

# IBM Power System IC922

## Technical Overview and Introduction

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 Analytics

Power Systems





IBM Redbooks

**IBM Power System IC922: Technical Overview and Introduction**

March 2020

**Note:** Before using this information and the product it supports, read the information in “Notices” on page v.

**First Edition (March 2020)**

This edition applies to the IBM Power System IC922 (9183-22X) server.

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# Preface

This IBM® Redpaper publication is a comprehensive guide that covers the IBM Power System IC922 (9183-22X) server that uses IBM POWER9™ processor-based technology and supports Linux operating systems (OSs). The objective of this paper is to introduce the system offerings and their capacities and available features.

The Power IC922 server is built to deliver powerful computing, scaling efficiency, and storage capacity in a cost-optimized design to meet the evolving data challenges of the artificial intelligence (AI) era. It includes the following features:

- ▶ High throughput and performance for high-value Linux workloads, such as inferencing data or storage-rich workloads, or cloud.
- ▶ Potentially low acquisition cost through system optimization, such as using industry standard memory and warranty.
- ▶ Two IBM POWER9 processor-based single-chip module (SCM) devices that provide high performance with 24, 32, or 40 fully activated cores and a maximum 2 TB of memory.
- ▶ Up to six NVIDIA T4 graphics processing unit (GPU) accelerators.
- ▶ Up to twenty-four 2.5-inch SAS/SATA drives.
- ▶ One dedicated and one shared 1 Gb Intelligent Platform Management Interface (IPMI) port.

This publication is for professionals who want to acquire a better understanding of IBM Power Systems products. The intended audience includes:

- ▶ Clients
- ▶ Sales and marketing professionals
- ▶ Technical support professionals
- ▶ IBM Business Partners
- ▶ Independent software vendors (ISVs)

This paper expands the current set of IBM Power Systems documentation by providing a desktop reference that offers a detailed technical description of the Power IC922 server.

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# Architectural and technical description

The IBM Power System IC922 (9183-22X) server is built to deliver powerful computing, scaling efficiency, and storage capacity in a cost-optimized design to meet the evolving data challenges of the artificial intelligence (AI) era.

The *IC* in IC922 stands for inference and cloud. The *I* can also stand for I/O.

The new Power IC922 server is a powerful 2-socket server that offers 24, 32 or 40 fully activated cores and I/O configuration flexibility to help meet accelerated computing needs. The server features are designed for high-performance data analytics and high-performance computing (HPC) workloads with up to six NVIDIA Tesla T4 graphics processing unit (GPU) accelerators.

## 1.1 Power IC922 hardware overview

The Power IC922 server is engineered to put your AI models to work and unlock business insights. It uses cooptimized hardware and software to deliver the necessary components for AI inference. The Power IC922 server fits into your AI workflow and integrates with the IBM Power System AC922 training platform. Thanks to the Power IC922 server's modular design, it can scale with business needs.

The Power IC922 server supports two processor sockets, offering 12-core (2.8 - 3.8 GHz), 16-core (3.35 - 4.0 GHz), and 20-core (2.9 - 3.8 GHz) POWER9 processor-based system configurations in a 19-inch rack-mount with a 2U (EIA units) drawer configuration.

The Power IC922 server provides two hot-swap and redundant power supplies and 32 DIMM memory slots. 16 GB, 32 GB, and 64 GB supported memory features allow for a maximum system memory of 2 TB.

The Power IC922 server also provides:

- ▶ High throughput and performance for high-value Linux workloads, such as inferencing data or storage-rich workloads, or cloud.
- ▶ Potentially low acquisition cost through system optimization, such as using industry standard memory and warranty.
- ▶ Up to six NVIDIA T4 GPU accelerators.
- ▶ Multiple I/O options in the system with the standard Peripheral Component Interconnect Express (PCIe) Riser, including:
  - Two PCIe x16 Gen 3 full height full length (FHFL) slots (supports double-wide accelerators)
  - Two PCIe x16 Gen 4 low-profile (LP) slots
  - Two PCIe x8 Gen 3 FHFL slots (physically x16)
  - Two PCIe x8 Gen 3 FHFL slots
  - Two PCIe x16 Gen 3 LP slots
- ▶ Up to twenty-four 2.5-inch SAS/SATA drives.
- ▶ Optional Mellanox InfiniBand or high-performance Ethernet.
- ▶ Two rear USB 3.0 ports and one front USB 3.0 port.
- ▶ Nineteen-inch rack-mount with 2U configuration.
- ▶ Red Hat Enterprise Linux (RHEL) 7.6alt, Red Hat Enterprise Linux (RHEL) 8.2 for IBM Power LE (POWER9), or later operating system.

The Power IC922 server is shown in Figure 1-1



Figure 1-1 Angle right view of the Power IC922 server

### 1.1.1 Minimum features

The minimum Power IC922 server initial order must include two processor modules, 64 GB of memory, two power supplies, two power cords, rack-mounting hardware, a system software indicator, a specified rack integrator, and a specified language group.

Table 1-1 shows the minimum configuration for the Power IC922 server.

Table 1-1 Power IC922 server minimum configuration

Feature code (FC)	Minimum	Description
EK00 or EK01 or EK02	2	12-core 2.8 - 3.8 GHz (max) POWER9 Processor Module  16-core 3.35 - 4.0 GHz (max) POWER9 Processor Module  20-core 2.9 - 3.8 GHz (max) POWER9 Processor Module.
EM62	4	16 GB DIMMs, 2666 MHz, and 4 Gb DDR4 DRAM.
EC16	1	Open Power Abstraction Layer (OPAL).
4650	1	Rack Indicator - Not Factory Integrated.
EKMP	2	AC Power Supply, 2000 Watt (220 V).
Power cords	2	Select two power cords from the supported list. Feature 4558 is the default (FC 4558 Power Cord To power distribution unit (PDU) / UPS (100-240V/16A)).
2147	1	Primary OS Linux.
93xx	1	Language Group Specify (select one from announced features).

**Note:** If you want a rack, it must be ordered as separate machine type and model in the initial system order. It is sent in the same shipment but in separate packing material. IBM does not offer IBM Manufacturing rack integration of the server into the rack before shipping now.

## 1.1.2 Supported configurable features

Table 1-2 shows the configurable feature matrix of the Power IC922 server. The five columns represent the supported configurations. Only the configuration within a column is valid. For example, in the third column (highlighted with a gray fill), three disk backplanes (with no backplane fillers) support up to 24 disks with the specified SAS/SATA adapters and do not support a NVIDIA T4 GPU.

**Note:** If a system is configured with FC EK47, the maximum number of GPUs supported is five.

Table 1-2 Configurable feature matrix of the Power IC922 server

Processor <sup>a</sup>	2 (up to 40 cores)
Memory DIMMs <sup>b</sup>	4, 8, 12, 16, 24, or 32 (up to 2 TB of memory)



Storage	Total	3 backplanes (up to 24 drives)				
	Drive backplane 2.5-inch SAS/SATA (FC EK36)	1	0	3	1	0
	Drive backplane filler (from factory)	2	3	0	2	3
PCIe riser		PCI Risers Standard (FC EK30)				
PCIe adapter	Total slot	10	10	10	10	10
	SAS/SATA Host Bus Adapter (HBA) 8i (FC EK41 or FC EK47)	1	0	1	1	0
	SAS/SATA HBA 16i (FC EK43)	0	0	1	0	0
	NVIDIA T4 GPU (FC EK4L or FC EK4M)	1 - 6	1 - 6	0	0	0

- a. No mixing of processors.
- b. All memory RDIMMs must be of the same feature.

## 1.2 Operating system support

The Power IC922 server supports Linux, which provides a UNIX like implementation across many computer architectures.

For more information about the software that is available on Power Systems, see [Linux on Power Systems](#).

### 1.2.1 Red Hat Enterprise Linux

Red Hat Enterprise Linux (ppc64le) Version 8.2 for POWER9 is supported on the server with support for later distributions as they become available.

**Note:** There is also an Red Hat Enterprise Linux Version 7.6 for IBM POWER8®. Be sure to use Version 7.6-alt for the Power IC922 server.

For more questions about this release and supported Power Systems servers, see the [Red Hat Hardware Catalog](#).

## 1.3 Operating environment

Table 1-3 lists the electrical characteristics for the Power IC922 server.

Table 1-3 Electrical characteristics for Power IC922 server

Electrical characteristics	Properties
Rated voltage and frequency <sup>a</sup>	200 - 240 V AC at 50 or 60 Hz plus or minus 3 Hz
Thermal output (maximum) <sup>b</sup>	6143 BTU/hr
Maximum power consumption <sup>b</sup>	1800 W
Maximum kVA <sup>c</sup>	1.855 kVA
Phase	Single

a. The power supplies automatically accept any voltage with the published, rated-voltage range. If dual power supplies are installed and operating, the power supplies draw approximately equal current from the utility (electrical supply) and provide approximately equal current to the load. Each power supply has an IEC 320-C20 inlet.

b. Power draw and heat load vary greatly by configuration. When you plan for an electrical system, it is important to use the maximum values.

c. To calculate the amperage, multiply the kVA by 1000 and divide that number by the operating voltage.

**Power sockets:** The Power IC922 server takes IEC 60320 C19/C20 mains power and not C13. Ensure that the correct power cords and PDUs are ordered or available in the rack.

**Note:** The Power IC922 server should always have both power supplies mounted and running so that if there is one power supply failure, the system continues to operate at full performance, for example, no CPU throttling takes place.

Table 1-4 lists the environment requirements for the Power IC922 server.

Table 1-4 Environment requirements for the Power IC922 server

Properties	Recommended operating	Allowable operating <sup>a b c</sup>
ASHRAE class		A2 (Fourth edition)
Airflow direction	Front-to-back	
Temperature	18.0°C - 27.0°C (64.4°F - 80.6°F)	10.0°C - 35.0°C (50.0°F - 95.0°F)
Low end moisture	-9.0°C (15.8°F) dew point	-12.0°C (10.4°F) dew point and 8% relative humidity
High end moisture	60% relative humidity and 15°C (59°F) dew point	85% relative humidity and 21.0°C (69.8°F) dew point
Maximum altitude		5000 m (16,400 ft)

- a. Must derate the maximum allowable temperature 1°C (1.8°F) per 175 m (574 ft) above 900 m (2953 ft) up to a maximum allowable elevation of 3050 m (10000 ft).
- b. The minimum humidity level is the larger absolute humidity of the -12°C (10.4°F) dew point and the 8% relative humidity. These levels intersect at approximately 25°C (77°F). Below this intersection, the dew point (-12°C) represents the minimum moisture level, while above it, the relative humidity (8%) is the minimum. For the upper moisture limit, the limit is the minimum absolute humidity of the dew point and relative humidity that is stated.
- c. The following minimum requirements apply to data centers that are operated at low relative humidity:

Data centers that have do not have ESD floors and where people are allowed to wear non-ESD shoes might want to consider increasing humidity given that the risk of generating 8 kV increases slightly at 8% relative humidity, when compared to 25% relative humidity.

All mobile furnishings and equipment must be made of conductive or static dissipative materials and be bonded to ground.

During maintenance on any hardware, a properly functioning and grounded wrist strap must be used by any personnel who comes in contact with information technology (IT) equipment.

**Note:** The recommended operating environment is provided as the long-term operating environment that can result in the greatest reliability and energy efficiency. The allowable operating environment represents where the equipment is tested to verify functions. Due to the stresses that operating in the allowable envelope can place on the equipment, these envelopes must be used for short-term operation, not continuous operation.

## 1.4 Physical package

The Power IC922 server is offered exclusively as a rack-mounted 2U server. The dimensions of the server are shown in Table 1-5.

Table 1-5 Physical dimensions for the Power IC921 server

Dimension	Power IC921 server
Width	436 mm (17.2 in.)
Depth	820 mm (32.3 in.)
Height	86 mm (3.4 in.)
Weight (maximum)	32.765 kg (72.23 lb)

Figure 1-2 shows the front view of the Power IC922 server.



Figure 1-2 Front view of the Power IC922 server

## 1.5 System architecture

In this section, we show the detailed system architecture of the Power IC922 server. Figure 1-3 illustrates the block diagram of the Power IC922 server that uses the standard PCIe riser cards (FC EK30).

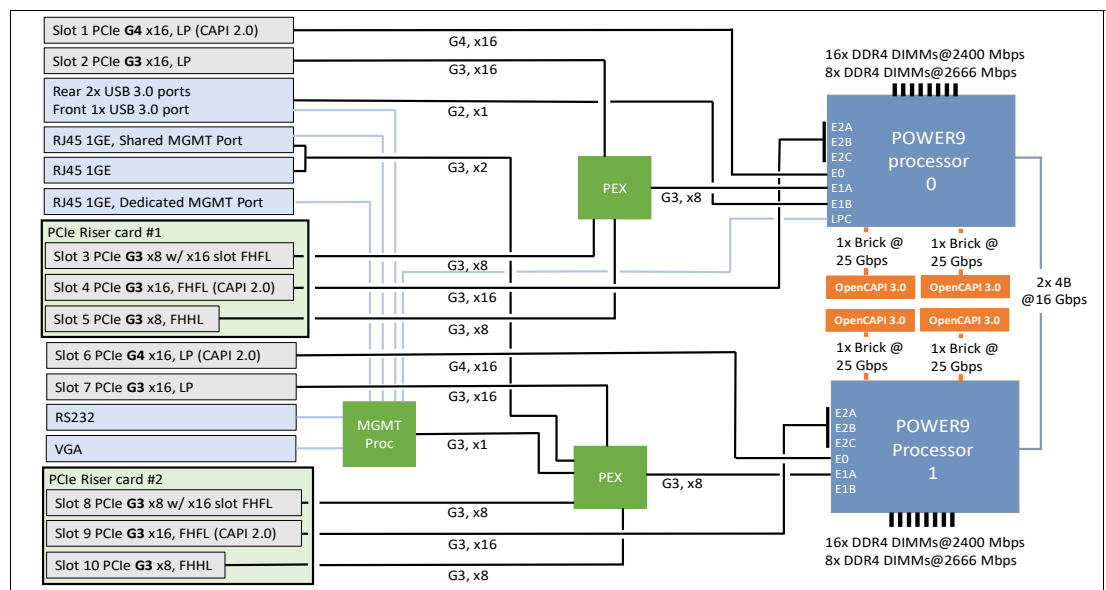


Figure 1-3 Power IC922 server logical system diagram with standard riser cards

The Power IC922 server is a powerful 2-socket server that offers 24, 32, or 40 fully activated cores and the I/O configuration flexibility to help meet accelerated computing needs. It is equipped with the latest DD2.3 POWER9 processor modules and supports eight lanes to the memory slots per processor with up to 32 DIMMs in total (up to 16 for each processor).

The system has 10 PCIe slots in different form factors and bandwidths. Four LP slots are mounted directly on the system board, with the PCIe cards plugged in vertically. Six more slots are mounted on two riser cards with the PCIe cards plugged in horizontally. The feature code for the riser cards is EK30, which includes both riser cards that are required for the server.

In a system with the standard FC EK30 riser cards, the most performant slots 1 and 6 are directly connected to the processors and support a Gen 4, x16 bandwidth (32 GBps).

The slots 4 and 9 are also directly connected to the processor, but operate at Gen 3, x16 speed.

The six remaining slots are connected over PCIe switches (PEX). Although the slots 2 and 7 are Gen3, x16 slots and also are connected by using a Gen 3, x16 connections between the slot and the PEX, the bandwidth is limited to Gen 3 x8 (8 GBps). The reason is the connection from the PEX to the processor has a bandwidth of Gen 3, x8.

The remaining slots (3, 5, 8, and 10) have a maximum throughput of a Gen 3, x8 connection up to 8 GBps.

**Note:** Although slots 3 and 8 have an x8 performance, the slots on the system board are x16 slots.

Because the bandwidth between the PEX and processors is limited to Gen 3, x8, see the PCIe adapter placement rules in [IBM Knowledge Center](#) to get your preferred bandwidth performance.

In an Power IC922 server that uses the FC EK30 riser card, the slots 1, 4, 6, and 9 are Coherent Accelerator Processor Interface (CAPI) 2.0-enabled. Only these slots are CAPI 2.0 enabled because they are directly connected to the processor with no PEX in between.

The system also provides four OpenCAPI 3.0 ports. These ports are on the system board and can be used with OpenCAPI 3.0-capable cards. Such cards are plugged in to a PCIe slot and are cabled to the OpenCAPI 3.0 ports.

For the external ports, such as USB, Ethernet, RS232, and VGA, a systems management chip is used to connect the ports to the processors. This chip also provides access to the open baseboard management controller (OpenBMC). To access the OpenBMC, use the right Ethernet port (rear view). For a redundant OpenBMC connection, use the left Ethernet port (rear view). This port is a shared port with two MAC addresses that provide access to the OpenBMC, and it can be used as a standard Ethernet port inside the OS. For more information about the Ethernet ports for the OpenBMC, see Figure on page 25.

Bandwidths that are provided throughout this section are theoretical maximums that are used for reference.

The speeds that are shown are at an individual component level. Multiple components and application implementation are key to achieving the preferred performance. Always do the performance sizing at the application workload environment level and evaluate performance by using real-world performance measurements and production workloads.

Figure 1-4 shows an overview of the system board and locations of the various parts.

