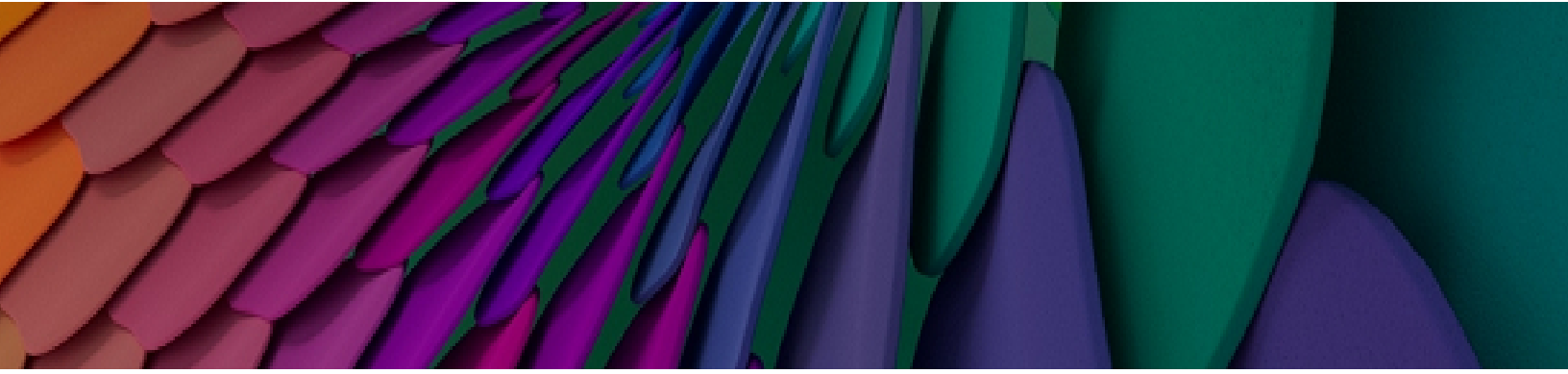

Power Over Ethernet (PoE) Planning and Implementation Guide for AOS-CX Switches

Hewlett Packard Enterprise

Published: March 2024
Edition: 5

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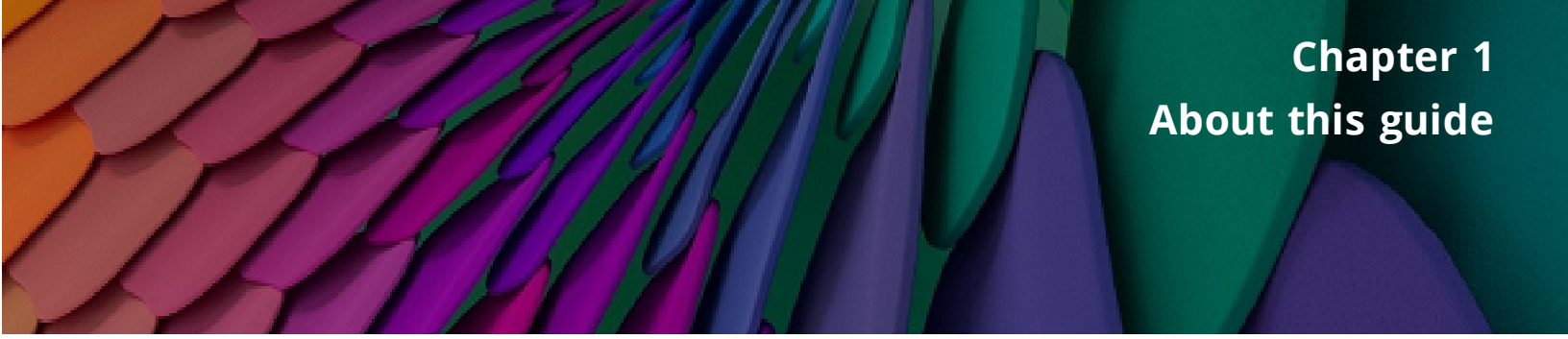


Chapter 1
About this guide

This guide includes:

- General information on Power Over Ethernet (PoE) technology
- PoE application information for specific AOS-CX switches that support PoE operation

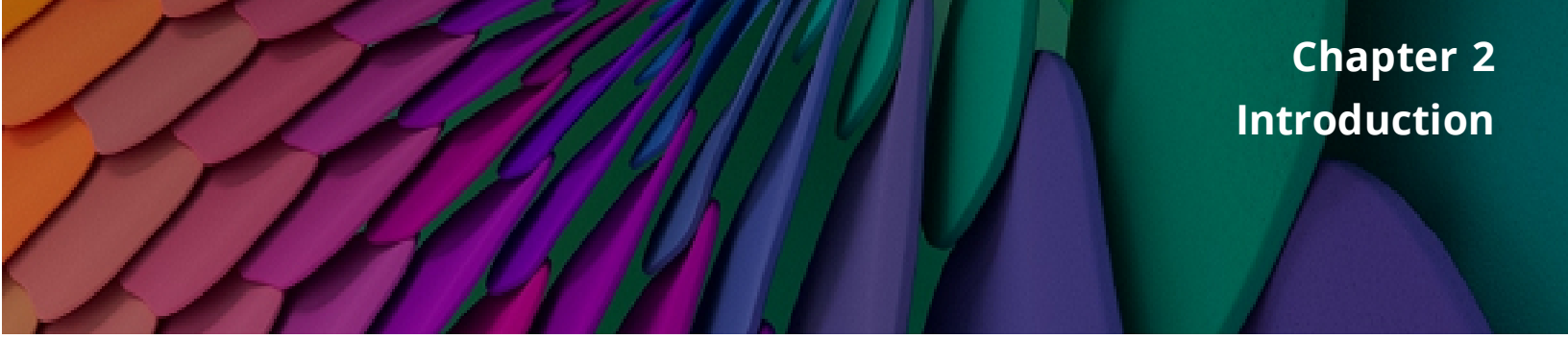
To locate the PoE information for your specific AOS-CX switch, see the Table of Contents at the front of this guide, or the Quick reference table.

Related publications

For product information not covered in this guide, see the latest version of the following guides:

- *HPE Aruba Networking 6300 Switch Series Installation and Getting Started Guide*
- *HPE Aruba Networking 6400 Switch Series Installation and Getting Started Guide*
- *Monitoring Guide*
- *Fundamentals Guide*

To find related publications, visit the HPE Networking Support Portal.



Chapter 2 Introduction

This chapter provides an overview of:

- Power over Ethernet (PoE)
- Reasons why you might want to implement PoE in your network environment
- How PoE supplies power over twisted pair cable
- The capabilities of the HPE Aruba Networking switches used to provide PoE

PoE capabilities of the HPE Aruba Networking switch products

HPE Aruba Networking switches are designed to be used primarily in wiring closets directly connected to computers, printers, and servers to provide dedicated bandwidth to those devices. Additionally, the HPE Aruba Networking switch family supports the IEEE 802.3af, IEEE 802.3at, and IEEE 802.3bt standards. (See the Quick reference table for a listing of AOS-CX switches supporting PoE operation.) They can supply power over a twisted-pair cable to power devices such as VoIP telephones, wireless access points, IP Gateways, and audio and video remote monitoring.

The HPE Aruba Networking PoE switches offer multiple data ports and can be used to build high-performance switched networks with PoE. These switches are store-and-forward devices that offer low latency for high-speed networking. The PoE switches are designed to support Redundant Power Supply and Power over Ethernet technologies.

For more information about the PoE capabilities of the following switch models, see the chapters in this document that describe PoE support for your switch.

- HPE Aruba Networking 6300 Switch Series
- HPE Aruba Networking 6400 Switch Series with one or more PoE-capable line modules installed

Overview

Power over Ethernet (PoE) technology allows IP telephones, wireless LAN Access Points, and other appliances to receive power as well as data over existing LAN cabling, without needing to modify the existing Ethernet infrastructure.

PoE has become a standard feature of Ethernet switches, as the cost of adding power supplies to the Ethernet switches is small. PoE 1 (IEEE 802.3af and IEEE 802.3at) is an extension to the existing Ethernet standards. It offers the first truly international standard for power distribution (consider how many different AC power plugs exist worldwide).

Almost all appliances require both data connectivity and a power supply. Just as telephones are powered from the telephone exchange through the same twisted pair that carries the voice, we can do the same thing with Ethernet devices.

The technology is pervasive in the world of embedded computing. Where the systems are increasingly connected to LANs and the internet, providing power and data through a single cable offers significant advantages. Consider a typical application: a system for a multi-level car parking garage that includes security cameras, information signs,

call-for-help telephones and vehicle sensors. Such a system is distributed over a significant area, where main power is not easily available. A single link to a PoE Ethernet Switch makes implementing this system faster and less expensive than using a non-PoE switch and separate AC or DC power lines to the individual appliances.

Ethernet Alliance PoE Certified

Certified HPE Aruba Networking PoE power sourcing equipment (PSE) has been verified for IEEE 802.3 PoE interoperability by passing the Ethernet Alliance (Gen 1 or Gen 2) PoE Certified program test plan, minimizing interoperability issues between PoE products.

The Ethernet Alliance PoE Certification Program provides thorough testing of PoE devices for interoperability with IEEE 802.3 PoE standard devices. Certified products will be easily recognizable by the logos below, which also identify the amount of power available or required. User experience will be enhanced by minimizing confusion between standards-based PoE from proprietary powering solutions.

