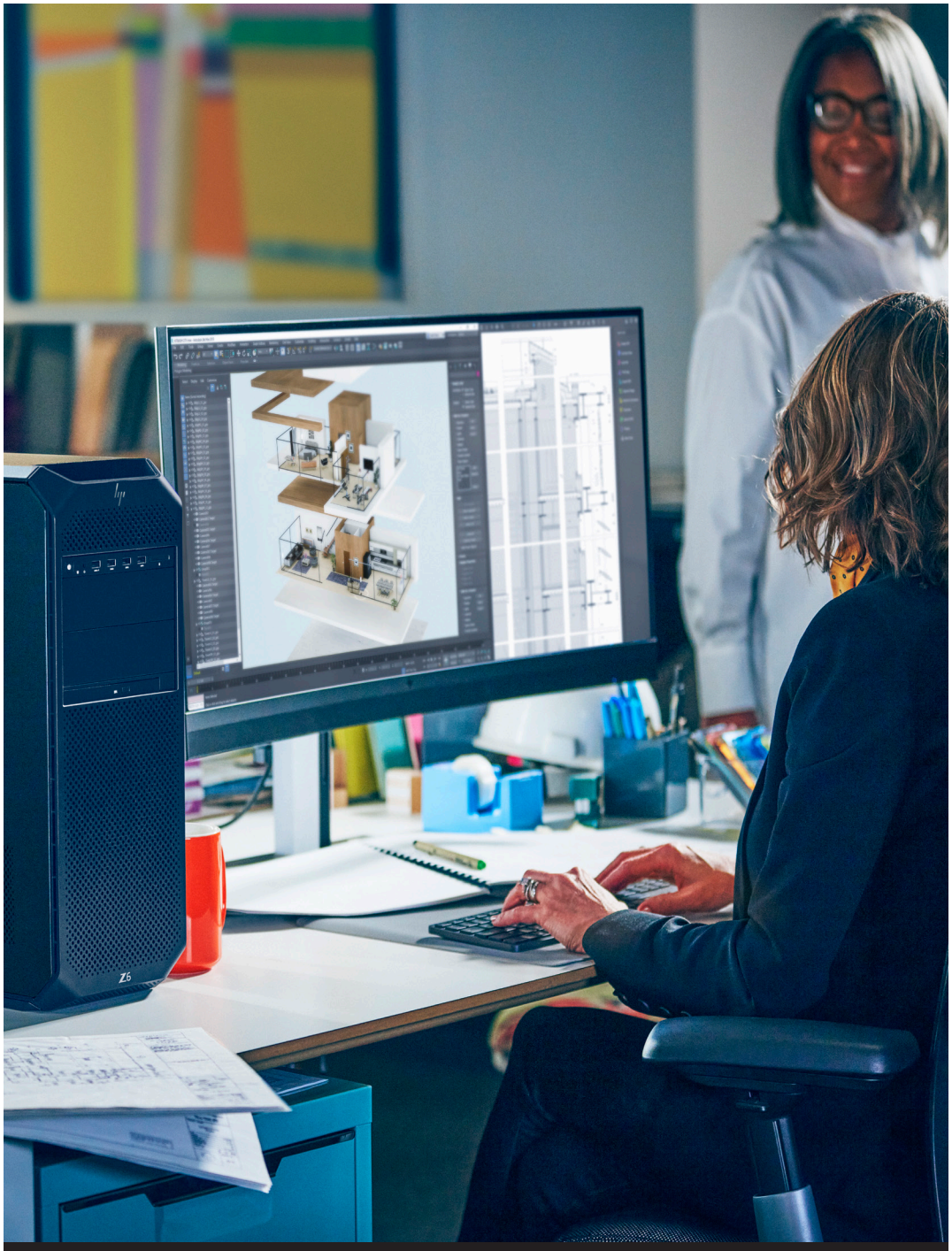
Technical White Paper

Contents & navigation



HP Z6 G5 Workstation Architecture

Technical White Paper

Contents & navigation

Introduction

The HP Z6 G5 is the successor to the HP Z6 G4 workstation. Its architecture introduces several improved functionalities and technologies including the latest Intel® Xeon W-3500 processors, DDR5 memory architecture, PCIe Gen 5 technology, integrated Wi-Fi®, front removable hot-swappable NVMe storage, improved thermal management and increased performance.

