Power Guidelines for Workstation Products

Application Note

DA-07261-001_v14 | July 2023

Document History

DA-07261-001_v14

Version	Date	Authors	Description of Change
01	June 6, 2014	VL, SM	Initial Release
02	June 2, 2015	JK, SM	• Updated to include Quadro M6000, Quadro K5200, Quadro K4200, Quadro K2200, Quadro K1200, Quadro K620, and Quadro K420 • Updated with Quadro M6000 power guidelines • Updated PCIe connectors figure (Figure 2) • Added a power requirements for 250 W cards (single 8-pin connector) section • Added a dual 6-pin to 8-pin adapter cable section
03	July 8, 2015	JK, SM	Updated error Table 1
04	May 5, 2017	JK, SM	Updated to include Quadro GP100, Quadro P6000, Quadro P5000, Quadro P4000, Quadro P2000, Quadro P1000, Quadro P600, and Quadro P400
05	March 21, 2018	PV, SM	• Updated Figure 1 • Updated Table 1
06	December 12, 2018	JK, SM	Updated to include Quadro RTX 4000, Quadro RTX 5000, Quadro RTX 6000, and Quadro RTX 8000
07	January 25, 2019	HG, SM	Updated pin numbers in Figure 2
08	October 22, 2020	AS, SM	• Added NVIDIA RTX A6000 information to Table 1 • Updated "Power Connectors" section and Figure 2 to reflect CPU 8-Pin connection option • Updated "Power Adapters" section with CPU 8-Pin standard cable information
09	July 29, 2021	AS, SM	Added NVIDIA RTX A5000, A4000, and A2000 information to Table 1
10	February 1, 2022	AS, SM	• Added NVIDIA RTX A5500, RTX A4500 and RTX A2000-12GB information to Table 1 • Updated application meet to current NVIDIA standards
11	April 15, 2022	AS, SM	Updated power connector diagram in Figure 2
12	October 3, 2022	AS, SM	• Added 2 separate notes within "Power Requirements for 250 W Cards with a Single PCIe 8-Pin Connector" section. • Added "PCIe CEM 5.0 16-Pin Power Connector" chapter

Version	Date	Authors	Description of Change
13	April 21, 2023	AS, SM	Updated both power connectors 2 x PCIe 8-pin to 1 x CEM5 16-pin and 1 x CPU 8-pin to 1 x CEM5 16-pin part number (NVPN) and mechanical drawing.
14	July 24, 2023	AS, SM	Updated Table 1 to include NVIDIA RTX 6000 Ada Generation, RTX 5000 Ada Generation, RTX 4000 SFF Ada Generation, and RTX 4000 Ada Generation information.

Table of Contents

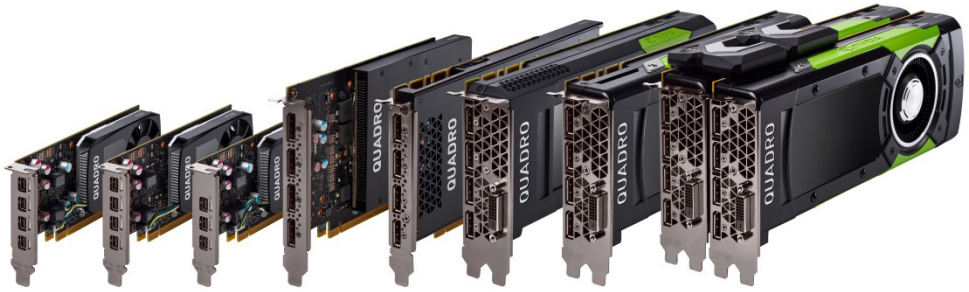
List of Figures

List of Tables

Overview

This application note discusses the power requirements of the NVIDIA® workstation products based on NVIDIA RTX™, and Quadro RTX™ line of graphics cards. A suitable power supply is necessary to maintain system integrity under computational load.

Figure 1. NVIDIA Workstation Graphics Cards



Power Requirements

The workstation desktop graphics cards may require auxiliary power within the host chassis. Ensure that your system can deliver the necessary wattage and auxiliary power connectors for all cards in the system. If the supplied power is not adequate, the cards will not function properly. Table 1 specifies the power requirements and power connectors for the various workstation desktop graphics cards.

