The Basics of Selecting Rack-Mount Power Distribution Units (PDUs) and Power Strips

By David Knapp
Product Marketing Manager
Chatsworth Products (CPI)

CHATSWORTH PRODUCTS

Introduction

Almost every Information and Communications Technologies (ICT) equipment rack used to store compute, storage or network equipment requires a rack-mount Power Distribution Unit (PDU) or power strip (Figure 1) to distribute power to equipment. But, if you are unfamiliar with electrical power distribution systems or even the differences in industry jargon, selecting a PDU or power strip can be challenging.

This white paper, by Chatsworth Products (CPI), presents an overview of the basics of selecting PDUs and power strips. It covers the key questions to ask about the site, rack and equipment to help simplify the selection process and quickly identify the right PDU or power strip. It concludes with additional resources that will help you select the right PDU or power strip for your application.

Definitions in this White Paper
- *Rack(s) refers to information and communications technologies equipment racks and cabinets—any 19" EIA rack-mount support structure for computer servers, data storage or network switches.*

- *Rack-mount is used to describe attachment of PDUs or power strips and ICT equipment into data center cabinets and racks.*

- *Rack-level is used to describe the placement of PDUs or power strips in both cabinets (cabinet-level) and on racks (rack-level), and the monitoring of conditions inside and immediately around the cabinet or rack.*

Fast Fact
If you are already familiar with selection of PDUs and power strips and just need to find a part number quickly, try the CPI Power Selector www.selectapdu.com. If you would like some help selecting a product or have a technical question, please contact our Technical Support department at techsupport@chatsworth.com.

Fast Fact
To learn more about PDUs and power strips, download the companion white paper: Additional Considerations When Selecting Power Distribution Units and Power Strips at www.chatsworth.com/white-papers

Figure 1: PDUs and Power Strips are used to distribute power into ICT racks and cabinets.

What is the Difference Between a PDU and a Power Strip?

At the rack level, the terms PDU and power strip may be used interchangeably. Each manufacturer has a specific product category name: PDU, power strip, Rack Distribution Unit (RDU), Cabinet Distribution Unit (CDU), etc. Within the CPI product line, power strips are lower voltage, with minimal features. CPI power strips include optional surge protection against voltage spikes, which is advised when connecting directly to utility power, a typical requirement in premise equipment rooms. CPI PDUs are higher voltage, with more features. CPI eConnect® PDUs have robust remote monitoring and control capabilities, which are advised when connecting to conditioned power, and typical in purpose-built data centers and computer rooms.

Regardless of slight differences in categorization and product branding, the basics of selecting a PDU or power strip are universal. PDUs and power strips have a power delivery function, decided by input plug, breakers and outlets; and a monitoring function decided by the metering or remote monitoring capabilities.

How to Select a PDU or Power Strip

At the most basic level, you need to know whether the rack is large enough for a vertical PDU; what type and how many branch power connections are in each rack; how much equipment will be in the rack; and if monitoring is required.

Critical decisions when selecting a PDU or Power Strip *(see Figure 2)*

1. **Form Factor** – use a vertical PDU in a full-height, free-standing rack to maximize possible equipment connections. Use a horizontal PDU in smaller wall-mount racks.

2. **Input Plug** – must match the branch power circuit receptacle at the rack and determines the total amount of power available to equipment in the rack.

3. **Outlets** – match the plug(s) on equipment in the rack. There are two approaches: either select the model with the highest number of outlets used in region, or select the model with the highest number of mixed C13 and C19 outlets.

4. **Functionality** – match the level of monitoring required: no metering, local metering, remote monitoring of the input and breakers, remote monitoring including each outlet, remote control of outlets, or remote monitoring and control of outlets.

Figure 2: Critical decisions when selecting a PDU or power strip

1. Form Factor - rack size

The first decision when selecting a PDU or powers strip is the form factor. There are two options: vertical and horizontal configuration (Figure 3). The vertical configuration attaches to brackets positioned alongside the mounting rails on the rack. The horizontal configuration uses 1U or 2U of rack-mount space. *Ask if a vertical or horizontal (rack-mount) PDU is required*.