System Highlights

Extreme Workstation Performance

Z by HP innovations start with the customer to deliver the performance benefits needed whether it's importing and working with large models and assemblies, running complex simulations, or training complex deep learning and machine learning models faster. The HP Z6 G5 accelerates graphics-intensive workflows with up to 3x NVIDIA 6000-class GPUs based on the increased PCIe expandability of the latest Intel® Xeon® W-3500 processor architecture. With up to 36 processing cores, three high-end double-wide graphics cards, and 1TB of DDR5 memory, the Z6 G5 delivers significant performance for users demanding a machine that scales with their increased model and dataset complexity.

HP Z6 G5 product benefits include:

1. **Remarkable performance. Whisper-quiet acoustics.**
   Tackle graphics-intensive workflows with up to 3 high-end GPUs[1], an Intel® Xeon® W CPU with up to 36 cores[2], and 1 TB DDR5 RAM[3]—all while running whisper quiet. With a world-class acoustic design, push your system to the max without disruptive noise.

2. **Upgrade. Expand. Evolve.**
   Need to upgrade your device? Go for it. Easily expand and add components as your work evolves with room for up to 3 high-end graphics cards[4], 1 TB memory, 88 TB storage, 4 front accessible NVMe bays, 6 PCIe slots (up to Gen 5), and tool-less access.[5]

3. **Comprehensive security. Reliability You Can Trust.** Get peace of mind with a desktop workstation that's built to endure. The Z6 undergoes 360K hours of rigorous testing, MIL-STD testing[6], and is certified for pro apps. With HP Wolf Security for Business[7], it's protected below, in and above the OS.

4. **Maximize your IT lifecycle.**
   Designed for simpler IT management, the Z6 is built for longevity with a 3-year lifecycle—longer than entry workstations. Plan for the future and avoid re-qualifying devices every year, saving you serious time and money.

Technical White Paper

Contents & navigation

HP and Sustainability

HP continues to be a dedicated player in the world of technology and sustainability* in order to help protect our shared future. Sustainably built, this product contains 40% recycled plastics** and is EPEAT Gold and TCOv9 Certified. Regarding packaging, the outer box and fiber cushions are 100% sustainably sourced.*** The production of this workstation prevented materials from ending up in the ocean or a landfill, as its fans contain ocean-bound plastic**** and all G5 products contain 10% post-industrial recycled metal. HP has also taken steps to minimize the amount of polyvinyl chloride in our products, as it is now only present in external power cables and keyboard/mouse cables.

*Based on US EPEAT® registration according to IEEE 1680.1-2018 EPEAT®. EPEAT® status varies by country. Visit **www.epeat.net** for more information.

**Recycled plastic content percentage is based on the definition set in the IEEE 1680.1-2018 EPEAT standard.

***Fiber cushions made from 100% recycled wood fiber and organic material. Any plastic cushions are made from >90% recycled plastic.

****Fans contain up to 25% ocean-bound plastic by weight.

Latest Technologies

The Latest Intel® Processor

The HP Z6 G5 Workstation uses the Intel® W790 Chipset to support the latest Intel® Xeon® W family processors up to 36 cores and up to 310W. The Intel® Xeon® W family processors utilize two integrated memory controllers, each supporting two DDR5 channels that increase the memory capacity and bandwidth. The architecture supports 112 PCIe lanes and includes PCIe Gen5 technology providing a substantial I/O performance increase over the previous generation.