Table 1. Workstation GPU Power Specifications

Model	TGP	Required Auxiliar Power Connectors
NVIDIA RTX 6000 Ada Generation	300 W	CEM5 16-pin
NVIDIA RTX 5000 Ada Generation	250 W	CEM5 16-pin
NVIDIA RTX 4000 SFF Ada Generation	70 W	Not applicable
NVIDIA RTX 4000 Ada Generation	130 W	CEM5 16-pin
NVIDIA RTX A6000	300 W	CPU 8-pin (EPS-12V)
NVIDIA RTX A5500	230 W	PCIe 8-pin
NVIDIA RTX A5000	230 W	PCIe 8-pin
NVIDIA RTX A4500	200 W	PCIe 8-pin
NVIDIA RTX A4000	140 W	PCIe 6-pin
NVIDIA RTX A2000 12GB	70 W	Not applicable
NVIDIA RTX A2000	70 W	Not applicable
Quadro RTX 8000	260 W	PCIe 8-pin + PCIe 6-pin
Quadro RTX 6000	260 W	PCIe 8-pin + PCIe 6-pin
Quadro RTX 5000	230 W	PCIe 8-pin + PCIe 6-pin
Quadro RTX 4000	125 W	PCIe 8-pin
Quadro GV100	250 W	PCIe 8-pin
Quadro GP100	235 W	
Quadro P6000	250 W	
Quadro M6000 24GB	250 W	
Quadro M6000	250 W	
Quadro K6000	225 W	PCIe 6-pin + PCIe 6-pin

Model	TGP	Required Auxiliar Power Connectors
Quadro P5000 Quadro M5000 Quadro K5200 Quadro K5000	180 W 150 W 150 W 122 W	PCIe 8-pin PCIe 6-pin PCIe 6-pin PCIe 6-pin
Quadro P4000 Quadro M4000 Quadro K4200 Quadro K4000	105 W 120 W 108 W 80 W	PCIe 6-pin
Quadro P2000 Quadro M2000 Quadro K2200 Quadro K2000 Quadro K2000D	75 W 75 W 60 W 51 W 51 W	Not applicable
Quadro P1000 Quadro K1200	47 W 45 W	Not applicable
Quadro P620 Quadro P600 Quadro K620	40 W 40 W 41 W	Not applicable
Quadro P400 Quadro K420	30 W 41 W	Not applicable

The total graphics power (TGP) represents the maximum amount of graphics board power that the system power supply should be able to provide to the graphics card.

Power Connectors

Depending on the workstation graphics card the end customer is utilizing, external power connectors may be required to fully power up the graphics card. The supported power connectors on workstation graphics card are CPU 8-pin, PICe 8-pin and PCIe 6-pin.

Figure 2. Power Connectors

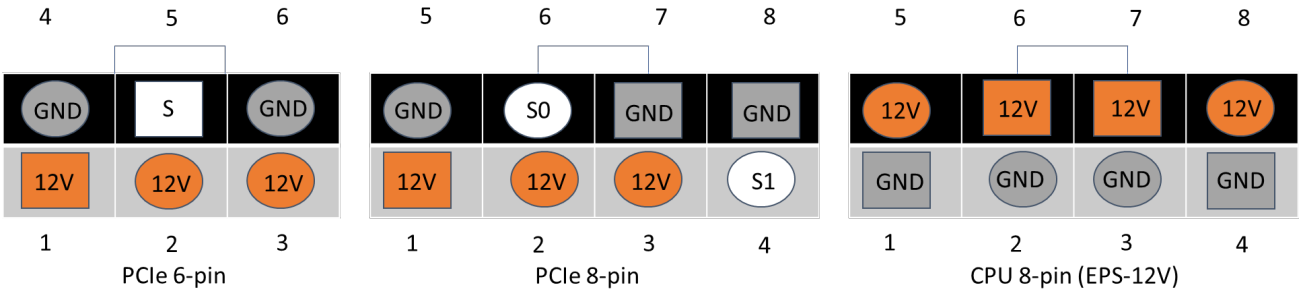


Table 2. Power Connectors Pin Description

Pin	CPU 8-Pin	PCIe 8-Pin	PCIe 6-Pin
1	GND (0)	12V	12V
2	GND (0)	12V	12V
3	GND (0)	12V	12V
4	GND (0)	SENSE1	GND (0)
5	12V	GND (0)	SENSE
6	12V	SENSE0	GND (0)
7	12V	GND (0)	Not applicable
8	12V	GND (0)	Not applicable

Power Requirements for 250 W Cards with a Single PCIe 8-Pin Connector

Typically, the PCIe slot is rated for 75 W and a PCIe 8-pin connector is rated for 150 W. However, based on NVIDIA testing and surveying of the current ecosystem, it is found that the PCIe 8-pin connector can carry up to 175 W. Along with the PCIe slot power, a graphics card consuming up to 250 W can potentially be supported.

