DS8880 High Performance Flash Enclosure Gen2

Michael Stenson
The DS8880 High Performance Flash Enclosure (HPFE) Gen2 is a 2U Redundant Array of Independent Disks (RAID) flash enclosure with associated Flash RAID adapters that can be used exclusively with DS8880 models.

The flash enclosure and Flash RAID adapters are installed in pairs. Each storage enclosure pair can support 16, 32 or 48 encryption-capable flash drives (2.5-inch, 63.5 mm form factor).

Figure 1 shows the flash enclosure used in the HPFE Gen2.

![Flash Enclosure](image)

Figure 1   Flash Enclosure

**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 fabric, enabling increased bandwidth compared to Fibre Channel attached standard drive enclosures in the HPFE Gen2.
- 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.
- With the release of Microcode version 8.31 there are newly available *High Capacity Flash Drives*. These drives offer higher capacity than *High Performance Flash* drives, but have otherwise similar characteristics.
- High performance flash drives, are considered as Tier 0 storage. High capacity flash drives can be either Tier 0 or Tier 1, depending on the other drive types in the pool.
Both high performance and high capacity 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, flash drives in HPFE Gen-2 offer even higher throughput using the Flash RAID adapters which have a direct PCIe connectivity to the processor complexes.

The IBM® Easy Tier® intra-tiering auto-rebalance (micro-tiering) feature is used to distribute the workload among traditional flash drives (SSDs) and high performance flash drives according to their IOPS capacity within the storage tier.

Available flash drive capacities: 400 GB, 800 GB, 1.6 TB, 3.2 TB high performance flash drives, and 3.8 TB high capacity flash drives.

Each HPFE Gen2 pair contains up 48 flash drives with up to 153.6 TB of raw capacity based on the 3.2 TB flash drive or a 182.4 TB raw capacity based on the 3.8 TB high capacity flash drive.

Up to 16 HPFE Gen2 pairs per DS8888F, with two expansion racks, for a total of 2,918.4 TB of raw capacity.

Flash drives in the HPFE Gen2 support full drive encryption.

Architecture and key component

The HPFE Gen2 pair (feature code 1600) provides two 2U flash enclosures and 2 interface adapters.

Flash RAID adapters

With DS8880 microcode Release 8.3, there is an additional type of interface adapter for HPFE Gen2, this new adapter is used to add HPFE Gen2 only on DS8888 models that were ordered with microcode release 8.1 through 8.2.x.

Microbay

Each Microbay contains a Flash RAID adapter, PCIe switch card, and 2 cooling fans.

Figure 2 shows the components of the Microbay and Figure 3 on page 3 shows the Microbay connectors.

SAS device adapter

SAS device adapters are used when adding HPFE Gen2 enclosures to model 982 and 98F DS8884 instead of Microbays. Each SAS Device adapter contains a RAID adapter installed in the I/O Bay that connects directly to the flash enclosure via optical SAS cables.
Enclosure power supplies

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

Enclosure midplane

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

Flash drives in the HPFE Gen2

A flash enclosure (shown in Figure 5) has either eight, sixteen, or twenty-four 2.5-inch encryption-capable flash drives installed. The flash drives are installed in groups of 16, with
half in each enclosure. A HPFE Gen2 pair is installed with a minimum of sixteen 2.5-inch flash drives. An optional second and third set of 16 flash drives can be installed for a maximum total of 48 flash drives. Drive capacities may be intermixed, but requires an RPQ. Sets of fillers must be installed in the empty slots.

**Note:** Flash drives are not available as capacity on demand (CoD) features.

---

**Flash RAID adapter**

Each HPFE Gen2 pair includes two Flash RAID adapters that provide redundant data paths to the flash drives in the enclosures.

Each adapter has a dual-core PowerPC® processor and integrated cooling fans. Microbay based adapters are directly connected over a PCIe fabric to the I/O enclosures, with a Gen3 PCIe cable. In the DS8880, each cable provides an eight-lane, 8 GBps full duplex connection. SAS device adapters are installed directly in the I/O enclosures and connect to the flash expander modules via optical SAS cables.

---

### Virtualization

The HPFE Gen2 pair contains 16, 32 or 48 flash drives. Two of the initial 16 flash drives are allocated as spares. HPFE Gen2 supports RAID 6, RAID 10 and RAID 5 arrays.

RAID 6 is the default and RAID 10 is available. For flash drives smaller than 1 TB, RAID 5 is available, with a warning of risks associated with dual drive failure in RAID 5 arrays.

