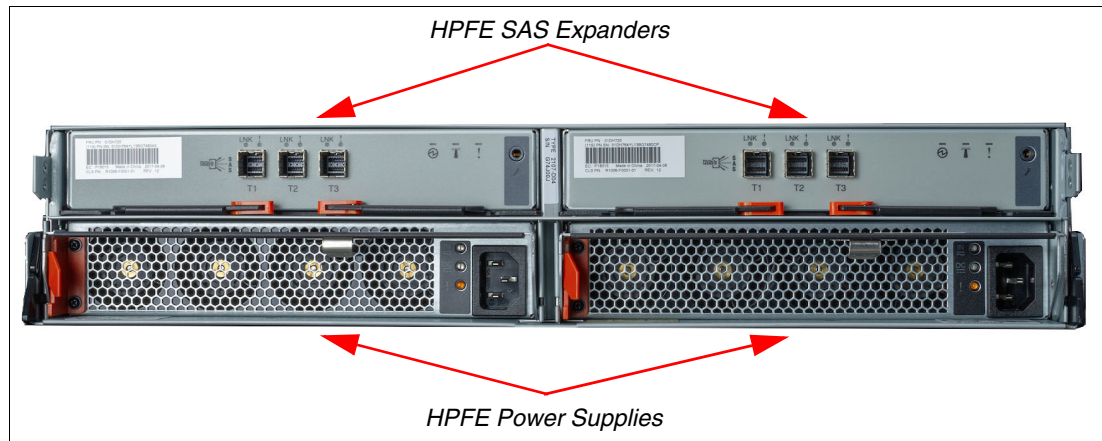


Figure 3 HPFE Gen2 rear view showing SAS expanders and power supplies

### Enclosure midplane

The enclosure midplane provides the connectivity for the two SAS expander modules, two power supplies, and 24 flash drive slots for each flash enclosure.

### Flash RAID adapters

The DS8900F flash RAID adapters are PCIe adapters that are installed in the DS8900F I/O enclosures. The DS8880 flash RAID adapters are PCIe adapters that are either installed in the DS8880 I/O enclosures or remotely connected to the I/O enclosures through PCIe cables.

The flash RAID adapters have a PCIe3 eight-lane connection to the I/O enclosures that provides PCIe connectivity to the processor nodes of the DS8900 and DS8880.

The main processor is a RAID engine that provides RAID and sparing management to the flash drives in the HPFE Gen2 flash enclosures. Each flash RAID adapter has four SAS ports, which provide connectivity from the flash RAID adapters to the HPFE Gen2 enclosures.

The flash RAID adapters are installed as a pair, one in each of an I/O enclosure pair. This is known as a *device adapter pair* (DA pair). Logical configuration should be balanced across the DA pair for load balancing and the highest throughput. The redundant DA pair ensures continued availability in the event of a flash RAID adapter or a logical I/O enclosure failure.

The flash RAID adapter is specifically designed for connectivity and management of the HPFE Gen2.

The flash RAID adapter is available in three different form factors, depending on the DS8000 model and location within that model. Internally, the three different form factors have the same core hardware and function.

**DS8900F:** The DS8900F supports only one form factor: the SAS flash RAID adapter.

To differentiate between the three form factors, they have unique naming and features:

- ▶ Microbay flash RAID adapter
  - Remotely connected to the I/O enclosures by a PCIe3 x8 cable to a standalone enclosure
  - Connects to HPFE Gen2 pairs in models 984, 985, 986, and the first eight HPFE Gen2 pairs for model 988
  - The microbay enclosure has its own power supplies and integrated cooling
  - Feature code 1600 is a pair of HPFE Gen2 storage enclosures, and a pair of Microbay flash RAID adapters and all associated cabling
  - This adapter is not available in the DS8900.
- ▶ SAS flash RAID adapter
  - Installed directly into a PCIe3 x8 adapter slot in the I/O enclosure
  - Connects to HPFE Gen2 pairs nine to sixteen in model 988
  - Feature code 1602 is a pair of HPFE Gen2 storage enclosures (no flash RAID adapters)
  - Feature code 1604 is a pair of SAS flash RAID adapters and associated cabling
- ▶ Base I/O expander with flash RAID adapter
  - A PCIe3 x8 adapter that is physically imbedded into the base PCIe I/O expander, which is installed in the DS8882F 2U I/O enclosure
  - Exclusively available only in the DS8882F model 983

For more information about the locations of HPFE Gen2 storage enclosures, Microbay flash RAID adapters, and SAS flash RAID adapters, see “DS8880 models support for HPFE Gen2” on page 9.

For more information about the DS8882F and its HPFE Gen2 enclosures and associated flash RAID adapters, see *Introducing the IBM DS8882F Rack-Mounted Storage System*, REDP-5505. Information specific to its successor and replacement model can be found in *IBM DS8910F Model 993 Rack-Mounted Storage System*, REDP-5566.

## DS8900F models support for HPFE Gen2

The DS8900 family encompasses a total of 3 models that all support HPFE Gen2 flash enclosures, associated flash RAID adapters and flash drives. The families are the all-flash models 993, 994, and 996. Table 2 on page 7 provides a summary of the HPFE Gen2 pairs and associated models' support.



Table 2 DS8900F models and number of HPFE Gen2 pairs.

Model	Processors per CEC	Expansion	HPFE Gen2 pairs / Flash drives (Max)
993 <sup>1</sup>	8-cores	N/A	1 / 48
993 <sup>2</sup>	8-cores	N/A	2 / 96
994	8-cores	N/A	4 / 192
996	10-cores	N/A	4 / 192
	20-cores	E96	8 / 384

Note:  
 1. Installed in a compatible IBM Z® or LinuxONE rack.  
 2. Installed in a compatible customer-provided rack

Diagrams in the following pages show the maximum HPFE Gen2 pairs supported by each DS8900F model, and the installed locations and DA pair IDs. Install order is from the bottom up in each frame, filling each frame to the maximum allowed pairs for that frame, then populating the next frame.