Note that if a PCIe 8-pin connector is used to carry up to 175 W to the NVIDIA card, the system PSU must be able to drive at least 18 A of dedicated current to that PCIe 8-pin connector.

Note also that the auxiliary power input of some NVIDIA cards is specified at the full TGP of the card. If so then a card TGP of 250 W will require the auxiliary power input to be able to supply up to the entire 250 W. This power is beyond the capability of a single PCIe 8-pin connector.

Power Adapters

It is extremely important to understand the board power requirements when selecting power supplies. It is recommended to use a power supply that has all the required connectors. However, if the required connector is not available on a given power supply, it is possible to use adapters to convert existing connectors to PCIe or CPU auxiliary connectors.

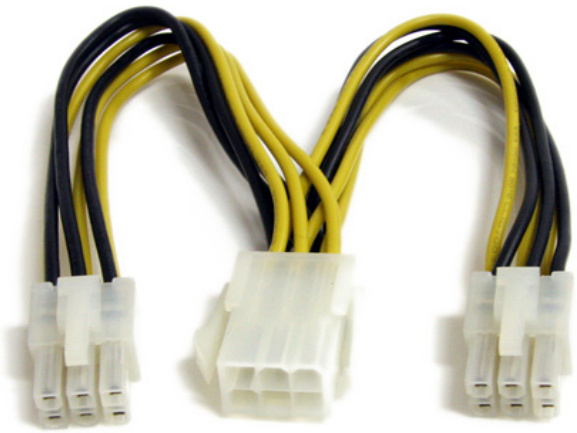
When using power adapters, it is important to evaluate the rated amperage on the 12V rail that is being used to source the adapter cable. The information is available in the power supply's user manual, or it is printed on the power supply casing.

> **!** **CAUTION**: System builders should review the power specifications and guidelines outlined on their system power supply to ensure that the connector limits are not exceeded when using adapters.

PCIe 6-Pin Y-Splitter Cable

It is possible to split a single 6-pin auxiliary PCIe connector into two 6-pin auxiliary PCIe connectors. While NVIDIA does not recommend using the Y-splitter with the Quadro cards, it is extremely important to ensure that the 12V rail on the power supply driving this can handle the additional connector if one must use the splitters.

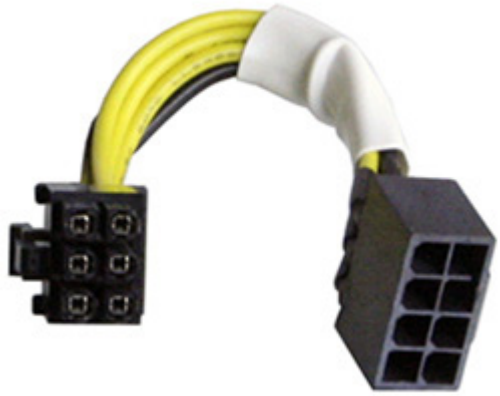
Figure 3. 6-Pin Y-Splitter Cable



PCIe 8-Pin to 6-Pin Adapter Cable

It is possible to split a single 8-pin auxiliary PCIe connector into a single or two 6-pin auxiliary PCIe connectors. If you are using such a splitter, it is important to ensure that the 12V rail on the power supply driving this can handle the additional connector. Refer to the rated amperage on the 12V rail sourcing the splitter to ensure that the connector limits are not exceeded.