Next Generation Intel® Active Management Technology

New features for Intel® AMT 16.x include:

- Upgrade to Boot Guard Gen 1.1.
- PCHC Firmware Component.
- Intel® Total Memory Encryption (Intel® TME)

DDR5 Memory Technology

The HP Z6 G5 Workstation introduces support for DDR5 Registered DIMMs up to 4800MHz at 1 DIMM per channel and up to 4400MHz at 2 DIMMs per channel. The speed that the memory runs is determined by the processors and is limited to 4800MHz for the Intel® Xeon® W processor generation. The HP Z6 G5 supports up to 1TB* of memory. NUMA and Non-NUMA modes are supported, and dynamic power saving is enabled. ECC memory is supported.

*May not be available at launch

USB 3.2 Gen2x2 Type-C

The HP Z6 G5 configured with the Premium Front I/O module provides two USB 3.2 Gen2x2 Type-C® ports in addition to two USB3.1 Gen1 Type-A ports. The Type-C® ports each deliver up to 15W of power (3A @ 5V) when the system is running. More information on USB Technology and Performance measurements can be found in the “Resources, contacts, or additional links” section below.

Flex-IO Interface

The HP Z6 G5 adds a rear Flex-IO interface which grants customers the ability to customize their rear I/O ports without using additional PCIe slots or USB ports with external adapters. See the external I/O section for more details.

Wi-Fi 6[8] and Wi-Fi 6E[9]

The HP Z6 G5 offers flexible Wi-Fi connectivity with an option for Wi-Fi 6 via Flex-IO module and an integrated antenna, or Wi-Fi 6E via PCIe slot module and an external antenna.

I/O and Storage

Internal I/O

The HP Z6 G5 provides a total of six high-performance Graphics and I/O slots including one PCIe5 x16, two PCIe4 x4 dedicated electrical slots. An additional two PCIe4 x4 buses feed the two on-board M.2 slots. The Z6 G5 also supports an optional Front Removable NVME storage and has four PCIe4 x4 buses to support four Front removeable M.2.

The HP Z6 G4 provides an internal 1-port USB3.0 header, an internal 2-port USB 2.0 header and an internal 1-port USB 2.0 header.

External I/O

On the front I/O area, the HP Z6 G5 can be configured two ways.

- The Entry Front I/O option provides 4 USB 3.1 Gen1 Type-A ports (the left-most supports battery charging), combo headset/microphone jack, and the option for an SD card reader.
- The Premium Front I/O option provides 2 USB 3.2 Gen2x2 Type-C ports, 2 USB 3.1 Gen1 Type-A ports (the left-most supports battery charging), combo headset/microphone jack, and the option for an SD card reader.

In the rear I/O area, the HP Z6 G5 provides 4 USB 3.1 Gen1 ports via a hub and 2 direct USB3.2 Gen1 ports, 2 gigabit Ethernet LAN ports, audio Line-In, audio Line-Out and PS/2 ports.

The HP Z6 G5 rear I/O area also provides a Flex-IO module connector which can support up to one of the following (optional) Flex-IO Modules: Serial Port v.3, Dual USB-A 3.2 Gen1, USB-C 3.2 Gen2, 10GbE RJ45 single port, 2.5GbE RJ45 LAN single port, 1GbE LC Fiber single port, 1GbE RJ45 single port, and a WiFi6 + BT5.2 WLAN w/ INTAnt.

Additional rear I/O ports can be added via PCIe add-in cards.

Storage

The HP Z6 G5 supports five 6Gb/s SATA ports on the Intel® W790 Alder Lake-S chipset's SATA controller. The SATA controller operates in AHCI mode or RAID mode and supports RAID modes 0, 1, 5 and 10.

A header is provided for installation of an Intel® VROC Upgrade Module to enable NVMe RAID.

Graphics

The HP Z6 G5, depending on system and power supply configurations, can support up to six 75W cards, or up to three 300W cards. Confirm power supply and configuration support using configurator on hp.com.
If a graphics card is not configured in this system at the time of purchase, it is highly recommended that the following fan AVs be added to the configuration in order to ensure full performance and avoid POST errors when a graphics card is added later: 57F11AV (HP Z6 G5 PCIe Retainer with Fans) and 57D40AV (HP Z6 G5 Fan and Front Card Guide Kit). Note that the HP Z6 G5 Fan and Front Card Guide Kit is required in order to use the HP Z6 G5 PCIe Retainer with Fans. These fans can also be purchased aftermarket. Please consult the platform QuickSpecs for more information."