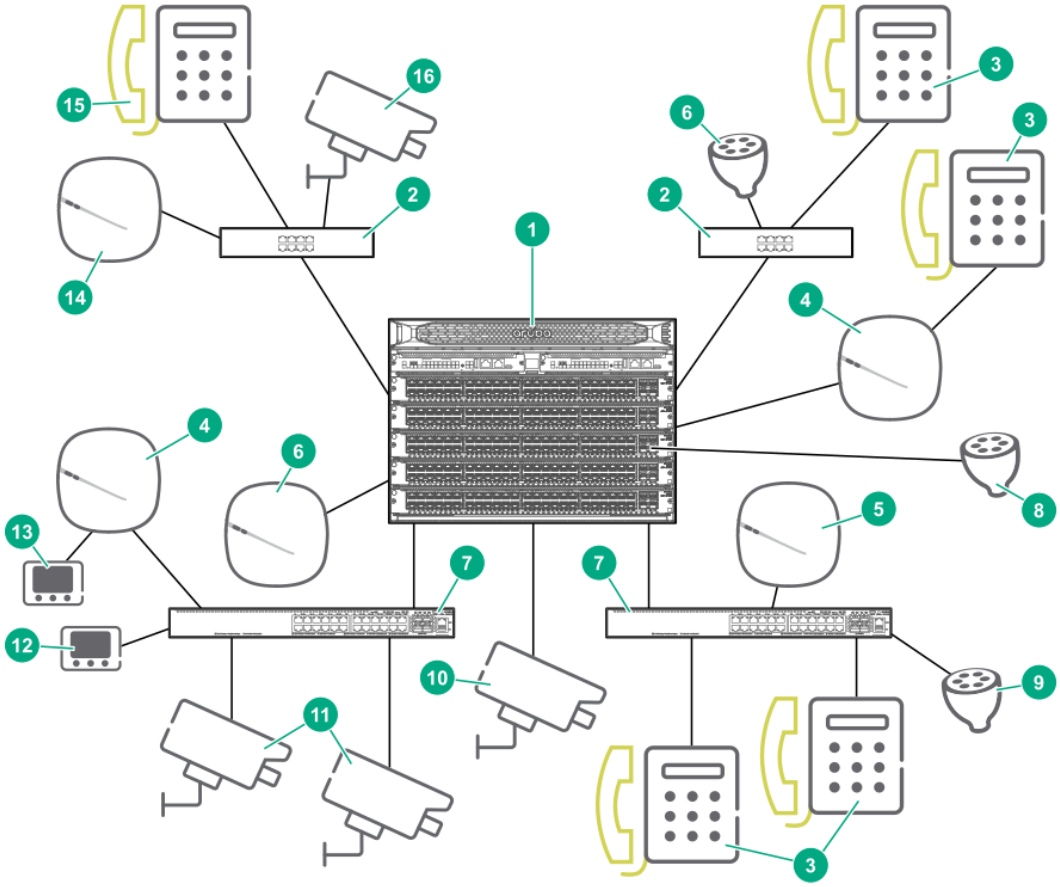
Gen 1 EA PoE Certified Logo	Gen 2 EA PoE Certified Logo
	

For more information on EA PoE Certification, visit the Ethernet Alliance website.

PoE applications and standards

This figure shows a typical system implemented to power appliances such as IP telephones and wireless access points. The PoE Ethernet switches are installed to supply power over the twisted pair LAN cables to run phones or other appliances as required.

Figure 1 *Example of a PoE implementation*



Identifier	PoE switches and powered devices
1	HPE Aruba Networking 6400 switch with PoE modules installed
2	PoE powered switches forwarding PoE power to other PDs
3	IP telephones powered by PoE
4	HPE Aruba Networking 303P Wireless Access Points forwarding PoE power to other PDs
5	HPE Aruba Networking 535P Wireless Access Point receiving power from Aruba 6300 Switch
6	HPE Aruba Networking 555P Wireless Access Point receiving power from Aruba 6400 Switch PoE line module
7	HPE Aruba Networking 6300 PoE switches
8	LED light poArubawered by HPE Aruba Networking 6400 Switch PoE line module
9	LED light powered by HPE Aruba Networking 6300 PoE Switch
10	IP camera powered by HPE Aruba Networking6400 Switch PoE line module
11	IP cameras powered by HPE Aruba Networking 6300 PoE Switch

Identifier	PoE switches and powered devices
12	Digital display powered by HPE Aruba Networking 6300 PoE Switch
13	Digital display powered by HPE Aruba Networking 303P Wireless Access Point
14	HPE Aruba Networking 303P Wireless Access Point that receives its power from a PoE switch powered by an HPE Aruba Networking 6400 Switch PoE line module
15	IP telephone powered through a PoE switch receiving its power from an HPE Aruba Networking 6400 Switch PoE line module.
16	IP camera powered through a PoE switch that receives its power from an HPE Aruba Networking 6400 Switch PoE line module

The detection and classification functions ensure that if two PoE sources are interconnected using an Ethernet cable, power will not be improperly applied at the connected ports.

The benefits of an implementation such as the above include:

- Simplifies installation and saves space - only one set of wires to bring to your appliance.
- Saves time and money - there is no need to pay for additional electrical power runs or to delay your installation schedule to power network devices.
- Minimal disruption to the workplace - the appliance can be easily moved, to wherever you can lay a LAN cable.
- Safer - no AC voltages need to be added for additional network devices.
- In addition to the data transfer to and from the appliance, you can use SNMP network management infrastructure to monitor and control the appliances.
- Appliances can be shut down or reset remotely - no need for a reset button or power switch.
- When implementing wireless LAN systems it simplifies the radio frequency (RF) survey task, as the access point can easily be moved and wired in.

PoE connections to embedded computers

- Enable a less expensive installation (no AC cabling, lower labor costs).
- Facilitate updating the installation and repositioning end devices (such as wireless access points and security cameras) without electricians.
- Maintain full control over every node through the network.

HPE Aruba Networking switches support these PoE standards:

Table 1: PoE 1 and PoE 2 power class and wire usage

Brand	Standard	Class	Minimum power at the PSE port	Maximum power consumed at the PD port	Wire usage
PoE 1	IEEE 802.3af	0-3	15.4W	13W	2 pair only
	IEEE 802.3at	4	30W	25.5W	

Brand	Standard	Class	Minimum power at the PSE port	Maximum power consumed at the PD port	Wire usage
PoE 2	IEEE 802.3bt	1-3	15.4W	13W	2 pair or 4 pair
		4	30W	25.5W	
		5	45W	40W	4 pair only
		6	60W	51W	
		7	75W	62W	
		8	90W	71.3W	

PoE Types differentiate PoE features and capabilities of both power sourcing equipment (PSE) such as certain HPE Aruba Networking switches, and powered devices (PDs), such as HPE Aruba Networking wireless access points.

PoE 1 - IEEE 802.3af PoE features

The IEEE 802.afstandard permits a Type 1 PSE to deliver power to class 0 through 3 PoE devices, and:

- Use two pair of Ethernet Cat 3 cabling supporting 10/100 Base-T.
- Use two pair of a four-pair Ethernet Cat 5e or higher cable supporting 10M/100M/1G Base-T.
- Provide a minimum of 15.4W of power at the PSE port.
- Provide 13W to a Powered Device (PD) over a 100m cable reach.
- Support LLDP Power via MDI TLV with 7 or 12 octets.

PoE 1 - IEEE 802.3at PoE features

IEEE 802.3at standard permits a Type 2 PSE to deliver power to class 0 through 4 PoE devices. Like Type 1, Type 2 PSEs use two pairs of a four-pair Ethernet cable.

The IEEE 802.3at standard (previously referred to as "PoE+") is a superset of the IEEE 802.af with the following enhancements:

- Provides a minimum of 30W of power at the PSE port; 25.5W to a Powered Device (PD) over 100m cable reach. It allows this power to also run on cabling designed for 1000BASE-T.
- Provides a new mechanism for communicating power capability and requirements using the IEEE 802.1ab Link Layer Discovery Protocol (LLDP). This protocol addition allows IEEE 802.3at and previous IEEE 802.3af switches to deliver power more efficiently and thereby provide power to more devices for a given power supply capacity.
- Supports power delivery with data speeds including 2.5G/5G/10G Base-T with amendments from IEEE 802.3bt.

Because IEEE 802.3at provides higher power than IEEE 802.3af, Class D (Cat5e) or better cables are required. IEEE 802.3atalso increases the minimum output voltage of the Power Source Equipment (PSE) from 44 volts to 50 volts. For this reason, you may note that IEEE 802.3atdevices with amendments from IEEE 802.3btuse a 54-volt power supply.

PoE 2 - IEEE 802.3bt PoE features

IEEE 802.3bt, ratified on September 27, 2018, is a standard enabling up to 90W of power delivered across a network cable supporting all standardized copper link speeds up to 10G-BaseT. IEEE 802.3bt specifications permit Type 3 and 4 PSEs to deliver power over all 4-pairs of the Ethernet cable. Type 3 PSEs can optionally deliver power over 2-pairs of the Ethernet cable for class 1-4 devices.

IEEE 802.3bt specifications permit Type 3 and 4 PSEs to deliver power over all 4-pairs of the Ethernet cable, enabling a higher efficiency and power delivery to remote devices.

IEEE 802.3bt offers these features:

- **Short Maintain Power Signature (MPS)** that improves the minimum standby power
- **Autoclass** is a classification mechanism that allows the PSE to measure the maximum power consumption at the PD and optimize the PSE power budget
- **Dual Signature PDs** supported using two independent power channels on a single port
- **Connection Check** provides a method to determine the PD architecture and cable integrity
- **LLDP Power via MDI TLV extensions** up to 29 octets supporting fine grain power delivery between Type 3-4 devices and backwards compatible with Type 1-2 devices using the first 12 octets
- **Supports power delivery** with 10M/100M/1G/2.5G/5G/10G Base-T

IEEE 802.3bt standard PSEs are backwards compatible with previous PoE standard devices (IEEE 802.3af and IEEE 802.3at). Such devices can deliver or receive power up to their maximum IEEE 802.3 PoE classification.

Minimum cabling requirements for Class 1-8 PDs

On HPE Aruba Networking PoE Class 6 PoE switches, for 60W of PoE you need a minimum of CAT5e to support up to 100 meters. However, for multigigabit applications up to a 100 meter reach, the recommended cable versions are:

- For 1G/2.5G = minimum CAT5e (class D or better)
- For 5G = minimum CAT5e (class D or better), up to 55m in high alien noise environment; up to 100m in low alien noise environment
- For 5G = minimum shielded CAT5e (class D), up to 100m; CAT6 (class E or better), up to 100m
- For 10G = minimum CAT6 (class E), up to 55m; CAT6A (class EA), up to 100m

Frequently asked questions

The following are frequently asked questions regarding PoE implementations on AOS-CX switches.

What are PSE and PD?

There are two parts to PoE: PSE and PD.

1. Power sourcing equipment (PSE) are devices that rovide power through a standard Ethernet cable. AOS-CX PoE switches are PSEs.
2. A powered device (PD) is a device powered by a PSE. Examples of PDs are VoIP phones, wireless APs, and IP cameras.

How does a PSE know that a PD is connected?

When a PD or any network cable is connected to a PSE port, the PSE applies a detection voltage and measures the resistance value of the PD. If the resistance is within IEEE standard values (23 – 26k ohm), then the connected device is treated as a PD and classification begins. For legacy devices (pre-IEEE standard devices), capacitance, rather than resistance, is measured. For a legacy device to be detected, the user needs to enable pre-standard detection on the switch.

What types and classes of PDs are supported on AOS-CX PoE switches?

PDs are divided into different types and classes based on PD power requirements.