Figure 4 shows DS8900F model 993 installed in a compatible customer provided rack with two HPFE Gen2 pairs.

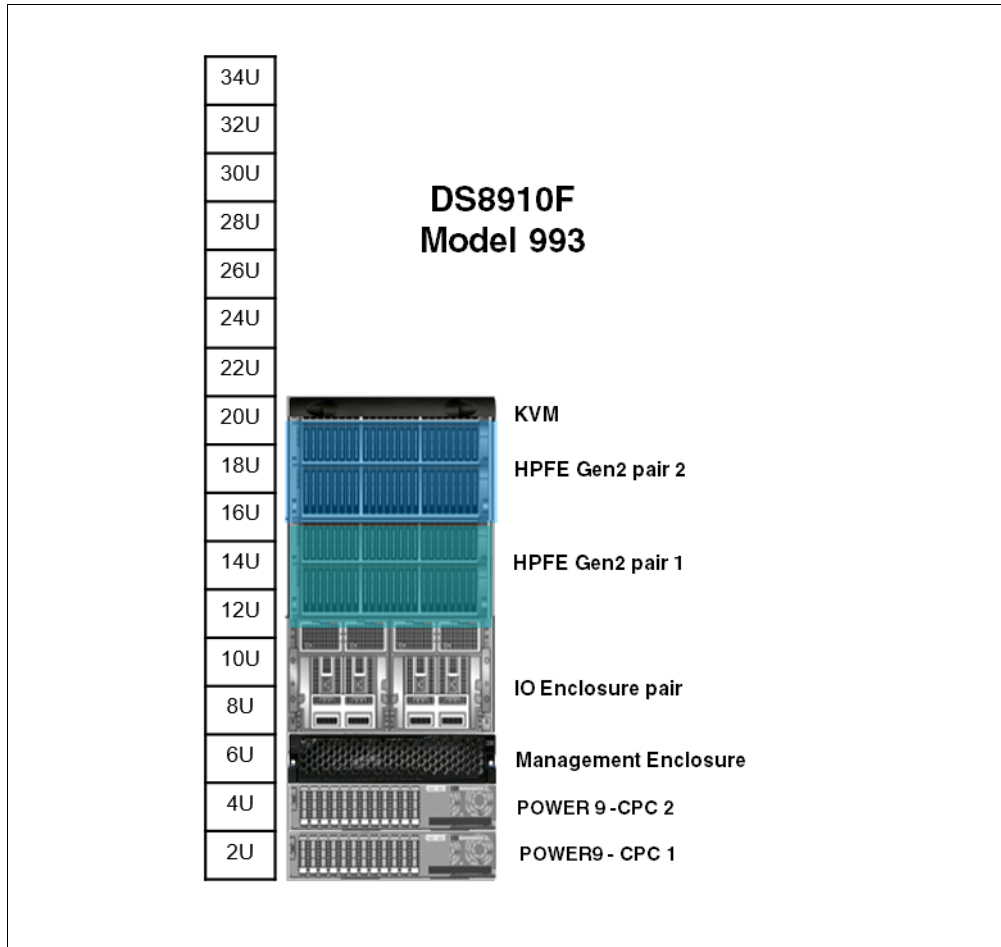


Figure 4 DS8900F model 993

Figure 5 shows Shows DS8900F model 994 with a total of 4 HPFE Gen2 pairs.

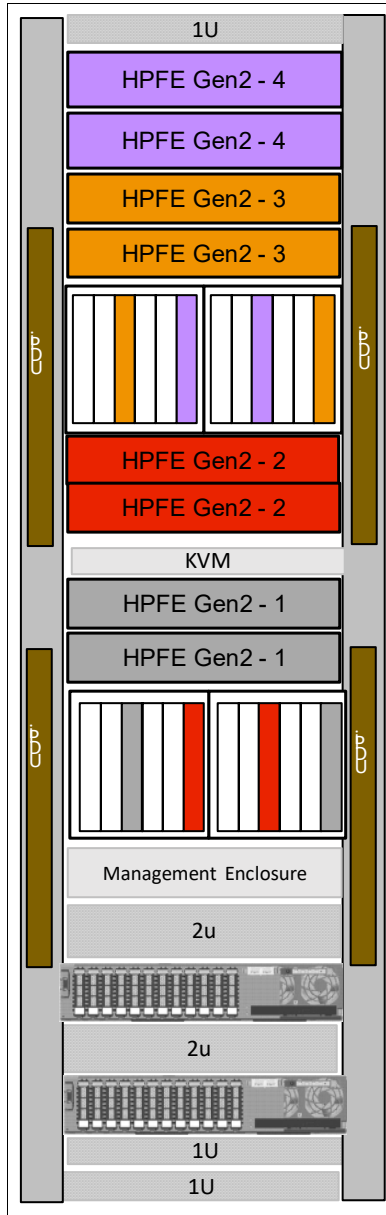


Figure 5 DS8900F model 994

Figure 6 shows DS8900F model 996 having one E96 expansion with a total of 8 HPFE Gen2 pairs:

