

*Power and Cooling Best Practices for
IP Communications*

Executive Summary

IP telephony and Power over Ethernet (PoE) are driving the requirement for increasing uptime levels, power capacity and the need for dedicated precision air conditioning across the network. High-availability environments, such as data centers and computer rooms, may have the power and cooling infrastructure in place to handle these changes, but in many cases, equipment rooms and wiring closets do not.

Power and cooling considerations must be factored into IP telephony to ensure required availability levels can be achieved. Every environment delivering critical services to end users should be evaluated with the following questions in mind:

- Can the power system provide adequate backup power during utility outages (generated externally or internally)?
- Is the power protection system capable of achieving desired levels of availability and handling future capacity levels?
- How will the heat load in the room change as a result of the transition? Can existing cooling systems handle the expected heat load?
- How will remote equipment be monitored?

These questions will help guide the development of a power and cooling infrastructure that allows the full benefits of network convergence to be realized. This white paper provides specific guidance on ensuring proper power and cooling support for the Cisco routers and switches operating in network closets and equipment rooms.

As a Cisco Technology Developer Partner, Liebert has worked with Cisco to develop Liebert IP Telephony power protection solutions for Cisco's Unified Communications portfolio, Unified CallManager and Unified CallManager Express. Liebert teamed with Cisco to jointly develop the NterpriseIP system, a unique AC-powered DC UPS for Cisco Catalyst switches. The Liebert IP Telephony protection solutions and NterpriseIP have completed Cisco compatibility testing.

CISCO SYSTEMS



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Convergence and the Network Infrastructure

Adding voice and video to the data network represents a fundamental change in how the network is utilized, managed and supported. This change can have a significant impact on the power and cooling infrastructure that supports network equipment.

Unlike traditional PBX phone systems, IP telephony distributes critical nodes and their power source throughout the facility. These critical nodes support voice and data traffic, including emergency 9-1-1 calls, increasing the cost and impact of downtime across the network.

In addition, the density of new IP communications equipment is typically higher than the equipment being displaced. New IP switches pack more power into smaller packages, increasing power requirements and the amount of heat that is generated.

This is compounded if PoE is deployed. IEEE 802.3af set standards for powering devices such as IP phones. The IEEE standard classifies powered devices (PDs) into four groups based on power consumption. Table 1 shows power requirements for the four classes. If no class is detected, the device receives 15.4 Watts of power from the switch.

When specifying power and cooling for IP switches supporting PoE, it is important to account for losses within the switch and from the switch to the powered device. For example, the line cards that support PoE in a Cisco

IEEE Class	Max Output Power at PSE	Max Power Input at PD
Class 0:	15.4W	.44W to 12.95W
Class 1:	4W	.44W to 3.84W
Class 2:	7W	3.84W to 6.49W
Class 3:	15.4W	6.49W to 12.95W

Table 1. IEEE 802.3af allows powered devices to be classified based on power requirements.

Catalyst 4500 Series switch have an efficiency of 89 percent. In order to provide 15.4 Watts of output power per PoE port, input power to the switch must be 17.3 Watts per port. The 11 percent of power that is used within the switch is converted to heat, which can raise the temperature in a small room to dangerous levels if the cooling system is unable to handle the extra load.

Devices other than phones can be powered via PoE as long as they comply with IEEE 802.3af. New devices are continually being introduced and power levels are increasing. A PoE Plus standard is in development (IEEE 802.3at) that will enable higher-powered devices, such as laptop computers, to use PoE, driving power requirements and heat loads even higher.

Clearly, a converged network requires a more robust and adaptive power and cooling system than may have been required to support only data communications.

The UPS provides real-time remote monitoring and controlled shutdown of protected equipment.

Critical Power Availability

Availability is the percentage of time a system is on line and capable of doing productive work. It is typically described as an annual percentage, or number of “nines.” “Fives nines” — the standard telecommunications networks are designed to achieve — translates into less than six minutes of downtime annually. This is often the objective for IP telephony applications to ensure the availability and reliability of voice communications is not compromised when IP telephony is implemented. Determining the level of availability that is required for an application drives key decisions about the UPS system configuration and architecture.