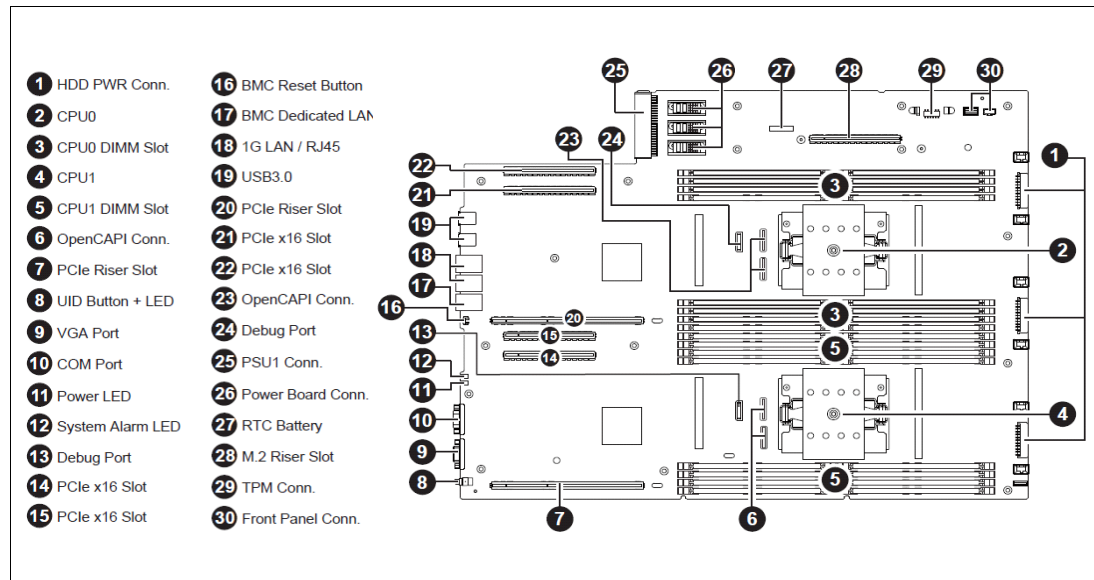


Figure 1-4 System board overview

## 1.6 The POWER9 processor

This section introduces the current processor in the Power Systems product family and describes its main characteristics and features in general.

The POWER9 processor in the Power IC922 server is at the time of writing the most current DD2.3 generation of the IBM POWER® processor family based on the LaGrange chip that is offered by the OpenPOWER foundation.

For more information about the LaGrange module or the other modules of the IBM POWER processor family, see [IBM Portal for OpenPOWER](#).

### 1.6.1 POWER9 processor overview

The IBM POWER9 processor is a super-scalar symmetric multiprocessor (SMP) that is designed for use in servers and large-cluster systems. It supports a maximum SMP size of two sockets and is targeted for high CPU-consuming workloads.

The POWER9 processor offers superior cost and performance benefits. The target market segments are:

- ▶ Technical computing

The POWER9 processor provides superior floating-point performance and high-memory bandwidth to address this market segment. It also supports off-chip floating-point acceleration.

- ▶ Cloud operating environments

The POWER9 processor enables efficient cloud management software, enforces service-level agreements (SLAs), and provides facilities for chargeback accounting that is based on the resources that are consumed.

- ▶ Big data analytics
  - The POWER9 processor with CAPI-attached large caches and on-chip accelerators provides a robust platform for analytic and big data applications.
- ▶ HPC, high-performance data analysis (HPDA), and AI.

## 1.6.2 Processor features

The POWER9 processor is an SCM that is based on complementary metal-oxide-semiconductor (CMOS) 14-nm technology with 17 metal layers. It is optimized for cloud and data center applications. Within a 50 × 50 mm footprint, designs have eight direct-attached memory channels for scale-out configurations. Each DDR4 channel supports up to 2666 Mbps for one DIMM per channel or 2400 Mbps for two DIMMs per channel. Two processors are tightly coupled through two 4 byte, 16 Gbps elastic differential interfaces (EDIs) for SMP. There are 42 lanes of PCIe Gen4 adapters at 16 Gbps.

The POWER9 processor consists of the following main components:

- ▶ Twenty POWER9 cores, which include both L1 instruction and data caches, shared L2 and L3 caches, and a non-cacheable unit (NCU).
- ▶ Each core has up to four threads that use simultaneous multithreading (SMT4).
- ▶ On-chip accelerators:
  - On-chip: Compression, encryption, and data moves are initiated by the hypervisor, compression engine, or a Nest Memory Management Unit (NMMU) to enable user access to all accelerators.
  - In-core: User invocation encryption (Advanced Encryption Standard (AES) and Secure Hash Algorithm (SHA)).
  - CAPI 2.0 allows an FPGA or ASIC to connect coherently to the POWER9 processor-based SMP interconnect through the PCIe bus.
- ▶ Two memory controllers that support direct-attached DDR4 memory:
  - Supports eight direct-attach memory buses.
  - Supports ×4 and ×8, 4 - 16 GB DRAMs and 3D stacked DRAMs.
- ▶ Processor SMP interconnect:
  - Supports two inter-node SMP X-bus links with 4B running at 16 Gbps, which allows a peak inter-node performance of 120 GBps.

**Note:** The inter-node SMP X-bus connection has double the performance compared to a Power LC922 server because it has two X-busses.

- Maximum of a two-socket SMP.
- ▶ Two 25G Link bricks with support for OpenCAPI 3.0 and NVIDIA NVLink 2.0 interconnect.
 

OpenCAPI 3.0 allows an FPGA or ASIC on a PCIe card to connect coherently to the POWER9 processor-based SMP by using OpenCAPI cables from the PCIe card to a OpenCAPI 3.0 port on the system board. For the location of the ports, see Figure 1-4 on page 10.

- ▶ Three PCIe Controllers (PECs) with 42 lanes of PCIe Gen4 I/O:
  - PEC0: One ×16 lanes.
  - PEC1: One ×8 lanes and one ×2 lane (bifurcation).
  - PEC2: One ×16 lanes, two ×8 lanes (bifurcation), or one ×8 lane and two ×4 lanes (trifurcation).
  - PEC0 and PEC2 support CAPI 2.0.
- ▶ Power management.
- ▶ Pervasive interface.

From a logical perspective, the POWER9 processor consists of four main components:

- ▶ SMP interconnect (also known as an internal fabric interconnect)
- ▶ Memory subsystem
- ▶ PCIe I/O subsystem
- ▶ Accelerator subsystem

For more information about the LaGrange POWER9 SCM, see the [POWER9 LaGrange Single-Chip Module \(SCM\) data sheet](#).

Figure 1-5 shows a POWER9 processor with up to 24 cores (the maximum available cores in the Power IC922 server is 20).

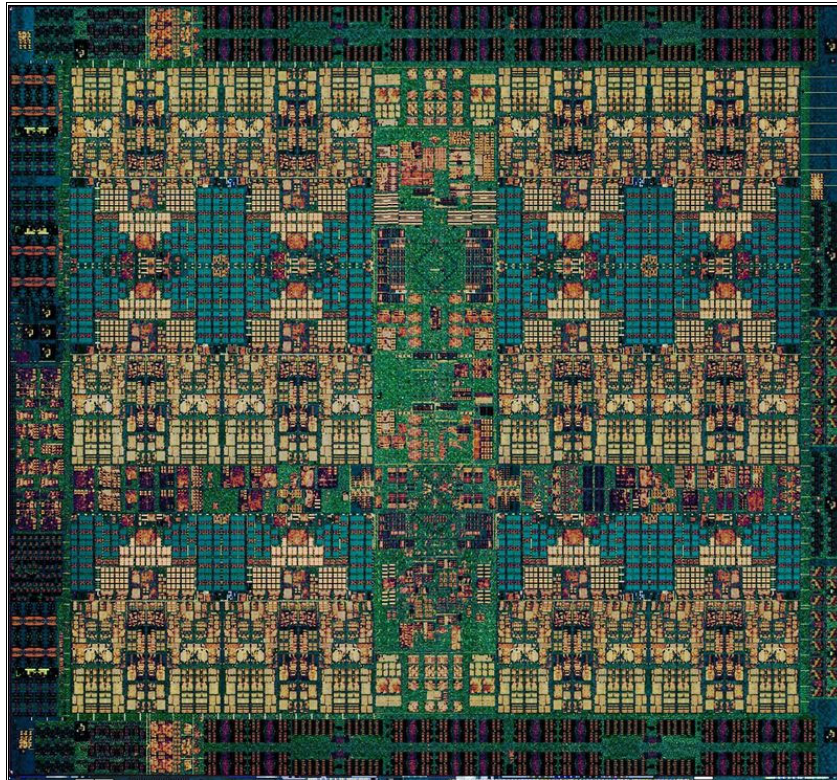


Figure 1-5 POWER9 processor with 24 cores



### 1.6.3 Supported technologies

The POWER9 processor supports the following technologies:

- ▶ IBM Power Instruction Set Architecture (ISA) Book I, II, and III (Version 3.0)
- ▶ Linux on IBM Power Architecture® Platform Reference
- ▶ IEEE P754-2008 for binary and decimal floating-point compliance
- ▶ Little Endian and strong-ordering support extension
- ▶ A 51-bit real address and a 68-bit virtual address

### 1.6.4 Simultaneous multithreading

The POWER9 processor has improvements in multi-core and multi-thread scaling compared to previous generations of POWER processors. A significant performance opportunity comes from parallelizing workloads to enable the full potential of the microprocessor, and the large memory bandwidth. Application scaling is influenced by both multi-core and multi-thread technology.

Simultaneous multithreading (SMT) allows a single physical processor core to dispatch simultaneously instructions from more than one hardware thread context. With SMT, each POWER9 processor core can present four hardware threads. Because there are multiple hardware threads per physical processor core, more instructions can run concurrently.

SMT is primarily beneficial in commercial environments where the speed of an individual transaction is not as critical as the total number of transactions that are performed. SMT typically increases the throughput of workloads with large or frequently changing working sets, such as database servers and web servers.

Table 1-6 shows a comparison between the different POWER9 processors options for the Power IC922 server and the number of threads that are supported by each SMT mode.

*Table 1-6 Number of threads that are supported by a Power IC922 server*

Cores per system	SMT 0	SMT 2	SMT 4
24	24 HTpS <sup>a</sup>	48 HTpS	96 HTpS
32	32 HTpS	64 HTpS	128 HTpS
40	40 HTpS	80 HTpS	160 HTpS

a. Hardware Threads per System.

## 1.6.5 Processor feature codes

The Power IC922 server supports three processor configurations, as shown in Table 1-7.

Table 1-7 Power IC922 supported processor features codes

Feature code	Description	Minimum	Maximum	OS support
EK00	12-core 2.8 - 3.8 GHz (max) POWER9 Processor	2	2	Linux
EK01	16-core 3.35 - 4.0 GHz (max) POWER9 Processor	2	2	Linux
EK02	20-core 2.9 - 3.8 GHz (max) POWER9 Processor	2	2	Linux

The Power IC922 server supports only two processor modules; a one-processor system is not available. No processor activation features are used or orderable on the Power IC922 server. All processor cores are always fully activated.

## 1.6.6 Coherent Accelerator Processor Interface 2.0

CAPI 2.0 is the evolution of CAPI that defines a coherent accelerator interface structure for attaching special processing devices to the POWER9 processor bus. As with the original CAPI, CAPI 2.0 can attach accelerators that have coherent shared memory access with the processors in the server and share full virtual address translation with these processors by using standard PCIe Gen 4 buses with twice the bandwidth compared to the previous generation.

Applications can have customized functions in FPGAs and queue work requests directly in shared memory queues to the FPGA. Applications can also have customized functions by using the same effective addresses (pointers) that they use for any threads running on a host processor. From a practical perspective, CAPI enables a specialized hardware accelerator to be seen as an extra processor in the system with access to the main system memory and coherent communication with other processors in the system.

Figure 1-6 shows a comparison of the traditional model, where the accelerator must go through the processor to access memory with CAPI.

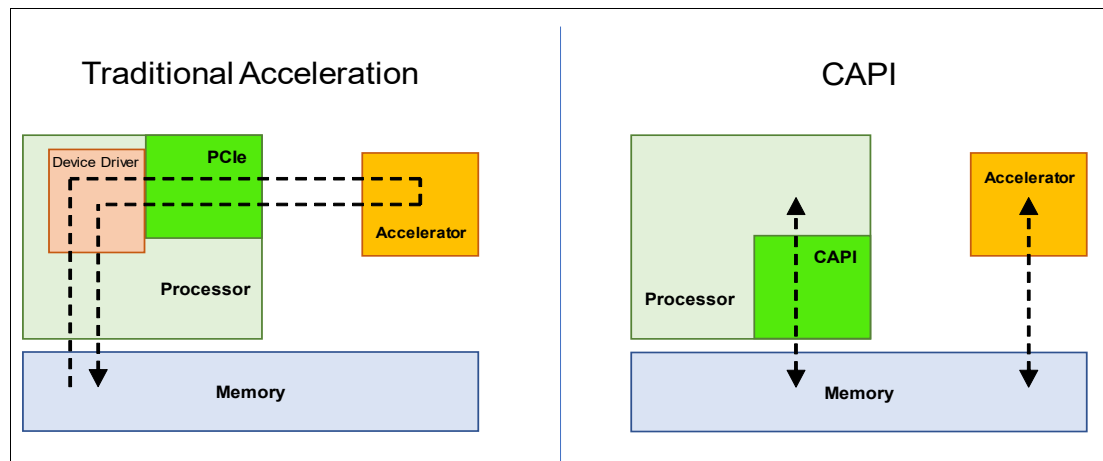


Figure 1-6 CAPI accelerator that is attached to the POWER9 processor

The benefits of using CAPI include the ability to access shared memory blocks directly from the accelerator, perform memory transfers directly between the accelerator and processor cache, and reduce the code path length between the adapter and the processors. This reduction in the code path length might occur because the adapter is not operating as a traditional I/O device, and there is no device driver layer to perform processing. CAPI also presents a simpler programming model.

CAPI implements the Power Service Layer (PSL), which provides address translation and system memory cache for the accelerator functions. The custom processors on the system board, consisting of an FPGA or an ASIC, use this layer to access shared memory regions, and cache areas as though they were a processor in the system. This ability enhances the performance of the data access for the device and simplifies the programming effort to use the device. Instead of treating the hardware accelerator as an I/O device, it is treated as a processor, which eliminates the requirement of a device driver to perform communication. It also eliminates the need for direct memory access (DMA) that requires system calls to the OS kernel. By removing these layers, the data transfer operation requires fewer clock cycles in the processor, improving the I/O performance.

The implementation of CAPI on the POWER9 processor enables hardware companies to develop solutions for specific application demands. Companies use the performance of the POWER9 processor for general applications and the custom acceleration of specific functions by using a hardware accelerator with a simplified programming model and efficient communication with the processor and memory resources.

To use CAPI 2.0, the accelerator PCIe card must be mounted into a CAPI 2.0-enabled PCIe slot. In a Power IC922 server that uses the FC EK30 riser card, the slots 1, 4, 6, and 9 are CAPI 2.0-enabled.

### **1.6.7 OpenCAPI 3.0**

Although CAPI is a technology that is present in IBM POWER processors and depends on IBM intellectual property (the PSL), several industry solutions might benefit from having a mechanism of connecting different devices to the processor with low latency, including memory attachment. The PCIe standard is pervasive to every processor technology, but its design characteristics and latency do not enable the attachment of memory for load/store operations.

Therefore, the OpenCAPI Consortium was created, with the goal of defining a device attachment interface to open the CAPI interface to other hardware developers and extending its capabilities. OpenCAPI aims to enable memory, accelerators, network, storage, and other devices to connect to the processor through a high-bandwidth, low-latency interface, becoming the interface of choice for connecting high-performance devices.

By providing a high-bandwidth, low-latency connection to devices, OpenCAPI enables several applications to improve networking, use FPGA accelerators, use expanded memory beyond server internal capacity, and reduce latency to storage devices. Some of these use cases and examples are shown in Figure 1-7.