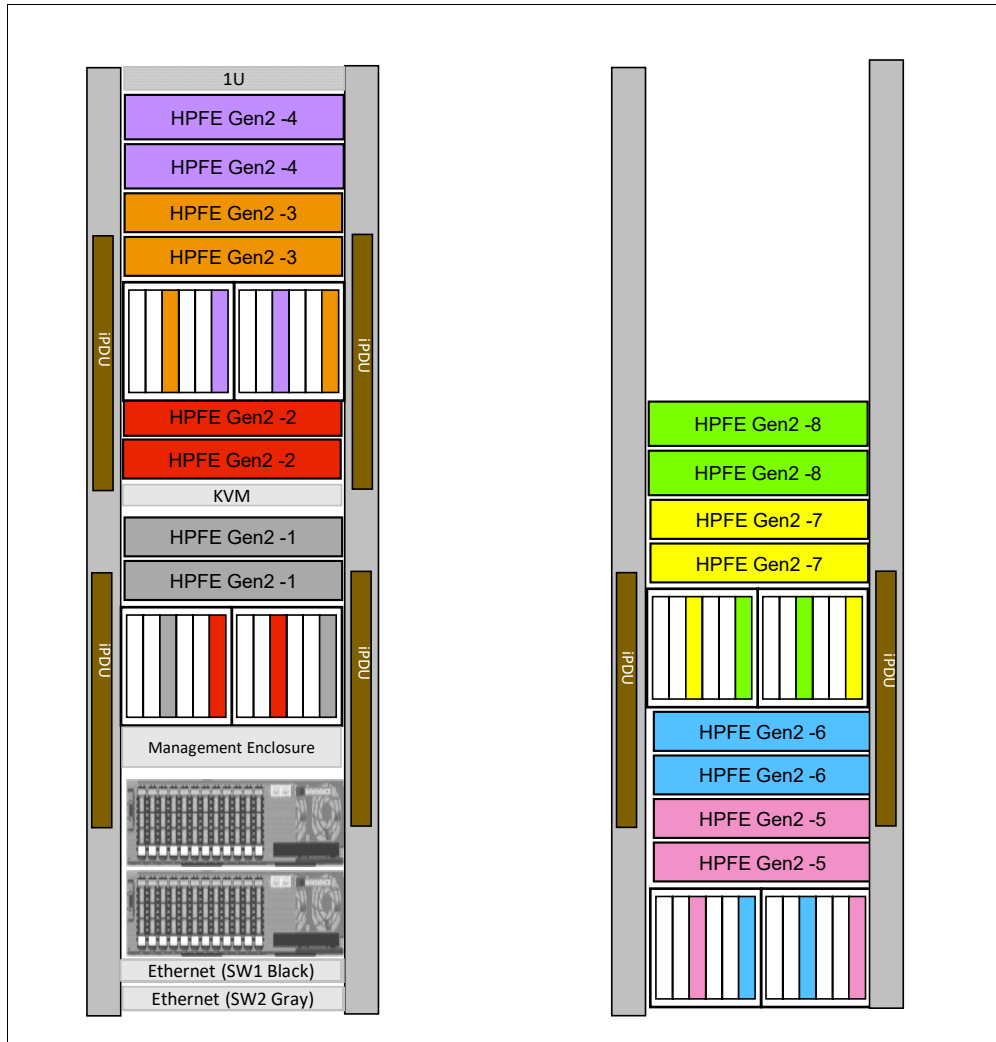


Figure 6 DS8900F model 996 having one E96 expansion

## DS8880 models support for HPFE Gen2

The DS8880 family encompasses a total of 8 models that support HPFE Gen2 flash enclosures, associated flash RAID adapters and flash drives. The families are the all-flash 533x machine type and the hybrid 283x machine type. While the DS8880 models are no longer actively marketed, they can still be upgraded with HPFE. This section provides a summary of the HPFE Gen2 pairs the two machine types and associated models support.

**Note:** For more information about HPFE Gen2 support for first generation DS8880 models 980, 981 and 982, see Appendix E of the *IBM DS8880 Version 8 Release 5 Introduction and Planning Guide*, GC27-8525.

## DS8880 all-flash models

An all-flash model means the system supports only flash drives installed in HPFE Gen-2 drive enclosures.

There are five DS8880 all-flash models belonging to the 533x machine type:

- ▶ DS8888F Analytic class (model 988)
- ▶ DS8886F Enterprise class 3-phase (model 986)
- ▶ DS8886F Enterprise class 1-phase (model 985)
- ▶ DS8884F Business class (model 984)
- ▶ DS8882F Rack Mounted (model 983)

Figure 7 Summarizes maximum HPFE Gen2 pairs and flash drives per frame of each all-flash model (machine type 533x) based on processor and memory configuration.

Models (machine type 533x)	Processor Cores	Total System Memory (GB)	Max # HPFEs Gen 2 pairs base frame	Max # HPFEs Gen 2 pairs 1st exp frame	Max # HPFEs Gen 2 pairs 2nd exp frame	Max # flash drives per system
DS8888F	24	1024	4	N/A	N/A	192
	48	2048		12	12	768
DS8886F	8	128	4	N/A	N/A	192
		256				
	16	256	4	8	N/A	384
		512				
	24	1024	4	8	N/A	384
		2048				
DS8884F	6	64	2	N/A	N/A	96
		128	4	N/A	N/A	192
		256				
	12	256	4	N/A	N/A	192
		512				
DS8882F	6	64	1	N/A	N/A	48
		128				
		256				

Figure 7 HPFE Gen2 pairs and flash drives by processor and memory for machine type 533x

Diagrams in the following pages show the maximum HPFE Gen2 pairs supported by each all-flash model (machine type 283x), and the installed locations and DA pair IDs. Install order is from the bottom up in each frame, filling each frame to the maximum allowed pairs for that frame, then populating the next frame.