Figure 4. 8-Pin to 6-Pin Adapter Cable



PCIe Dual 6-Pin to 8-Pin Adapter Cable

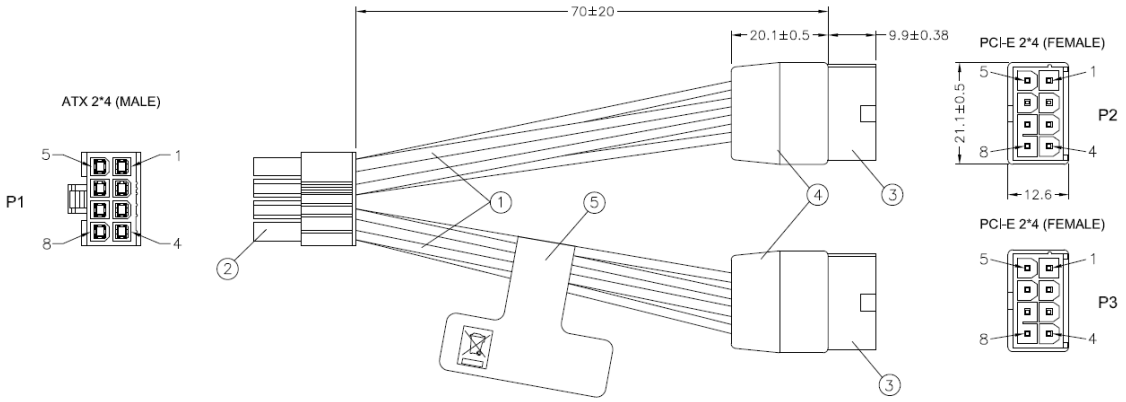
It is possible to combine two 6-pin auxiliary PCIe connectors into a single 8-pin auxiliary PCIe connector. If you are using such an adapter, it is important to ensure that the 12V rail on the power supply driving this adapter is rated for at least 18A.

Figure 5. Dual 6-Pin to 8-Pin Adapter Cable

CPU 8-Pin Standard Power Adapter Cable

For NVIDIA products with a CPU 8-pin connector, a power adapter to convert two PCIe 8-pin connectors to a single CPU 8-pin may be used.

Figure 6. CPU 8-Pin Standard Adapter Cable



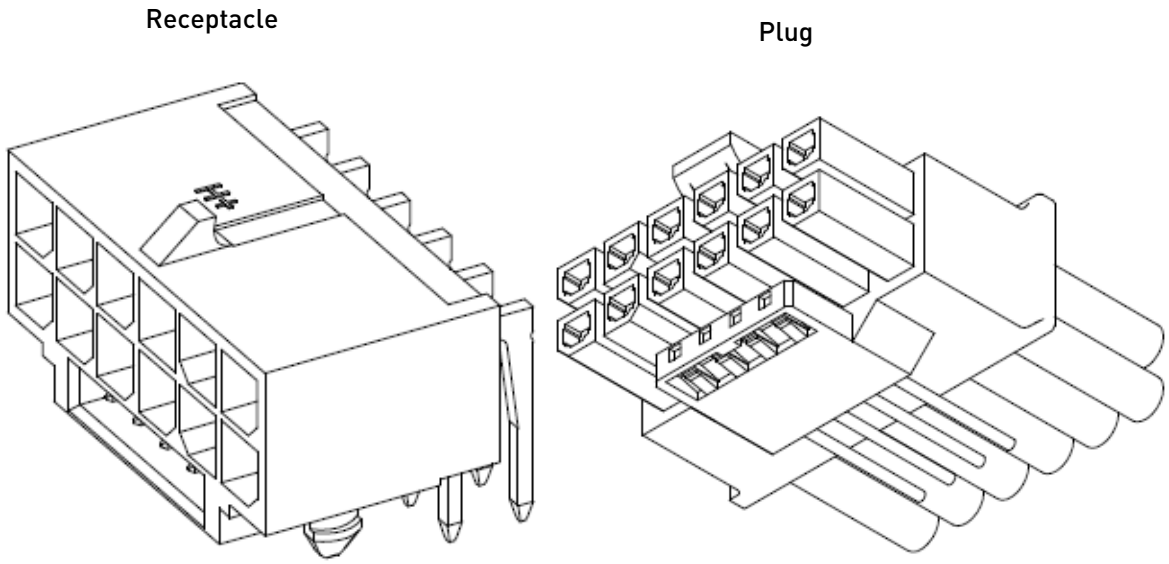
PCIe CEM 5.0 16-Pin Power Connector

This chapter contains details on the PCIe CEM5 16-pin power connector that is used on the next generation NVIDIA ProViz workstation graphics cards. The information in this chapter is intended for OEM and power supply vendors. This chapter also discusses active power and idle power recommendations for OEM partners and system builders.