Technical White Paper

Contents & navigation

Other Features

Three PSU options are available with output wattages of up to 1125W at 115V/60 Hz and 1450W at 230V/50Hz. Rear panel power on/off switch and LED for easier rack maintenance

- ENERGY STAR® qualified configurations, China's Energy Conservation Program (CECP) configurations, European Union's ErP LOT6 2013 power limit of 0.5W in Max Power Savings off mode.
- Intel® vPro™ manageability with support both for DASH and Intel® AMT (Advanced Manageability Technology) on all the Xeon® processors. IT managers have increased flexibility in optimizing their Enterprise manageability strategy across HP's Commercial Laptops, Desktops and Workstations.

HP Z6 G5 vs HP Z6 G4 Feature Comparison

Figure 1: Z6 G5 vs Z6 G4 Feature comparison

	HP Z6 G5	HP Z6 G4
Processors	**Intel® Xeon W Processor 5th Generation up to 310W**	**Intel® Xeon Scalable Processor**
New Instruction Set	**AMX**	**AVX-512**
Memory Technology	**DDR5: Registered DIMMs up to 4800MHz**	**DDR4: Registered and LR-DIMMs up to 2933MHz**
PCIe Support	**Up to PCIe Gen 5**	**PCIe Gen 3**
USB Enhancement	**Two USB 3.2 Gen2x2 Type-C® ports (Premium Front I/O option)**	**Two USB 3.1 Gen2 Type-C® ports (Premium Front I/O option)**
USB SuperSpeed Ports	**6 Rear, 4 Front (Entry Front I/O) or 2 Front (Premium Front I/O), 1 Internal**	**6 Rear, 4 Front (Entry Front I/O) or 2 Front (Premium Front I/O), 1 Internal**
Manageability	**Intel® ME16, Intel® vPro™**	**Intel® ME11/AMT11, Intel® vPro™**
Operating System	**Windows 11 Pro for Workstations 64-bit Windows 10 Pro for Workstations 64-bit**	**Windows 11 Professional 64-bit Windows 10 Professional 64-bit**

Technical White Paper

Contents & navigation

HP Z6 G5 - CPUs Supported

Figure 2: Intel® Xeon® W-3500 Processors supported at CPU Refresh

Name	Cores	Base Clock Speed (GHz)	Cache (MB)	Memory Speed (MHz)	TDP (W)
Xeon W7-3545 processor	2.7	24	67.5	4800*	310W
Xeon W5-3535X processor	2.9	20	52.5	4800*	300W
Xeon W5-3525 processor	3.2	16	45	4800*	290W

Figure 3: Intel® Xeon® W-3400 Processors supported at introduction

Name	Cores	Base Clock Speed (GHz)	Cache (MB)	Memory Speed (MHz)	TDP (W)
Intel® Xeon® w9-3475X processor	36	2.2	82.5	4800	300W
Intel® Xeon® w7-3465X processor	28	2.5	75	4800	300W
Intel® Xeon® w7-3455 processor	24	2.5	67.5	4800	270W
Intel® Xeon® w7-3445 processor	20	2.6	52.5	4800	270W
Intel® Xeon® w5-3435X processor	16	3.1	45	4800	270W
Intel® Xeon® w5-3433 processor	16	2	45	4400	220W
Intel® Xeon® w5-3425 processor	12	3.2	30	4800	270W
Intel® Xeon® w5-3423 processor	12	2.1	30	4400	220W

All processors feature Intel® vPro™ Technology, feature Intel® Turbo Boost Technology, and support hyperthreading.