The power supplied by the PSE will be higher than the power the PD will draw to accommodate for line losses that can result with the use of the standard's maximum length cable (100m).

Different Types of PD:

- Type 2: PSE can supply a maximum of 30W, and PD can draw a maximum of 25.5W
- Type 3: PSE can supply a maximum of 60W, and PD can draw a maximum of 51W
- Type 4: PSE can supply a maximum of 90W, and PD can draw a maximum of 71.3W (Not supported by AOS-CX PoE switches)

Different Classes of PD:

- Class 0: Type1 PD, it can draw a maximum of 13W
- Class 1: Type1 PD, it can draw a maximum of 3.84W
- Class 2: Type1 PD, it can draw a maximum of 6.49W
- Class 3: Type1 PD, it can draw a maximum of 13w
- Class 4: Type2 PD, it can draw a maximum of 25.5W
- Class 5: Type3 PD, it can draw a maximum of 40W
- Class 6: Type3 PD, it can draw a maximum of 51W
- Class 7: Type4 PD, it can draw a maximum of 62W (Not supported by AOS-CX PoE switches)
- Class 8: Type4 PD, it can draw a maximum of 71.3W (Not supported by AOS-CX PoE switches)

What is 4Pair PoE?

IEEE 802.3bt introduced 4Pair PoE as a means of supplying higher power to PDs that need more than the current 25.5W supplied by 802.3at. In order to increase the available power without damaging the Ethernet cable, the standard introduced the ability to use all 4 pairs within the Ethernet cable instead of the 2 pairs used by previous standards (802.3at, 802.3af). AOS-CX utilizes the new LTC429x PoE controllers to provide this functionality.

Which PoE protocols are supported on AOS-CX switches?

AOS-CX PoE switches support the following standards:

- IEEE 802.3af
- IEEE 802.3at
- IEEE 802.3bt
- Pre-standard PoE implementations

What are single signature and dual signature PDs?

- Single signature PDs share the same detection signature (resistance/capacitance of the PD during detection by the PSE), classification signature (current drawn by the PD during classification), and maintain power signature (MPS; current waveform drawn by the PD to stay powered) between both pair sets.
  - Detection resistance is shared between pair sets and has an effective resistance of 25K ohms.
  - The classification current is shared by the two pair sets.
  - The MPS is shared between pair sets.
- Dual signature PDs have independent detection signatures, classification signatures, and MPS on each pair set.
  - 25K ohms detection resistance on each pair set.
  - Independent classification currents on each pair set.
  - The MPS is enforced on each pair set.

What are the grounding requirements for PoE?

There are no additional grounding requirements when running any of the PoE or other remote powering applications on structured cabling. The same grounding requirements exist when running standard Ethernet applications.

What is "always-on" PoE?

Always-on PoE is a feature that provides the ability for the switch to continue to provide power across a soft reboot. It is applicable only to the ports which were connected and delivering power before the soft reboot. Power will not be delivered if power to the switch is interrupted. By default, always-on PoE is enabled for the switch.

PDs only remain powered—no data transfer or PoE power negotiation can occur until the switch has completely booted up and is in normal operation. PD faults occurring prior to full switch boot up will result in PoE power removal and restart the detection process only after switch returns to normal operation.

What is the default interface PoE power priority on AOS-CX switches?

Per-port power is enabled by default with a priority of **low**. The administrator can configure this to be **high** or **critical**. See the *Monitoring Guide* for more information.

How does the PoE power priority and module power-priority work?

PoE uses both PoE port priority and module power-priority for power budgeting in the event of power over-subscribtion. PoE ports are powered based on PoE priority, If the ports have same PoE priority then the port which has the higher module power-priority gets precedence. With same PoE priority and same module power-priority, lower numbered line-modules ports have higher precedence.

If a newly inserted module is not powered on due to insufficient power, then the PoE powered devices connected to the module also will not get power.

Configuration example for power budgeting based on priority for chassis based device:

- LC 3:
  - Power_priorty: 50
  - PoE priority:
    - Ports 1-10: Critical
    - Ports 11-25: High
    - Ports 26+: Low (default)
- LC 4:
  - Power_priorty: 254
  - PoE priority:
    - Ports 1-10: Critical
    - Ports 11-25: High
    - Ports 26+: Low (default)
- LC 5:
  - Power_priorty: 128 (default)
  - PoE priority:
    - Ports 1-10: Critical
    - Ports 11-25: High
    - Ports 26+: Low (default)

Power Request module power granted order:

1. LC 4
2. LC 5
3. LC 3

What are the PoE allocation methods supported on AOS-CX PoE switches and how do they work?

AOS-CX PoE switches support two methods: by usage and by class. All AOS-CX PoE switches default to power allocation by usage. The administrator can configure the power allocation method. In the power allocation method based on usage, the PSE allocated power value will be the LLDP power when LLDP exchange takes place between the PSE and the PD. When there is no LLDP negotiation, the PSE allocated power value will be the actual instantaneous power draw. Reserve power is based on actual consumption.

In the power allocation method based on class, the PSE allocated power value will be the LLDP power when LLDP exchange takes place between the PSE and the PD. When there is no LLDP negotiation, the PSE allocate power value with be based on the PD class. Reserve power is based on the PD Class.

How do you enable pre-standard phones on AOS-CX PoE switches?

AOS-CX switches use the **power-over-ethernet pre-std-detect** command to enable pre-standard PoE devices:

```
switch(config)# interface 1/1/1
switch(config-if)# power-over-ethernet pre-std-detect
switch(config-if)# no power-over-ethernet pre-std-detect
```

Before IEEE standardized Power over Ethernet, vendors had shipped PoE-capable switches and PDs. HPE Aruba Networking switches are backward compatible, supporting both the IEEE standard and pre-standard PDs concurrently. The **power-over-ethernet pre-std-detect** command allows the user to enable or disable pre-802.3af-standard device detection and power on the specified port.

When **power-over-ethernet pre-std-detect** is enabled, power will be delivered on Pair A only. The default is disabled.

How do you limit power on AOS-CX PoE switches?

You can limit PoE power based on the assigned class. When a user assigns a maximum class to an interface, the PSE will not allow any connected PDs to be powered at a class higher then the assigned class. This will cap the amount of power that the connected PD is allowed to draw to the maximum power of the assigned class by demoting the PD to the assigned class. PoE ports cannot set an assigned class when quick PoE is enabled on the subsystem. The default assigned class is 6.

The interface assigned class cannot be configured when quick PoE is enabled.

What is quick PoE?

Quick PoE is a feature that provides the ability for the switch to provide power to the connected PD as soon as possible after a switch cold reboot. When quick PoE is enabled on the subsystem, PoE port disablement and PD demotion is not allowed. Quick PoE enablement is not allowed if any of the port is disabled on the subsystem.

- You should not over-subscribe the PoE power when quick PoE is enabled.
- A quick PoE saved configuration will work irrespective of the configuration change at reboot.
- By default, quick-PoE is disabled for the subsystem.

Is LLDP dot3 TLV and MED TLV supported on AOS-CX PoE switches?

Yes, by default LLDP dot3 TLV and MED TLV are enabled on PoE ports.

When both dot3 and MED are enabled, dot3 takes precedence. Priority override is by default disabled and can be configured.

What is the PoE threshold?

You can set the threshold at which the system will send an excess power consumption notification trap. The default threshold value is 80 percent. Configure the threshold using the **power-over-ethernet threshold <PERCENTAGE>** command.

How do you configure a PoE SNMP trap?

Use the **power-over-ethernet trap** command to enable/disable SNMP trap generation for PoE-related events at the system level. PoE trap generation is enabled by default.

Power through the cable

A standard CAT5 or CAT6 Ethernet cable has four twisted pairs. Only two of these pairs are used for 10Base-T and 100Base-TX data; all four are used for 1000Base-T data. Cable types for use with the PoE standards supported by HPE Aruba Networking switches include:

Brand	PoE standard	Class	Minimum cable type	Transmission speed
PoE 1	IEEE 802.3af	0-3	Cat 3	10M/100M/1G/2.5G/5G/10G
	IEEE 802.3at	4	Cat 5e	
PoE 2	IEEE 802.3bt	1-8	Cat 5e	

- **The spare pairs are used.**

  The pair on pins 4 and 5 are connected together and form the positive supply, and the pair on pins 7 and 8 are connected and form the negative supply.

- **The data pairs are used.**

  Since Ethernet pairs are transformer-coupled at each end, it is possible to apply DC power to the center tap of the isolation transformer without upsetting the data transfer. In this mode of operation the pair on pins 1 and 2 and the pair on pins 3 and 6 can be of either polarity.

PoE 1 wire usage over 2-pairs

The IEEE 802.3af and IEEE 802.3at standards enable Type 1 and Type 2 PSEs to deliver power over two pairs of a four-pair Ethernet cable. They do not allow both the spare and data pairs to be used - a choice must be made. The

Power Sourcing Equipment (PSE) applies power to either set of wires. An HPE Aruba Networking switch, as a PSE, supplies PoE power over the “data pair” or, pins 1, 2 and 3, 6. The Powered Device (PD) must be able to accept power from all four pairs because mid-span equipment must supply power over the “spare pair” or pins 4, 5, 7, and 8.

PoE 2 wire usage over 4-pairs and 2-pairs

The IEEE 802.3bt standard enables Type 3 and Type 4 PSEs to deliver power over all four pairs of Ethernet cable. Type 3 and Type 4 PSEs delivery power over both the "data pair" and "spare pair" in a 4-pair wire usage configuration. Type 3 PSEs may optionally deliver power over only the "data pair" or "spare pair" in a 2-pair wire usage configuration when connected to a class 0-4 PD. The PD must be able to accept power from all 4-pairs.

Damage protection

An obvious requirement of the specification is to prevent damage to existing Ethernet equipment. A discovery process, run from the PSE, examines the Ethernet cables, looking for devices that comply with the PoE 1 and PoE 2 specifications. It does this by applying a small current-limited voltage to the cable and checks for the presence of a 25k ohm resistor in the powered device.

Once discovered, a different voltage is applied, and based upon the current drawn, the class of PD can be determined. This indicates how much power the PD has requested. The PoE 1 and PoE 2 standards provide both a physical classification and a logical classification, utilizing LLDP to communicate even more precise power classification levels over ethernet data.

Only when valid PD detection and classification has completed, will the full PSE assigned class power be delivered up to PD requested class but the PSE is still current-limited to prevent damage to cables and equipment in fault conditions.

The PD must continue to draw a minimum current. If it does not (for example, when the device is unplugged) then the PSE removes the power and the discovery process begins again when the same or another PD is plugged into that port.