Figure 8 Shows DS8888F Analytic class (model 988, machine type 533x) HPFE Gen2 pairs:

- ▶ 16 HPFE Gen2 pairs maximum for the system
- ▶ 4 HPFE Gen2 pairs in the base frame
- ▶ 6 HPFE Gen2 pairs in first expansion frame
- ▶ 6 HPFE Gen2 pairs in second expansion frame

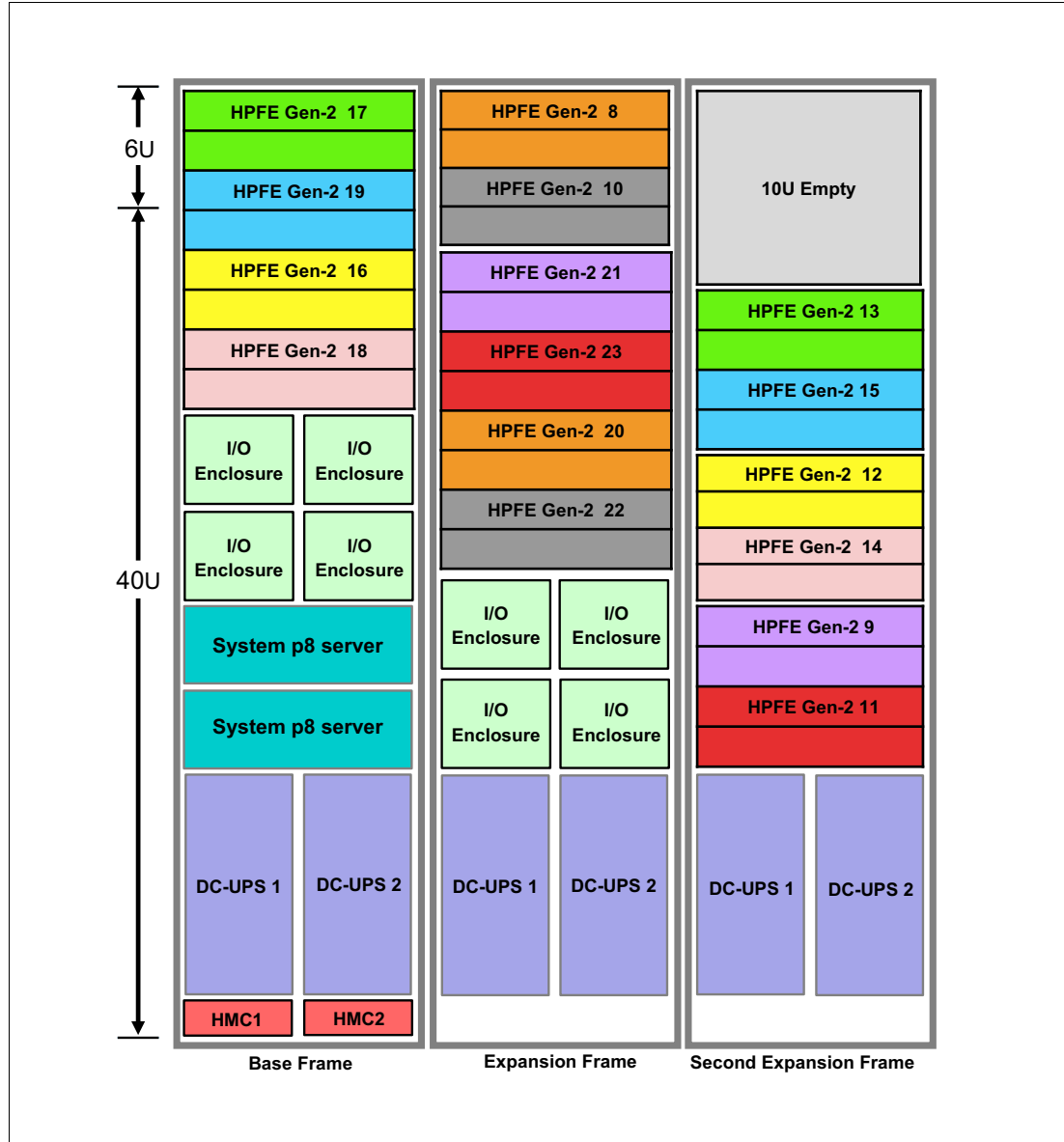


Figure 8 DS8888F (machine type 533x) HPFE Gen2 maximum 16 pairs

Figure 9 shows DS8886F Enterprise class (model 986, machine type 533x) HPFE Gen2 pairs. The model 986 (3 phase) and the model 985 (1 phase) support the same number of HPFE Gen2 pairs per frame and system total:

- ▶ 8 HPFE Gen2 pairs maximum for the system
- ▶ 4 HPFE Gen2 pairs in the base frame
- ▶ 4 HPFE Gen2 pairs in first expansion frame