Fast Fact

If the form factor is unknown, select a vertical PDU for a rack that has 42U or more of rack-mount space and is a minimum of 6' (2 m) in height and 23.6" (600 mm) in width. Select a horizontal (rack-mount) PDU for a rack with less than 42U of rack-mount space or if less than 6' (2 m) in height, including any wall-mount rack.

Vertical and horizontal (rack-mount) form factor is standard on all CPI PDUs and power strips.

Figure 3: Vertical PDUs and power strips are typically used in cabinets and racks that are 6' (2 m) high, 23.6" (600 mm) wide, and 42U or larger. Horizontal PDUs and power strips are used in wall-mount racks and cabinets.

2. Input Plug - the branch circuit receptacle and available power

The second decision when selecting a PDU or powers strip is the type of input plug. The input plug must match the branch circuit receptacle at the rack. *Ask what type of input plug is required or what the power receptacle is at the rack to identify the matching plug* (use Table 1 below).

How many type of input plugs are there?

There are many types of input plugs. There are several power systems globally and several branch circuits in each power system. Additionally, most nations have their own plug standards (plug designs), and there is also an international plug standard.

For safety, plugs and matching receptacles are physically different (keyed) for each type of branch circuit connection to prevent accidental connection between incompatible devices. Most PDU and power strip manufacturers offer a mix of national and international plugs.

Which input plugs are used most frequently?

It depends on where your site is located. It will be the regional plug or a plug that meets the International standard. CPI offers PDUs and power strips with input plugs that meet the American National Standards Institute (ANSI)/National Electrical Manufacturers Association (NEMA) standards and the International Electrotechnical Commission (IEC) standards:

- ANSI/NEMA WD 6-2016 Wiring Devices – Dimensional Specifications[1]
- IEC 60309-2012 – Plug, Socket-Outlets and Couplers for Industrial Purposes[2]
- IEC 60320-2018 – Appliance Couplers for Household and Similar General Purposes[3]

The ANSI/NEMA standard is used primarily in North America. The IEC standard is used globally, including for some high Amperage connections in North America. The (Table 1) below illustrates the range of circuits and plugs supported by CPI PDUs and power strips.

Fast Fact *If the branch circuits are still being defined and only the total power requirement for the rack is known, then you can suggest some options using the capacity (kW) values in (Table 1). Be sure to explain that the branch circuit needs to be defined before the PDU or power strip can be selected so that the input plugs will match the branch circuit receptacles. You should never advise or attempt field modification of plugs.*