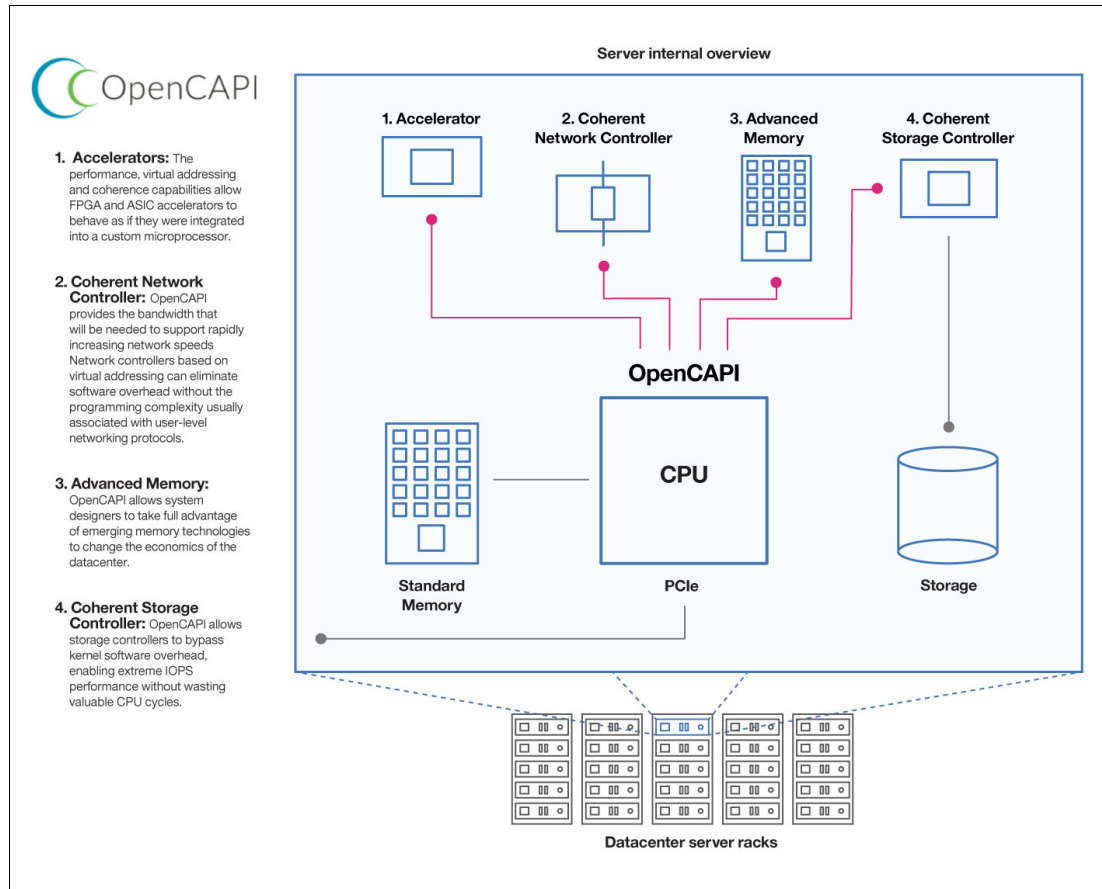


Figure 1-7 OpenCAPI use cases

The design of OpenCAPI enables low latency in accessing attached devices (in the same range of DDR memory access, that is, 10 ns), which enables memory to be connected through OpenCAPI and serve as main memory for load/store operations. In contrast, PCIe latency is 10 times larger (around 100 ns). Therefore, OpenCAPI is significantly enhanced compared to traditional PCIe interconnects.

OpenCAPI is neutral regarding processor architecture, so the electrical interface is not defined by the OpenCAPI consortium or any of its workgroups. On the POWER9 processor, the electrical interface is based on the design from the 25G workgroup within the OpenPower Foundation, which encompasses a 25 Gbps signaling and protocol that is built to enable a low-latency interface on CPU and attached devices.

The current design for the adapter is based on a PCIe card that draws power from the PCIe slot while connecting to the OpenCAPI port on the system board through a 25-GBps cable, as shown in Figure 1-8.

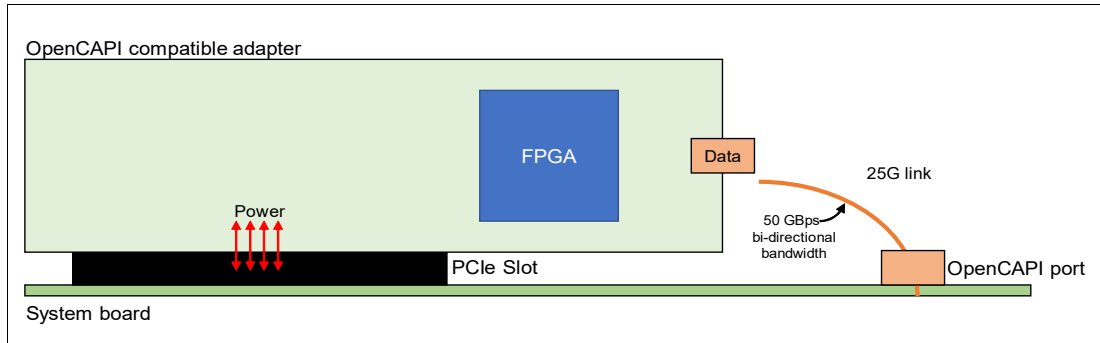


Figure 1-8 OpenCAPI compatible adapter and 25G link

The OpenCAPI interface uses the same electrical interconnect as NVLink 2.0. Systems can be designed to have an NVLink-attached GPU, an OpenCAPI-attached device, or both. For the Power IC922 server, NVLink is not supported because these interconnects can be used only for OpenCAPI 3.0 solutions.

Figure 1-9 shows the four OpenCAPI 3.0 ports, which are named P1T1, P1T2, P1T3, and P1T4.

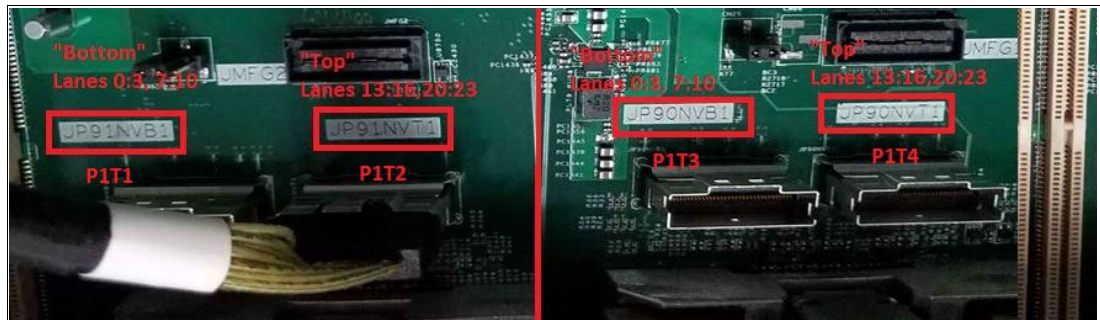


Figure 1-9 OpenCAPI 3.0 ports in the Power IC922 server

For more information about CAPI, see [CAPI on IBM Power Systems](#).

## 1.7 Memory subsystem

The POWER9 memory subsystem consists of a POWER9 processor that supports eight channels. Each memory port or channel supports single- or dual-drop industry-standard RDIMMs, so each channel can accommodate one or two DIMMs. The POWER9 processor connects to the DIMMs by using the standard DDR4 memory interface.

**Note:** Although the DIMMs are industry-standard RDIMMs, only DIMMs that are sold by IBM are supported in the system.

Figure 1-10 shows the memory slot location of the Power IC922 server.

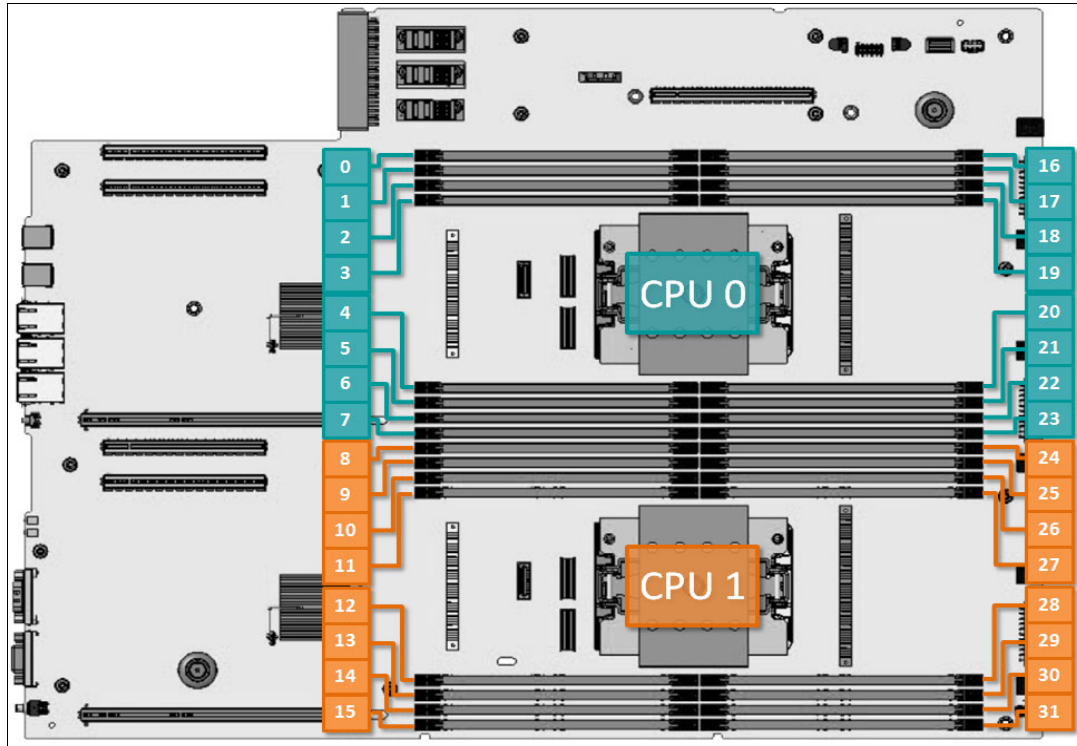


Figure 1-10 Memory slot locations

The corresponding slot location codes of the slots in Figure 1-10 are as shown in Table 1-8 and Table 1-9.

Table 1-8 DIMM location codes left side

Memory DIMM slot	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Location code	P1-C35	P1-C34	P1-C33	P1-C32	P1-C31	P1-C30	P1-C29	P1-C28	P1-C27	P1-C26	P1-C25	P1-C24	P1-C23	P1-C22	P1-C21	P1-C20

Table 1-9 DIMM location codes right side

Memory DIMM slot	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Location code	P1-C19	P1-C18	P1-C17	P1-C16	P1-C15	P1-C14	P1-C13	P1-C12	P1-C11	P1-C10	P1-C9	P1-C8	P1-C7	P1-C6	P1-C5	P1-C4

Memory DIMMs in the Power IC922 server can be installed in increments of four, up to 32 DIMMs per system.

**Note:** Twenty-DIMM and a 28-DIMM configurations are not supported.

All DIMMs in a system must be the same size. One feature code that is shown in Table 1-10 provides one DIMM, so the feature codes must be ordered in increments of four.

Table 1-10 Memory feature codes for the Power IC922 server

Feature code	Description
EM62	16 GB 1RX4 2666 MHz DDR4 RDIMM
EM63	32 GB 2RX4 2666 MHz DDR4 RDIMM
EM64	64 GB 4RX4 2666 MHz DDR4 2H 3DS RDIMM

Table 1-11 shows the possible memory configurations for the Power IC922 server.

Table 1-11 Possible memory configurations

Feature code	Size	4 DIMMs	8 DIMMs	12 DIMMs	16 DIMMs	24 DIMMs	32 DIMMs
EM62	16 GB	64 GB	128 GB	192 GB	256 GB	384 GB	512 GB
EM63	32 GB	128 GB	256 GB	384 GB	512 GB	768 GB	1024 GB
EM64	64 GB	256 GB	512 GB	768 GB	1024 GB	1536 GB	2048 GB

**Recommendation:** Populate 16 slots for a maximum bandwidth or 32 slots for a maximum memory size of 2 TB.

### 1.7.1 DIMM placement rules

In the system, the DIMMs slots that are populated first are the white-colored plastic slots (single-drop). The remaining slots are black-colored. This general rule is also followed in the placement rules for the system. The Power IC922 server has specific placement rules that are shown in Figure 1-11.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
4 DIMMs						●									●		
8 DIMMs	●					●			●						●		
12 DIMMs	●					●		●	●						●		●
16 DIMMs	●		●			●		●	●		●				●		●
24 DIMMs	●	●	●	●	●	●	●	●	●		●				●		●
32 DIMMs	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Figure 1-11 DIMM placement rules for the Power IC922 server

To identify a slot, see Figure 1-10 on page 18 or [IBM Knowledge Center](#).

## 1.7.2 Memory bandwidth

The system is memory performance-optimized with 16 DIMMs populated because in this configuration all memory DIMMs work in single-drop mode at a speed of 2666 Mbps. If in a memory channel both DIMMs are populated (dual-drop), the speed is reduced to 2400 Mbps.

The maximum bandwidth of the system depends on the number of channels that are used and if the channel operates in single-drop or dual-drop mode. A DDR4 DIMM that is clocked with 2666 MHz has a maximum transfer rate of 21.3 GBps. A DDR4 DIMM clocked with 2400 MHz has a maximum transfer rate of 19.2 GBps. To calculate the maximum bandwidth, use the following formula:

Maximum Bandwidth =(Number of DIMMs in single-drop mode \* 21.3 GBps) + ((Number of DIMMs in dual-drop mode / 2) \* 19.2 GBps)

Table 1-12 shows the maximum memory bandwidth for the Power IC922 server, depending on the number of DIMMs that are populated.

*Table 1-12 Maximum memory bandwidth for the Power IC922 server*

DIMM quantity	Maximum bandwidth in GBps
4	85
8	170
12	255
16	340
24	323 <sup>a</sup>
32	306 <sup>b</sup>

a. Processor 0 operates at 2400 Mbps.

b. Both processors operate at 2400 Mbps.



## 1.8 The Trusted Platform Module

The Power IC922 server is equipped with a Trusted Platform Module (TPM). The TPM card is mounted on the system board, as shown in Figure 1-12. The TPM module can sign the hardware and firmware by using cryptographic keys, which is the basis for a secure boot of the OS.

An OS that is enabled for secure boot makes sure that the hardware and firmware were not modified, which might prevent the OS from booting, or at least informs the system administrator whether something was modified. The trusted hardware and firmware together with the OS that securely boots is called a *trusted platform*.

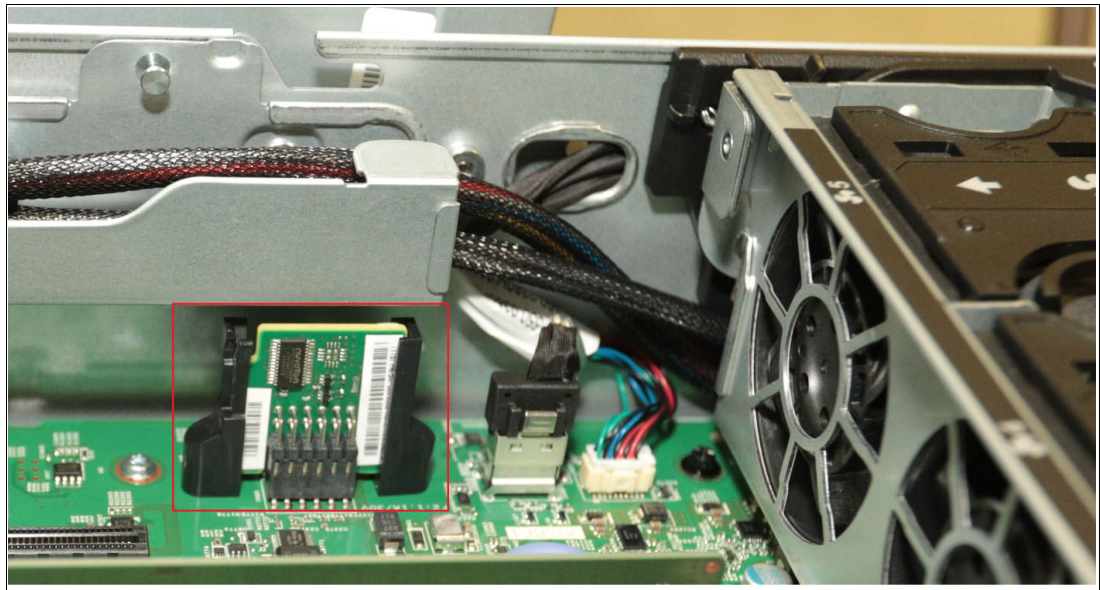


Figure 1-12 Trusted Platform Module

## 1.9 Internal I/O subsystem

The key components of the I/O subsystem are described in this section.

### 1.9.1 PCIe Express Controller and Peripheral Component Interconnect Express

The PEC acts as a bridge between the internal processor bus and the high-speed serial (HSS) links that drive the PCIe I/O. The PEC acts as a processor bus master on behalf of the PCIe port, converting inbound memory read and write packets into processor bus DMA traffic. The PEC also acts as a processor bus subordinate, transferring processor load and store commands to the PCIe devices that are attached to the port.

PCIe uses a serial interface and enables point-to-point interconnections between devices by using a directly wired interface between these connection points. A single PCIe serial link is a dual-simplex connection that uses two pairs of wires, one pair for transmit and one pair for receive, and can transmit only 1 bit per cycle. These two pairs of wires are called a *lane*. A PCIe link can consist of multiple lanes. In these configurations, the connection is labeled as x1, x2, x8, x12, x16, or x32, where the number is effectively the number of lanes.

PCI Gen4 has double the bandwidth from previous generation PCI Gen3 adapters. The x16 PCI Gen4 adapter can handle 256 Gbps data and is ready for a 200 Gbps network connection if such a network becomes available.

The Power IC922 server provides a total of 10 PCIe slots. Slots 1, 2, 6, and 7 are part of the system board. The rest of PCIe slots are provided by the PCIe riser. The server requires one PCIe riser feature (providing two PCIe riser cards).

The Power IC922 server can support three different form factors of PCIe adapters:

- ▶ PCIe LP cards
- ▶ PCIe double-width, FHFL cards
- ▶ PCIe FHFL cards

If you are installing a new feature, ensure that you have the software that is required to support the new feature and determine whether there are existing update prerequisites to install. To obtain this information, see [Power Systems Prerequisites](#).

## 1.9.2 Slot configuration

The Power IC922 server provides PCIe Gen 3 and PCIe Gen 4 slots.

Figure 1-13 shows the rear view of the system with the PCIe adapter slots.