Switch quick reference tables

Table 2: HPE Aruba Networking 6300M/F PoE switches

HPE Aruba Networking 6300 PoE switches	Port type	PoE port count/PoE watts per port	EA Certified logo
HPE Aruba Networking 6300M 48-port HPE Smart Rate 1/2.5/5GbE Class 6 PoE and 4-port SFP56 Switch (JL659A)	100M/1G/2.5G/5G BASE-T	48 / 60W	
HPE Aruba Networking 6300M 24-port HPE Smart Rate 1/2.5/5GbE Class 6 PoE and 4-port SFP56 Switch (JL660A)	100M/1G/2.5G/5G BASE-T	24 / 60W	
HPE Aruba Networking 6300M 48-port 1GbE Class 4 PoE and 4-port SFP56 Switch (JL661A)	10/100/1000 BASE-T	48 / 30W	

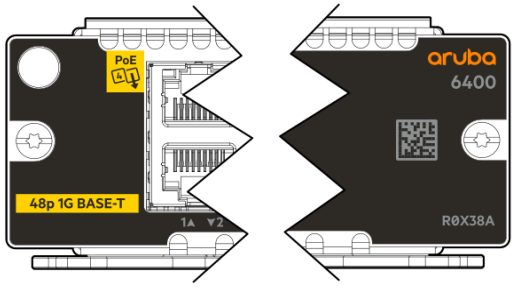
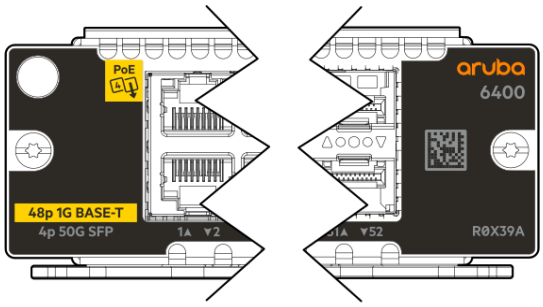
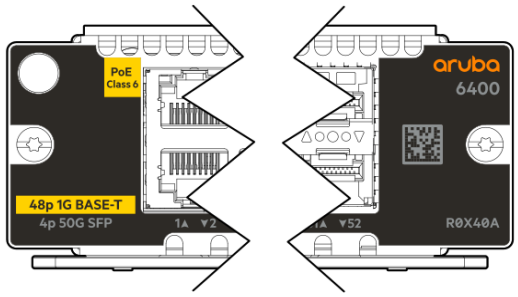
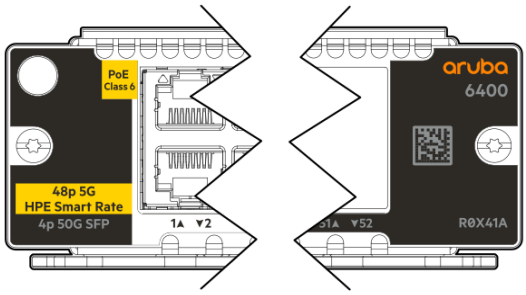
HPE Aruba Networking 6300 PoE switches	Port type	PoE port count/PoE watts per port	EA Certified logo
HPE Aruba Networking 6300M 24-port 1GbE Class 4 PoE and 4-port SFP56 Switch (JL662A)	10/100/1000 BASE-T	24 / 30W	
HPE Aruba Networking 6300F 48-port 1GbE Class 4 PoE and 4-port SFP56 Switch (JL665A)	10/100/1000 BASE-T	48 / 30W	
HPE Aruba Networking6300F 24-port 1GbE Class 4 PoE and 4-port SFP56 Switch (JL666A)	10/100/1000 BASE-T	24 / 30W	

Table 3: HPE Aruba Networking 6400 chassis switches

HPE Aruba Networking 6400 switch chassis	Port type (in optional modules)	PoE port count/PoE watts per port	EA Certified logo
HPE Aruba Networking6405	10/100/1000 2.5G/5G* *R0X41A SmartRate line module only.	HPE Aruba Networking 6405 switch supports 48-240 PoE ports in per-module increments of 48 ports.	
HPE Aruba Networking 6410	10/100/1000/ 2.5G/5G* *R0X41A SmartRate line module only.	HPE Aruba Networking 6410 chassis supports 48-480 PoE ports in per-module increments of 48 ports.	

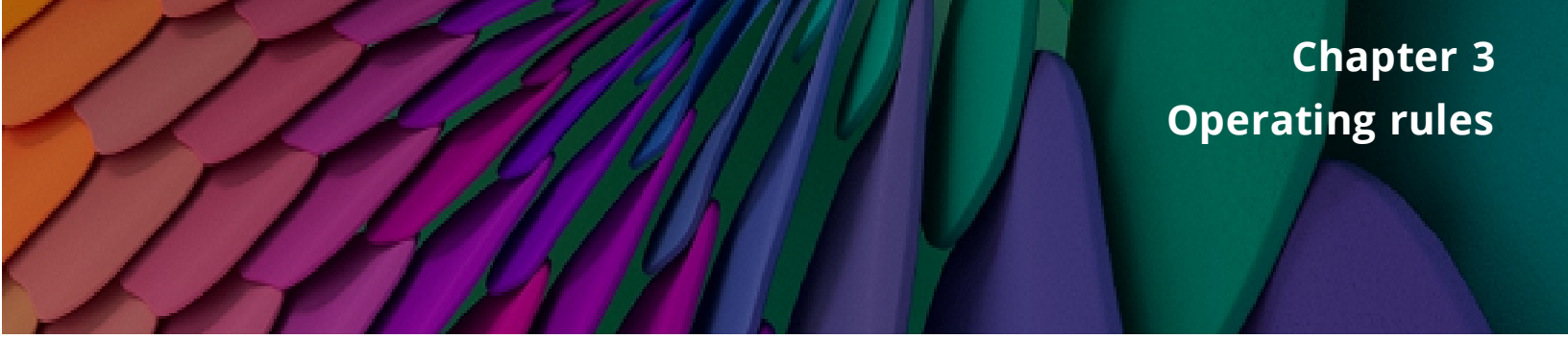
Table 4: PoE line modules for the HPE Aruba Networking 6400 chassis switches

PoE Modules for HPE Aruba Networking 6400 chassis switches:	Port Type	PoE Port Count/PoE watts per port	EA Certified logo
HPE Aruba Networking 6400 48-port 1G PoE Class 4 Module (R0X38B)	10/100/1000	Up to 30 watts*	

PoE Modules for HPE Aruba Networking 6400 chassis switches:	Port Type	PoE Port Count/PoE watts per port	EA Certified logo
			
HPE Aruba Networking 48-port 1G PoE Class 4 & 4-port SFP56 Module (R0X39B) 	10/100/1000	Up to 30 watts*	
HPE Aruba Networking 6400 48-port 1G PoE Class 6 & 4-port SFP56 Module (R0X40B) 	10/100/1000 BASE-T	Up to 60 watts**	
HPE Aruba Networking 48-port SR PoE Class 6 & 4-port SFP56 Module (R0X41A) 	Smart Rate 100M/1G/2.5G/5G BASE-T	Up to 60 watts**	

*The number of 30W PoE ports in a module depends on power supply configuration.

**The number of 60W PoE ports in a module depends on power supply configuration.



Chapter 3
Operating rules

This chapter introduces the operating rules and characteristics of the AOS-CX switches and networking product capabilities. Included is an overview of how PoE power is configured on these devices, and how the switches prioritize PoE provisioning to their network ports.

Using the CLI to configure PoE power

Allocating PoE power by class or user-defined power level

The AOS-CX switches provide maximum flexibility by allowing the switch to detect and classify 802.3af, 802.3at, and 802.3bt device types. Power is allocated based on the PD requested class. For example, when a class 6 PD is connected, the switch allocates a minimum of 60W. Similarly, when a class 4 PD is connected, the switch allocates a minimum of 30W. The default power allocation re-purposes unused power back into the total power budget allowing existing PDs to increase power consumption or to power on new PD connections. Power allocations can be modified by the network administrator.

There are four methods to allocate PoE power:

- By device usage (default). The switch provides full power based on the PD requested class and dynamically allocates power based on actual PD usage while it re-purposes unused power into the total power budget
- By class specified in 802.3af, 802.3at, or 802.3bt. The switch allocates full power based on the PD requested class and reduces the total power budget using the full switch assigned class power.
- By assigned class configuration. The default PSE assigned class delivers the maximum PSE capable power at initial power-up based on PD requested class. To configure allocation by class, use `power-over-ethernet allocate-by class` For more information on PoE allocate by class, see the latest version of the *Monitoring Guide* for your switch.
- By LLDP negotiated between the switch and PD. LLDP uses valid Power via MDI TLVs specified in 802.3af, 802.3at, and 802.3bt to allocate fine grain power values based on the PD requested class. For more on LLDP and PoE, see the latest *Monitoring Guide* for your switch.

Switch port priority

Using a `port-number priority` method, a lower-numbered port has priority over a higher-numbered port within the same configured priority class, for example, port A1 has priority over port A5 if both are configured with **High** priority.

A port can be assigned a power priority that alters the assignment of power to it by the switch. For more information, see the latest *Monitoring Guide* for your switch.

Switch priority class

Using a priority class method, a power priority of **Low** (the default), **High**, or **Critical** is assigned to each enabled PoE port. This assignment is done through the switch CLI and alters the hardware port-number-based priority for power allocation.

- Low (the default) - This priority class receives power only if all other priority classes are receiving power. If there is enough power to provision PDs on only some of the ports with a low priority, then power is allocated to the ports in ascending order, beginning with the lowest-numbered port in the class until all available power is in use.
- High - This priority class receives power only if all PDs on ports assigned with a critical priority are receiving full power. If there is not enough power to provision PDs on ports assigned with a high priority, then no power goes to the low priority ports. If there is enough power to provision PDs on only some of the high priority ports, then power is allocated to the high priority ports in ascending order, beginning with lowest-numbered high priority port, until all available power is in use.
- Critical - This priority class is the first to be allocated power. If there is not enough power to provision PDs on all of the ports configured for this class, then no power goes to “High or Low” priority ports. If there is enough power to provision PDs on only some of the critical ports, then power is allocated to the critical ports in ascending order, beginning with the lowest-numbered port in the class.

For more information, see the latest *Monitoring Guide* for your switch.