OEMs, and PSU vendors are recommended to use the CEM5 16-pin connector for CDP designs and partners should refer to this connector as "CEM5 16-pin" in all documents and communication. The CEM5 16-pin power connector is described as follows. For pinout information, refer to the *PCIe CEM 5.0 Specification*.

- Connector has six 12 V power pins and up to six GND (0) pins.
- Sense and Sideband pins are present on this connector.
- The exact connector orientation may depend on the NVIDIA graphics card product.

Figure 7. PCIe CEM5 16-Pin Power Connector Header and Plug



The allowed configurations for the ProViz workstation power adapter are as follows:

- 2 x PCIe 8-pin to 1 x CEM5 16-pin
- 1 x PCIe 8-pin to 1 x CEM5 16-pin
- 1 x CPU 8-pin to 1 x CEM5 16-pin

CEM5 Sense Pin Power Classes

The PCIe CEM5 specification defines four power classes that a system may signal to the PCIe card using Sideband signals Sense1 (Sideband signal S4) and Sense0 (Sideband signal S3). See Table 3 for those levels.

Table 3. Sense1, Sense0 Power Class Definitions

CEM5 16-Pin Connector Sideband Signal		Indicated Power Availability (Maximum)
Sense1 (S4)	Sense0 (S3)	
GND (0)	GND (0)	600 W
GND (0)	OPEN (1)	450 W
OPEN (1)	GND (0)	300 W
OPEN (1)	OPEN (1)	150 W

Power Adaptors

NVIDIA workstation power adaptor designs are described as follows.

2 x PCIe 8-pin to 1 x CEM5 16-pin Power Adapter

For NVIDIA PCIe card products requiring power input into single CEM5 16-pin connectors, a power adaptor exists to deliver power up to 300 W from dual PCIe 8-pin connectors to the single CEM5 16-pin connectors of the NVIDIA card. The dual PCIe 8-pin connector rails are combined to form a single 12V and single ground rail. This power adaptor makes use of the CEM5 16-pin connector's Sense0 and Sense1 pins to signal to the NVIDIA card the power available to the CEM5 16-pin connectors on the card (Sense1 and Sense0 levels are default-strapped to [1,0] per Table 3). The Sense1 and Sense0 levels required for a given NVIDIA card to operate are stated in each card's product specification.

This adapter also incorporates active circuitry intelligence to ensure both PCIe 8-pin connectors are sourcing power. With both PCIe 8-pin connectors attached on the adapter's power supply end, the adapter's Sense1 and Sense0 signals indicate that up to 300 W is available to the CEM5 16-pin connector at the card end (see third row of Table 3). If a single PCIe 8-pin connector is attached on the adapter's power supply end, the adapter intelligently alters the Sense1 and Sense0 signals to indicate less power available on the CEM5 16-pin

connector (the two sense pins become [1,1] to indicate only 150 W of available power). This active circuitry intelligence provides a protection mechanism to ensure that the NVIDIA card is aware of the reduced power availability. If the Sense pin levels indicate insufficient power, the NVIDIA card will not boot.

The adapter is mechanically compatible only with NVIDIA cards that require power input into single CEM5 16-pin receptacle connectors.

1 x PCIe 8-pin to 1 x CEM5 16-pin Power Adapter

For NVIDIA products with a single CEM5 16-pin connector, a power adaptor exists to deliver power up to 150 W from a single PCIe 8-pin connector to the single CEM5 16-pin connector of the NVIDIA card. This power adaptor does not incorporate active circuitry. The Sense1 and Sense0 signals are statically configured to indicate to the NVIDIA card that a maximum of 150 W is available to the NVIDIA card (see fourth row of Table 3). If 150 W is insufficient for the card's needs, the card will not boot.

The adapter is mechanically compatible only with NVIDIA cards that require power input into single CEM5 16-pin connectors.

1 x CPU 8-pin to 1 x CEM5 16-pin Power Adapter

For NVIDIA products with a single CEM5 16-pin connector, a power adaptor exists to deliver power up to 300 W from a single CPU 8-pin connector to the single CEM5 16-pin connector of the NVIDIA card. This power adaptor does not incorporate active circuitry. The Sense1 and Sense0 signals are statically configured to indicate to the NVIDIA card that a maximum of 300 W is available to the NVIDIA card (see third row of Table 3). If 300 W is insufficient for the card's needs, the card will not boot.