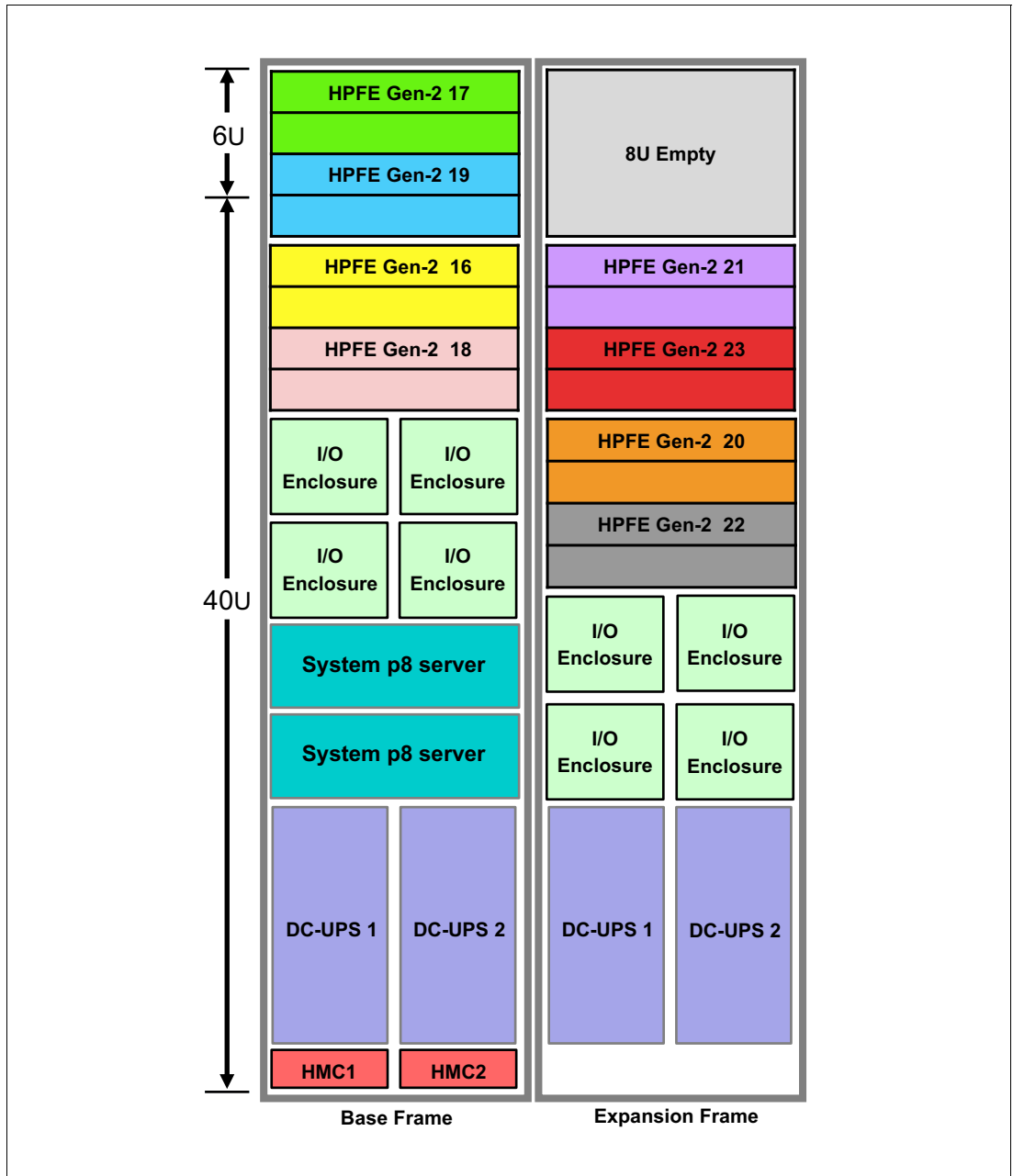


Figure 9 DS8886F (machine type 533x) HPFE Gen2 maximum 8 pairs

Figure 10 shows DS8884F Business class (model 984, machine type 533x) HPFE Gen2 pairs:

- ▶ 4 HPFE Gen2 pairs maximum for the system
- ▶ 4 HPFE Gen2 pairs in the base frame