Uninterruptible Power Supply (UPS) systems provide three key functions that affect the availability of IP communications equipment. First, they serve as a source of backup power in the event of an outage. If a backup generator is available, the UPS provides uninterrupted power to the switch while the generator is started. The UPS will continue to condition the power during generator operation. If no generator is present, UPS battery capacity determines how long the switch can operate during an outage. When planning desired power availability for an IP communications switch, consider whether a generator is present and, if not, how long UPS batteries need to power the switch. If no generator is present, a minimum of two hours of battery run-time is recommended for IP telephony.

The second function of the UPS system is power conditioning. In most applications, the UPS removes sags, noise and other power quality problems that can damage equipment or degrade performance. The type of

UPS that is used determines how power is conditioned. Online double conversion and line interactive are the most common types of AC UPS in use in network closets and equipment rooms. Online double-conversion systems provide the highest level of power conditioning.

Third, the UPS provides real-time remote monitoring and controlled shutdown of protected equipment. Ethernet-based communication systems, such as Liebert OpenComms Web Card and Liebert Nform, allow for monitoring of remote power devices and provide real-time event notification and alarms. They also allow the UPS to be restarted remotely. Power monitoring software, such as Liebert MultiLink, monitors UPS battery capacity and executes a graceful shutdown of the switch when necessary to prevent damage and packet loss.

There are four basic power protection architectures, each providing a different level of protection and availability depending on UPS configuration (Table 2). For more information on these architectures, refer to the white paper *Five Questions to Ask When Designing a High Availability Power System* available at www.Liebert.com.

Cooling Critical Electronics

Failing to maintain a proper environment for critical electronics, such as switches, can result in reduced performance and premature failure.

For sensitive electronics, environmental control means more than simple cooling. Comfort air conditioning systems are

designed for the comfort of people and simply cannot provide the environment required by high performance computer and communications equipment.

- **Temperature Control:** Sensitive electronics are best maintained in a stable environment of 72°F ± 2°F (22.2°C ± 1°C). The heat load in a computer room or similar application is higher and more concentrated than in general office environments, exceeding the capacity of ordinary air conditioning systems. And the problem goes beyond just capacity. The air conditioning system must have the precision to react quickly to drastic changes in heat load and prevent wide temperature fluctuations, something building systems cannot do.
- **Humidity Control:** Electronics must be protected from both internal condensation and static electricity discharges. Maintaining the correct humidity level

in the room is just as important as maintaining proper temperature. When humidity is too high, condensation can form inside equipment and damage it. If humidity is too low, static electricity can disrupt operation or shut down the system. A building air conditioning system cannot control the environment within these boundaries.

- **Air Volume:** Computers and other sensitive electronics require greater air volumes than building air conditioning can provide. Typical comfort systems are designed to provide between 300 and 400 CFM (cubic feet per minute) per ton of cooling. Computer systems require between 500 and 600 CFM per ton.

The high density heat load in a relatively small space also requires more changes of air than a less dense comfort application. While a normal office space requires only

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Tier	Availability (9s)	Downtime/Year	Typical Solution
Tier 1	3 nines (99.9%)	8:46:00	TVSS surge
Tier 2	4 nines (99.99%)	0:53:00	Single UPS Single Bus
Tier 3	5-6 nines (99.999% to 99.9999%)	0:05:30 to 0:00:31.6	Redundant UPS or DC UPS (one active power path to critical equipment)
Tier 4	7-8 nines (99.99999% to 99.999999%)	0:00:03 to 0:00:00.3	Redundant UPS or DC UPS (two active power paths to critical equipment)

Table 2. The design of the power system will determine what level of power availability can be achieved. For this analysis, other site infrastructure such as generators, automatic transfer switches, and air conditioning are not discussed. The power solutions highlighted in this paper must be combined with additional site infrastructure to achieve these levels of availability. Redundant power solutions also assume redundant power supplies in the Cisco communication equipment.