Threshold

You can configure one of the following thresholds:

- A global power threshold that applies to all modules on the switch. This setting acts as a trigger for sending a notice when the PoE power consumption on any PoE module installed in the switch crosses the configured global threshold level. (Crossing the threshold level in either direction—PoE power usage either increasing or decreasing—triggers the notice.) The default setting is 80%.
- A per-slot power threshold that applies to an individual PoE module installed in the designated slot. This setting acts as a trigger for sending a notice when the module in the specified slot exceeds or goes below a specific level of PoE power consumption.

For example if the threshold is set at 50%, the switch informs you that the switch has exceeded the threshold when 51% of available PoE power is being used.

For more information, see the *Monitoring Guide* for your switch.

PoE power characteristics

Line loss

A certain amount of power is consumed by the resistance of the wire in the LAN cable connected from the switch to the powered device. This typically amounts to less than 16% loss. Power loss is caused by cable length, cable quality, and other factors.

Line loss provisions for IEEE 802.3af and IEEE 802.3at

The IEEE 802.3af and IEEE 802.3at specifications have addressed power loss by permitting the power source to provide more power than a powered device requires. Also, depending upon the PD requested class (Class 0-8), the switch provides a minimum power in excess of the PD requested class to address the specific power needs of that end device taking into account line loss over 100m cable reach.

Line loss provisions for IEEE 802.3bt

The IEEE 802.3bt specification improves line loss by 50% when the switch provides power to class 0-4 devices over all 4-pairs.

PD power requirements

A PD is classified based on the maximum power it draws across all input voltages and operational modes. As an example, 15.4 watts - Power Loss (16%) = 13 watts.

Table 5: Power usage

PD Class	Minimum Power Levels at Output of PSE (Watts)	Range of Maximum Power required by the PD (Watts)
0	15.4W	0.44 to 12.95W
1	4.0 W	0.44 to 3.84W
2	7.0 W	3.84 to 6.49W
3	15.4W	6.49 to 13W
4	30.0W	0.05 to 25.50W
5	45.0W	0.5 to 40 W
6	60.0W	0.5 to 51 W
7	75.0W	0.5 to 62 W
8	90.0W	0.5 to 71.3

The "Power usage" table for classes 0-3 shows that IEEE 802.3af-compliant PDs require up to 13 watts. The switch provides a minimum of 15.4 watts at the port to ensure enough power to run class 3 PDs, after accounting for line loss. For class 4, the switch provides 30 watts at the port to ensure enough power to run a class 4 PD, after accounting for line loss. For class 6, the switch provides 60 watts at the port to ensure enough power to run a class 6 PD, after accounting for line loss.

PSE minimum power delivered

When a PoE port delivers power to a connected PD after successful detection and classification, the PD begins its initial power-up sequence not to exceed the following power levels):

Table 6: *Minimum power at initial power-up*

Device class	Minimum power required at the PSE port
0-3 (IEEE 802.af)	15.4W
4 (IEEE 802.3at)	30W
5-6 (IEEE 802.3bt)	60W
7-8 (IEEE 802.3bt)	90W

Once the power class is determined and power is supplied, any power beyond the maximum power requirements for that class of PD is available for use by other detected PDs.

In the default switch configuration all PoE ports have the Low priority. If the switch has less PoE power available than listed in Table 6, the switch transfers power from lower-priority ports to higher-priority ports.

See Switch priority class on page 19 for information on the use of PoE port priority classifications. Within each priority class, a lower numbered port is supplied power before a higher numbered port.

Disconnecting a PD from a port causes the switch to stop providing power to that port and makes that power available to other ports configured for PoE operation.

Provisioning power for PoE

Switches addressed in this guide support the use of multiple power supply units (PSUs). Also, most of these switch models can operate with multiple PSUs, which provides the flexibility to provision for one or more levels of redundant power, depending on the switch model and PoE load. It is important to understand how PoE power is provisioned in order to use redundant power effectively.

By installing more than the minimum number of PSUs, you can optionally provision more PoE wattage per port and/or supply the switch with redundant power to operate in case an installed PSU fails.

For example, if you operate an HPE Aruba Networking 6405 switch needing two 3000W PSUs to support the intended PoE load, installing a third PSU in the HPE Aruba Networking 6405 switch provides *N* + 1 redundancy (where *N* is the number of PSUs required to operate the switch with the intended load). If one of the PSUs fails, the switch will continue to operate at its intended load on the remaining two PSUs, Actual load depends on the switch operating power load plus how many PoE ports are being supplied with power.

For information on provisioning PoE power by your switch, see the chapter in this manual for your switch model.

Stacking operation with PoE on the HPE Aruba Networking 6400 switches

In the stacked environment, PoE will still be managed at the member level. This means that power available to one member cannot be shared with other members. The PoE features will have to be configured on an interface basis, based on the member number. For example:

```
(config)# interface 1/3/1-1/3/24
(config-if-<1/3/1-1/3/24)# no power
```

To configure stacking by using CLI commands, see the *Monitoring Guide* .

LLDP operation with PoE on the HPE Aruba Networking switches

Examples in this document are representative and might not match your particular switch or environment. The slot and port numbers in this document are for illustration only and might be unavailable on your device.

The software notation for identifying interfaces uses member/slot/port notation, such as 1/1/1. For standalone (fixed-port) switches, such as the HPE Aruba Networking 6300 switches, the slot designation is always 1.

By default, LLDP on AOS-CX switches is enabled. LLDP is used after the PD is powered on to negotiate for finer grain power levels below the PD requested class. Upon successful LLDP power negotiation, the new PD requested power value is used to replace the physical layer PD requested class power value and the allocate by actual field changes from **usage** to **lldp**.

To disable LLDP on a specific switch port, disable the lldp dot3 poe TLV on the port. For example, to disable LLDP on port 1/3/5:

```
switch(config-if)# int 1/3/5
switch(config-if)# no lldp dot3 poe
```

To verify the configuration:

```
switch(config-if)# show run int 1/3/5
switch(config-if)# interface 1/3/5
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# vlan access 1
switch(config-if)# no lldp dot3 poe
switch(config-if)# exit
```

To enable and verify LLDP on an LLDP-disabled port:

```
switch(config-if)# lldp dot3 poe
switch(config-if)# show run int 1/3/5
switch(config-if)# interface 1/3/5
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# vlan access 1
switch(config-if)# exit
```

LLDP is not required for power negotiation, therefore, the static power option is not a configurable option on the AOS-CX platform.

For a more comprehensive coverage of LLDP commands for PoE, see the latest *Monitoring Guide* for your switch.

Chapter 4
PoE planning and implementation for HPE Aruba Networking 6300 switches

The power for HPE Aruba Networking 6300 PoE Switch applications is compatible with these standards and some prestandard devices:

SKU	Switch model	IEEE 802.3bt	IEEE 802.3at	IEEE 802.3af
JL659A	HPE Aruba Networking 6300M 48SR5 CL6 PoE 4SFP56 Swch	Yes	Yes	Yes
JL660A	HPE Aruba Networking 6300M 24SR5 CL6 PoE 4SFP56 Swch			
JL661A	HPE Aruba Networking 6300M 48G CL4 PoE 4SFP56 Swch	No		
JL662A	HPE Aruba Networking 6300M 24G CL4 PoE 4SFP56 Swch			
JL665A	HPE Aruba Networking 6300F 48G CL4 PoE 4SFP56 Swch			
JL666A	HPE Aruba Networking 6300F 24G CL4 PoE 4SFP56 Swch			

HPE Aruba Networking 6300 PoE switches

The PoE capabilities of the HPE Aruba Networking 6300 PoE switches and the applicable Aruba power supply units (PSUs) that provide PoE power to connected powered devices (PDs), are described in this chapter. The PoE power available depends on:

- switch model
- number and power rating of installed or internal fixed PSUs
- number of cooling fans in use

SKU	PoE switch model	PoE Ports	PoE Standards	PSU options and power ratings[1]	Internal fixed power supply
JL659A	HPE Aruba Networking 6300M 48-port HPE Smart Rate 1/2.5/5GbE Class 6 PoE and 4-port SFP56 Switch	48	802.3af 802.3at 802.bt (up to 60W/port)	JL086A: 300W JL087A: 600W JL670A (110-120V AC): 600W JL670A (200-240V AC): 1300W	N/A
JL660A	HPE Aruba Networking 6300M 24-port HPE Smart Rate 1/2.5/5GbE Class 6 PoE and 4-port SFP56 Switch	24			
JL661A	HPE Aruba Networking 6300M 48-port 1GbE Class 4 PoE and 4-port SFP56 Switch	48	802.3af 802.3at	JL086A: 370W JL087A: 740W JL670A (110-120V AC): 740W JL670A (200-240V AC): 1440W	
JL662A	HPE Aruba Networking 6300M 24-port 1GbE Class 4 PoE and 4-port SFP56 Switch	24			
JL665A	HPE Aruba Networking 6300F 48-port 1GbE Class 4 PoE and 4-port SFP56 Switch	48	802.3af 802.3at	740W Max	950W
JL666A	HPE Aruba Networking 6300F 24-port 1GbE Class 4 PoE and 4-port SFP56 Switch	24	802.3af 802.3at	370W Max	950W

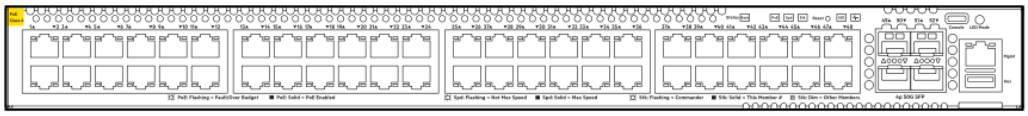
HPE Aruba Networking 6300 24/48-port PoE switches

HPE Aruba Networking Networks offers four PoE class 4 and two PoE class 6 switches that operate with:

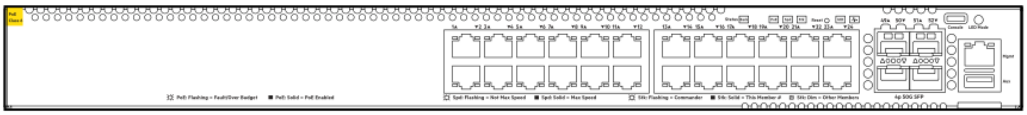
- Always-on PoE for continued power during scheduled reboots and firmware upgrades. Always-on PoE is enabled by default, and no additional configuration is needed.
- Support for pre-standard PoE detection that provides power to some legacy PoE devices
- PoE allocation by usage or class using LLDP and LLDP-MED to enable allocation of PoE power for more efficient power management and energy savings

HPE Aruba Networking 6300 modular 48/24 Class 6 PoE 4SFP56 switches (JL659A and JL660A)

JL659A



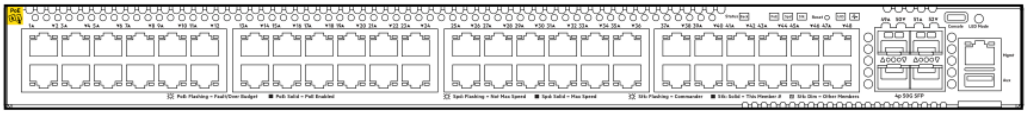
JL660A



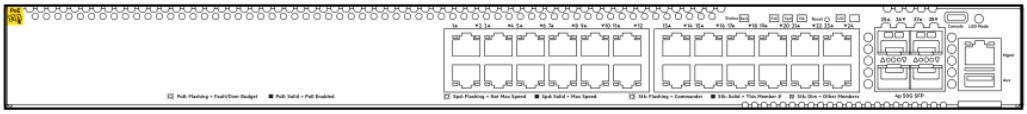
The JL659A and JL660A Aruba 6300M switches provide industry-standard IEEE 802.3bt high power PoE class 6 with up to 60W per port for support of IoT devices and APs. The ports are IEEE 802.3bt-compliant and allow for the current and future bandwidth demands of modern 11ac and 11ax access points, as well as any other emerging high-throughput powered devices.