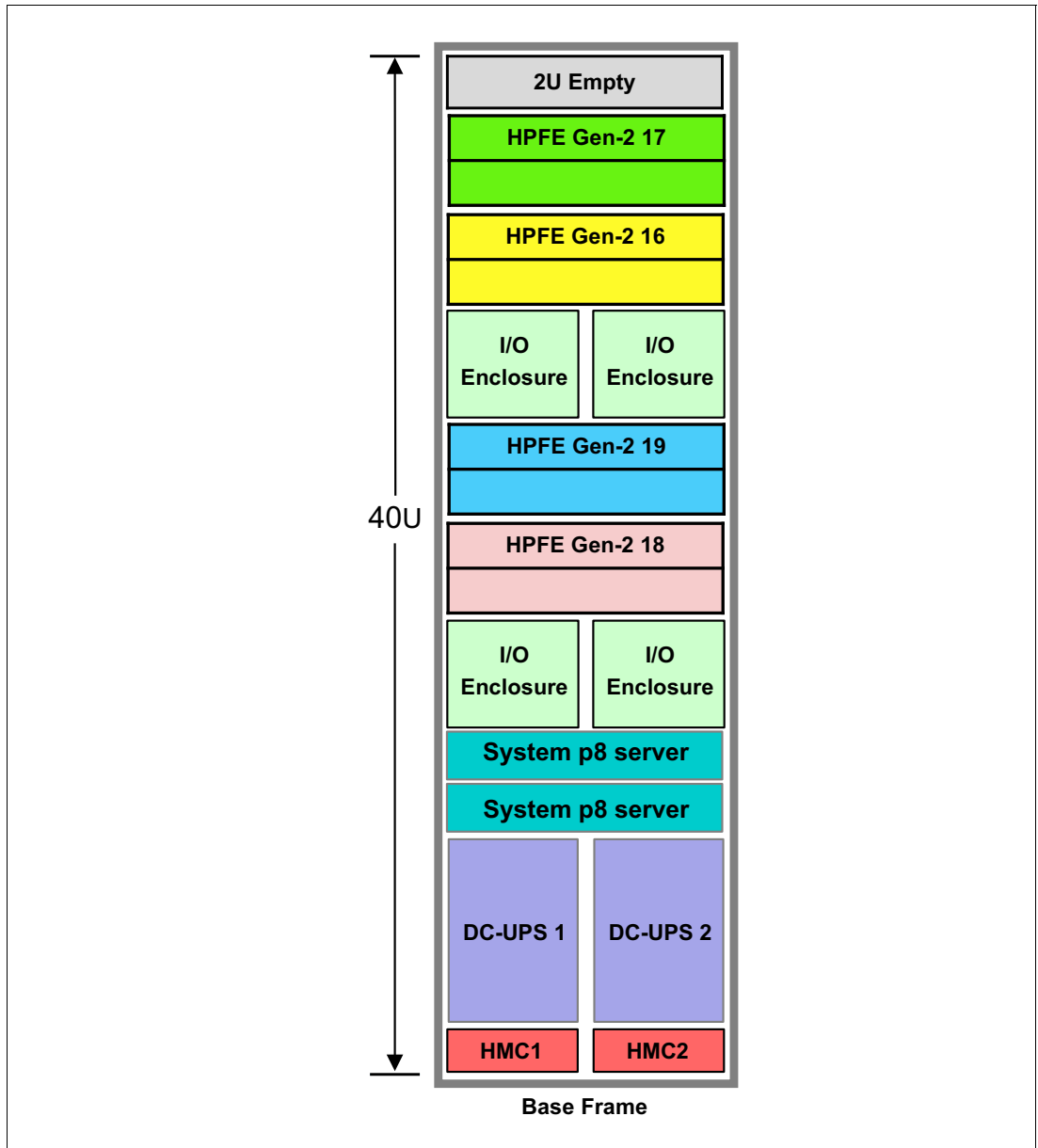


Figure 10 DS8884F (machine type 533x) HPFE Gen2 maximum 4 pairs

Figure 11 shows DS8882F Rack Mounted (model 983, machine type 533x) HPFE Gen2 pairs:

- ▶ 1 HPFE Gen2 pairs maximum for the system

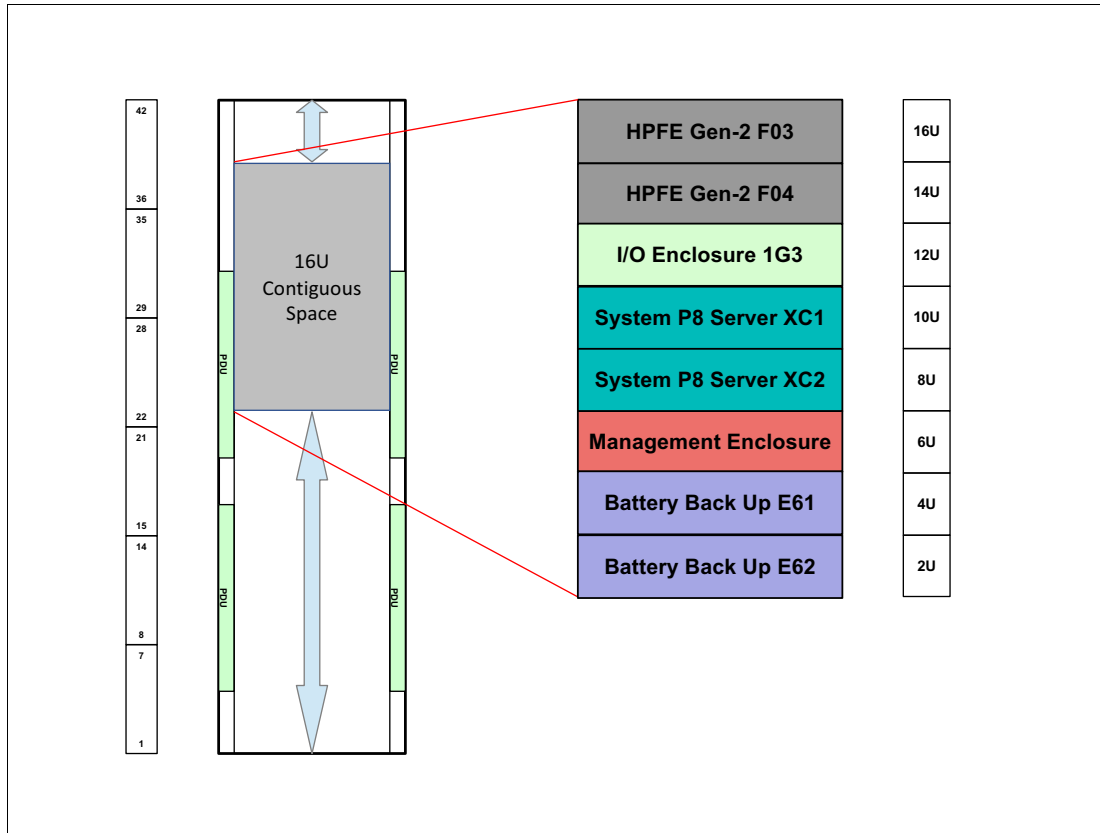


Figure 11 DS8882F (machine type 533x) HPFE Gen2 maximum 1 pair

## DS8880 hybrid models

A hybrid model is one in which the system supports both flash drives installed in HPFE Gen-2 drive enclosures and standard drive enclosure pairs with spinning drives.

There are three DS8880 hybrid models belonging to the 283x machine type family that support HPFE Gen2 pairs and flash drives:

- ▶ DS8886 Enterprise class 3-phase (model 986)
- ▶ DS8886 Enterprise class 1-phase (model 985)
- ▶ DS8884 Business class (model 984)



Figure 12 summarizes maximum HPFE Gen2 pairs and flash drives per frame of each hybrid model (machine type 283x) based on processor and memory configuration.