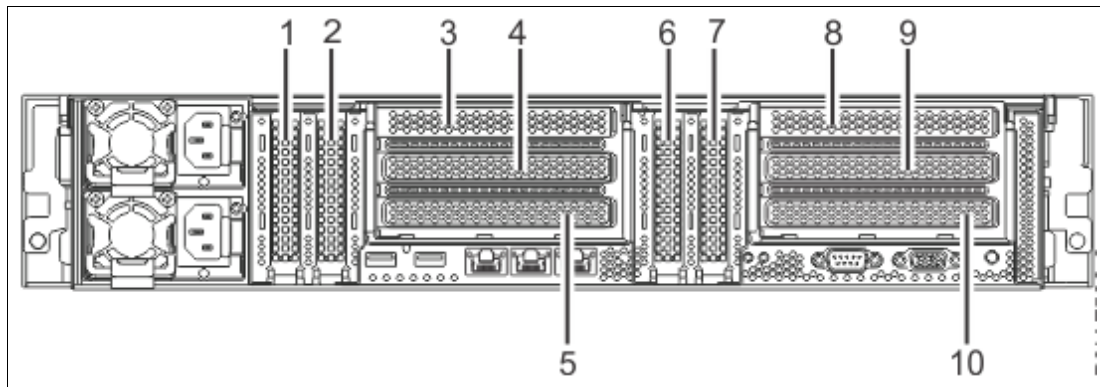


Figure 1-13 Rear view of the Power IC922 server with PCIe slots indicated

Slots 1, 2, 6, and 7 are part of the system board and as such do not depend on the PCIe riser that is selected. As part of the system board, these slots (1, 2, 6 and 7) support only LP adapters that are vertically mounted.

The slots that are provided by the PCIe riser are horizontal slots, so the PCIe adapters are horizontally mounted. Slots 3, 4, 8, and 9 accept FHFL and full height, half length (FHHL) PCIe adapters. Slots 5 and 10 accept only FHHL PCIe adapters.

Table 1-13 shows the available PCIe riser for the Power IC922 server.

Table 1-13 Available PCIe riser for the Power IC922 server

Feature code	CCIN	Description	Min	Max	OS support
EK30		PCI Risers Standard	0	1	

Figure 1-14 show the riser card FC EK30 with some mounted PCIe cards.



Figure 1-14 Riser card feature code EK30

Table 1-14 lists the PCIe adapter slots and details for the system. The Power IC922 server supports full-height, full-length, and half-length PCIe adapters.

Table 1-14 PCIe slots and descriptions for the Power IC922 server with feature code EK30 riser

Slot identification	Description	Adapter size	Processor module	Coherent Accelerator Processor Interface (CAPI) 2.0
1	PCIe Gen 4 x16	LP	CPU 0	Yes
2	PCIe Gen 3 x16	LP	CPU 0	No
3	PCIe Gen 3 x16	FHFL	CPU 0	No
4	PCIe Gen 3 x16	FHFL <sup>a</sup>	CPU 0	Yes
5	PCIe Gen 3 x8	FHFL	CPU 0	No
6	PCIe Gen 4 x16	LP	CPU 1	Yes
7	PCIe Gen 3 x16	LP	CPU 1	No
8	PCIe Gen 3 x16	FHFL	CPU 1	No
9	PCIe Gen 3 x16	FHFL <sup>a</sup>	CPU 1	Yes
10	PCIe Gen 3 x8	FHFL	CPU 1	No

a. Supports double-wide adapters.

### 1.9.3 GPUs

Table 1-15 lists the GPUs that are available for the Power IC922 server.

Table 1-15 Available GPUs for the Power IC922 server

Feature code	CCIN	Description	Min	Max	OS support
EK4L		NVIDIA T4 GPU with PCIe Gen 3 x16 LP (16 GB)	0	4	Linux
EK4M		NVIDIA T4 GPU with PCIe Gen 3 x16 (16 GB)	0	2	Linux

The NVIDIA T4 PCIe GPU accelerator adapter is a single-slot, 6.6-inch PCIe Gen 3 universal deep learning accelerator that is based on the TU104 NVIDIA GPU. The adapter can be used in either an x8 or x16 PCIe slot in the system. The NVIDIA T4 adapter has 16 GB GDDR6 memory and a maximum power limit of 70 W. FC EK4L is a short, LP adapter. FC EK4M is a short adapter with a full-height tail stock.

For more information about T4 GPUs, see [NVIDIA T4](#).

The Power IC922 server supports up to six NVIDIA T4 GPUs.

Figure 1-15 shows the T4 GPU plug order, which is shown by yellow numbers. The PCIe Gen 3 x8 slots are outlined in red.

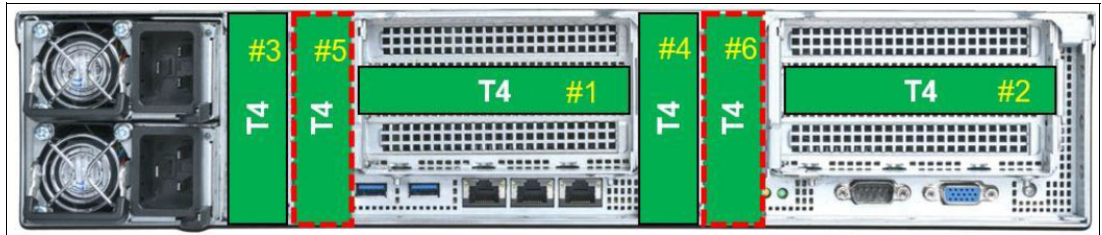


Figure 1-15 NVIDIA T4 GPU plug order

### 1.9.4 Field-Programmable Gate Array

There is no available OpenCAPI FPGA at the time of writing.

### 1.9.5 PCI adapters

This section describes the types and functions of the PCI adapters that are supported by the Power IC922 server.

#### Local area network adapters

To connect the Power IC922 servers to a local area network (LAN), you can use the LAN adapters that are supported in the PCIe slots of the system in addition to the two 1GE RJ45 ports that are present in every system.

Figure 1-16 shows the two 1GE RJ45 ports that are integrated into the system.

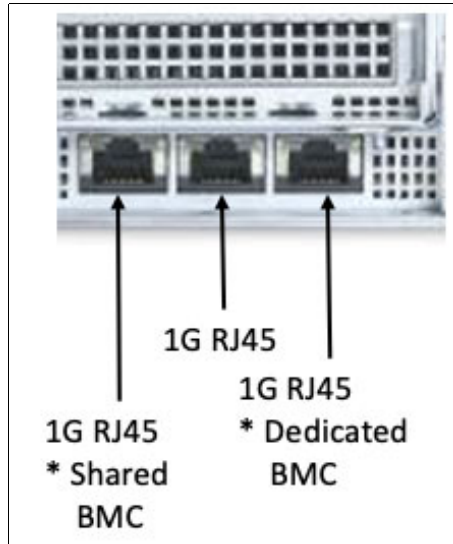


Figure 1-16 Integrated LAN port

Table 1-16 lists the LAN adapters that are available for the Power IC922 server.

Table 1-16 Available LAN adapters for the Power IC922 server

Feature code	CCIN	Description	Min	Max	OS support
EC2R	58FA	PCIe3 LP 2-Port 10 Gb NIC&ROCE SR/Cu Adapter	0	4	Linux
EC2S	58FA	PCIe3 2-Port 10 Gb NIC&ROCE SR/Cu Adapter	0	6	Linux
EC2T	58FB	PCIe3 LP 2-Port 25/10 Gb NIC&ROCE SR/Cu Adapter	0	4	Linux
EC2U	58FB	PCIe3 2-Port 25/10 Gb NIC&ROCE SR/Cu Adapter	0	6	Linux
EC62	2CF1	PCIe4 LP 1-port 100 Gb EDR InfiniBand CAPI adapter	0	2	Linux
EC64	2CF2	PCIe4 LP 2-port 100 Gb EDR InfiniBand CAPI adapter	0	2	Linux
EC67	2CF3	PCIe4 LP 2-port 100 Gb ROCE EN LP adapter	0	2	Linux
EL3Z	2CC4	PCIe2 LP 2-port 10/1 GbE BaseT RJ45 Adapter	0	4	Linux
EL4L	576F	PCIe2 4-port 1 GbE Adapter	0	6	Linux
EL4M	576F	PCIe2 LP 4-port 1 GbE Adapter	0	4	Linux
EL55	2CC4	PCIe2 2-port 10/1 GbE BaseT RJ45 Adapter	0	6	Linux
EN0S	2CC3	PCIe2 4-Port (10 Gb+1 GbE) SR+RJ45 Adapter	0	6	Linux

Feature code	CCIN	Description	Min	Max	OS support
EN0T	2CC3	PCIe2 LP 4-Port (10 Gb+1 GbE) SR+RJ45 Adapter	0	4	Linux
EN0U	2CC3	PCIe2 4-port (10 Gb+1 GbE) Copper SFP+RJ45 Adapter	0	6	Linux
EN0V	2CC3	PCIe2 LP 4-port (10 Gb+1 GbE) Copper SFP+RJ45 Adapter	0	4	Linux

### Fibre Channel adapters

The servers support a direct or storage area network (SAN) connection to devices that use Fibre Channel connectivity.

Table 1-17 summarizes the available Fibre Channel adapters. All of them have LC connectors. The infrastructure that is used with these adapters determines whether you must procure LC fiber converter cables.

*Table 1-17 The PCIe Fibre Channel adapters that are available for the Power IC922 server*

Feature code	CCIN	Description	Min	Max	OS support
EL43	577F	PCIe3 LP 2-port 16 Gb Fibre Channel Adapter	0	4	Linux
EL5B	577F	PCIe3 16 Gb 2-port Fibre Channel Adapter	0	6	Linux
EL5U	578F	PCIe3 32 Gb 2-port Fibre Channel Adapter	0	6	Linux
EL5V	578F	PCIe3 LP 2-port 32 Gb Fibre Channel Adapter	0	4	Linux

### SAS/SATA host bus adapters

Table 1-18 lists the SAS/SATA HBAs that are available for the Power IC922 server. These adapters are used to connect internally from the rear of the system to the three drive backplanes in front of the system, as described in 1.10, “.Internal storage” on page 27.

**Note:** If a system is configured with FC EK47, the maximum number of GPUs supported is five.

*Table 1-18 The SAS/SATA HBAs that are available for the Power IC922 server*

Feature code	CCIN	Description	Min	Max	OS support
EK41		Broadcom 9300-8i SAS/SATA HBA PCIe3 x8 LP	0	2	Linux
EK43		Broadcom 9305-16i SAS/SATA HBA PCIe3 x8 LP	0	1	Linux
EK47		Broadcom (LSI) MegaRAID 9361-8i SAS3 Controller with 8 internal ports (2 GB Cache) PCIe 3.0 x8 with cables	0	2	Linux

## 1.10 Internal storage

The Power IC922 server supports up to twenty-four 2.5-inch SAS/SATA hard disk drives (HDDs) / solid-state drives (SSDs) through three front-mounted backplanes. Each backplane has eight drive slots.

The Power IC922 server does not have an integrated disk controller. You must install SAS/SATA HBAs depending on how many drive backplanes are installed. The Broadcom MegaRAID 9361-8i HBA (FC EK47) supports RAID levels 0, 1, 5, 6, 10, 50, and 60, and Just a Bunch of Disks (JBOD). The other HBAs support only JBOD.

**Note:** If a system is configured with FC EK47, the maximum number of GPUs supported is five.

There are various internal storage configurations for the server:

- ▶ One FC EK41 or FC EK47 HBA in PCIe slot 5, and one 2.5-inch SAS/SATA drive backplane (FC EK36) (Figure 1-17)

You can install a maximum of eight 2.5-inch SAS/SATA drives.

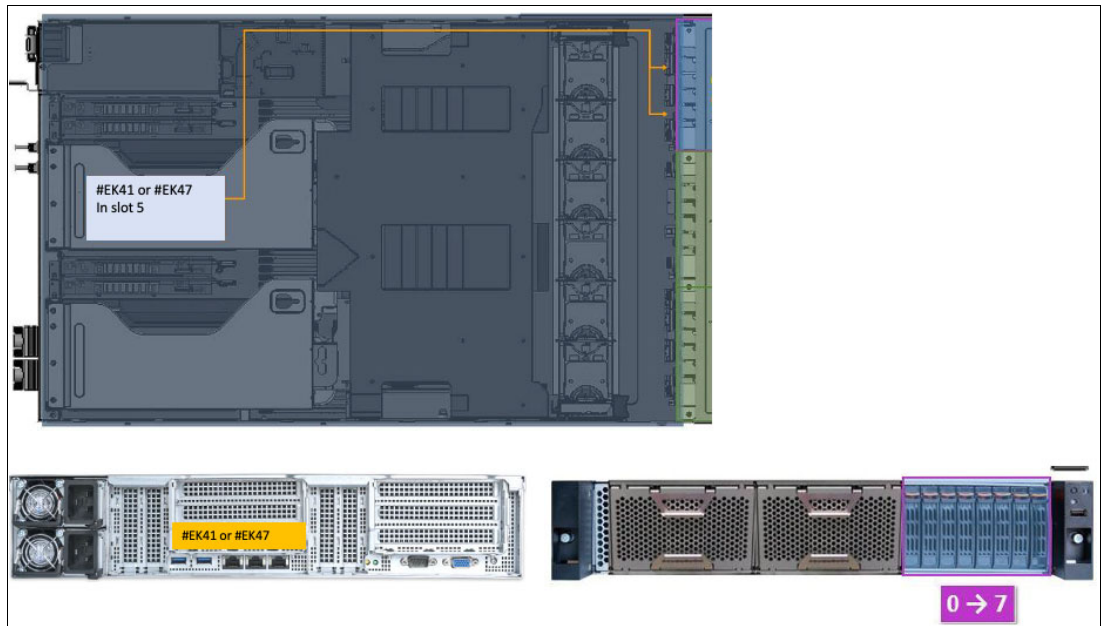


Figure 1-17 One SAS/SATA HBA and one SAS/SATA drive backplane

- ▶ One FC EK41 or FC EK47 HBA in PCIe slot 5, one FC EK42 in PCIe slot 10, and three 2.5-inch SAS/SATA drive backplanes (FC EK36) (Figure 1-18)
- You can install a maximum of twenty-four 2.5-inch SAS/SATA disks.

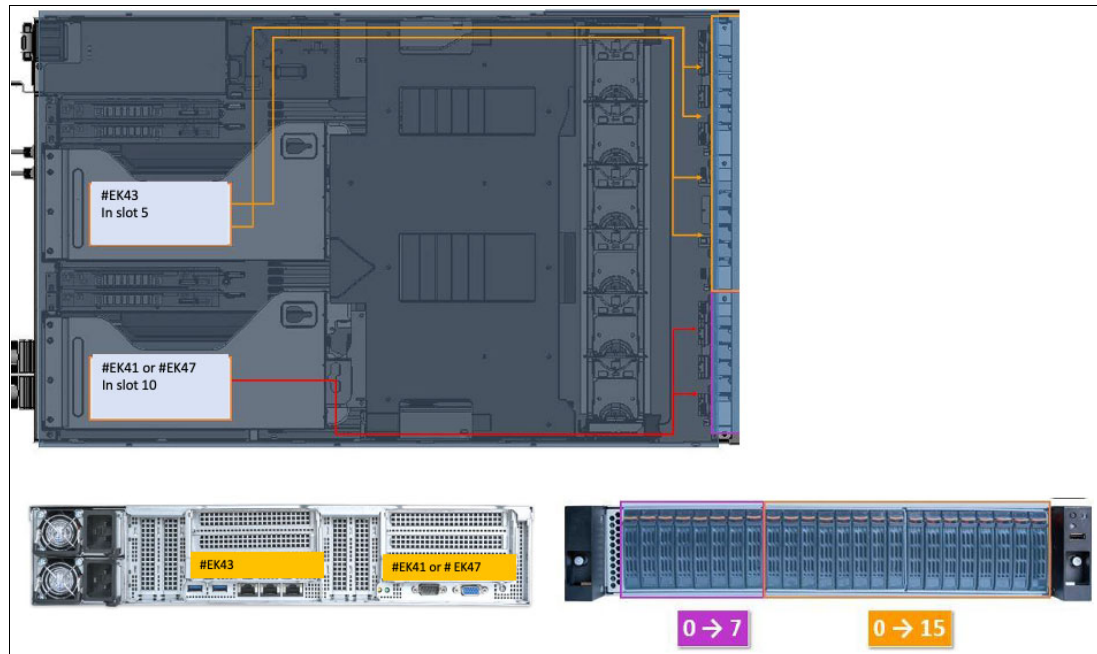


Figure 1-18 Two SAS/SATA HBAs and three SAS/SATA drive backplanes

### 1.10.1 Drive backplanes

Up to three drive backplanes are supported in the Power IC922 server. Table 1-19 shows the available drive backplanes.

Table 1-19 Available drive backplanes for the Power IC922 server.

Feature code	CCIN	Description	Min.	Max	OS support
EK36		Drive backplane 2.5-inch SAS/SATA, 8x bays, 8x carriers, 12 V power cable	0	3	Linux

Figure 1-19 shows the location of the three front backplanes.