HPE Aruba Networking 6300 modular 48/24 Class 4 PoE 4SFP56 switches (JL661A and JL662A)

JL661A



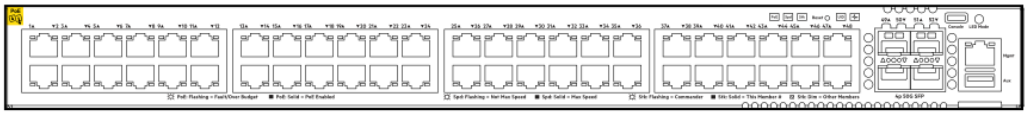
JL662A



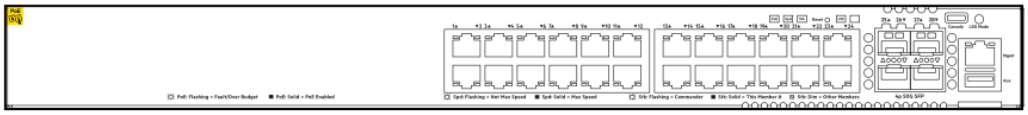
The JL661A and JL662A modular switches provide IEEE802.3at PoE support for up to 30W per port for support of IoT devices and APs, as well as any IEEE802.3af-compliant powered devices.

HPE Aruba Networking 6300 fixed 48/24 Class 4 PoE 4SFP56 switches (JL665A and JL666A)

JL665A



JL666A



The JL665A and JL666A fixed switches provide IEEE802.3at PoE support for up to 30W per port, as well as any IEEE802.3af-compliant powered devices.

Power redundancy in 6300 modular switches

An HPE Aruba Networking 6300M switch with two PSUs installed and connected to separate circuits reduces the risk of the switch shutting down due to a power failure. In an Aruba 6300 modular PoE switch, you can help prevent an unexpected loss of PoE power to installed PoE ports due to a PSU failure by using one PSU as a reserve (redundant) power source in case an installed PSU fails. For example, if a 6300M PoE switch requires an Aruba X372 54VDC 1050W PSU to run the switch and support PoE operation, then installing a second Aruba 1050W PSU provides

redundancy to keep the switch operating at full capacity if one power supply fails. This example can be expressed as *N* + 1, where "*N*" is the power supply needed to support the switch and PoE load, and "1" is the redundant PSU installed as a backup in case there is a power failure in one of the installed PSUs.

In the default configuration, HPE Aruba Networking 6300M Switch power redundancy is disabled. For information on enabling power redundancy and other PoE commands, see the latest *Monitoring Guide* for your switch.

HPE Aruba Networking 6300 PoE switch power supply capacities and options

The HPE Aruba Networking 6300 PoE switch power options include modular and fixed power supplies.

Table 7: Power supplies for 6300 modular PoE switches

SKU	Power supplies for 6300 modular PoE switches	Maximum PoE power	Maximum PSU power
JL086A	HPE Aruba Networking X372 54VDC 680W 100-240VAC Power Supply	370W	680W
JL087A	HPE Aruba Networking X372 54VDC 1050W 110-240VAC Power Supply	740W	1050W
JL670A	HPE Aruba Networking X372 54VDC 1600W 110-240VAC Power Supply (110-120V AC)	740W	1050W
JL670A	HPE Aruba Networking X372 54VDC 1600W 110-240VAC Power Supply (200-240V AC)	1440W	1600W

Combining different PSU models in the same modular switch chassis is not supported and reduces PoE capacity. Unbalanced PSUs may not operate with the desired level of redundancy, depending on the configuration and the installed PSUs.

Table 8: 6300 fixed PoE switches

SKU	6300 fixed PoE switches	Maximum PoE power	Maximum PSU power
JL665A	HPE Aruba Networking 6300F 48G CL4 PoE 4SFP56 Switch	740W	950W
JL666A	HPE Aruba Networking 6300F 24G CL4 PoE 4SFP56 Switch	370W	950W

High line and low line limitations

The available power for PoE may not be the same for low line (100-120VAC) and high line (200-240VAC). For example, JL670A supports a maximum of 740W with AC low line and 1440W with AC high line.

You must note the following for the regions with 100V AC nominal AC mains voltage:

The JL087A only is supported for 110-120V AC for low line mains input AC line voltage. The remaining power supplies operates in all international regions from 100-240V AC.

While the JL087A does not support low line at 100V AC, it does support the full high line range (200-240V AC). Due to this limitation, the JL087A is not recommended for use at low-line in Japan where the nominal low-line voltage is 100V AC. The high line in Japan is recommended for the JL087A. The JL087A will function to its full specification in all other regions that have 110V AC or higher.

Planning the PoE configuration

The maximum possible available PoE power for a given PoE switch is based on the power rating of the installed PSU (s).

The tables in this section map the PoE power available for redundant and nonredundant PoE on the HPE Aruba Networking 6300M switches.

1. Determine whether to use Redundant mode or Nonredundant mode to power your PDs. (See the following two sections for more information on Redundant mode and Nonredundant mode.)
2. Determine your PoE power needs for your selected PoE switch by totaling the maximum amount of PoE power each connected PD requires, using maximum power in watts (usually found on a PD's data sheet).

   For these calculations, assume worst-case device power and 100M cables. They provide the most conservative estimate of what can be supported. Actual power usage and number of devices supported will be different in each case.
3. Install your specific PSU configuration, ensuring that it delivers the PoE power you calculated as necessary to drive the PDs you will connect to the switch.

PoE power in redundant (N + 1) mode

When the switch is configured for redundant mode with two power supplies installed and powered, and if a single power supply fails or loses AC power, then no loss of functionality to the switch or PoE devices occurs.

The following table shows the maximum possible power available for HPE Aruba Networking 6300M PoE switches for redundant power configuration.

In redundant (*N + 1*) mode with two PSUs installed, the following PoE support is available.

Table 9: PoE support for JL659A and JL660A

JL086A power supplies installed	JL087A power supplies installed	JL670A power supplies installed	Total PoE power available	PoE ports at 15.4W	PoE ports at 30W	PoE ports at 60W
2	--	--	300W	24	12	6
--	2	--	600W	48	24	12
--	--	2	600W (AC low line input) 1300W (AC high line input)	48	48	24

Table 10: PoE support for JL661A and JL662A

JL086A power supplies installed	JL087A power supplies installed	JL670A power supplies installed	Total PoE power available	PoE ports at 15.4W	PoE ports at 30W
2	--	--	370W	24	12
--	2	--	740W	48 / 24	24
--	--	2	740W (AC low line input) 1440W (AC high line input)	48 / 24 48 / 24	24 / 24 48 / 24

PoE power in nonredundant mode

If the switch is configured for nonredundant mode with two power supplies installed and powered, then a failure of single power supply or loss of AC power may cause some or all of the PoE ports to automatically lose power. However, with the power failure, there is no impact on other switch functionality.

At the time of power failure, the ports that have the PoE power removed depends on the amount of PoE power lost and the priority of the port. The ports with low priority will lose power first, followed by high priority ports.

The ports are powered down in the order of highest numbered to lowest numbered ports, within a priority. if given a common power priority, then the lower numbered ports have a precedence over the higher number ports for example, port 39 is higher priority than 40. As a result, port 40 will power down before port 39 in case of a loss of adequate PoE power to the switch. All attempts are made through the system firmware to maintain the PoE power on as many ports as required.

The following table shows the maximum possible power available for HPE Aruba Networking 6300M PoE switches for nonredundant power configuration.

Table 11: Maximum power possible for JL659A and JL660A

JL086A # of power supplies installed	JL087A # of power supplies installed	JL670A # of power supplies installed	Total PoE power available	PoE ports at 15.4W	PoE ports at 30W	PoE ports at 60W
1	--	--	300W	24	12	6
2	--	--	600W	48	12	12
--	1	--	600W	48	24	12
--	2	--	1440W	48	24	24
—	—	1	600W (AC low line input) 1300W (AC high line input)	48	20 43	10 21
--	--	2	1300W (AC low line input) 2600W (AC high line input)	48	43 48	21 41

Table 12: Maximum power possible for JL661A (48 port) and JL662A (24 port)

JL086A # of power supplies installed	JL087A # of power supplies installed	JL670A # of power supplies installed	Total PoE power available	PoE ports at 15.4W	PoE ports at 30W
1	--	--	370W	24	12
2	--	--	740W	48 / 24	24
--	1	--	740W	48 / 24	24
--	2	--	1440W	48 / 24	48 / 24
--	--	1	740W (AC low line input) 1440W (AC high line input)	48 / 24 48 / 24	24 / 24 48 / 24

JL086A # of power supplies installed	JL087A # of power supplies installed	JL670A # of power supplies installed	Total PoE power available	PoE ports at 15.4W	PoE ports at 30W
--	--	2	1440W (AC low line input) 2880W (AC high line input)	48 / 24 48 / 24	48 / 24 48 / 24

PoE allocation using LLDP information

LLDP Power through MDI TLVs is used to communicate PoE feature capabilities and dynamically negotiate fine grain power allocation to efficiently manage the overall switch power budgeting.

By enabling PoE LLDP dot3Tlv detection (enabled by default), available information about the power requirements of the Powered Devices (PDs) may be used by the switch to configure the power allocation. If more accurate configuration information is provided by way of LLDP, the initial configuration for PoE ports may change.