Region	Typical Circuit	Circuit Receptacle	Input Plug	Capacity (kW)
North America	Single-Phase, 15 A, 120 VAC	NEMA L5-15R	NEMA L5-15P	1.4
	Single-Phase, 20 A, 120 VAC	NEMA L5-20R	NEMA L5-20P	1.9
	Single-Phase, 20 A, 120 VAC	IEC C19	IEC C20	1.9
	Single-Phase, 30 A, 120 VAC	NEMA L5-30R	NEMA L5-30P	2.8
	Single-Phase, 20 A, 120/208 VAC	NEMA L14-20R	NEMA L14-20P	3.3
	Single-Phase, 20 A, 208 VAC	NEMA L6-20R	NEMA L6-20P	3.3
	Single-Phase, 20 A, 208 VAC	IEC C19	IEC C20	3.3
	Single-Phase, 30 A, 120/208 VAC	NEMA L14-30R	NEMA L14-30P	4.9
	Single-Phase, 30 A, 208 VAC	NEMA L6-30R	NEMA L6-30P	4.9
	Three-Phase, 20 A, 120/208 VAC	NEMA L21-20R	NEMA L21-20P	5.7
	Three-Phase, 20 A, 208 VAC	NEMA L15-20R	NEMA L15-20P	5.7
	Three-Phase, 30 A, 120/208 VAC	NEMA L21-30R	NEMA L21-30P	8.6
	Three-Phase, 30 A, 208 VAC	NEMA L15-30R	NEMA L15-30P	8.6
	Three-Phase, 20 A, 240/415 VAC	NEMA L22-20R	NEMA L22-20P	11.4
	Three-Phase, 50 A, 208 VAC	CS8364	CS8365	14.3
	Three-Phase, 60 A, 208 VAC	IEC 60A 3P+E 9h	IEC 60A 3P+E 9h	17.3
	Three-Phase, 30 A, 240/415 VAC	NEMA L22-30R	NEMA L22-30P	17.3
International	Single-Phase, 16A, 230 VAC	IEC C19	IEC C20	3.6
	Single-Phase, 16A, 230 VAC	IEC 16A 1P+N+E 6h	IEC 16A 1P+N+E 6h	3.6
	Single-Phase, 32A, 230 VAC	IEC 32A 1P+N+E 6h	IEC 32A 1P+N+E 6h	7.3
	Three-Phase, 16A, 230 VAC	IEC 16A 3P+N+E 9h	IEC 16A 3P+N+E 9h	11.0
	Three-Phase, 32A, 230 VAC	IEC 32A 3P+N+E 9h	IEC 32A 3P+N+E 9h	22.1

Table 1: Table of branch power circuits, receptacles, matching input plugs and maximum capacity. Note: International IEC plugs and receptacles (sockets) may also be designated by the number of poles and wires (#P#W) on the plug: IEC 1P+N+E are 2P3W, 3P+N+E are 4P5W, and 3P+E is 3P4W.

What is the difference between single-phase and three-phase power?

Commercial building power is delivered in three phases and may be distributed to the rack as three-phase or as single-phase power. A three-phase circuit delivers more power than a single-phase circuit (compare capacity in Table 1, Page 5). The impact on PDU or power strip selection is simply matching the correct input plug.

3. Outlets - connections for equipment

The third decision when selecting a PDU or power strip is the number and type(s) of outlets required. There is an outlet (receptacle) to match each type of input plug, so you can choose a regional outlet or the international outlets. Also, whenever available, select outlets with a locking mechanism to ensure power cords remain plugged. *Ask how many pieces of equipment, how many power connections for each piece of equipment and if any device requires other than a C13 or C19 outlet.*

Fast Fact

If the type of outlet required is unknown once you have determined the input plug, then select the PDU or power strip with the highest number of C13 and C19 outlets. Maximize the number of C19 outlets to support higher power blade servers or network chassis.

If there is legacy equipment that requires a NEMA 5-20R outlet, then plan to consolidate it into a single cabinet and power with a PDU or power strip that includes a mix with NEMA 5-20R outlets.

Selecting the best outlet

There is an outlet to match every input plug. However, most pluggable rack-mount equipment powers between 100-250 VAC, under 16 Amperes and uses a power supply with an IEC 60320 C14 or C20 power input. So, you can connect most equipment to a PDU or power strip with jumpers using a mix of IEC 60320 C13 (matches C14) or C19 (matches C20) outlets.

CPI, like many PDU and power strip manufacturers, uses a mix of these outlet styles on our intelligent eConnect PDUs to deliver a more universal solution:

• IEC 60320, C13, capable of delivering 10 Amperes and 100-250 VAC nominal.
  The C13 is used to attach a C14 connection and will power most rack-mount equipment.
• IEC 60320, C19, capable of delivering 16 Amperes and 100-250 VAC nominal.
  The C19 is used to attach a C20 connection and will power larger blade server and switch chassis. Note that you can power a C14 connection with a C19 to C14 jumper.
• ANSI/NEMA WG-6, NEMA 5-20R, capable of delivering 20 Amperes and 100-120 VAC nominal. The NEMA 5-20R is used to attach a NEMA 5-20P or NEMA 5-15P plug and will power legacy 120 VAC equipment, LCD monitors, keyboard trays and basic appliances.