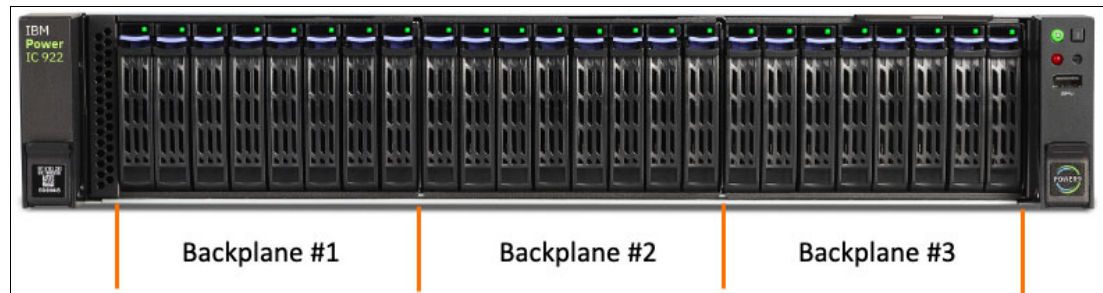


Figure 1-19 The location of the three front drive backplanes

A backplane filler is required for each drive backplane that is not installed. The backplane fillers are installed in the factory automatically, so there is no need to order them separately.



## 1.10.2 HDDs and SSDs

The Power IC922 server supports HDDs, SSDs, or a mixture of HDDs and SSDs in 2.5-inch SAS/SATA drive backplanes. Mixing HDDs and SSDs applies even within a single disk backplane.

Table 1-20 lists the HDDs and SSDs that are available for the Power IC922 server.

Table 1-20 Available HDDs and SSDs for the Power IC922 server

Feature code	CCIN	Description	Min.	Max	OS support
EK27		3.8 TB 2.5-inch SAS3 1-DWPD NONSED <sup>a</sup>	0	24	Linux
EK20		240 GB 2.5-inch SATA SSD 1.4-DWPD <sup>b</sup> NONSED <sup>a</sup>	0	24	Linux
EK21		960 GB 2.5-inch SATA SSD 2.5-DWPD <sup>b</sup> NONSED <sup>a</sup>	0	24	Linux
EK22		1.9 TB 2.5-inch SATA SSD 2.5-DWPD <sup>b</sup> NONSED <sup>a</sup>	0	24	Linux
EK23		3.8 TB 2.5-inch SATA SSD 2.5-DWPD <sup>b</sup> NONSED <sup>a</sup>	0	24	Linux
EK1A		600 GB 2.5-inch SAS3 HDD 4KN/512e SED	0	24	Linux
EK1B		1.2 TB 2.5-inch SAS3 HDD 4KN/512e SED	0	24	Linux
EK1C		2.4 TB 2.5-inch SAS3 HDD 4KN/512e NONSED <sup>a</sup>	0	24	Linux

a. NONSED: Non-Self Encrypting Drive

b. DWPD: Whole Drive Writes Per Day

**Note:** The Power IC922 server may be ordered with zero disk features. Each FC EK36 can contain up to eight HDDs or SSDs.

## 1.10.3 NVMe Express

NVMe is a specification defining how host software communicates with non-volatile memory across a PCIe bus. It is the industry standard for PCIe SSDs in all form factors (U.2, M.2, AIC, and EDSFF).

There are many form factors of NVMe SSD for IBM Power Systems servers:

- ▶ Add-in card (ASIC):
  - x4 / x8 PCIe Gen 3 / 4
  - High performance and power (25 - 50 W)
  - Focus on high capacity
  - Best performance and lowest latency

- ▶ 2.5-inch SFF (U.2):
  - 2x2 / 1x4 PCIe Gen 3 / 4, dual-port support, 8639 Connector
  - Split into two power offerings: 15 - 25 W (15 mm), 9 - 12 W (7 mm)
  - Expected to be direct-attached to the CPU instead of through the HBA
- ▶ M.2:
  - x2 / x4 PCIe Gen 3, size 22x30, 22x42, 22x60, 22x80, or 22x110mm
  - Power less than 9 watts, unencapsulated, with no hot swap

No NVMe disks are supported for the Power IC922 server at the time of writing.

## 1.11 System ports

The rear of the Power IC922 server has a VGA port, a serial port (RS232), a BMC port, two USB 3.0 ports, and two 1 Gbps RJ45 ports. The front of the server has a USB 3.0 port. They are integrated into the system board. The server supports redundant power supplies.

Figure 1-20 shows the system ports in the rear view of the Power IC922 server.

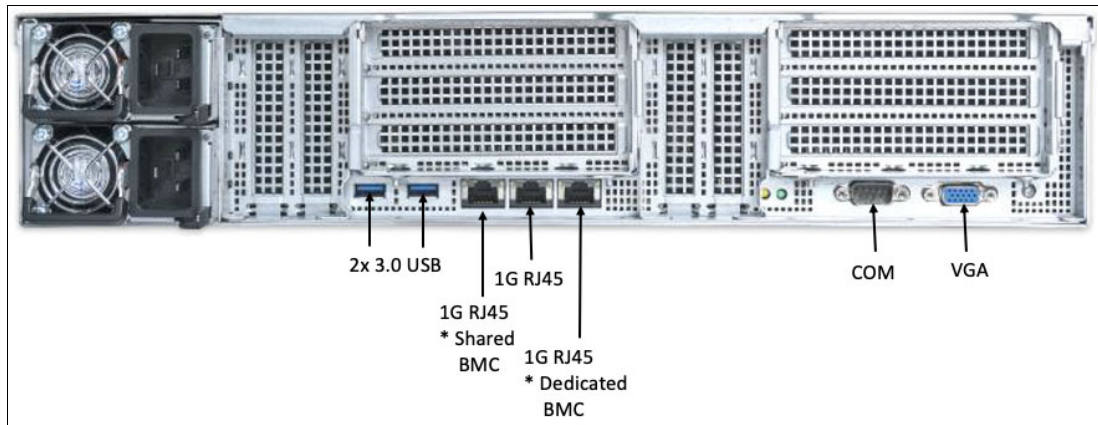


Figure 1-20 System ports in the rear view of the Power IC922 server

## 1.12 External I/O subsystems

The Power IC922 server does not support I/O drawers.

## 1.13 IBM Systems Storage

The IBM System Storage™ disk systems products and offerings provide storage solutions with superior value for all levels of business, from entry-level to high-end storage systems. For more information about the various offerings, see [IBM Storage](#).

The following section highlights a few of the offerings.

### **1.13.1 IBM Flash Storage**

The next generation of IBM Flash Storage delivers the extreme performance and efficiency that you need. It has a new pay-as-you-go option to reduce your costs and scale on demand. For more information about the hardware and software, see [IBM Flash Storage](#).

### **1.13.2 Software-defined storage**

Software-defined storage (SDS) manages data growth and enables multi-cloud flexibility by providing an agile, scalable, and operations-friendly infrastructure. For more information, see [Software-defined storage](#).

### **1.13.3 IBM Hybrid Storage**

Use IBM Hybrid Storage to optimize your mixture of storage media, including flash storage, to achieve the best balance of performance and economics. For more information, see [IBM Hybrid Storage](#).

### **1.13.4 IBM storage area network**

IBM SAN storage offers a comprehensive portfolio of Fibre Channel SAN switches that support your virtualization, cloud, and big data requirements. For more information, see [IBM SAN Storage](#).





# Systems management

The IBM Power System IC922 server is an excellent choice for clients that want to run their big data, Java, open source, and industry applications on a platform that is optimized for data and Linux.

This chapter identifies and clarifies the tools that are available for managing Linux on Power servers.

## 2.1 Service processor

The Power IC922 server among others uses as a service processor called the *baseboard management controller* (BMC) for system service management, monitoring, maintenance, and control. The BMC is a specialized service processor that monitors the physical state of the system by using *sensors*. The BMC also provides access to the system event log (SEL) files. A system administrator or service representative can communicate with the BMC through an independent connection.

The BMC is provided by the OpenBMC project as a part of the Linux Foundation.

There are several ways to work with the BMC, as described in the following sections.

**Note:** Do not work with the OpenBMC when the system is under heavy load.

### 2.1.1 Intelligent Platform Management Interface

The *Intelligent Platform Management Interface* (IPMI) is an open standard for monitoring, logging, recovery, inventory, and control of hardware that is implemented independently of the main processor, I/O, and the operating system (OS). It is the default console to use when you configure the server.

The **ipmitool** is a utility for managing and configuring devices that support IPMI. It provides a simple command-line interface (CLI) to the service processor. You can install the **ipmitool** from the Linux distribution packages in your workstation or another server (preferably on the same network as the installed server). For example, to do the installation in Red Hat, run the following command:

```
# yum install ipmitool
```

**Note:** There is also an **ipmitool** that is available for Microsoft Windows.

To connect to your system with IPMI, you must know the IP address of the server and have a valid password. To turn on the server with **ipmitool**, complete the following steps:

1. Open a terminal program.
2. Turn on your server by running the following command:  

```
# ipmitool -I lanplus -H fsp_ip_address -U <user> -P <password> power on
```
3. Activate your IPMI console by running the following command:  

```
# ipmitool -I lanplus -H fsp_ip_address -U <user> -P <password> sol activate
```

For more information about configuring Linux on a Linux on Power server, see [IBM Knowledge Center](#).

### 2.1.2 Petitboot bootloader

Petitboot is a kexec-based bootloader that can start an OS. After the system turns on, the Petitboot bootloader scans local boot devices and network interfaces to find boot options that are available to the system. Petitboot returns a list of boot options that are available to the system.

If you are using a static IP or if you did not provide boot arguments in your network boot server, you must provide the details to Petitboot. You can configure Petitboot to find your boot server by following the instructions that are found at [IBM Knowledge Center](#).

You can edit Petitboot configuration options, change the amount of time before Petitboot automatically starts, and so on, by following the instructions found at [IBM Knowledge Center](#).

After you start the Linux installer, the installer wizard walks you through the steps to set up disk options, your root password, time zones, and so on.

You can read more about the Petitboot bootloader program at [IBM Knowledge Center](#).

### 2.1.3 Configuring the network to the BMC

In this section, you can learn how to find the right network port for the BMC, how to set the initial password, and how to do an initial network configuration.

#### Initial password change

When the system is in factory default, the default password `OpenBmc` for root is invalidated for security reasons. You first must change or set the password by logging in to the OpenBMC GUI or SSH by using the `ipmitool` in a local session with a local keyboard and screen, and by using the REST API. You *cannot* use `ipmitool` remotely to change the password because the necessary password to enter the BMC is invalidated and a change password dialog is not available by using the remote `ipmitool`.

When using the GUI or SSH, a change password dialog appears.

In a local session, you can use the `ipmitool` to change the password. To change it, you need the ID for the user. For the root user, the ID is usually 1. To make sure that user root is ID 1, run the following command:

```
# ipmitool user list 1
```

**Note:** The 1 stands for the channel number. There are two channel numbers (1 and 2). Channel number 1 is used for the dedicated BMC port of the system (the right Ethernet port). Channel number 2 is used for the shared BMC port (the left Ethernet port). By differentiating 1 and 2, it is possible to define different access rights on the two ports. But the password is the same for both channels, so you do not need to specify it when changing the password.

To change the password, run the following command:

```
# ipmitool user set password <ID of the user> <password>
```

The requirement for a password is 8 - 20 characters, and the password is checked against `pam_cracklib`. Passwords must not be dictionary words, palindromes, and others. For example, "abcd1234" is not an allowed password.

For more information about allowed passwords, see the [Linux man page for pam\\_cracklib](#).

## Network ports for accessing the BMC interface

The Power IC922 server has three 1 GB network ports with RJ-45 connectors. Figure 1-16 on page 25 shows these ports on the back side of the system. To access the BMC, two ports can be used. The right port is the dedicated BMC port. The left port is a shared port that can be used to create a redundant connection to the BMC, but also as a network port for the OS. To make that possible, this port has two MAC addresses: one is available in the BMC environment, and one in the OS. The port in the middle is for the OS.

Table 2-1 gives an overview of the ports and their usage.

Table 2-1 Network ports and their usage

Port location	MAC example	Port name	Accessible in	Usage
Left	08:.....:92	eth1	BMC	Shared BMC port
Left	08:.....:93	eth0	OS	Network interface card (NIC) port 0
Middle	08:.....:94	eth1	OS	NIC port 1
Right	08:.....:91	eth0	BMC	Dedicated BMC port

## Initial configuration of the BMC network ports

There are two ways to configure initially the network ports to access the BMC:

- ▶ DHCP.

A system in factory default, both BMC network ports are configured with DHCP. When you plug in the network cable and your network provides a DHCP server, an IP address is assigned to the network port. When you can discover the IP address that was assigned, you can use that one for the initial connection to the BMC. For example, use the OpenBMC GUI to set the network parameters of the management ports. Section 2.1.5, “The OpenBMC GUI” on page 38 describes how to connect to the GUI.

**Note:** If the system is in factory default, the password for root is invalidated. You first must set the password. This action cannot be done by using `ipmi tool` remotely. Use the OpenBMC GUI, a local attached keyboard and screen, SSH, or the REST API to set the password.

- ▶ Attach a VGA monitor and keyboard.

If you do not have a DHCP server, the easiest way to configure the BMC network is to attach a local VGA monitor and a USB keyboard. When the system starts, it enters the Petitboot loader. From there, you can exit to a shell, as shown in Figure 2-1.

```

Petitboot (v1.11)                                     9183-22X
-----
System information
System configuration
System status log
Language
Rescan devices
Retrieve config from URL
Plugins (0)
*Exit to shell
  
```

Figure 2-1 The Petitboot loader



**Note:** It is also possible to use a console or a terminal program that is attached to the serial port to access the system monitor. If you want to use this method, try it at 115200 baud.

In the Petitboot loader, you can use the `ipmitool` command to configure the network as follows:

- To configure the *dedicated* management port with a static IP address, run the following commands:

```
# ipmitool lan set 2 ipsrc static
# ipmitool lan set 2 ipaddr <Your IP address for the BMC>
# ipmitool lan set 2 netmask <Your Subnet Mask>
# ipmitool lan set 2 defgw ipaddr <Your gateway server>
```

- To set the port back to DHCP, run the following command:

```
# ipmitool lan set 2 ipsrc dhcp
```

- To view the current configuration, run the following command:

```
# ipmitool lan print 2
```

- To configure the *shared* management port with a static IP address, run the following commands:

```
# ipmitool lan set 1 ipsrc static
# ipmitool lan set 1 ipaddr <Your IP address for the BMC>
# ipmitool lan set 1 netmask <Your Subnet Mask>
# ipmitool lan set 1 defgw ipaddr <Your gateway server>
```

- To set the port back to DHCP, run the following commands:

```
# ipmitool lan set 1 ipsrc dhcp
```

- To view the current configuration, run the following command:

```
# ipmitool lan print 1
```

## 2.1.4 Systems management by using the OpenBMC tool

The OpenBMC tool provides a communication method to the BMC by using a CLI. The OpenBMC tool can be used either from a remote system or from the host OS console window.

**Note:** The minimum required version for the OpenBMC tool is 1.17 (the recommended version is Version 1.18). The new version is also compatible with other IBM systems that support the OpenBMC tool.

You may download the OpenBMC tool from [Scale-out LC System Event Log Collection Tool](#).

To run the OpenBMC tool, you need the following prerequisites installed on the system:

- ▶ Python 3
- ▶ Python 3 requests

**Note:** When you install Python 3 and are looking for a Python 3 request, you can run the following command to install it:

```
# python -m pip install requests
```

To use the OpenBMC tool, enter the connection data and the credentials for the system and a command. The following examples show how to see the power status and to power on and off the system:

- ▶ To check the power status of the system, run the following command:  

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis power status
```
- ▶ To power on the system, run the following command:  

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis power on
```
- ▶ To power off the system normally, run the following command:  

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis power softoff
```
- ▶ To power off the system immediately, run the following command:  

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis power hardoff
```

Figure 2-2 shows an example of how to query the power status of the system.

```
# openbmctool.py -U root -P <secret> -H <system> chassis power status  
Attempting login...  
Chassis Power State: On  
Host Power State: Running  
BMC Power State: Ready  
User root has been logged out
```

Figure 2-2 OpenBMC tool example

For a complete list of commands, see the Managing BMC-based systems with OpenBMC document in [IBM Knowledge Center](#).

## 2.1.5 The OpenBMC GUI

The OpenBMC GUI provides feature-rich web access to the OpenBMC service processor. To access the OpenBMC GUI, open a supported web browser. In the address bar, enter the IP address of the BMC to which you want to connect. For example, you can use the format `https://<BMC IP>` in the address bar of the web browser.

### Notes:

- ▶ Only HTTPS connections are possible (HTTP does not work).
- ▶ The default user for the OpenBMC is root, and the default password is OpenBmc (0 = zero, not O).
- ▶ When you log in to the BMC of a system that is in the factory default state, the password is invalidated and you must change the password immediately.

After the login, you see a window similar to Figure 2-3.