Disclaimers:

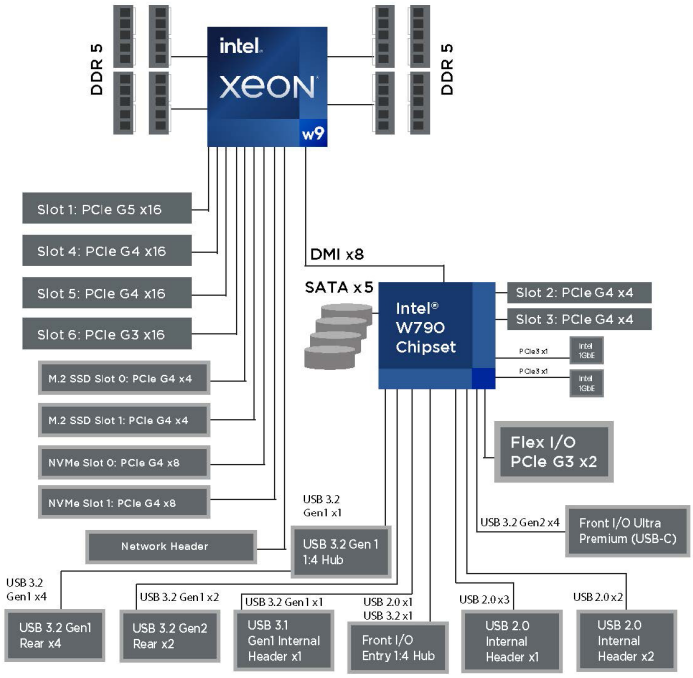
Intel® vPro™ requires Windows 10 Pro 64 bit or higher, a vPro supported processor, vPro enabled chipset, vPro enabled wired LAN and/or Wi-Fi 6E WLAN and TPM 2.0. Some functionality requires additional third-party software in order to run. Features of vPro Essentials and Enterprise vary. See http://intel.com/vpro.

Intel® Turbo Boost performance varies depending on hardware, software and overall system configuration. See www.intel.com/technology/turboboost for more information.

Technical White Paper

Contents & navigation

HP Z6 G5 Block Diagram and PCI-Express Performance



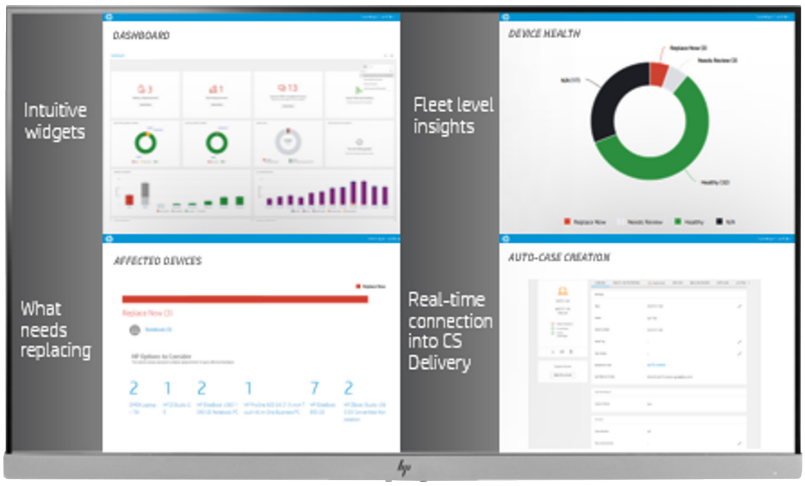
Integrated PCI-Express 5.0

The HP Z6 G5 uses the Intel® Xeon® W processor family, with integrated PCI-Express 5.0 controllers to deliver a peak bandwidth of 64 GB/s per direction (4 GB/s per lane). PCI-Express 5.0 is backward compatible with 1.0, 2.0, 3.0, and 4.0. All PCIe slots will train to the highest common speed. PCI-Express slots will initialize at 1.0 and then transition to the max common speed through a training sequence that involves multiple adaptive training phases. It is recommended to carefully evaluate and validate PCI-Express devices that are not available or supported by HP.