This approach also provides the flexibility to power a mix of equipment from a single PDU (Figure 4) allowing you to standardize on one or several PDUs instead of a different PDU for each region.
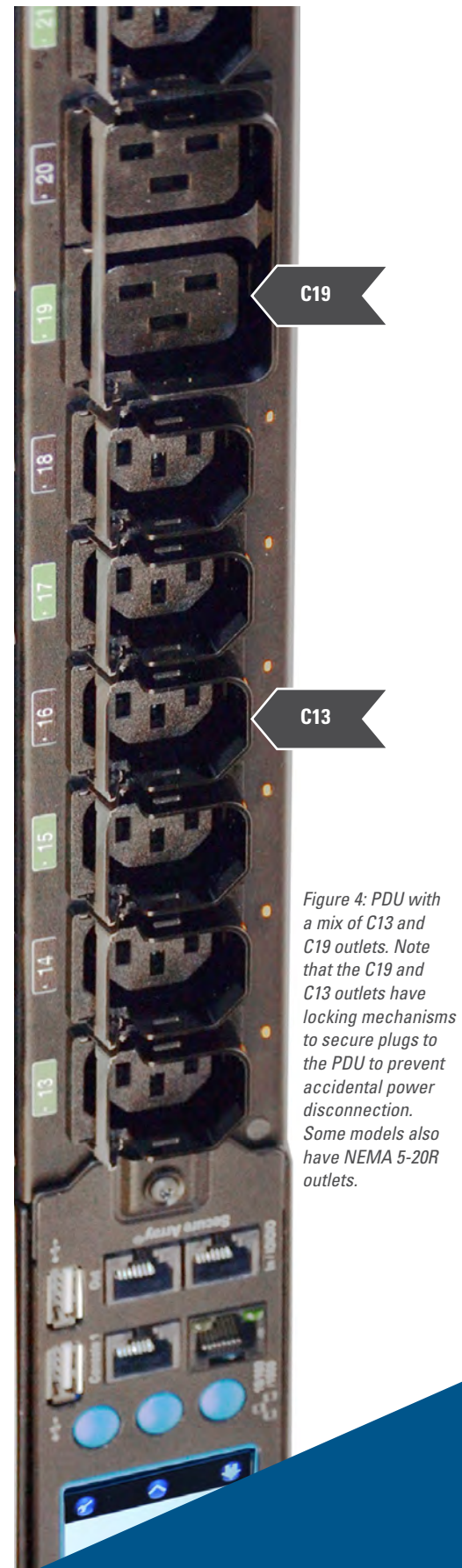

C19

C13

Figure 4: PDU with a mix of C13 and C19 outlets. Note that the C19 and C13 outlets have locking mechanisms to secure plugs to the PDU to prevent accidental power disconnection. Some models also have NEMA 5-20R outlets.

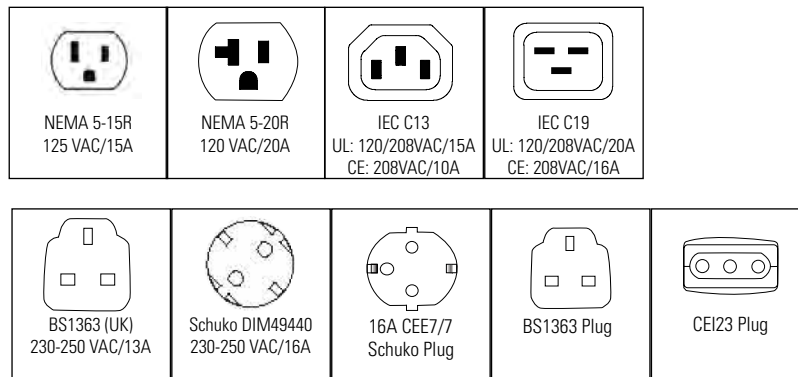There is also a wide range of power strips with the standard regional outlets *(figure 5)* to accept local plugs.