The adapter is mechanically compatible only with NVIDIA cards that require power input into single CEM5 16-pin connectors.

System Power Solution

A production workstation system power delivery solution would be one of the following:

- Native system cabling that implements sense pin levels as noted in Table 3:
  - [Sense1, Sense0] = [1, 0] for 300W-capable power delivery
  - [Sense1, Sense0] = [1, 1] for 150W-capable power delivery
- NVIDIA-designed power adapter obtained from a vendor on the Approved Vendor List (see "Approved Power Adaptor Vendor List" section of this application note)
- Partner-designed power adapter ensuring proper sense pin levels

When designing a power adapter, care must be taken to ensure sufficient current-handling ability on the power supply end. PCIe 8-pin connectors are rated to a maximum of 150 W each Thus, an adapter whose sense pins indicate 300 W of available power would need at least two

PCIe 8-pin connectors on the power supply end. CPU 8-pin connectors can carry up to 300 W of power, so an adapter whose sense pins indicate 300 W of available power could use a single CPU 8-pin connector on the power supply end (However, if the adapter sense pins are strapped to indicate up to 450 W or 600 W of available power as in rows 1 or 2 of Table 3, then a single CPU 8-pin connector on the power supply end is insufficient.).

If the power adapter is designed with multiple connectors on the power supply end, there is a possibility that in operation not all connectors are connected and sourced with power. If this is the case, for operational and safety reasons the NVIDIA card must be aware that less power is available on the card end of the adapter. Thus, the adapter should be able to sense whether all connectors are sourced with power and should reflect the true power availability in its sense pin settings.

Partners can use a programmable IC such as a CPLD, or alternatively discrete components, to implement the desired logic for such an intelligent power adaptor design. As an example, the logic implemented by the NVIDIA 2 x PCIe 8-pin to 1 x CEM5 16-pin adapter is provided in Table 4 for reference.

Table 4. NVIDIA 2 x PCIe 8-Pin to 1 x CEM5 16-Pin Adapter Logic

PCIe 8-Pin Receptacle A[1]	PCIe 8-Pin Receptacle B[2]	Resulting Sense Pins of 16-Pin Power Connector		
Pin 4 (Sense Pin)	Pin 4 (Sense Pin)	SENSE1 (S4)	SENSE0 (S3)	Indicated Power Level[3]
GND (0)	GND (0)	OPEN (1)	GND (0)	max 300 W
GND (0)	OPEN (1)	OPEN (1)	OPEN (1)	max 150 W
OPEN (1)	GND (0)	OPEN (1)	OPEN (1)	max 150 W
OPEN (1)	OPEN (1)	Not Applicable; no power available on 16-pin connector		

Note:

[1] "Receptacle A" represents one of the 1 x PCIe 8-pin input connectors. If its Pin 4 is pulled to GND, the receptacle is determined to be connected to the PSU.

[2] "Receptacle B" represents one of the 1 x PCIe 8-pin input connectors. If its Pin 4 is pulled to GND, the receptacle is determined to be connected to the PSU.

[3] Only the listed power availability levels are supported by this adaptor design.

As Table 4 indicates, the NVIDIA intelligent adapter implements presence detection on each receptacle connector of the adaptor's power supply end; it determines connectivity by verifying a true GND level on sense Pin 4 of the receptacle. If the true GND level is not observed, the receptacle is considered unconnected.

Approved Power Adaptor Vendor List

This section provides a list of approved vendors for the NVIDIA CEM5 16-pin power adaptors. Table 5 lists the components on the approved vendor list.

Note: The mechanical drawings for the components used on the 16-pin power connector and power plug are in the attached PDF documents.

To access the attached file, click the Attachment icon on the left-hand toolbar on this PDF (using Adobe Acrobat Reader or Adobe Acrobat). Select the file and use the Tool Bar options (Open, Save) to retrieve the documents.

The CEM5 16-pin power plug houses two different terminals for power delivery and Sideband signals respectively. The 3.00 mm pitch terminal is used for power delivery; the 2.00 mm terminal is used for Sideband signaling. Refer to the *PCIe CEM 5.0 Specification* for more information on the two different types of terminals used on the power plug.