PCI-Express Performance

The HP Z6 G5 integrates several features within the processor: multiple PCIe 5.0 controllers, DMA caching, and two 2-channel memory controllers per processor (2 DIMMs per channel). This produces excellent performance in I/0 bandwidth, remote bandwidth, and latency.

Figure 4: x16 Peak Bandwidth per Direction (GB/s)



Recipe for Optimizing PCI-Express I/O Performance

For high I/O bandwidth applications, the choice of slot loading, processor, and memory configuration can be optimized to ensure maximum bandwidth available. Applications and cards sensitive to I/O latency may benefit as well from some of the tips below.

Recommended configuration steps

1. Place GPU and graphics cards first, following the slot order listed in Figure 4.

2. Place I/O cards next, from highest bandwidth to lowest, following the slot order listed in Figure 4. This is the optimal load order for most applications.

3. Additional I/O bandwidth refinements may be possible. If necessary, refer to the tips below

Figure 5: HP Z6 G5 I/O Slot Recommended Load Order

Card Load Priority	Card Description	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6
		PCIe5_ x16 CPU	PCIe4_ x4 PCH	PCIe4_ x4 PCH	PCIe4_ x16 CPU	PCIe4_ x16 CPU	PCIe3_x16 CPU
1	1st Graphics	Only					
2	2nd Graphics				1	2	3
3	3rd Graphics (T400 4GB, T1000, or T1000 8GB)						1
4	3rd Graphics					1	2
5	Thunderbolt-4 (2-port)			Only			
6	Z Turbo Drive Quad Pro (4x M.2 card)				1	2	3
7	Z Turbo Drive Dual Pro (2x M.2 w/Bracket)*				1	2	3
8	Network Interface (LAN, WLAN, etc.)			4	1	2	3
	HP Integrated Remote System Controller		3	2	5	4	1
9	PS2/Serial Module		1	2	5	4	3

Additional Tips

• For applications doing direct bus Peer-to-Peer transfers between cards, load the corresponding cards in slots located off the CPU

• If possible, make sure all I/O cards are loaded in slots that have a PCI-Express Lane Width at least as wide as the card (see Figure 4).

• For predictable latencies, try disabling NUMA (Non-Uniform Memory Access) mode (BIOS setup menu -> Advanced -> Performance Options -> Non-Uniform Memory Access (NUMA) = Disable).

• For cards that are latency sensitive, load these cards in processor slots.

• Ensure Idle Power Savings BIOS setting is set to Normal (BIOS setup menu -> Advanced -> Power Options -> Idle Power Savings = Normal).

• Use the latest system BIOS version available on hp.com.

• Check for updates in the latest performance optimization white papers (link below).

Technical White Paper

Contents & navigation

HP Z6 G5 Memory Configurations and Optimization

The purpose of this section is to provide an overview of the memory configurations for the HP Z6 G5 Workstation and to provide recommendations to optimize performance.

Supported Memory Modules

Types of memory supported on an HP Z6 G5 Workstation are: .

- 16 GB, 32 GB, 64GB PC5-4800-R 4800 MHz, and 5600MHz MHz DDR5 Registered DIMMs
- 128 GB PC5-4800 3DS 4800 MHz, and 5600MHz DDR5 3DS Registered DIMMs
- Single and dual rank DIMMs based on 16Gb and 32Gb[10] DRAMs are supported
- Quad and octal rank 3DS RDIMMs are supported
- 128GB PCI5-5600 5600MHz DDR5 Registered DIMMs[10]

Types of memory NOT supported on an HP Z6 G5 Workstation include:

- Unbuffered DIMMs
- Non-ECC DIMMs
- DDR, DDR2, DDR3, DDR4 DIMMs

See Memory Technology White Paper for more memory module technical information.