By default, PSE ports automatically provide assigned class power matching the PD requested class. LLDP Power via MDI TLVs is enabled by default allowing PSE ports to adjust the assigned class power to match new fine grain PD requested class power values received from the PD.

LLDP is not required for power negotiation, therefore, the static power option is not a configurable option on the AOS-CX platform.

For more configuration information, see the latest *Monitoring Guide* for your PoE switch model.

Chapter 5

PoE planning and implementation for HPE Aruba Networking 6400 switches

HPE Aruba Networking 6400 switches

The PoE capabilities of the Aruba 6400 chassis switch products, along with the Aruba 6400 power supplies (PSUs) and line modules that provide PoE power to connected powered devices (PDs), are described in this chapter. The PoE power available depends on the number of management modules, line cards, fan trays, and power supplies used.

The HPE Aruba Networking 6405 Switch supports up to five line modules with up to 48 PoE ports per module and up to 240 PoE ports on the switch.

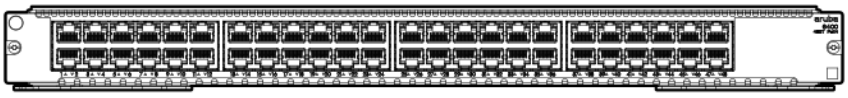
The HPE Aruba Networking 6410 Switch supports up to ten line modules with up to 48 PoE ports per module and up to 480 PoE ports on the switch.

HPE Aruba Networking 6400 48-port 1G PoE line modules

Aruba Networks offers two PoE class 4 and two PoE class 6 line modules that operate with:

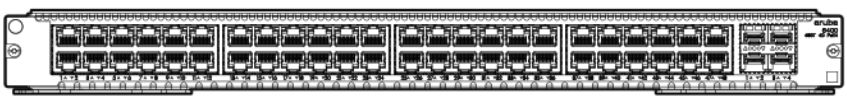
- Always-on PoE for continued power during scheduled reboots and firmware upgrades. Always-on PoE is enabled by default, and no additional configuration is needed.
- Support for pre-standard PoE detection that provides power to legacy PoE devices
- PoE allocation by usage or class using LLDP and LLDP-MED to enable allocation of PoE power for more efficient power management and energy savings

HPE Aruba Networking 6400 48-port 1G PoE Class 4 Module (R0X38B)



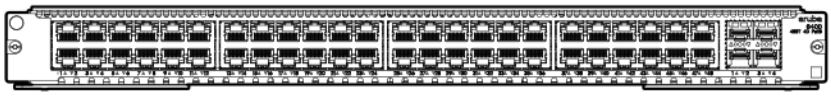
The R0X38B module provides IEEE 802.3at PoE support for up to 30W per port, as well as any IEEE 802.3at-compliant powered device.

HPE Aruba Networking 6400 48-port 1G PoE Class 4 & 4-port SFP56 Module (R0X39B)



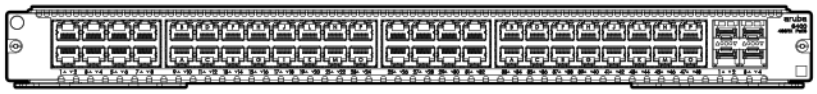
The R0X39B module provides IEEE 802.3at PoE support for up to 30W per port, as well as any IEEE 802.3at-compliant powered devices.

HPE Aruba Networking 48-port 1G PoE Class 6 & 4-port SFP56 Module (R0X40B)



The R0X40B module provides industry standard IEEE 802.3bt High Power PoE class 6 with up to 60W per port for support of IoT devices and APs. The PoE ports are 802.3bz-compliant and allow for the current and future bandwidth demands of modern 11ac and11ax access points, as well as any other emerging high-throughput powered devices.

HPE Aruba Networking 6400 48-port SR PoE Class 6 & 4-port SFP56 Module (R0X41A)



The R0X41A module provides industry standard IEEE 802.3bt High Power PoE class 6 with up to 60W per port for support of the latest IoT devices and APs. The PoE ports are 802.3bt-compliant and allow for the current and future bandwidth demands of modern 11ac and 11ax access points, as well as any other emerging high-throughput powered devices.

Power redundancy

By ensuring that each PSU on the switch is connected to a separate circuit, you can reduce the risk of a switch shutdown due to a power failure. To help prevent an unexpected loss of PoE power to installed PoE ports due to a PSU failure, plan on using one PSU as a reserve (redundant) power source in case an installed PSU fails. For example, if your hardware configuration requires a minimum of two PSUs to support the switching load, then installing a third PSU provides redundancy to keep the switch operating at full capacity if one power supply fails. This example can be expressed as *N* + 1, where "*N*" is the minimum number of power supplies needed to support the chassis, management modules, line modules, and PoE load and "1" is the number of redundant PSUs installed.

In the default configuration, the Aruba 6400 Switch power redundancy is disabled.

HPE Aruba Networking 6400 Switch power supply units (PSUs)

The HPE Aruba Networking 6400 switches have four power supply slots that support these PSUs:

- R0X35A HPE Aruba Networking 6400 1800W power supply
- R0X36A HPE Aruba Networking 6400 3000W power supply

Both power supply models support PoE operation. System power usage (chassis, management modules, and line modules) has the highest power priority. All remaining power goes into the power pool.

Combining R0X35A 1800W PSUs and R0X36A PSUs in the same switch chassis is not supported and reduces PoE capacity. Unbalanced PSUs may not operate with the desired level of redundancy, depending on the configuration and the installed PSUs.

On a running switch, to replace the PSUs having a given power rating with another set of PSUs having a different power rating, see the latest version of the *Installation and Getting Started Guide* for that switch model.

System power capacity

Up to four power supplies provide a single power source for the switch chassis, management modules, line modules, and PoE operation.

Total system power is a function of:

- Type of PSU (R0X36A 3000W or R0X35A 1800W)
- Number of PSUs installed (up to four)
- The input AC voltage (110-127V AC or 200-240V AC)

Table 13: Total system power

Total System Power				
# of PSUs	Using R0X36A 3000W PSUs **NOTE:** The R0X36A PSU must be paired with the C20 AC Inlet Accessory.		Using R0X35A 1800W PSUs **NOTE:** The R0X35A PSU must be paired with the C16 AC Inlet Accessory	
	110-127V AC input	200-240V AC input	110-127V AC input	200-240V AC input
1	1500W	3000W	1100 W	1800 W
2	2970W	5940W	2178 W	3564 W
3	4440 W	8880 W	3256 W	5328 W
4	5910W	11820 W	4334 W	7092W

Aruba does not support pairing an R0X36A PSU with a C16 AC Inlet Accessory or pairing an R0X35A PSU with a C20 AC Inlet Accessory. The type of AC Inlet Accessory used with a PSU affects the PSU output described in the following table.

Figure 2 *C20 AC Inlet Accessory*

PSU	C20 Inlet Accessory			C16 Inlet Accessory	
	110-127V AC	200-240V AC		110-127V AC	200-240V AC
R0X36A	1500W	3000W		1100W	1800W
R0X35A	1100W	1800W		1100W	1800W

System power budget and allocation

1. Determine total available system power. This is the aggregate of the power delivered by the installed PSUs.
2. Determine total usable power available for switch redundancy configuration. This is the number of PSUs held in reserve for power redundancy.
3. Allocate power for the base switch (including installed management modules). From the total usable power in step 2, subtract the power needed for the installed management modules.

4. Allocate power for installed line modules. From the total usable power in step 3, subtract the power needed to run the line modules.
5. The power remaining after step 4 is your budget available for PoE use.

Once power is allocated to a component, the power remains assigned to that component until it is returned to the internal switch power pool. Line module and management module power is returned by removing or de-initializing the module. PoE-allocated power to remote PDs is returned by disconnecting the PD device.

Table 14: HPE Aruba Networking 6400 switch component power budget

HPE Aruba Networking 6400 Switch components	Power Budget
HPE Aruba Networking 6405 base switch: 7-slot chassis, two fan trays, two management modules	645W
HPE Aruba Networking 6410 base switch: 12-slot chassis, two fan trays, two management modules	1194W
HPE Aruba Networking 6400: 48-port 1GbE Class 4 PoE line module. Includes power for transceiver modules	113W
HPE Aruba Networking 6400: 48-port 1GbE Class 4 PoE and SFP56 line module. Includes power for transceiver modules	121W
HPE Aruba Networking 6400: 48-port 1GbE Class 6 PoE and 4-port SFP56 line module. Includes power for transceiver modules	121W
HPE Aruba Networking 6400: 48-port HPE Smart Rate 1/2.5/5GbE Class 6 PoE and 4-port SFP56 line module. Includes power for transceiver modules	249W
HPE Aruba Networking 6400: 24-port 10GBASE-T and 4-port SFP56 line module. Includes power for transceiver modules	240W
HPE Aruba Networking 6400: 24-port SFP+ and 4-port SFP56. Includes power for transceiver modules	156W
HPE Aruba Networking 6400: 48-port 10/25 GbE SFP28. Includes power for transceiver modules	424W
HPE Aruba Networking 6400: 12-port 40/100GbE QSFP28 line module. Includes power for transceiver modules	352W

Guidelines for configuring PoE redundancy

When considering redundant power, also consider the power source for the power supplies. Each power supply should be connected to a separate power source circuit in order to supply complete redundancy. If one ciruit fails, it is then possible for another circuit to continue supplying power to the second power supply in the switch, keeping the switch running.

When power redundancy is enabled (by using the CLI power-redundancy command), PoE redundancy occurs automatically. The switch keeps track of power use and does not supply PoE power to additional PoE devices trying to connect if that results in the switch not having enough power in reserve for redundancy if one of the power supplies should fail. The redundancy methods are:

- No PoE redundancy enforcement (the default setting). All available PoE power can be allocated.
- N+N full redundancy. One half of the totally available PoE power can be allocated and the other half is held in reserve for redundancy. (Requires an even number of PSUs.)

- N + 1 redundancy. One installed power supply is held in reserve for redundancy. If a single power supply fails, no powered devices are shut down.

When changing from one of these methods to another, check the current level of PoE usage before implementing the change. The change could cause existing connections to lose PoE power.

Example of redundancy options

This example shows the maximum PoE power support to an HPE Aruba Networking 6405 switch in each of the redundancy configurations. The combined available power to the switch in this example is:

- No redundancy: 11820W
- N+1 redundancy: 8880W
- N+N redundancy: 5940W

total available power - max_system_power = available_PoE_power

The total available power on the switch is reduced by two per cent due to PSU load sharing. This reduction is not a linear calculation.