Models (machine type 283x)	Processor Cores	Total System Memory (GB)	Max # HPFEs Gen 2 pairs base frame	Max # HPFEs Gen 2 pairs 1st exp frame	Max # flash drives per system
DS8886	8	128	2	N/A	96
		256			
	16	256	2	2	192
		512			
		1024			
24	2048	2	2	192	
	2048				
DS8884	6	64	1	N/A	48
		128	1	1	96
	256				
	12	256	1	1	96

Figure 12 HPFE Gen2 pairs and flash drives by processor and memory for machine type 283x

The following graphics show the maximum HPFE Gen2 pairs supported by each hybrid model (machine type 283x), and the installed locations and DA pair IDs. Install order is from the bottom up in each frame, filling each frame to the maximum allowed pairs for that frame, then populating the next frame.

Figure 13 shows DS8886 Enterprise class (model 986, machine type 283x) HPFE Gen2 pairs. The model 986 (3-phase) and the model 985 (1-phase) support the same number of HPFE Gen2 pairs per frame and system total:

- ▶ 4 HPFE Gen2 pairs maximum for the system
- ▶ 2 HPFE Gen2 pairs in the base frame
- ▶ 2 HPFE Gen2 pairs in first expansion frame

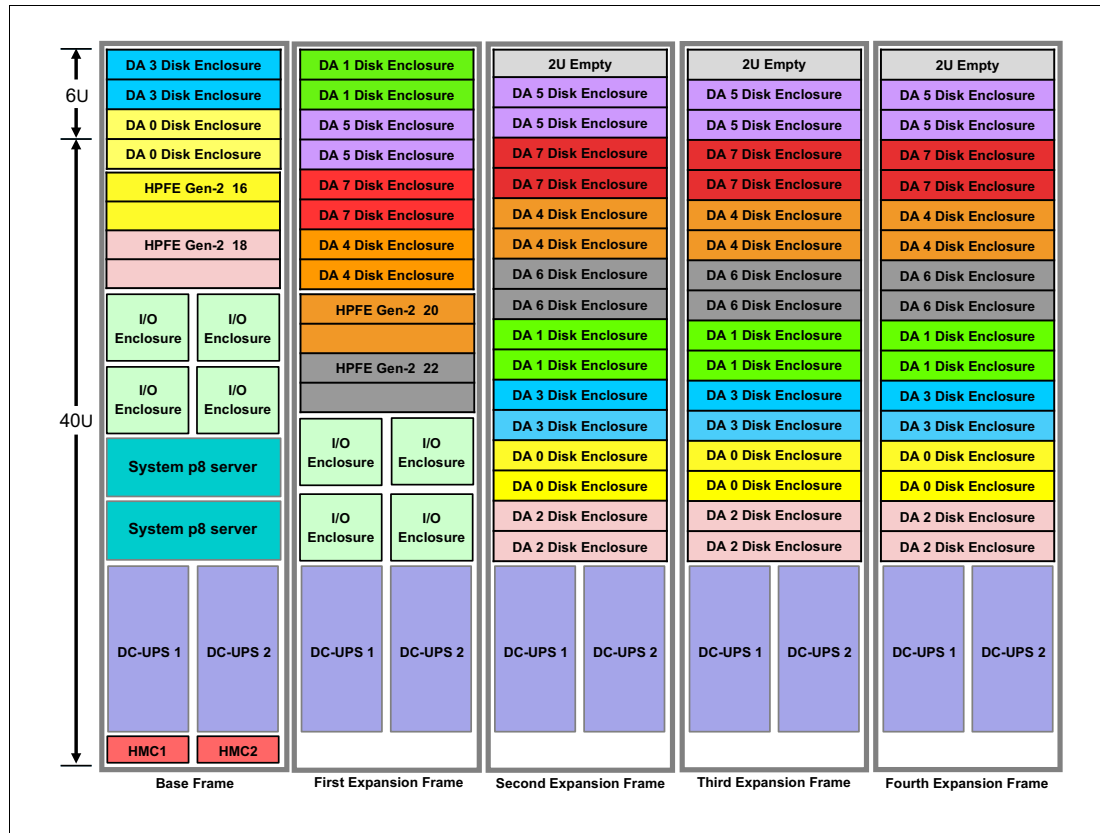


Figure 13 DS8886 (machine type 283x) HPFE Gen2 maximum 4 pairs

Figure 14 shows DS8884 Business class (model 984, machine type 283x) HPFE Gen2 pairs:

- ▶ 2 HPFE Gen2 pairs maximum for the system
- ▶ 1 HPFE Gen2 pairs in the base frame
- ▶ 1 HPFE Gen2 pairs in first expansion frame