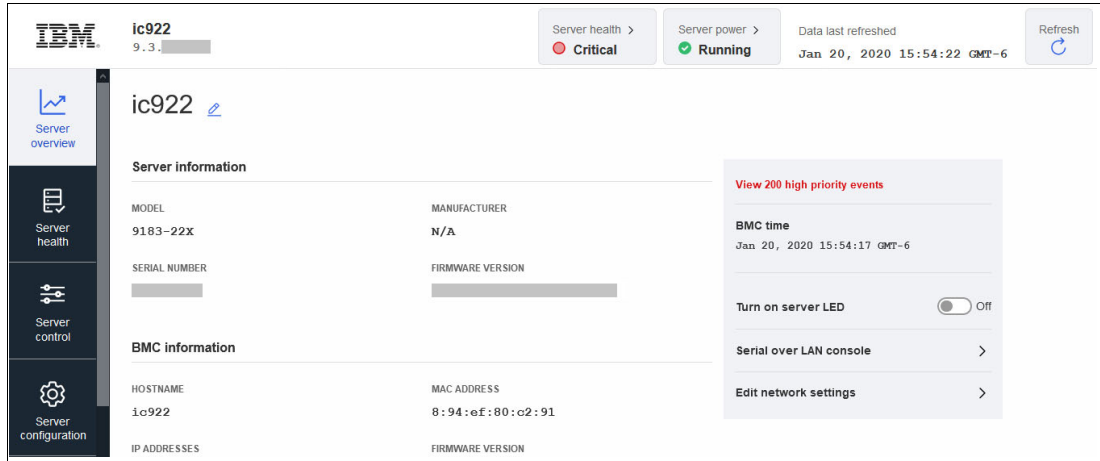


Figure 2-3 The OpenBMC GUI

The BMC GUI provides access to various service applications and available actions. The service interface enables client and support personnel to manage system resources, inventory, and service information in an efficient and effective way.

In the BMC GUI, the following tasks can be accomplished:

- ▶ Get the server health state and see the event logs.
- ▶ Get a detailed hardware inventory, including serial numbers of many components.
- ▶ Show sensor data, such as the temperature of many components, the RPM of the fans, or the total power consumption in watts.

Figure 2-4 shows a screen capture with some sensor data examples.

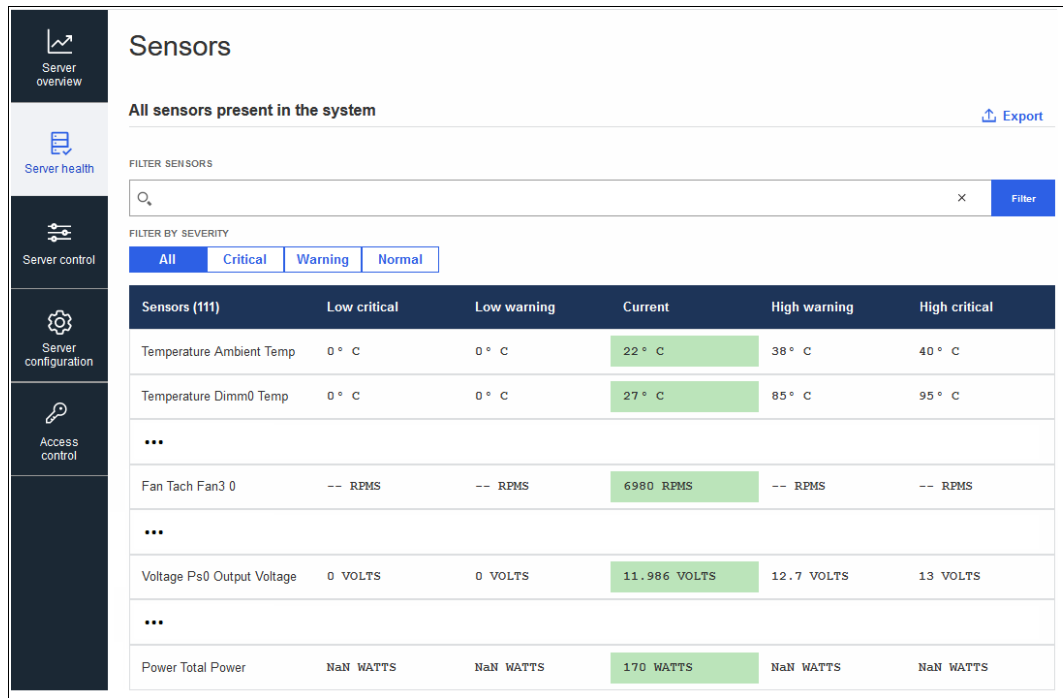


Figure 2-4 Sensor data examples in the OpenBMC

- ▶ Server control:
  - Server power operations
    - Shutdown or restart the server.
  - Manage power usage
    - The minimum allowed power capping for the Power IC922 server is 500 W, which cannot be maintained in all system configurations and environments. The system firmware attempts to maintain the power capping by reducing the processor core frequency down to the minimum (about 2.3 GHz), but the firmware might not maintain 500 W over all system configurations and environments. If the power capping cannot be maintained or processor core frequency and system performance is unacceptable, then the power cap should be raised.
  - Server LED
    - Turn on and turn off the server LED to identify the system.
  - Reboot BMC
    - A restart of the BMC does not affect the OS. You can restart the BMC even when the OS is running.
  - Serial over LAN (SOL) console
    - With a SOL console, when the OS is running, you can access the Linux even if no network is configured yet.
    - When no OS is running, you can access the Petitboot menu, and there you may use `ipmitool` to configure the system, for example, the network access to the BMC.
  - Virtual Media
    - Under Virtual Media, you can upload an ISO image that is presented to the system as a virtual DVD so that you can remote install the OS.
- ▶ Server configuration:
  - Configuration of the network settings of the BMC
    - To identify the right port, see “Network ports for accessing the BMC interface” on page 36.
  - SNMP settings
    - Here you can add an SNMP server to send SNMP traps to.
  - Managing the BMC and server firmware
  - Date and time settings
    - Here it is also possible to define a Network Time Protocol (NTP) server.
- ▶ Configure access control:
  - LDAP configuration
    - It is possible to manage users and roles within OpenLDAP or Active Directory.
  - Local user management
    - Here you can add more local users and their privileges or change the password of a user.
  - Managing SSL certificates

## 2.1.6 Connecting to the BMC by using SSH

The OpenBMC also supports SSH access. Use the IP or host name of the BMC and log in by using a user and password.

### Notes:

- ▶ The default user for the OpenBMC is root and the default password is 0penBmc (0 = zero, not O).
- ▶ When you log in to the BMC of a system that is in the factory default state, the password is invalidated, and you must change the password immediately.

The SSH access provides the following commands (among others):

### ▶ **obmcutil:**

- **obmcutil state**  
Shows you the state of the system, the BMC, and the OS.
- **obmcutil poweron**  
Powers on the system.
- **obmcutil poweroff**  
Powers off the system.

### ▶ **obmc-console-client:**

Opens a shell in the OS. When the system has no OS running, it opens a shell in the initial program load (IPL) dialog or Petitboot loader.

### Notes:

- ▶ Do not write to the persistent storage of the BMC.
- ▶ To close the shell, enter ~.

It is also possible to log in directly to a remote console (without using the **obmc-console-client** command) by using SSH and connecting to port 2200.

## 2.1.7 Using a Hardware Management Console for systems management

The Power IC922 server can also be attached to a Hardware Management Console (HMC). If the system is attached to an HMC, the following tasks can be accomplished:

- ▶ Power on / off the system.
- ▶ Start BMC System Management.
- ▶ Call home.

When the HMC is configured to receive SNMP traps and the Power IC922 server is configured to send SNMP traps, then the HMC can send events to IBM by using the Call Home feature of the HMC.

- ▶ Firmware updates.
- ▶ Activate and deactivate the identification LED.

For more information about attachment to an HMC, see “Managing BMC-based systems by using the HMC” in [IBM Knowledge Center](#).

## 2.1.8 Working with the BMC over the REST API

OpenBMC -based systems such as the Power IC922 server can be managed by using the Distributed Management Task Force, Inc. (DMTF) Redfish APIs. Redfish is a Representational State Transfer application programming interface (REST API) that is used for platform management and standardized by the Distributed Management Task Force, Inc. Redfish enables platform management tasks to be controlled by client scripts that are developed by using secure and modern programming paradigms.

The following example shows how to get the status of the identification LED, and how to activate and deactivate it by using the REST API of the system:

1. Log in to OpenBMC by running the following command:

```
# curl -c cjar -k -X POST -H "Content-Type: application/json" -d '{"data": ["root", "OpenBmc"]}' https://<BMC_IP>/login
```

2. Turn on the system by running the following command:

```
# curl -b cjar -k -H "Content-Type: application/json" -X PUT -d '{"data": 1}' https://<BMC_IP>/xyz/openbmc_project/led/groups/enclosure_identify/attr/Asserted
```

3. Turn off the system by running the following command:

```
# curl -b cjar -k -H "Content-Type: application/json" -X PUT -d '{"data": 0}' https://<BMC_IP>/xyz/openbmc_project/led/groups/enclosure_identify/attr/Asserted
```

4. Check the identify LED status by running the following command:

```
# curl -b cjar -k -H "Content-Type: application/json" -X GET -d '{"data": []}' https://<BMC_IP>/xyz/openbmc_project/led/physical/rear_id
```

For more information about the REST API of the Power IC922 server, see “Managing BMC-based systems with OpenBMC” in [IBM Knowledge Center](#).

For more information about DMTF Redfish APIs in general, see [Redfish DMTF](#).

## 2.2 Installing the operating system

There are several options to install the OS. All options start from the Petitboot loader. The installation ISO, media, or network boot loader must be recognized by the Petitboot loader. Possible installation methods are:

- ▶ Virtual DVD by using the OpenBMC
- ▶ USB stick with the installation content
- ▶ Locally attached USB DVD drive
- ▶ Network boot by using a Pre-Boot Execution Environment (PXE) server

## 2.2.1 Installing the operating system by using virtual media

To use the virtual DVD of the OpenBMC to install the OS, complete the following steps:

1. Download the Linux ISO image to your computer that you use to access the OpenBMC by using a web browser. Then, open the OpenBMC GUI and select **Server control** → **Virtual Media** to network-attach the ISO to the Power IC922 server, as shown in Figure 2-5. After clicking **Start**, the ISO is attached to the system.

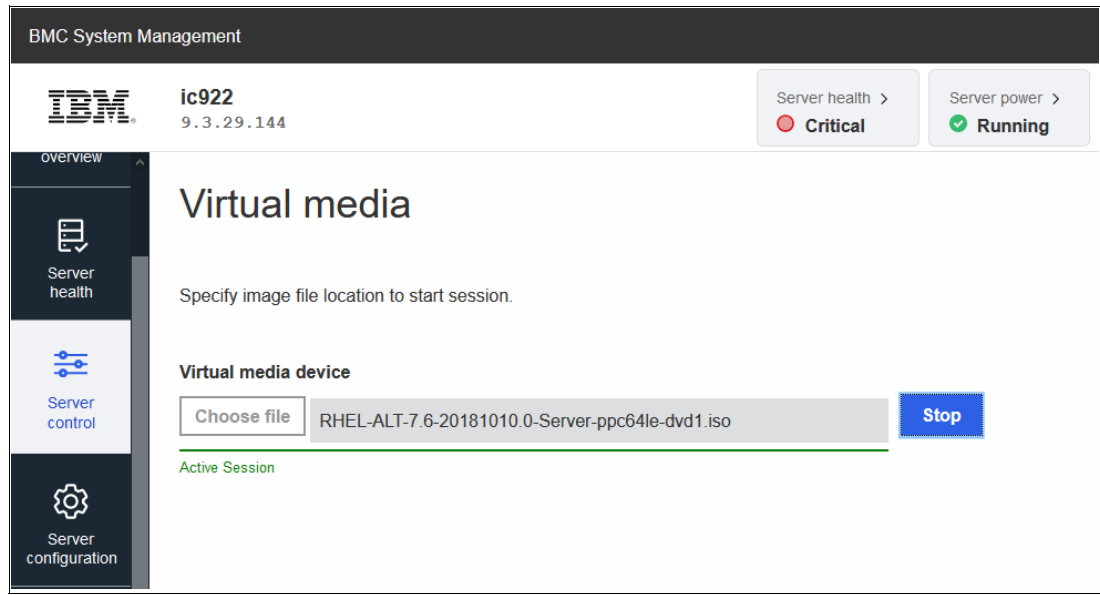


Figure 2-5 OpenBMC Virtual media

2. After starting the system, the installation media appears in Petitboot, and you can select the boot entry, but do not start the installation yet. If you do so, you cannot finish the installation and the system shows errors similar to the following string:

```
dracut-initqueue[3537]: Warning: dracut-initqueue timeout - starting timeout scripts
```

Before you continue, remember the UUID of the virtual media boot device. In the example that is shown in Figure 2-6, the UUID is 2018-10-10-22-13-55-00.

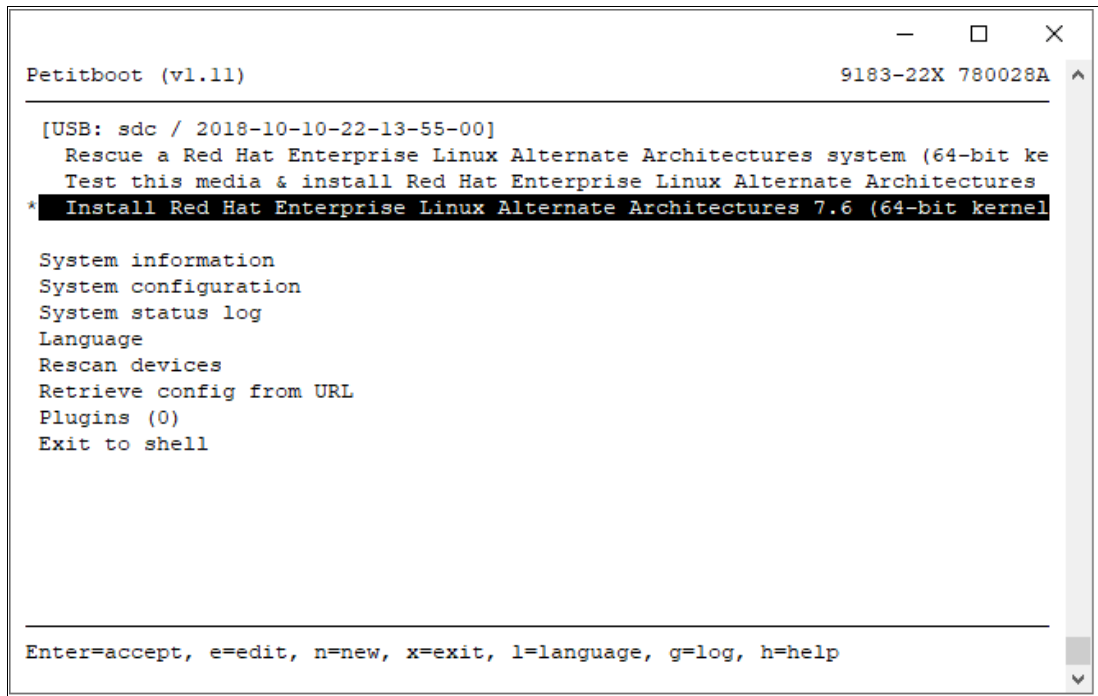


Figure 2-6 Red Hat installation from Petitboot

3. Before you boot the installation media, press e for edit when the Install Red Hat line is highlighted. Then, add the boot arguments as shown in Figure 2-7. Replace the UUID with the one from your virtual media device from step 2 on page 43.

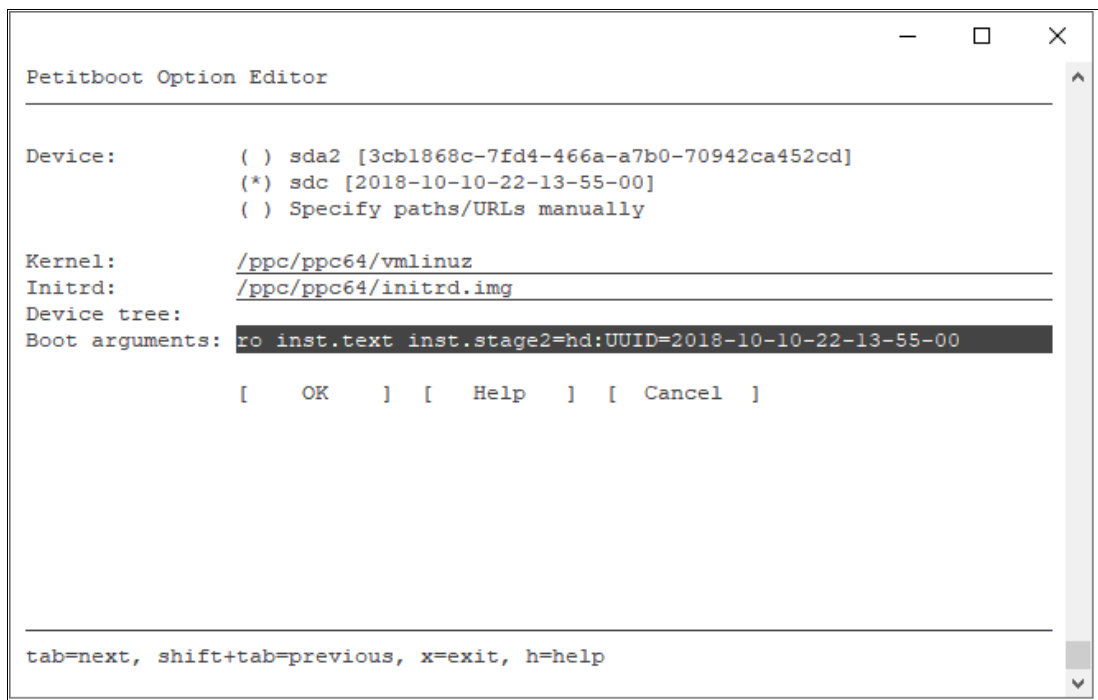


Figure 2-7 Boot arguments in Petitboot



4. Click OK. The boot menu opens again, as shown in Figure 2-6 on page 44. Start the installation by pressing Enter while the Install Red Hat line in Petitboot is highlighted.