Component	Max active power per unit	Max system power	Total PoE ports	Combined available PoE with NO redund-ancy (10570W)	Combined available PoE with N+1 redund-ancy (7630W)	Combined available PoE with N+N redundancy (4690W)
6405 chassis with four 3000W PSUs, two fan trays, and two Management modules	645W **NOTE:** On the 6410 switch, this value is 1194W	1250W	240	240 ports @ 15.4W 240 ports @ 30W 176 ports @60W	240 ports @ 15.4W 240 ports @ 30W 127 ports @ 60W	240 ports @ 15.4W 156 ports @ 30W 78 ports @ 60W
48-port 1GbE Class 6 PoE and 4-port SFP56 line module	121W					
48-port 1GbE Class 6 PoE and 4-port SFP56 line module	121W					
48-port 1GbE Class 6 PoE and 4-port SFP56 line module	121W					
48-port 1GbE Class 6 PoE and 4-port SFP56 line module	121W					

Component	Max active power per unit	Max system power	Total PoE ports	Combined available PoE with NO redund-ancy (10570W)	Combined available PoE with N+1 redund-ancy (7630W)	Combined available PoE with N+N redundancy (4690W)
48-port 1GbE Class 6 PoE and 4-port SFP56 line module	121W					

Example of system power budget and allocation at 220V AC

This example demonstrates power budgeting on an HPE Aruba Networking 6405 Switch with these components installed:

- four 3000W PSUs (R0X36A) at 220V AC
- two management modules (R0X31A)
- five line modules

Figure 3 *Example of system power budget and allocation at 220V AC*

Installed components	Power usage	Total usable power	Notes
Four 3000W PSUs (R0X361) at 220V AC	--	11820W	Power allocated to base switches and line modules are pre-defined values automatically subtracted from the total usable power during system boot.
System configured for N+1 redundant power mode	2940W reserved	8880W	Reserves 2940W of redundant power; one PSU capacity.
Two fan trays; management modules in slots 1 and 2	645W	8235W	
Slot 3: 48-port 10G/25G SFP28 Module (R0X44A)	424W	7827	
Slot 4: 48-port SR PoE Class 6 & 4-port SFP56 (R0X41A)	249W	7578	SR 5 GbE
Slot 5: 48-port SR PoE Class 6 & 4-port SFP56 (R0X41A)	249W	7329	SR 5 GbE
Slot 6: 48p 1G Class 4 PoE (R0X38B)	121W	7208	
Slot 7: 48p 1G Class 4 PoE (R0X38B)	121W	7087	Power available for PoE

PoE provisioning for HPE Aruba Networking 6400 switches

The power for Aruba 6400 Switch PoE applications is compatible with these standards and some pre-standard devices:

- IEEE 802.af
- IEEE 802.3at
- IEEE 802.3bt

This chapter discusses the planning process to follow for implementing Power over Ethernet (PoE) on the HPE Aruba Networking 6405 and 6410 switches.

HPE Aruba Networking 6400 power redundancy configuration examples

Without power supply redundancy, a simple power outage or generator failure can quickly bring your network to a halt. Power supply redundancy can ensure enough power redundancy for the switch to operate without any power deficiencies. In the default configuration, the HPE Aruba Networking 6400 Switch comes up without redundancy configured. The switch supports management configuration of both N+1 and N+N.

Example of a default power redundancy configuration

```
6400# show environment power-redundancy

Configured Operational

Redundancy Redundancy
-------------------------
none       none

6400# show power-over-ethernet

System Power Status

PoE Power Status : No redundancy
Operational Power Status : No redundancy
Total Available Power : 2677.00 W
Total Failover Pwr Avl : 913.00 W
Total Redundancy Power : 0.00 W
Total Power Drawn : 50.73 W
Total Power Reserved : 53.70 W
Total Remaining Power : 2623.30 W
Trap Threshold : 80 %
Always-on PoE Enabled : 1/3,1/7
Internal Power:
Total Power

PS    (Watts)      Status
----- ------------ ----------------------
1/1   1800         OK
1/2   1764         OK
1/3   0            Absent
1/4   0            Absent
N+1 Redundancy configuration:
6400#

6400(config)# power-redundancy
n+1 Enable N+1 chassis power redundancy
```

```
n+n Enable N+N chassis power redundancy
none Disable chassis power redundancy
```

Example of a non-default power redundancy configuration

```
6400# conf t
6400(config)# power-redundancy n+1

Changing the redundancy mode will affect the total power available for PoE ports.

Lower priority ports may lose power.
Do you want to continue (yes/no)? yes
PSU Redundancy set to n+1
6400(config)#

6400(config)# show environment power-redundancy

Configured Operational

Redundancy Redundancy
-------------------------
n+1        n+1

6400(config)#
6400# show power-over-ethernet

System Power Status

PoE Power Status : n+1 redundancy
Operational Power Status : n+1 redundancy
Total Available Power : 913.00 W
Total Failover Pwr Avl : 913.00 W
Total Redundancy Power : 1764.00 W
Total Power Drawn : 50.73 W
Total Power Reserved : 53.70 W
Total Remaining Power : 859.30 W
Trap Threshold : 80 %
Always-on PoE Enabled : 1/3,1/7
Internal Power:
Total Power

PS    (Watts)      Status
----- ------------ ---------------------
1/1   1800         OK
1/2   1764         OK
1/3   0            Absent
1/4   0            Absent

6400#

N+N Redundancy configuration:

6400(config)# power-redundancy n+n

Changing the redundancy mode will affect the total power available for PoE ports.

Lower priority ports may lose power.
Do you want to continue (yes/no)? yes
PSU Redundancy set to n+n
```

```
6400(config)# show environment power-redundancy

Configured Operational

Redundancy  Redundancy
----------- --------------
n+n                                                    n+n

6400# show power-over-ethernet

System Power Status

PoE Power Status : n+n redundancy
Operational Power Status : n+n redundancy
Total Available Power : 913.00 W
Total Failover Pwr Avl : 913.00 W
Total Redundancy Power : 913.00 W
Total Power Drawn : 50.28 W
Total Power Reserved : 53.17 W
Total Remaining Power : 859.83 W
Trap Threshold : 80 %
Always-on PoE Enabled : 1/3,1/7
Internal Power:
Total Power
PS (Watts) Status
----- ------------ ---------------------
1/1   1800         OK
1/2   1764         OK
1/3   0            Absent
1/4   0            Absent

6400#
```

This section provides a sampling of how to configure LLDP actions using the switch CLI.

LLDP operation with PoE on the HPE Aruba Networking switches

Examples in this document are representative and might not match your particular switch or environment. The slot and port numbers in this document are for illustration only and might be unavailable on your device.

The software notation for identifying interfaces uses member/slot/port notation, such as 1/1/1. For standalone (fixed-port) switches, such as the HPE Aruba Networking 6300 switches, the slot designation is always 1.

By default, LLDP on AOS-CX switches is enabled. LLDP is used after the PD is powered on to negotiate for finer grain power levels below the PD requested class. Upon successful LLDP power negotiation, the new PD requested power value is used to replace the physical layer PD requested class power value and the allocate by actual field changes from **usage** to **lldp**.

To disable LLDP on a specific switch port, disable the lldp dot3 poe TLV on the port. For example, to disable LLDP on port 1/3/5:

```
switch(config-if)# int 1/3/5
switch(config-if)# no lldp dot3 poe
```

To verify the configuration:

```
switch(config-if)# show run int 1/3/5
switch(config-if)# interface 1/3/5
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# vlan access 1
switch(config-if)# no lldp dot3 poe
switch(config-if)# exit
```

To enable and verify LLDP on an LLDP-disabled port:

```
switch(config-if)# lldp dot3 poe
switch(config-if)# show run int 1/3/5
switch(config-if)# interface 1/3/5
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# vlan access 1
switch(config-if)# exit
```

LLDP is not required for power negotiation, therefore, the static power option is not a configurable option on the AOS-CX platform.

For a more comprehensive coverage of LLDP commands for PoE, see the latest *Monitoring Guide* for your switch.

Examples of LLDP configuration actions using the CLI

For more on LLDP and LLDP commands, see the latest *Fundamentals Guide* for your switch model. Disable LLDP MED PoE priority-override on a specific port

```
switch(config-if)# no lldp med poe priority-override
switch(config-if)# show run int 1/3/25
switch(config-if)# interface 1/3/25
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# vlan access 1
switch(config-if)# exit
```

Chapter 7
Support and other resources

Accessing HPE Networking Support

Aruba Support Services	https://www.arubanetworks.com/support-services/
HPE NetworkingD Support Portal	https://networkingsupport.hpe.com/home
North America telephone	1-800-943-4526 (US & Canada Toll-Free Number) +1-408-754-1200 (Primary - Toll Number) +1-650-385-6582 (Backup - Toll Number - Use only when all other numbers are not working)
International telephone	https://www.arubanetworks.com/support-services/contact-support/

Be sure to collect the following information before contacting Support:

- Technical support registration number (if applicable)
- Product name, model or version, and serial number
- Operating system name and version
- Firmware version
- Error messages
- Product-specific reports and logs
- Add-on products or components
- Third-party products or components

Other websites that can be used to find information:

Airheads social forums and Knowledge Base	https://community.arubanetworks.com/
Software licensing	https://lms.arubanetworks.com/
End-of-Life information	https://www.arubanetworks.com/support-services/end-of-life/
Aruba software and documentation	https://networkingsupport.hpe.com/downloads

Accessing updates

Download product updates from the following locations:

- HPE Networking Support Portal
  https://asp.arubanetworks.com/downloads .

If you are unable to find your product in the HPE Networking Support Portal, you may need to search My Networking, where older networking products can be found:

- My Networking

  https://www.hpe.com/networking/support .

  To view and update your entitlements, and to link your contracts and warranties with your profile, go to the Hewlett Packard Enterprise Support Center **More Information on Access to Support Materials** page: https://support.hpe.com/portal/site/hpsc/aae/home/

Access to some updates might require product entitlement when accessed through the Hewlett Packard Enterprise Support Center. You must have an HP Passport set up with relevant entitlements.

Some software products provide a mechanism for accessing software updates through the product interface. Review your product documentation to identify the recommended software update method.

To subscribe to eNewsletters and alerts, go to https://www.hpe.com/support/e-updates.

Warranty information

To view warranty information for your product, go to https://www.arubanetworks.com/support-services/product-warranties/.

Regulatory information

To view the regulatory information for your product, view the *Safety and Compliance Information for Server, Storage, Power, Networking, and Rack Products*, available at https://www.hpe.com/support/Safety-Compliance-EnterpriseProducts

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