NEMA 5-15R 125 VAC/15A	NEMA 5-20R 120 VAC/20A	IEC C13 UL: 120/208VAC/15A CE: 208VAC/10A	IEC C19 UL: 120/208VAC/20A CE: 208VAC/16A

BS1363 (UK) 230-250 VAC/13A	Schuko DIM49440 230-250 VAC/16A	16A CEE7/7 Schuko Plug	BS1363 Plug	CEI23 Plug

Figure 5: Examples of regional outlets.

4. Level of Functionality - monitoring and control

The fourth decision when selecting a PDU or power strip is the level of functionality. *Ask what level of monitoring is required for the application: no power monitoring, local power monitoring, remote power monitoring, remote outlet monitoring, remote outlet control or remote outlet monitoring and control.*

> **Fast Fact**
>
> *If the level of functionality is unknown, then select metered or monitored functionalities with any three-phase PDU to provide at minimum a local load-balancing capability and switched at remote locations to provide remote reboot capability.*

No Metering

No metering provides no local or remote metering or monitoring capability. These units simply distribute power into the rack. This level of functionality is appropriate if the unit is attached to a rack-mount UPS or in data center applications where rack-level monitoring is not required. However, note that monitoring closer to the equipment provides more detail for identifying issues and optimizing power capacity utilization.

No metering is standard on CPI Basic eConnect PDUs and power strips.

Local Metering

Local metering includes at minimum an ammeter to measure and display input current (Figure 6). In multi-phase models, it is important to compare measurements and plug equipment to distribute power draw evenly across phases and breakers.

Local metering is standard on CPI Metered, Monitored, Switched, Monitored Pro and Switched Pro eConnect PDUs and power strips.

Figure 6: Metered PDU with LED panel to show current draw on each phase (L1, L2, L3)

Remote Monitoring

Remote monitoring includes a network connection with a web interface for network monitoring (Figure 7). There are typically two models that measure power at the input and breaker(s) and optionally at each outlet. Input monitoring on three-phase units allows you to balance loads across the phases, which helps upstream in the power distribution system. Breaker monitoring prevents overloading of circuits on the PDU. Outlet measurements show power draw by individual equipment.
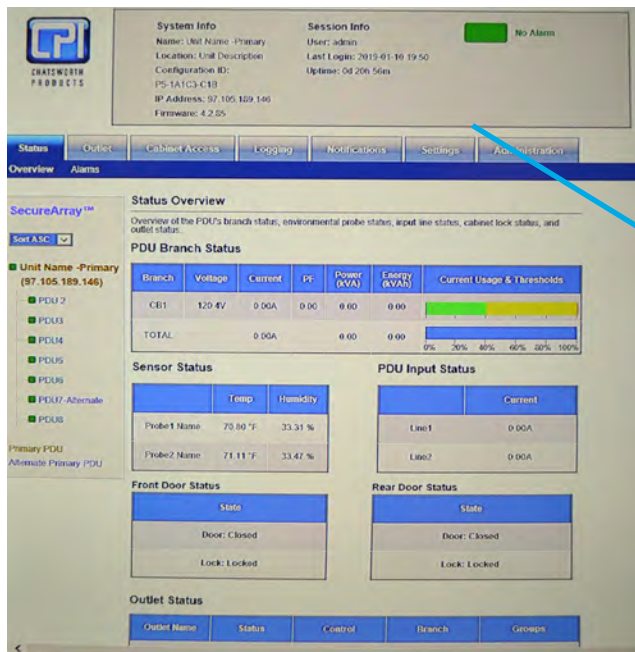

Figure 7: Monitored Pro eConnect PDU with network monitoring of power at the input, breakers and outlets

Look for models that can measure: line input current, branch voltage (V), current (A), power factor, power (kW), and energy (kWh) with +/- 1 percent accuracy. The firmware should support PDU and outlet naming, upper and lower voltage and current alarms, logging of measured values on user-defined interval, the ability to group outlets to show a combined measurement and third-party Data Center Infrastructure Management (DCIM) software integration.