After booting, the Anaconda installer appears, as shown in Figure 2-8, and you can now continue with defining the details of your installation.

```
Starting installer, one moment...
anaconda 21.48.22.147-1 for Red Hat Enterprise Linux 7.6 started.
* installation log files are stored in /tmp during the installation
* shell is available on TTY2
* when reporting a bug add logs from /tmp as separate text/plain attachments
00:08:43 Not asking for VNC because we don't have a network
=====
Installation
1) [x] Language settings                2) [!] Time settings
   (English (United States))           (Timezone is not set.)
3) [!] Installation source              4) [!] Software selection
   (Processing...)                     (Processing...)
5) [!] Installation Destination         6) [x] Kdump
   (No disks selected)                 (Kdump is enabled)
7) [ ] Network configuration            8) [!] Root password
   (Not connected)                     (Password is not set.)
9) [!] User creation
   (No user will be created)
Please make your choice from above ['q' to quit | 'b' to begin installation |
'r' to refresh]: █
[anaconda] 1:main* 2:shell 3:log 4:storage-lo> Switch tab: Alt+Tab | Help: F1
```

Figure 2-8 The Anaconda installer

## 2.2.2 Installing the operating system by using a USB stick

To use a USB stick for a Linux installation, complete the following steps:

1. Download the installation ISO image and copy it to a USB stick by running the following command (be sure to get the latest distro):  

```
# dd if=RHEL-ALT-7.6-20181010.0-Server-ppc64le-dvd1.iso of=/dev/usb/lp0 bs=32k
```
2. Plug the USB stick into any of the USB ports and start the system into the Petitboot loader. The USB stick appears in a way that is similar to what is shown in Figure 2-6 on page 44.
3. The steps for an installation from a USB stick are the same described in 2.2.1, “Installing the operating system by using virtual media” on page 43.

For more information about the installation of Linux for Power Systems, see [IBM Knowledge Center](#).





## Reliability, availability, and serviceability

The IBM Power System IC922 server brings POWER9 processor-based and memory reliability, availability, and serviceability (RAS) functions to a cloud data center, with open source Linux technology supplying the operating system (OS). The processor address paths and data paths, the control logic, state machines, and computational units are protected with parity or error correction code (ECC). The processor core soft errors or intermittent errors are recovered with processor instruction retry. Unrecoverable errors are reported as machine check (MC) errors, and errors that affect the integrity of data lead to a system checkstop.

## 3.1 Processor and cache reliability

The L1 data and instruction caches in each processor core are parity-protected. Data is stored through to L2 immediately. L1 caches have a retry capability for intermittent errors and a cache set delete mechanism for handling solid failures. The L2 and L3 caches in the POWER9 processor are protected with double-bit detect, single-bit correct ECC.

In addition, a threshold of correctable errors that is detected on cache lines can result in the data in the cache lines being purged and the cache lines removed from further access without requiring a restart. An uncorrectable error that is detected in these caches can trigger a purge and deletion of cache lines, which does not impact the current operation if the cache lines contained data that was unmodified from what was stored in system memory.

The memory subsystem has proactive memory scrubbing to help prevent the accumulation of multiple single-bit errors. The ECC scheme can correct the complete failure of any one memory module within an ECC word. After marking the module as unusable, the ECC logic can still correct single symbol (two adjacent bit) errors. An uncorrectable error of data of any layer of cache up to the main memory is marked to prevent usage of fault data. The processor's memory controller has retry capabilities for certain fetch and store faults.

### 3.1.1 L3 cache line delete

The L3 cache is protected by ECC and Special Uncorrectable Error (SUE) handling. The L3 cache also incorporates technology to handle memory cell errors through a special cache line delete algorithm.

During the central electronics complex initial program load (IPL), if a solid error is detected during L3 initialization, a full L3 cache line is deleted. During system run time, a correctable error is reported as a recoverable error to the service processor. If an individual cache line reaches its predictive error threshold, it is dynamically deleted.

The state of the L3 cache line deletion is maintained in a *deallocation record* and persists through system IPL, which ensures that cache lines *varied offline* by the server remain offline if the server restarts. Therefore, these *error-prone* lines cannot cause system operational problems. The server can dynamically delete up to several multiple cache lines. If this threshold is reached, the L3 is marked for persistent deconfiguration on subsequent system restarts until repaired.

### 3.1.2 Special Uncorrectable Error handling

The SUE handling prevents an uncorrectable error in memory or cache from immediately causing the system to stop. Rather, the system tags the data and determines whether it will ever be used again. If the error is irrelevant, it does not force a checkstop. If the data is used, termination may be limited to the program, kernel, or hypervisor owning the data, or a “freeze” occurs to the I/O adapters that are controlled by an I/O hub controller if data would be transferred to an I/O device.

### 3.1.3 Thermal management and current and voltage monitoring

The On Chip Controller (OCC) monitors various temperature sensors in the processor module, memory modules, and environmental temperature sensors, and steers the throttling of processor cores and memory channels if the temperature rises over thresholds that are defined by the design. The power supplies have their own independent thermal sensors and monitoring. Power supplies and voltage regulator modules (VRMs) monitor over-voltage, under-voltage, and over-current conditions. They report into a power good tree that is monitored by the service processor.

### 3.1.4 PCI extended error handling

PCI extended error handling (EEH)-enabled adapters respond to a special data packet that is generated from the affected PCI slot hardware by calling system firmware, which examines the affected bus, allows the device driver to reset it, and continues without a system restart. For Linux, EEH support extends to most of the frequently used devices, although some third-party PCI devices might not provide EEH support.

## 3.2 Serviceability

The server is designed for system installation and setup, feature installation and removal, proactive maintenance, and corrective repair that is performed by the client. Warranty Service Upgrades are offered for On Site Repair (OSR) by an IBM System Services Representative (IBM SSR) or authorized warranty service provider.

IBM Knowledge Center provides current documentation to service effectively the system:

- ▶ Installing and configuring, found in [IBM Knowledge Center](#).
- ▶ Removing and replacing parts, found in [IBM Knowledge Center](#).
- ▶ Troubleshooting, service, and support, found in [IBM Knowledge Center](#).
- ▶ Installing the Linux OS, found in [IBM Knowledge Center](#).

The documentation can also be downloaded as PDF, such as:

- ▶ [IBM Power System IC922 \(9183-22X\) Quick Install Guide](#)
- ▶ [Installing the System and Ordered Parts for the IBM Power System IC922 \(9183-@@@X\)](#)
- ▶ [Servicing the IBM Power System IC922 \(9183-22X\)](#)

For more PDFs about the Power IC922 server, see [IBM Knowledge Center](#).

### 3.2.1 Concurrent maintenance

The following components can be replaced without turning off the server:

- ▶ Hard disk drives (HDDs) and solid-state drives (SSDs)
- ▶ Redundant hot-plug power supplies

When replacing a power supply, the system continues to run at full performance. There is no performance degradation with only one running power supply.

- ▶ Redundant hot-plug cooling fans

All replacement parts in the system are customer-replaceable parts.

## 3.2.2 Service processor

The service processor supports Intelligent Platform Management Interface (IPMI 2.0), Data Center Management Interface (DCMI 1.5), and Simple Network Management Protocol (SNMP V2 and V3) for system monitoring and management. The service processor provides platform system functions such as power on/off, power sequencing, power fault monitoring, power reporting, fan/thermal control, fault monitoring, vital product data (VPD) inventory collection, Serial over LAN (SOL), Service Indicator LED management, code updating, and event reporting through system event logs (SELs).

All SELs can be retrieved either directly from the service processor by using the baseboard management controller (BMC) GUI, the IPMI tool, the OpenBMC tool, the REST API, or from the host OS (Linux). The service processor monitors the operation of the firmware during the boot process and also monitors the hypervisor for termination. A firmware code update is supported through the BMC GUI, the IPMI interface, and the OpenBMC tool. The firmware image can be updated or flashed regardless of its state.

For more information about how to work with the OpenBMC GUI, see 2.1.5, “The OpenBMC GUI” on page 38.

## 3.2.3 Getting SEL data by using the OpenBMC tool

The OpenBMC tool is a good way to list service event log data or collect service data. Here are a couple of example commands that you can use to work with SEL data:

- ▶ To list the SELs, run the following command:

```
# openbmctool -U <user> -P <password> -H <IP> sel print
```

- ▶ To collect service data, run the following command:

```
# openbmctool -U <user> -P <password> -H <IP> collect_service_data
```

On a Linux system, the data is stored under `/tmp/<IP>--<timestamp>`.

A complete list of commands for the OpenBMC tool can be found in the *Managing BMC-based systems with OpenBMC* document in [IBM Knowledge Center](#).

## 3.2.4 The system LEDs

The server contains a system identification LED button on the front and another LED on the rear side. The system identification LED can be turned on and off by pressing the system identification LED button on the front for at least 0.5 seconds. Another way to turn on or off the LED is to use the OpenBMC tool:

- ▶ Activate the blue system identify LED by running the following command:

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis identify on
```

- ▶ Deactivate the blue system identify LED by running the following command:

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis identify off
```

- ▶ Check the status of the blue system identify LED by running the following command:

```
# openbmctool -U <username> -P <password> -H <BMC IP address or BMC host name>  
chassis identify status
```

The system also has two red fault LEDs. One is at the front and one at the back.

Figure 3-1 shows the front LEDs and the System Identification LED button.

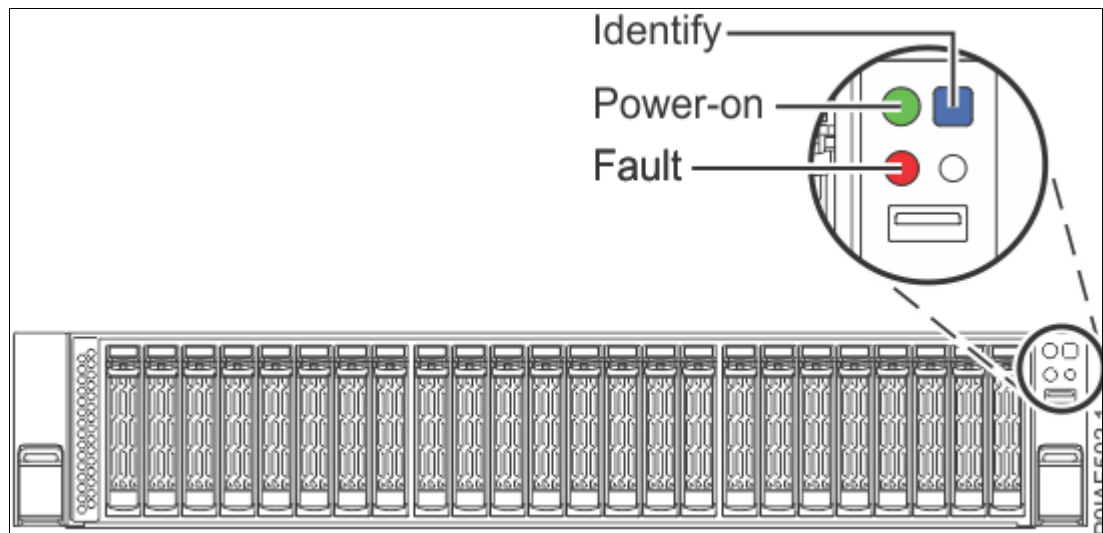


Figure 3-1 The Power IC922 server front LEDs

### 3.2.5 Factory reset

If the password to log in to the OpenBMC was lost, a factory reset of the system might be needed. To do so, boot into the local Petitboot shell (by using a monitor and a keyboard) and run the following command:

```
# ipmitool raw 0x3a 0x11
```

The factory reset function can take up to 15 minutes to complete.

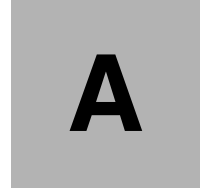
### 3.2.6 Error handling and reporting

If there is a system hardware failure or environmentally induced failure, the system error capture capability systematically analyzes the hardware error signature to determine the cause of failure. The processor and memory recoverable errors are handled through Processor Runtime Diagnostics (PRD) in the Open Power Abstraction Layer (OPAL), which generates a SEL. An extended SEL (eSEL) is associated with each SEL. It contains more First Failure Data Capture (FFDC) information for use by the support structure.

For system checkstop errors, the OCC collects Failure Information Register (FIR) data and saves it in nonvolatile memory. PRD analyzes the data upon restart and creates a SEL and eSEL. The host Linux OS can monitor the SELs on the service processor through the IPMI tool. Hardware and firmware failures are recorded in the SELs and can be retrieved through the IPMI interface. The system can report errors that are associated with Peripheral Component Interconnect Express (PCIe) adapters and devices through the host OS.







# Server racks and energy management

This appendix provides information about the racking options and energy management-related concepts that are available for the IBM Power System IC922 server.

## IBM server racks

The Power IC922 server mounts in 42U Slim Racks 7965-S42, 7014-T42, and 7965-94Y along with square hole industry-standard racks. These racks are built to the 19-inch EIA 310D standard.

**Order information:** The Power IC922 server cannot be integrated into these racks during the manufacturing process, and are not orderable together with servers. If the Power IC922 server and any of the supported IBM racks are ordered together, they are shipped at the same time in the same shipment, but in separate packing material. IBM does not offer integration of the server into the rack before shipping.

If a system is installed in a rack or cabinet that is not an IBM rack, ensure that the rack meets the requirements that are described in “Original equipment manufacturer racks” on page 60.

An IBM Business Partner can offer installation of these servers into a rack before delivery to a clients site, or at the client’s site.

**Responsibility:** The client is responsible for ensuring that the installation of the drawer in the preferred rack or cabinet results in a configuration that is stable, serviceable, safe, and compatible with the drawer requirements for power, cooling, cable management, weight, and rail security.

**Note:** Round hole interposers are automatically included in new systems that fit into the IBM branded T42 and 7965-S42 racks.

## IBM 42U SlimRack 7965-94Y

The 2.0-meter (79-inch) Model 7965-94Y is compatible with all Power Systems servers. It provides an excellent 19-inch rack enclosure for your data center. Its 600 mm (23.6 in.) width combined with its 1100 mm (43.3 in.) depth plus its 42 EIA enclosure capacity provides great footprint efficiency for your systems. It can be easily placed on standard 24-inch floor tiles.

The IBM 42U Slim Rack has a lockable perforated front steel door that provides ventilation, physical security, and visibility of indicator lights in the installed equipment within. In the rear, either a lockable perforated rear steel door (feature code (FC) EC02) or a lockable Rear Door Heat Exchanger (RDHX)(1164-95X) is used. Lockable optional side panels (FC EC03) increase the rack’s aesthetics, help control airflow through the rack, and provide physical security. Multiple 42U Slim Racks can be bolted together to create a rack suite (FC EC04).

Up to six optional 1U power distribution units (PDUs) can be placed vertically in the sides of the rack. More PDUs can be placed horizontally, but they each use 1U of space in this position.

**Note:** The 7965-94Y was withdrawn from marketing, but the Power IC922 server is also supported to be mounted in this type of rack.

## IBM 42U SlimRack 7965-S42

The 2.0-meter (79-inch) Model 7965-S42 is compatible with past and present Power Systems servers, and provides an excellent 19-inch rack enclosure for your data center. Its 600 mm (23.6 in.) width combined with its 1100 mm (43.3 in.) depth plus its 42 EIA enclosure capacity provides great footprint efficiency for your systems. It can be easily placed on standard 24-inch floor tiles.

Compared to the 7965-94Y Slim Rack, the Enterprise Slim Rack provides more strength and shipping and installation flexibility.

The 7965-S42 rack has space for up to four PDUs in side pockets. More PDUs beyond four are mounted horizontally and use 1U of rack space.

The Enterprise Slim Rack front door, which can be Basic Black/Flat (FC ECRM), High-End appearance (FC ECRF), or original equipment manufacturer (OEM) black (FC ECRE) has perforated steel, which provides ventilation, physical security, and visibility of indicator lights in the installed equipment within. It comes standard with a lock that is identical to the locks in the rear doors. The door (FC ECRG and FC ECRE only) can be hinged on either the left or right side.

## IBM 7014 Model T42 rack

The 2.0-meter (79.3-inch) Model T42 is compatible with past and present Power Systems servers. The features of the T42 rack are as follows:

- ▶ Has 42U (EIA units) of usable space.
- ▶ Has optional removable side panels.
- ▶ Has optional side-to-side mounting hardware for joining multiple racks.
- ▶ Has increased power distribution and weight capacity.
- ▶ Up to four PDUs can be mounted in the PDU bays (see Figure A-2 on page 58), but others can fit inside the rack. For more information, see “The AC power distribution unit and rack content” on page 57.
- ▶ Ruggedized Rack Feature

For enhanced rigidity and stability of the rack, the optional Ruggedized Rack Feature (FC 6080) provides more hardware that reinforces the rack and anchors it to the floor. This hardware is designed primarily for use in locations where earthquakes are a concern. The feature includes a large steel brace or truss that bolts into the rear of the rack.

It is hinged on the left side so it can swing out of the way for easy access to the rack drawers when necessary. The Ruggedized Rack Feature also includes hardware for bolting the rack to a concrete floor or a similar surface, and bolt-in steel filler panels for any unoccupied spaces in the rack.