Platform Capabilities

Maximum capacity: 1 TB

- Total of 8 memory sockets
- 2 Memory controllers with 2 channels per memory controller for a total of 4 channels and 2 sockets per channel

Speed

- 4800MHz, 4400MHz and 4000MHz memory speeds are supported in this platform
- For 1 DIMM per channel configurations, the max memory speed is 4800MHz
- For 2 DIMM per channel configurations, the max memory speed is 4400MHz
- Memory will operate at the speed of the slowest rated installed processor or DIMM

Mixing of DIMMs in a system

- Registered and 3DS Registered DIMMs cannot be mixed in a system
  1. HP supports two different types of 128GB DIMMs, 3DS RDIMM and standard RDIMM, when making changes to the system, make sure the different types of memory are not mixed.
- Mixing of x4 DRAMs with x8 DRAMs is not supported.
  1. 16GB and 32GB RDIMMs supported by HP are x8 and can be mixed in a system
  2. 64GB RDIMMs and 128GB RDIMMs (not 128GB 3DS RDIMMs) supported by HP are x4 and cannot be mixed with other sized DIMMs in a system

Memory Features

This platform supports the new DDR5 technology:

- DDR5 supports higher bandwidths, capacities, and power efficiencies.
- Improves reliability features
- DDR5 has increased technology efficiencies
- Adds support for on-die ECC
  - On-die ECC is where the data stored on the memory module is monitored by the DRAM for errors
  - Only single-bit errors are automatically corrected, multi-bit errors are not detected
- But system ECC is still supported on all RDIMMs
- Single-bit errors are automatically corrected.

- Multi-bit errors are detected and will cause the system to immediately reboot and halt with an F1 prompt error message.
- By way of comparison, non-ECC memory (not supported on this platform) does not detect or correct single-bit or multi-bit errors, which can cause instability or corruption of data in the platform. See Memory Technology White Paper for more information.

Command and Address parity is supported

- Command and Address errors are detected and will cause the system to immediately reboot and halt with an F1 prompt error message.

Optimize Performance

System performance is largely based on the applications being used. Generally, to obtain the best performance, it is advised that you follow the following guidelines:

- For best performance, it is recommended to load memory into all memory controllers and channels. Since these platforms have 2 memory controllers and 4 channels, install memory in sets of 4.
- Proper individual DIMM capacity selection is essential to maximizing performance. Evenly distributing total desired memory across all operational channels and memory controllers will deliver the best performance.
- To increase overall performance, install multiple ranks in each channel. This can be accomplished by installing 2 single ranked DIMMs in the same channel.
- Maximum performance can be achieved by changing the OS power mode to Ultimate Performance in BIOS.

Figure 6: Optimal configurations for the HP Z6 G5 (Note: the following tables do not include all available orderable configurations)

Configuration	DIMM1 black	DIMM2 white	DIMM3 black	DIMM4 white	CPU	DIMM5 white	DIMM6 black	DIMM7 white	DIMM8 black	Rating
16GB (1x16GB)	X									Good
32GB (2x16GB)	X								X	Better
32GB (1x32GB)	X									Good
64GB (4x16GB)	X		X				X		X	Best
64GB (2x32GB)	X								X	Better
64GB (1x64GB)	X									Good
128GB (8x16GB)	X	X	X	X		X	X	X	X	Best
128GB (4x32GB)	X		X				X		X	Best
128GB (2x64GB)	X								X	Better
256GB (8x32GB)	X	X	X	X		X	X	X	X	Best
256GB (4x64GB)	X		X				X		X	Best
256GB (2x128GB)	X								X	Better
512GB (8x64GB)	X	X	X	X		X	X	X	X	Best
512GB (4x128GB)	X		X				X		X	Best
1TB (8x128GB)	X	X	X	X		X	X	X	X	Best