Remote monitoring at the PDU level (rack-level) is standard on CPI Monitored, Switched, Monitored Pro and Switched Pro eConnect PDUs.

Remote monitoring at the outlet level (device-level) is standard on CPI Monitored Pro and Switched Pro eConnect PDUs.

Remote Control

Remote control includes a network connection and web interface for controlling outlets (Figure 8). Power to each outlet can be turned on, off or cycled remotely. Turn power off on unused outlets to force a review of new equipment before deployment. Cycle power to remote equipment as part of a troubleshooting process. Note that outlets can be both monitored and controlled.

Look for models that have an LED indicator next to the outlets to indicate "on" or "off" status and that can set a cycle time by outlet to prevent inrush currents or to sequence reboot processes. The firmware should support PDU and outlet naming, logging of power cycle events, the ability to group outlets to allow a single-click power cycle for dual- and multi-corded equipment and third-party DCIM software integration.

Remote control at the outlet level (the device level) is standard on CPI Switched and Switched Pro eConnect PDUs.

Switched Pro eConnect PDUs also monitor at the outlet level (the device level).

Conclusion: finding the right product

Once you have determined form factor, input plug, outlets and functionality, it is easy to select a PDU or power strip. CPI offers an easy-to-use, online tool, the CPI Power Selector *www.selectapdu.com* that will provide an exact part number and product specification based on your selections (Figure 9).

Figure 8: The Switched eConnect PDU with remote control outlets, blue LED indicating on, amber indicating off.
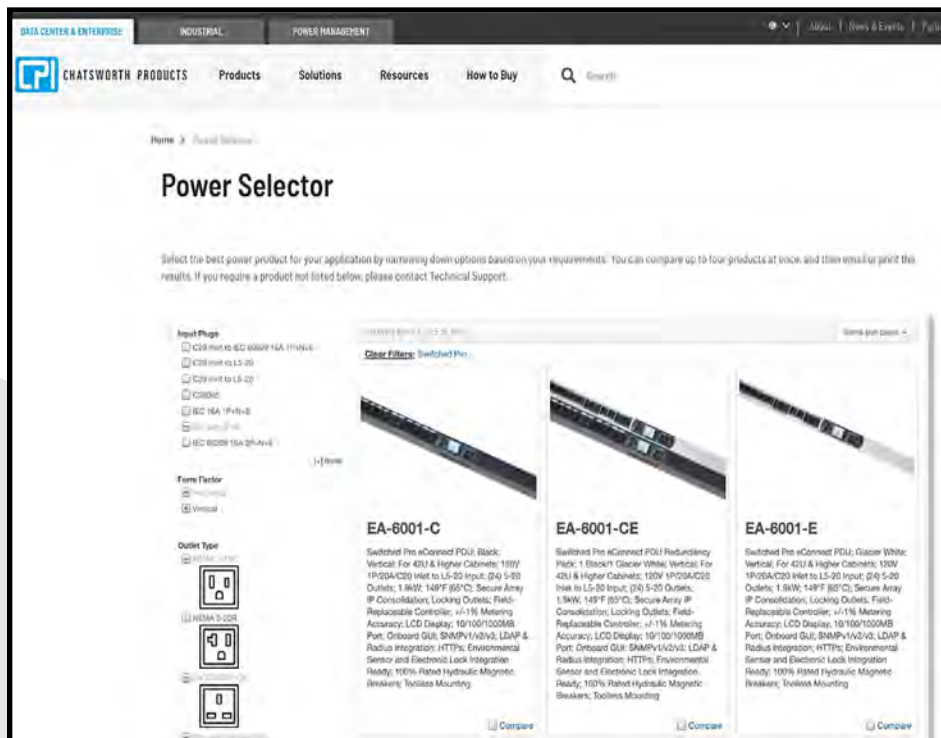
Figure 9: The CPI Power Selector is an easy-to-use, online tool for identifying and comparing CPI PDUs and power strips. Filter by form factor, input plug, outlets and functionality.