Until recently, many network closets and other remote locations have not required dedicated precision air conditioning because heat loads were relatively low. That is changing as new IP communications equipment is deployed.

two air changes per hour, a room filled with electronic equipment requires up to 30 changes per hour. Without proper air volume, hot spots and temperature fluctuations can develop within the room. Also, greater air volumes provide the higher sensible heat ratios required by computer equipment.

- **Air Filtration:** Build-up of dust and fibers attracted by operating electronics can cause faults and impair the operation of electromechanical devices, such as switches and disk drives. Today's electronics need the same precision environmental control as mainframe computers. The difference is that instead of one large computer room there are several small, often crowded rooms, widely dispersed throughout a building or campus. Precision air conditioning systems are designed to filter out contaminants that can affect equipment operation.
- **Year-Round Operation:** Comfort air conditioning systems cannot be relied upon 24 hours per day, 365 days per year. They are typically designed to operate 10 hours per

day, from spring to autumn. Many comfort systems have no provision for winter operation. A precision environmental control system is designed for operation at temperatures down to -30°F.

- **Fault Tolerance:** The cost of failure is higher for systems cooling sensitive electronics versus those cooling general office environments. Precision environmental control systems are designed with greater internal redundancy, can be locally and remotely monitored and are supported by mission-critical service programs.

Precision environmental control systems are standard in data center environments for these reasons. Until recently, many network closets and other remote locations have not required dedicated precision air conditioning because heat loads were relatively low. That is changing as new IP communications equipment is deployed.

Table 3 provides general guidelines for the type of cooling that should be applied depending on the amount of heat-generating equipment in a small room.

Total Heat Load	Recommended Cooling Solution
< 100 Watts	Leaks and wall conduction
100 - 500 Watts	Intake and exhaust grilles in door or walls
500 - 1000 Watts	Building ventilation system supply and return
1000 - 5000 Watts	Active cooling with remote heat rejection
> 5000 Watts	Precision air conditioning with remote heat rejection

Table 3. Many wiring closets are already above the threshold where active cooling is recommended. IP communications will drive heat loads even higher.

Power and Cooling Recommendations for Cisco Switches

Cisco provides the following guidelines for achieving five-nines availability of IP switches:

- Equipment is maintained at proper operating temperature at all times
- Equipment is protected by a UPS system with two-hour battery or generator backup
- The UPS system supports remote monitoring and has auto restart capability

The following sections expand on these guidelines by providing specific power and cooling recommendations based on the switch's power consumption and operating environment.

Cisco Switches with Embedded Power Supplies

Smaller Cisco switches, such as the Catalyst 3750, use embedded power supplies and support either 24 or 48 PoE ports. This simplifies UPS specification for these units, which are typically protected by smaller rack-mount UPS systems, such as the Liebert PSI or Liebert GXT systems.

The Liebert GXT is an online double-conversion UPS while the Liebert PSI is a line-interactive system. Online double-conversion UPS systems convert incoming power from AC to DC and back to AC within the UPS, providing continuous conditioned power and isolating the IP switch from power surges or other damaging anomalies.

They also rely less on their battery system for day-to-day power conditioning — preserving battery capacity for outages — and eliminate generator compatibility problems that can occur with line-interactive UPSs.

In general, the extra cost of a double-conversion UPS is warranted if any of the following conditions exist:

- Incoming power is especially erratic. A line-interactive UPS will draw on its battery system more frequently, reducing expected battery life.
- The UPS system is supported by a backup generator. Frequency variations and other power anomalies that occur during generator operation can create problems for line-interactive UPS systems.
- Mission-critical applications. The extra protection of a double-conversion UPS is warranted for applications where downtime is especially costly, such as large switches supporting hundreds of phones. Double-conversion UPS systems also provide an internal dynamic static bypass that provides an alternate source of power for added reliability.