The arrays are configured as follows based on RAID 6:

- **First 16 flash drives installed**
  - arraySite1 = 5+P+Q+S RAID 6
  - arraySite2 = 5+P+Q+S RAID 6

- **Optional second set of 16 flash drives installed**
  - arraySite3 = 6+P+Q RAID 6
  - arraySite4 = 6+P+Q RAID 6

- **Optional third set of 16 flash drives installed**
  - arraySite5 = 6+P+Q RAID 6
  - arraySite6 = 6+P+Q RAID 6

Each HPFE Gen2 pair can have a maximum of 182.4 TB raw capacity.

**Note:** A RAID intermix within a HPFE Gen2 pair is not permitted. Once the first array is created, the following arrays must be created with the same RAID type.
High-Performance Flash Enclosures Gen2 in the DS8880

The DS8880 is available in three models:

1. **DS8888F**
   - Supports up to four HPFE Gen2 pairs in the base frame
   - Supports up to six HPFE Gen2 pairs in the first expansion frame
   - Supports up to six HPFE Gen2 pairs in the second expansion frame

The DS8888F supports up to sixteen HPFE Gen2 pairs: four installed in the base frame, six installed in both the first expansion and second expansion frames. Refer to Figure 6 for locations. The installation order is as follows:

- R1-F07, F08 - DA pair 18
- R1-F05, F06 - DA pair 16
- R1-F03, F04 - DA pair 19
- R1-F02, F01 - DA pair 17
- R2-F11, F12 - DA pair 22
- R2-F09, F10 - DA pair 20
- R2-F07, F08 - DA pair 23
- R2-F06, F05 - DA pair 21
- R2-F04, F03 - DA pair 10
- R2-F02, F01 - DA pair 08
- R3-F12, F11 - DA pair 11
- R3-F10, F09 - DA pair 09
- R3-F08, F07 - DA pair 14
- R3-F06, F05 - DA pair 12
- R3-F04, F03 - DA pair 15
- R3-F02, F01 - DA pair 13

![Figure 6 DS8888F with sixteen HPFE Gen2 pairs installed](image)
2. DS8886
   - Supports up to two HPFE Gen2 pairs in the base frame
   - Supports up to two HPFE Gen2 pairs in the first expansion frame

The DS8886F supports up to eight HPFE Gen2 pairs: four installed in the base frame and four installed in the first expansion frame. The installation order is as follows:

- R1-F03, F04 - DA pair 18
- R1-F01, F02 - DA pair 16
- R1-F08, F07 - DA pair 19
- R1-F06, F05 - DA pair 17
- R2-F03, F04 - DA pair 22
- R2-F01, F02 - DA pair 20
- R2-F08, F07 - DA pair 23
- R2-F06, F05 - DA pair 21

Figure 7 on page 6 shows HPFE Gen2 locations and associated device adapter (DA) pair numbering for the DS8886, and shows the all-flash DS8886F, with eight HPFE Gen2 pairs installed.

![Diagram of DS8886/DS8886F with four/eight HPFE Gen2 pairs installed](image)
3. DS8884
   - Supports up to one HPFE Gen2 pairs in the base frame
   - Supports up to one HPFE Gen2 pairs in the first expansion frame

Figure 8 on page 7 shows HPFE Gen2 locations and associated device adapter (DA) pair numbering for the DS8884, and the all-flash DS8884F with one HPFE Gen2 pair installed.

The DS8884 supports up to two HPFE Gen2 pairs: one installed in the base frame and one installed in the first expansion frame. The installation order is as follows:
   - R1-F03, F04 - DA pair 18
   - R2-F03, F04 - DA pair 22

The DS8884F supports up to four HPFE Gen2 pairs: all installed in the base frame. The installation order is as follows:
   - R1-F03, F04 - DA pair 18
   - R1-F02, F01 - DA pair 19
   - R1-F08, F07 - DA pair 16
   - R1-F06, F05 - DA pair 17

Figure 8  DS8884 / DS8884F with two / four HPFE Gen2 pairs installed
Figure 9 provides a summary of HPFE Gen2 and flash drives supported in the DS8880 configurations. For more information about the DS8880 configuration and supported components, see *IBM DS8880 Architecture and Implementation (Release 8.3)*, SG24-8323.