CPI PDU and Power Strip Functionality Quick Reference

CPI offers all of the levels of functionality discussed in this white paper. CPI names the levels of eConnect PDU functionality: Basic, Metered, Monitored, Switched, Monitored Pro, Switched Pro. The capabilities are identified in the table below (Table 2).

Functionality	Basic Power Distribution	Inlet Metering	Branch Circuit Metering	Networking	Outlet Metering	Switched Outlets	Secure Array	Environmental Monitoring	Access Control
Basic - Simple, reliable power distribution to equipment in your cabinets. Select a Basic PDU when no power monitoring is required.	✓								
Metered - Includes local LED display for easy reading of input current across phases. Selected a Metered PDU when networking of PDUs is not an option.	✓	✓							
Monitored - Includes local and remote power monitoring for the PDU. Select a Monitored PDU when you want to monitor total power usage.	✓	✓	✓	✓			✓	✓	✓
Monitored Pro - Includes local and remote power monitoring for each outlet on the PDU. Select a Monitored Pro PDU when you need to remotely measure individual power used by each piece of equipment.	✓	✓	✓	✓	✓		✓	✓	✓
Switched - Includes local and remote power monitoring for the PDU and individual outlet control. Select a Switched PDU if you need to remotely turn power on or off at each outlet.	✓	✓	✓	✓		✓	✓	✓	✓
Switched Pro - Includes local and remote power monitoring for the PDU and each outlet on the PDU, as well as individual outlet control. Select a Switched Pro PDU to remotely measure and control power at each outlet.	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2: Features available for each CPI PDU and power strip functionality level.

Why Select a CPI PDU or Power Strip?

CPI has more than 300 standard PDU and power strip models encompassing all functionality levels, form factors and electrical configurations. CPI also provides custom configurations in case standard configurations do not meet all your needs.

CPI manufacturers a complete solution for the rack space. CPI can be your single source for PDU, rack, cable management, airflow management, environmental monitoring, access control and DCIM software. The complete solution is the CPI cabinet eco-system. You can order a cabinet with PDUs and all accessories preinstalled or kitted to match your site requirements. The systems are fully compatible, easy to configure and operate. Monitoring at the rack level provides the data you need to optimize space, power and cooling utilization at your site.

Fast Fact *If you would like some help selecting a product or have a technical question, contact our Technical Support department* techsupport@chatsworth.com

To learn more about PDUs and power strips, download the companion white paper: **Additional Considerations When Selecting Power Distribution Units and Power Strips** *https://www.chatsworth.com/white-papers*

References

[1]National Electrical Manufacturers Association. *ANSI/NEMA WD 6-2016 Wiring Devices–Dimensional Specifications.* Published 2016. *https://www.nema.org/Standards/Pages/Wiring-Devices-Dimensional-Specifications.aspx*

[2]International Electrotechnical Commission. *IEC 60309-1: 1999, 2005, 2012 Plugs, socket-outlets and couplers for industrial purposes – Part 1: general requirements.* Published 2012. *https://webstore.iec.ch/publication/1318*

[2]International Electrotechnical Commission. *IEC 60309-2: 1999, 2005, 2012 Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories.* Published 2012. *https://webstore.iec.ch/publication/1323*

[3]International Electrotechnical Commission. *IEC 60320-1:2015, 2018 Appliance Couplers for household and similar general purpose – Part 1: general requirements.* Published 2018. *https://webstore.iec.ch/publication/63846.*

Contributor

David Knapp | Product Marketing Manager

David Knapp is a Product Marketing Manager at Chatsworth Products (CPI). He has more than 20 years of experience in the telecommunications industry as a product-application expert and technical communicator. He is currently focusing on data center, enterprise networking and power management solutions.

CPI CHATSWORTH PRODUCTS