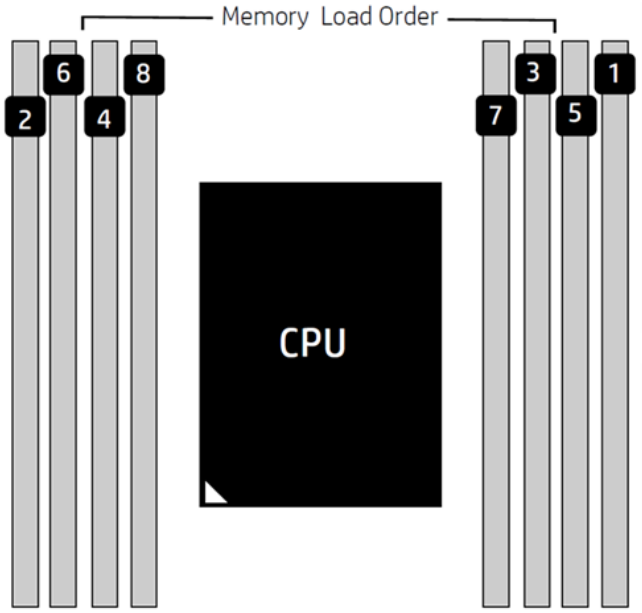
Technical White Paper

Contents & navigation

Loading Rules

- Load the memory modules in order of size, starting with the largest module and finishing with the smallest module.
- Each channel includes two DIMM sockets; black and white connector pairs represent a channel. The DIMMs should be loaded first in the black sockets and then in the white sockets. The DIMMs should be loaded starting with the DIMM furthest from the CPU, with the first DIMM loaded in the right-most socket and alternating sides of the CPU.
- See the figure below for loading order.

Figure 6: Loading order



Summary

The memory configurations of the HP Z6 G5 Workstation have been specifically crafted to meet strict long-term reliability standards with an optimized performance that provides users with seamless functionality. Design, cooling, and power solutions were validated to ensure DIMMs met max performance. HP values product quality and end user productivity, which is why the products discussed in this document are backed by HP's warranty. For more information, visit **https://www.hp.com/us-en/workstations/desktop-workstation-pc.html**.

Resources, Contacts, or Additional Links

Visit **HP's White Paper site** to learn more about the innovation in HP Workstations and the latest technologies offered in the products.

Disclaimers:

1. Graphics are sold separately or as an optional feature. 3 NVIDIA RTX™ A6000 GPUs are only configurable on the 1450W power supply (in 200V countries, which does not include USA).

2. Multicore is designed to improve performance of certain software products. Not all customers or software applications will necessarily benefit from use of this technology. Performance and clock frequency will vary depending on application workload and your hardware and software configurations. Intel®'s numbering, branding and/or naming is not a measurement of higher performance.

3. Optional, configurable features. 1TB DDR5 memory is planned to be available in the first half of 2023.

4. Graphics are sold separately or as an optional feature. 3 NVIDIA RTX™ A6000 GPUs are only configurable on the 1450W power supply (in 200V countries, which does not include USA).

5. Optional, configurable features. Configurations for 1TB memory, 88TB of storage, and front accessible NVME bays are planned to be available in the first half of 2023. Configuration for 88TB requires separate additional purchase. For storage drives, GB = 1 billion bytes. TB = 1 trillion bytes. Actual formatted capacity is less. Up to 35GB is reserved for system recovery software.

6. MIL-STD testing is not intended to demonstrate fitness for U.S. Department of Defense contract requirements or for military use. Test results are not a guarantee of future performance under these test conditions. Accidental damage requires an optional HP Accidental Damage Protection Care Service.

7. HP Wolf Security for Business requires Windows 10 or 11 Pro or higher, includes various HP security features and is available on HP Pro, Elite and Workstation products. See product details for included security features and OS requirement.

8. Wi-Fi 6: Wireless access point and Internet service required and sold separately. Availability of public wireless access points limited. Wi-Fi 6 (802.11ax) is backwards compatible with prior 802.11 specs.

9. Wi-Fi 6E: Wi-Fi 6E requires a Wi-Fi 6E router, sold separately, and Windows 11 to function in the 6GHz band. Availability of public wireless access points limited. Wi-Fi 6E is backwards compatible with prior 802.11 specs. And available in countries where Wi-Fi 6E is supported.

10. Not available until December 2024

LEARN MORE

4AA8-2817ENW , June 2024