<table>
<thead>
<tr>
<th>Processor Cores</th>
<th>System Memory (GB)</th>
<th>Max HPFEs Gen 2 Base Frame</th>
<th>Max HPFEs Gen2 1st Exp Frame</th>
<th>Max HPFEs Gen2 2nd Exp Frame</th>
<th>Max Flash Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DS8888 Configuration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-core</td>
<td>1024</td>
<td>8</td>
<td>N/A</td>
<td>N/A</td>
<td>192</td>
</tr>
<tr>
<td>48-core</td>
<td>2048</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>768</td>
</tr>
<tr>
<td><strong>DS8886 Configuration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-core</td>
<td>128</td>
<td>4</td>
<td>N/A</td>
<td>N/A</td>
<td>192</td>
</tr>
<tr>
<td>8-core</td>
<td>256</td>
<td>4</td>
<td>N/A</td>
<td>N/A</td>
<td>192</td>
</tr>
<tr>
<td>16-core</td>
<td>256</td>
<td>8</td>
<td>8</td>
<td>N/A</td>
<td>384</td>
</tr>
<tr>
<td>16-core</td>
<td>512</td>
<td>8</td>
<td>8</td>
<td>N/A</td>
<td>384</td>
</tr>
<tr>
<td>24-core</td>
<td>1024</td>
<td>8</td>
<td>8</td>
<td>N/A</td>
<td>384</td>
</tr>
<tr>
<td>24-core</td>
<td>2048</td>
<td>8</td>
<td>8</td>
<td>N/A</td>
<td>384</td>
</tr>
<tr>
<td><strong>DS8884 Configuration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-core</td>
<td>64</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>96</td>
</tr>
<tr>
<td>6-core</td>
<td>128</td>
<td>8</td>
<td>2^2</td>
<td>N/A</td>
<td>192</td>
</tr>
<tr>
<td>6-core</td>
<td>256</td>
<td>8</td>
<td>2^2</td>
<td>N/A</td>
<td>192</td>
</tr>
</tbody>
</table>

Notes:
1 - System memory is a total of memory from both CPCs
2 - Number of HPFEs Gen2 is independent of number of standard drive enclosures
3 - DS8884F does not support an expansion frame

*Figure 9  DS8880 HPFE Gen2 supported configurations*

**Connectivity**

The Flash RAID adapters of the HPFE Gen2 pair are directly attached to the I/O enclosure using PCIe Gen3 cabling. This is the latest generation of PCIe. The HPFE Gen2 flash enclosures are directly attached to the Flash RAID adapters using SAS cabling.

Figure 10 is a block diagram showing a simplified view of the PCIe and SAS cabling topology.
Figure 11 shows the PCIe connections in the DS8880 I/O enclosures. Host adapters (HA) and device adapters (DA) are also shown.

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, including Easy Tier Application and Easy Tier Heat Map Transfer.

All previously announced Easy Tier functions apply, including manual volume migration, automated sub-volume data relocation, automated performance rebalancing within drive tiers (in both single-tier and multi-tier drive pools), hot spot management, and rank depopulation.

Currently, IBM supports up to three drive classes or storage tiers that can be configured in the same DS8000® system:

- **Tier 0 (Flash class):** Can contain high performance flash drives, high capacity flash drives and traditional flash drives (SSDs). Although both high performance flash drives from an HPFE and traditional (SSDs) flash drives can be in the same tier, the Easy Tier intra-tier auto-rebalance function recognizes the higher IOPS capability of the HPFE, and migrates hotter extents accordingly.

- **Tier 1 (Enterprise class):** Can contain high capacity flash drives or Enterprise drives (SAS 15 k or 10 k rpm).
> Tier 2 or Nearline tier: Contains the Nearline drives (SAS 7.2 k rpm).

**Tip:** When either traditional flash drives or high performance flash drives are configured in the same pool with high capacity flash drives, the high capacity flash drives will be in tier 1 from an Easy Tier standpoint.

See Figure 12 on page 10 for more information on how drives are involved in tiering based on installed drive types.

![Figure 12](matrixShowingTiering.png)

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

**Disk Magic**

Disk Magic is a Windows-based storage system performance modeling tool that is used by IBM and IBM Business Partners to model storage subsystem performance. It supports disk systems from multiple vendors and offers detailed support for IBM storage systems. Contact your IBM Representative or IBM Business Partner to evaluate a Disk Magic study.

Disk Magic supports the High-Performance Flash Enclosure Gen2 in the DS8880 with Licensed Machine Code (LMC) R8.2 or later.

**Upgrades**

High-Performance Flash Enclosure Gen2 upgrades are supported in the DS8880 base and first expansion frames with Licensed Machine Code (LMC) R8.2.1 or later, with models 980, 981, 982, 984, 985, 986 and 988.

All upgrades to add HPFEs Gen2 or flash drive sets are non-disruptive, but might require co-requisite system memory and processor core upgrades. For DS8880, see Figure 9 on page 8.