Table 5. CEM5 16-Pin Power Connector

Component	Vendor	Part Number (NVPN)
2 x PCIe 8-pin to 1 x CEM5 16-pin	Astron	930-00030-1633-000
1 x PCIe 8-pin to 1 x CEM5 16-pin	Astron	930-00030-1569-000
1 x CPU 8-pin to 1 x CEM5 16-pin	Astron	930-00030-1636-000

Notice

This document is provided for information purposes only and shall not be regarded as a warranty of a certain functionality, condition, or quality of a product. NVIDIA Corporation ("NVIDIA") makes no representations or warranties, expressed or implied, as to the accuracy or completeness of the information contained in this document and assumes no responsibility for any errors contained herein. NVIDIA shall have no liability for the consequences or use of such information or for any infringement of patents or other rights of third parties that may result from its use. This document is not a commitment to develop, release, or deliver any Material (defined below), code, or functionality.

NVIDIA reserves the right to make corrections, modifications, enhancements, improvements, and any other changes to this document, at any time without notice.

Customer should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

NVIDIA products are sold subject to the NVIDIA standard terms and conditions of sale supplied at the time of order acknowledgement, unless otherwise agreed in an individual sales agreement signed by authorized representatives of NVIDIA and customer ("Terms of Sale"). NVIDIA hereby expressly objects to applying any customer general terms and conditions with regards to the purchase of the NVIDIA product referenced in this document. No contractual obligations are formed either directly or indirectly by this document.

NVIDIA products are not designed, authorized, or warranted to be suitable for use in medical, military, aircraft, space, or life support equipment, nor in applications where failure or malfunction of the NVIDIA product can reasonably be expected to result in personal injury, death, or property or environmental damage. NVIDIA accepts no liability for inclusion and/or use of NVIDIA products in such equipment or applications and therefore such inclusion and/or use is at customer's own risk.

NVIDIA makes no representation or warranty that products based on this document will be suitable for any specified use. Testing of all parameters of each product is not necessarily performed by NVIDIA. It is customer's sole responsibility to evaluate and determine the applicability of any information contained in this document, ensure the product is suitable and fit for the application planned by customer, and perform the necessary testing for the application in order to avoid a default of the application or the product. Weaknesses in customer's product designs may affect the quality and reliability of the NVIDIA product and may result in additional or different conditions and/or requirements beyond those contained in this document. NVIDIA accepts no liability related to any default, damage, costs, or problem which may be based on or attributable to: (i) the use of the NVIDIA product in any manner that is contrary to this document or (ii) customer product designs.

No license, either expressed or implied, is granted under any NVIDIA patent right, copyright, or other NVIDIA intellectual property right under this document. Information published by NVIDIA regarding third-party products or services does not constitute a license from NVIDIA to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property rights of the third party, or a license from NVIDIA under the patents or other intellectual property rights of NVIDIA.

Reproduction of information in this document is permissible only if approved in advance by NVIDIA in writing, reproduced without alteration and in full compliance with all applicable export laws and regulations, and accompanied by all associated conditions, limitations, and notices.

THIS DOCUMENT AND ALL NVIDIA DESIGN SPECIFICATIONS, REFERENCE BOARDS, FILES, DRAWINGS, DIAGNOSTICS, LISTS, AND OTHER DOCUMENTS (TOGETHER AND SEPARATELY, "MATERIALS") ARE BEING PROVIDED "AS IS." NVIDIA MAKES NO WARRANTIES, EXPRESSED, IMPLIED, STATUTORY, OR OTHERWISE WITH RESPECT TO THE MATERIALS, AND EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE. TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL NVIDIA BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF NVIDIA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Notwithstanding any damages that customer might incur for any reason whatsoever, NVIDIA's aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms of Sale for the product.

Trademarks

NVIDIA, the NVIDIA logo, NVIDIA RTX, Quadro, and Quadro RTX are trademarks and/or registered trademarks of NVIDIA Corporation in the U.S. and other countries. Other company and product names may be trademarks of the respective companies with which they are associated.

Copyright

NVIDIA Corporation | 2788 San Tomas Expressway, Santa Clara, CA 95051
http://www.nvidia.com