- ▶ Weights are as follows:
  - T42 base empty rack: 261 kg (575 lb)
  - T42 full rack: 930 kg (2045 lb)

Some of the available door options for the T42 rack are shown in Figure A-1.

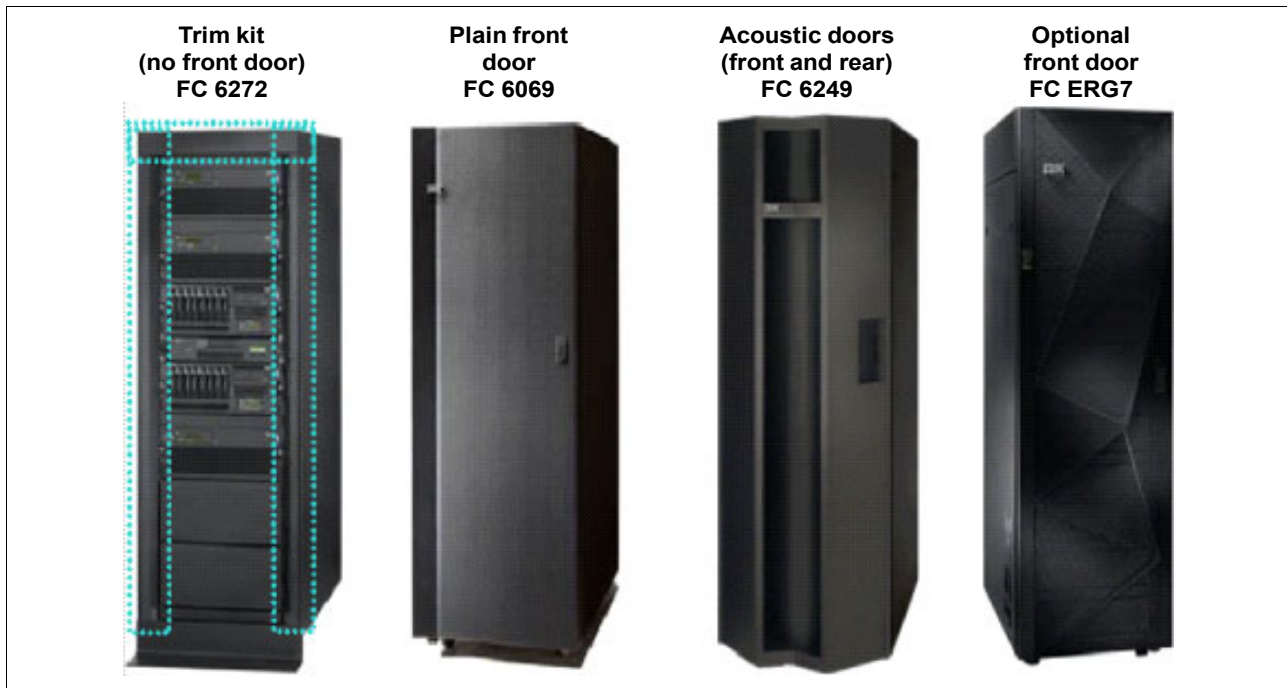


Figure A-1 Door options for the T42 rack

The door options are explained in the following list:

- ▶ The 2.0 m Rack Trim Kit (FC 6272) is used if no front door is used in the rack.
- ▶ The front door for a 2.0 m Rack (FC 6069) is made of steel, with a perforated flat front surface. The perforation pattern extends from the bottom to the top of the door to enhance ventilation and provide some visibility into the rack. This door is non-acoustic and has a depth of about 25 mm (1 in.).
- ▶ The 2.0 m Rack Acoustic Door (FC 6249) consists of a front door and a rear door to reduce noise by approximately 6 dB(A). It has a depth of approximately 191 mm (7.5 in.).
- ▶ FC ERG7 provides an attractive black full height rack door. The door is steel, with a perforated flat front surface. The perforation pattern extends from the bottom to the top of the door to enhance ventilation and provide some visibility into the rack. The non-acoustic door has a depth of about 134 mm (5.3 in.).

### Rear Door Heat Exchanger

To lead away more heat, a special door that is named the RDHX (FC 6858) is available. This door replaces the standard rear door on the rack. Copper tubes that are attached to the rear door circulate chilled water that is provided by the customer. The chilled water removes heat from the exhaust air being blown through the servers and attachments that are mounted in the rack. With industry-standard quick couplings, the water lines in the door attach to the customer-supplied secondary water loop.

For more information about planning for the installation of the RDHX, see [IBM Knowledge Center](#).

## The AC power distribution unit and rack content

Using IBM PDU features (FC 7188, FC 7109, and FC 7196) reduces the number of Power IC922 servers and other equipment that can be held most efficiently in a rack. The high-function PDUs provide more electrical power per PDU and offer better “PDU footprint” efficiency. In addition, they are intelligent PDUs that provide insight into actual power usage by receptacle and remote power on/off capability for easier support by individual receptacle. The new PDUs can be ordered as FC EPTJ, FC EPTL, FC EPTN, and FC EPTQ.

IBM Manufacturing integrates only the newer PDUs with the Power IC922 server. IBM Manufacturing does not support integrating earlier PDUs, such as FC 7188, FC 7109, or FC 7196 because these PDUs do not offer C19 / C20 connectors. Clients can choose to use older IBM PDUs in their racks, but must install those earlier PDUs at their site.

The high-function PDU feature codes are shown in Table A-1.

Table A-1 Available high-function PDUs

PDUs	Feature code for 1-phase or 3-phase depending on country wiring standards	Feature code for 3-phase 208 V depending on country wiring standards
Nine C19 receptacles <sup>a</sup>	EPTJ	EPTL
Twelve C13 receptacles	EPTN	EPTQ

a. The Power IC922 server has an AC power supply with a C19 / C20 connector.

**Important:** The Power IC922 server takes IEC 60320 C19 / C20 mains power and not C13. Ensure that the correct power cords and PDUs are ordered or available in the rack.

In addition, the following high-function PDUs were announced in October 2019:

► High Function 9xC19 PDU plus (FC ECJJ)

This item is an intelligent, switched 200 - 240 V AC PDU plus with nine C19 receptacles on the front of the PDU. The PDU is mounted on the rear of the rack so that the nine C19 receptacles are easily accessible. For comparison, this PDU is most similar to the earlier generation FC EPTJ PDU.

► High Function 9xC19 PDU plus 3-Phase (FC ECJL)

This item is an intelligent, switched 208 V 3-phase AC PDU plus with nine C19 receptacles on the front of the PDU. The PDU is mounted on the rear of the rack so that the nine C19 receptacles are easily accessible. For comparison, this PDU is most similar to the earlier generation FC EPTL PDU.

- ▶ High Function 12x C13 PDU plus (FC ECJN)  
This item is an intelligent, switched 200 - 240 V AC PDU plus with 12 C13 receptacles on the front of the PDU. The PDU is mounted on the rear of the rack so that the 12 C13 receptacles are easily accessible. For comparison, this PDU is most similar to the earlier generation FC EPTN PDU.
- ▶ High Function 12x C13 PDU plus 3-Phase (FC ECJQ)  
This item is an intelligent, switched 208 V 3-phase AC PDU plus with 12 C13 receptacles on the front of the PDU. The PDU is mounted on the rear of the rack so that the 12 C13 receptacles are easily accessible. For comparison, this PDU is most similar to the earlier generation FC EPTQ PDU.

Table A-2 lists the feature codes for the high-function PDUs that were announced in October 2019.

Table A-2 High-function PDUs that are available after October 2019

PDUs	Feature code for 1-phase or 3-phase depending on country wiring standards	Feature code for 3-phase 208 V depending on country wiring standards
Nine C19 receptacles <sup>a</sup>	ECJJ	ECJL
Twelve C13 receptacles	ECJN	ECJQ

a. The Power IC922 server has an AC power supply with a C19 / C20 connector.

Four PDUs can be mounted vertically in the back of the S42 and T42 racks. Figure A-2 shows the placement of the four vertically mounted PDUs. In the rear of the rack, two more PDUs can be installed horizontally in the T00 rack and three in the S42 and T42 rack. The four vertical mounting locations are filled first in the S42 and T42 racks.

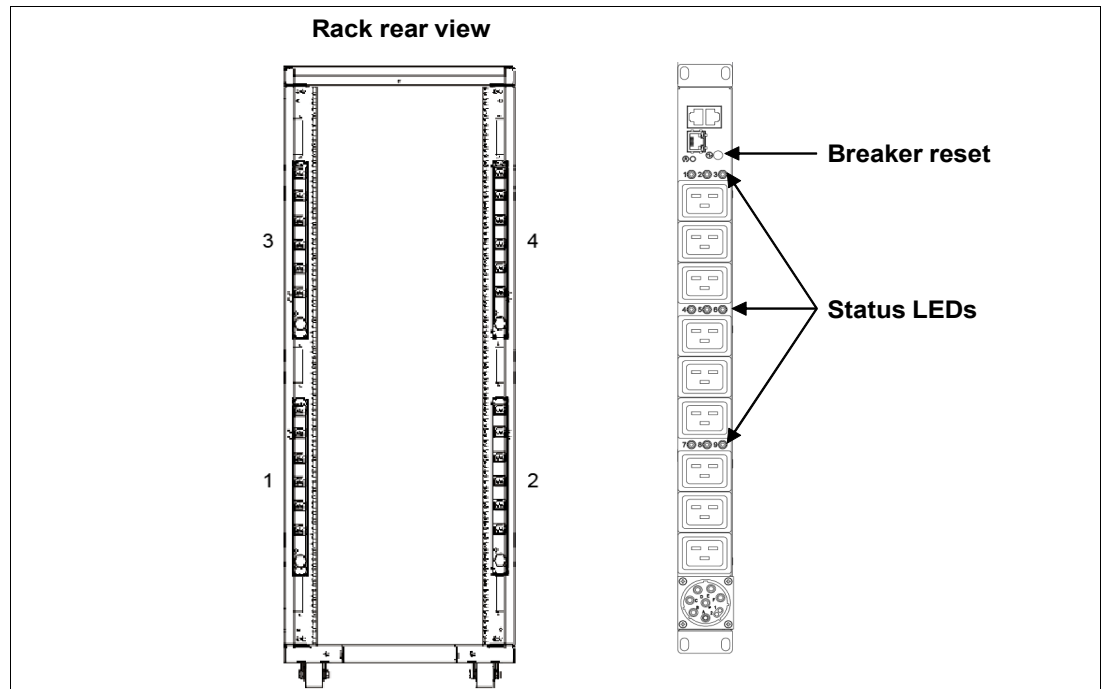


Figure A-2 Power distribution unit placement and view

Mounting PDUs horizontally uses 1U per PDU and reduces the space that is available for other racked components. When mounting PDUs horizontally, the preferred approach is to use fillers in the EIA units that are occupied by these PDUs to facilitate proper air-flow and ventilation in the rack.

The PDU receives power through a UTG0247 power-line connector. Each PDU requires one PDU-to-wall power cord. Various power cord features are available for various countries and applications by varying the PDU-to-wall power cord, which must be ordered separately. Each power cord provides the unique design characteristics for the specific power requirements. To match new power requirements and save previous investments, these power cords can be requested with an initial order of the rack or with a later upgrade of the rack features.

Table A-3 shows the available wall power cord options for the PDU and intelligent power distribution unit (iPDU) features, which must be ordered separately.

*Table A-3 Wall power cord options for the power distribution unit and iPDU features*

Feature code	Wall plug	Rated voltage (V AC)	Phase	Rated amperage	Geography
6653	IEC 309, 3P+N+G, 16 A	230	3	16 amps/phase	Internationally available
6489	IEC309 3P+N+G, 32 A	230	3	32 amps/phase	EMEA
6654	NEMA L6-30	200 - 208, 240	1	24 amps	US, Canada, Latin America, and Japan
6655	RS 3750DP (watertight)	200 - 208, 240	1	24 amps	US, Canada, Latin America, and Japan
6656	IEC 309, P+N+G, 32 A	230	1	24 amps	EMEA
6657	PDL	230 - 240	1	32 amps	Australia and New Zealand
6658	Korean plug	220	1	30 amps	North and South Korea
6492	IEC 309, 2P+G, 60 A	200 - 208, 240	1	48 amps	US, Canada, Latin America, and Japan
6491	IEC 309, P+N+G, 63 A	230	1	63 amps	EMEA
6667	PDL, 3P+N+G	230 - 240	1	32 amps	Australia and New Zealand
ECJ5	IEC 309, 3P+G	200 - 240	3	24 amps	United States, Canada, Latin America, Japan, and Taiwan
ECJ7	IEC 309, 3P+G	200 - 240	3	48 amps	United States, Canada, Latin America, Japan, and Taiwan

**Notes:** Ensure that the appropriate power cord feature is configured to support the power that is being supplied. Based on the power cord that is used, the PDU can supply 4.8 - 19.2 kVA. The power of all the drawers that are plugged into the PDU must not exceed the power cord limitation.

The Universal PDUs are compatible with previous models.

To better enable electrical redundancy, each server has two power supplies that must be connected to separate PDUs, which are not included in the base order.

For maximum availability, a preferred approach is to connect power cords from the same system to two separate PDUs in the rack, and to connect each PDU to independent power sources.

For detailed power requirements and power cord details about the 7014 and 7965-94Y racks, see [IBM Knowledge Center](#).

## Rack-mounting rules

Consider the following primary rules when you mount the system into a rack:

- ▶ The system can be placed at any location in the rack. For rack stability, start filling a rack from the bottom.
- ▶ Any remaining space in the rack can be used to install other systems or peripheral devices if the maximum permissible weight of the rack is not exceeded and the installation rules for these devices are followed.
- ▶ Before placing the system into the service position, be sure to follow the rack manufacturer's safety instructions regarding rack stability.

## Original equipment manufacturer racks

The system can be installed in a suitable square-hole OEM rack if that the rack conforms to the EIA-310-D standard for 19-inch racks. The pins of the rack mounting rails fit into both round and square holes. This standard is published by the Electrical Industries Alliance.

For more information, see [IBM Knowledge Center](#).

## Energy consumption estimation

For Power Systems servers, various energy-related values are important, such as maximum power consumption and power source loading values. These values are important for site planning. For more information, see [IBM Knowledge Center](#).



# Related publications

The publications that are listed in this section are considered suitable for a more detailed description of the topics that are covered in this paper.

## IBM Redbooks

The following IBM Redbooks publications provide more information about the topics in this document. Some publications that are referenced in this list might be available in softcopy only.

- ▶ *IBM PowerAI: Deep Learning Unleashed on IBM Power Systems Servers*, SG24-8409
- ▶ *Building a SAN-less Private Cloud with IBM PowerVM and IBM PowerVC*, REDP-5455  
*IBM Power System AC922 Technical Overview and Introduction* REDP-5494
- ▶ *IBM Power System E950: Technical Overview and Introduction*, REDP-5509
- ▶ *IBM Power System E980: Technical Overview and Introduction*, REDP-5510
- ▶ *IBM Power System L922 Technical Overview and Introduction*, REDP-5496
- ▶ *IBM Power Systems H922 and H924 Technical Overview and Introduction*, REDP-5498
- ▶ *IBM Power Systems LC921 and LC922: Technical Overview and Introduction*, REDP-5495
- ▶ *IBM Power Systems S922, S914, and S924 Technical Overview and Introduction*, REDP-5497
- ▶ *Networking Design for HPC and AI on IBM Power Systems*, REDP-5478

You can search for, view, download, or order these documents and other Redbooks publications, Redpapers, web docs, drafts, and additional materials, at the following website:

[ibm.com/redbooks](http://ibm.com/redbooks)

## Online resources

These websites are also relevant as further information sources:

- ▶ Distributed Management Task Force, Inc. (DMTF) Redfish APIs  
<http://www.dmtf.org/standards/redfish>
- ▶ Hardware Management Console (HMC) attachment  
[https://www.ibm.com/support/knowledgecenter/POWER9/p9hdx/9183\\_22x\\_pdf\\_files.htm](https://www.ibm.com/support/knowledgecenter/POWER9/p9hdx/9183_22x_pdf_files.htm)
- ▶ IBM 7014 Model T42 and IBM 42U SlimRack 7965-94Y racks: Power requirements and power cord details  
[https://www.ibm.com/support/knowledgecenter/POWER9/p9ia4/p9ia4\\_op\\_pdupowercords.htm](https://www.ibm.com/support/knowledgecenter/POWER9/p9ia4/p9ia4_op_pdupowercords.htm)
- ▶ IBM Fix Central  
<http://www.ibm.com/support/fixcentral/>

- ▶ IBM POWER processor family  
<https://www.ibm.com/systems/power/openpower/>
- ▶ IBM Power System IC922 server: Installing and configuring  
[https://www.ibm.com/support/knowledgecenter/POWER9/p9iaf/p9iaf\\_cif\\_9183\\_22x\\_kickoff.htm](https://www.ibm.com/support/knowledgecenter/POWER9/p9iaf/p9iaf_cif_9183_22x_kickoff.htm)
- ▶ IBM Power System IC922 server: Installing the Linux operating system (OS)  
[https://www.ibm.com/support/knowledgecenter/POWER9/p9hdx/p9hdx\\_installinux\\_9183\\_22x.htm](https://www.ibm.com/support/knowledgecenter/POWER9/p9hdx/p9hdx_installinux_9183_22x.htm)
- ▶ IBM Power System IC922 server: Removing and replacing parts  
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