For additional information on upgrades see *IBM DS8880 Architecture and Implementation (Release 8.3)*, SG24-8323.
Related Information

- *IBM DS8880 Architecture and Implementation*, SG24-8323:
  http://www.redbooks.ibm.com/abstracts/sg248323.html
- *IBM DS8000 Easy Tier*, REDP-4667:
  http://www.redbooks.ibm.com/abstracts/redp4667.html
- IBM publication *IBM DS8880 Introduction and Planning Guide*, GC27-8525:
  http://www.ibm.com/support/docview.wss?uid=ssg1S7005228
- DS8880 support:
  https://www.ibm.com/support/entry/portal/product/system_storage/disk_systems/enterprise_storage_servers/ds8880
- IBM Knowledge Center:
  http://www.ibm.com/support/knowledgecenter/

Now you can become a published author, too!

Here’s an opportunity to spotlight your skills, grow your career, and become a published author—all at the same time! Join an ITSO residency project and help write a book in your area of expertise, while honing your experience using leading-edge technologies. Your efforts will help to increase product acceptance and customer satisfaction, as you expand your network of technical contacts and relationships. Residencies run from two to six weeks in length, and you can participate either in person or as a remote resident working from your home base.

Find out more about the residency program, browse the residency index, and apply online at: ibm.com/redbooks/residencies.html

Stay connected to IBM Redbooks

- Find us on Facebook:
  http://www.facebook.com/IBMRedbooks
- Follow us on Twitter:
  http://twitter.com/ibmredbooks
- Look for us on LinkedIn:
  http://www.linkedin.com/groups?home=&gid=2130806
- Explore new publications, residencies, and workshops with the IBM Redbooks® weekly newsletter:
- Stay current on recent Redbooks publications with RSS Feeds:
  http://www.redbooks.ibm.com/rss.html
Notices

This information was developed for products and services offered in the US. This material might be available from IBM in other languages. However, you may be required to own a copy of the product or product version in that language in order to access it.

IBM may not offer the products, services, or features discussed in this document in other countries. Consult your local IBM representative for information on the products and services currently available in your area. Any reference to an IBM product, program, or service is not intended to state or imply that only that IBM product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any IBM intellectual property right may be used instead. However, it is the user's responsibility to evaluate and verify the operation of any non-IBM product, program, or service.

IBM may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not grant you any license to these patents. You can send license inquiries, in writing, to:
IBM Director of Licensing, IBM Corporation, North Castle Drive, MD-NC119, Armonk, NY 10504-1785, US

INTERNATIONAL BUSINESS MACHINES CORPORATION PROVIDES THIS PUBLICATION “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some jurisdictions do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this information to non-IBM websites are provided for convenience only and do not in any manner serve as an endorsement of those websites. The materials at those websites are not part of the materials for this IBM product and use of those websites is at your own risk.

IBM may use or distribute any of the information you provide in any way it believes appropriate without incurring any obligation to you.

The performance data and client examples cited are presented for illustrative purposes only. Actual performance results may vary depending on specific configurations and operating conditions.

Information concerning non-IBM products was obtained from the suppliers of those products, their published announcements or other publicly available sources. IBM has not tested those products and cannot confirm the accuracy of performance, compatibility or any other claims related to non-IBM products. Questions on the capabilities of non-IBM products should be addressed to the suppliers of those products.

Statements regarding IBM's future direction or intent are subject to change or withdrawal without notice, and represent goals and objectives only.

This information contains examples of data and reports used in daily business operations. To illustrate them as completely as possible, the examples include the names of individuals, companies, brands, and products. All of these names are fictitious and any similarity to actual people or business enterprises is entirely coincidental.

COPYRIGHT LICENSE:

This information contains sample application programs in source language, which illustrate programming techniques on various operating platforms. You may copy, modify, and distribute these sample programs in any form without payment to IBM, for the purposes of developing, using, marketing or distributing application programs conforming to the application programming interface for the operating platform for which the sample programs are written. These examples have not been thoroughly tested under all conditions. IBM, therefore, cannot guarantee or imply reliability, serviceability, or function of these programs. The sample programs are provided “AS IS”, without warranty of any kind. IBM shall not be liable for any damages arising out of your use of the sample programs.

© Copyright IBM Corp. 2017. All rights reserved.
Trademarks

IBM, the IBM logo, and ibm.com are trademarks or registered trademarks of International Business Machines Corporation, registered in many jurisdictions worldwide. Other product and service names might be trademarks of IBM or other companies. A current list of IBM trademarks is available on the web at “Copyright and trademark information” at http://www.ibm.com/legal/copytrade.shtml

The following terms are trademarks or registered trademarks of International Business Machines Corporation, and might also be trademarks or registered trademarks in other countries.

- Redbooks (logo)®, Easy Tier®, PowerPC®
- DS8000®, IBM®, Redbooks®

The following terms are trademarks of other companies:

Other company, product, or service names may be trademarks or service marks of others.