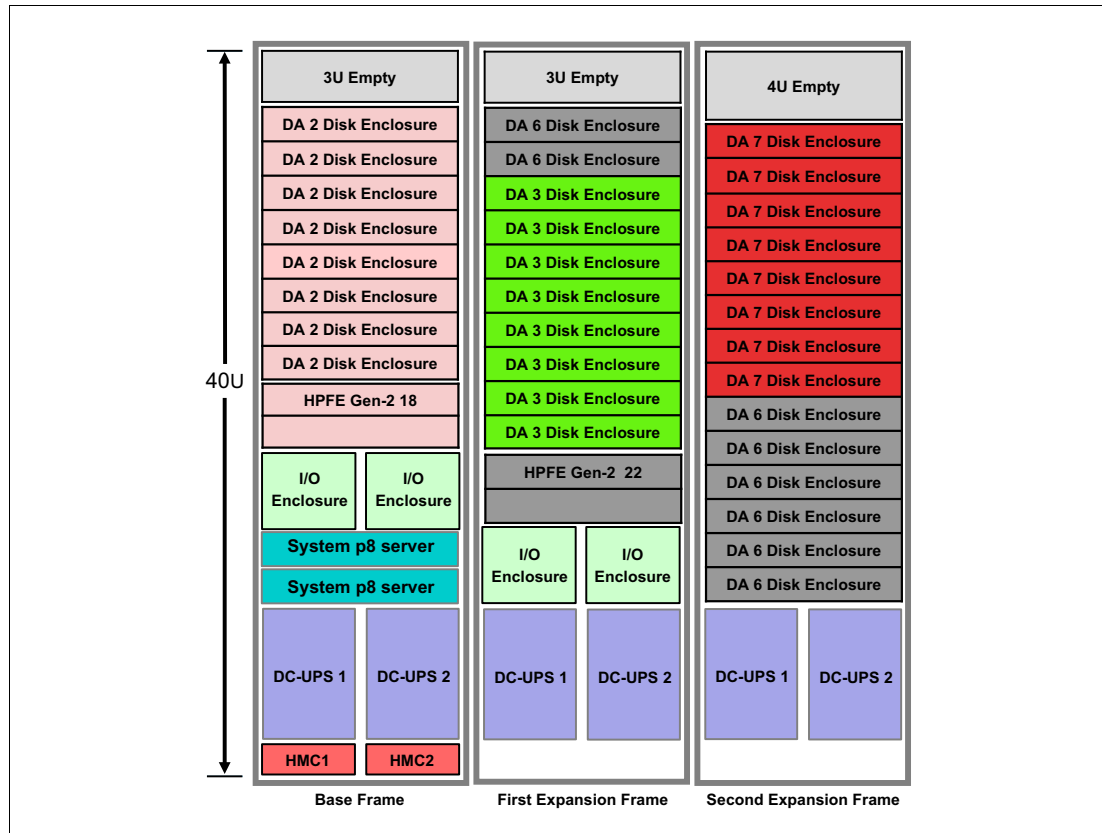


Figure 14 DS8884 (machine type 283x) HPFE Gen2 maximum 2 pairs

## Upgrades

Adding HPFE Gen2 pairs (inclusive of associated flash RAID adapters pairs) to models DS8900 models 993, 994, 996, and DS8880 models 984, 985, 986, 988 is supported. Adding drive sets to partially populated enclosure pairs to DS8880 models 983, 984, 985, 986, and 988 is also supported.

All upgrades to add HPFEs Gen2 pairs or flash drive sets are non-disruptive. However, upgrades might require co-requisite system memory and processor core upgrades. For DS8880 all-flash models (machine type 533x), see Figure 7 on page 10. For DS8880 hybrid models (machine type 283x) see Figure 12 on page 15.

For more information about intermix of drive sets in an HPFE G2 enclosure pair, see “Flash drive sets” on page 3.

For additional information about upgrades, see *IBM DS8900F Architecture and Implementation*, SG24-8456, or *IBM DS8880 Architecture and Implementation*, SG24-8323.

## Easy Tier and flash drives

IBM Easy Tier dynamically optimizes performance for multi-tiered systems. It can also rebalance data within a single tier to help maintain optimal performance. Easy Tier offers full support for the High-Performance Flash Enclosure Gen2, including Easy Tier Application and Easy Tier Heat Map Transfer.

Easy Tier Automatic Mode manages any combination of up to three tiers in a storage pool. For an HPFE Gen2 pair, the following drive classes are available, in order from highest to lowest performance:

- ▶ Flash Tier 0 drives
  - High-performance flash drives
  - The highest performance drives, which provide high I/O throughput and low latency
- ▶ Flash Tier 1 drives
  - The first tier of High-capacity flash drives
- ▶ Flash Tier 2 drives
  - The second tier of High-capacity flash drives

**Note:** Intermix of High Performance flash (Flash Tier 0) and High Capacity flash (Flash Tier 1 or 2) drives in the same HPFE Gen2 pair is not supported.

For further information, see *IBM DS8000 Easy Tier*, REDP-4667.

## Smart Rebuild

IBM Smart Rebuild for HPFE Gen2 is a function of the R9 firmware that is designed to help reduce the possibility of secondary failures and data loss of RAID arrays. It is available only for a RAID 6 array. Smart Rebuild predicts failures of a Flash Drive and starts cloning the data while the drive is still online, eliminating the need of a RAID rebuild.

A spare is brought into the array, as an additional member, at the same time. The suspect drive and the new member-spare are set up in a temporary RAID 1 association, enabling the suspect drive to be duplicated onto the spare rather than running a full RAID reconstruction from data and parity. The new member-spare is then made a regular member of the array and the suspect drive is rejected from the RAID array.

The array never goes through an  $n-1$  stage in which it might suffer a complete failure if another drive in this array encounters errors. The result saves substantial time, and provides a new level of availability that is not available in other RAID 6 products.

Only a single Smart Rebuild is allowed for a given array, but multiple Smart Rebuild can be run for each array behind an adapter pair.

## Related information

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this document.

- ▶ *IBM DS8900F Architecture and Implementation*, SG24-8456  
<https://www.redbooks.ibm.com/abstracts/sg248456.html>
- ▶ *IBM DS8880 Architecture and Implementation (Release 8.51)*, SG24-8323  
<https://www.redbooks.ibm.com/abstracts/sg248323.html>
- ▶ *Introducing the IBM DS8882F Rack-Mounted Storage System*, REDP-5505
- ▶ *IBM DS8910F Model 993 Rack-Mounted Storage System*, REDP-5566
- ▶ *IBM DS8000 Easy Tier*, REDP-4667  
<https://www.redbooks.ibm.com/abstracts/redp4667.html>
- ▶ *IBM DS8880 Introduction and Planning Guide*, GC27-8525  
<https://www.ibm.com/support/pages/node/655989>
- ▶ *IBM DS8900F Introduction and Planning Guide*, SC27-9560  
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