In a single UPS configuration, three options should be considered to enable the UPS to achieve the highest possible availability: extended battery capacity, an external maintenance bypass, and a communications card with SNMP support.

Rack-mount UPS systems typically include a battery that delivers five to ten minutes of backup at full load. If a backup generator is not available, this will prove insufficient for

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A multi-function network interface card, such as Liebert OpenComms, enables remote monitoring through SNMP and provides remote restart capability.

most IP telephony applications. Additional battery modules can be added to the UPS to extend runtimes to two hours or more.

The external maintenance bypass, like the Liebert Micropod option, allows the IP switch to continue to function during UPS maintenance by enabling incoming power to be routed around the UPS. This means operating without UPS protection for short periods, but is usually preferable to having to take the switch down during maintenance. For high-availability applications, redundant UPS systems are used to ensure the switch has UPS protection at all times.

A multi-function network interface card, such as Liebert OpenComms, enables remote monitoring through SNMP and provides remote restart capability. This allows the UPS to be managed across the network.

Figure 1 shows a typical power system for a Cisco switch with an embedded power supply featuring a single UPS with maintenance bypass and communications card.

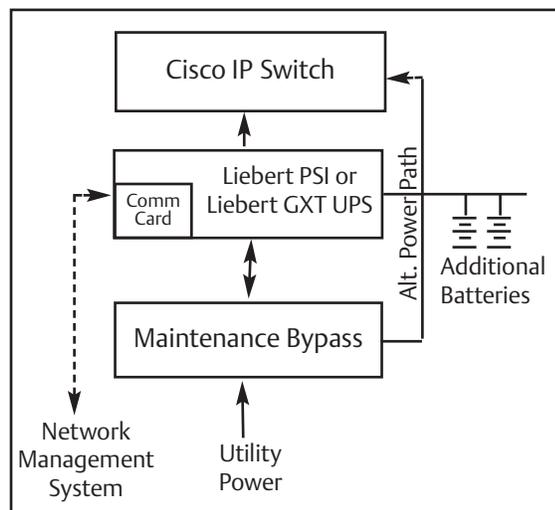


Figure 1. The performance of a single UPS system is enhanced by a maintenance bypass and remote monitoring capabilities.

This configuration can be deployed as a bundled solution using integrated enclosure systems such as the Liebert IP Telephony Availability (IPTA) System. The Liebert IPTA is certified compatible with Cisco CallManager, Cisco CallManager Express, Cisco Unity and Cisco Unity Express. It features a Liebert GXT UPS with maintenance bypass and OpenComms communications card in a physically secure enclosure designed to support Cisco switches in remote locations (Figure 2).

Building cooling may be adequate for a single switch in a well-ventilated environment. However, if the IP switch is added to an environment where other heat-generating equipment is already in operation, or multiple switches are deployed in a closet, the additional heat generated may drive the need for dedicated precision cooling. A ceiling-mounted cooling unit, such as the Liebert MiniMate, provides year-round environmental control for small spaces (Figure 3). If multiple switches are stacked, an integrated enclosure system such as the Liebert XDF can provide a



Figure 2. The Liebert IP Telephony Availability System delivers a complete power and enclosure solution for Cisco switches.

plug-and-play power and cooling solution for up to 14.4 kW of equipment.

Cisco Switches with Modular Power Supplies

Cisco Catalyst 4500 and 6500 Series switches feature modular power supplies and line cards for PoE support. This has an impact on the power and cooling requirements for these switches.

Power Protection

The power requirements for a chassis-based system supporting PoE are largely dependent on the number of PoE ports and line cards.

The Cisco Catalyst chassis has two power supply bays that support two of the same supplies in a redundant mode or in combined power sharing mode. In redundant mode, the second supply is online and provides half the power the system is using. This allows the switch to withstand the loss of a power supply without affecting the operation of any devices receiving power from the switch.

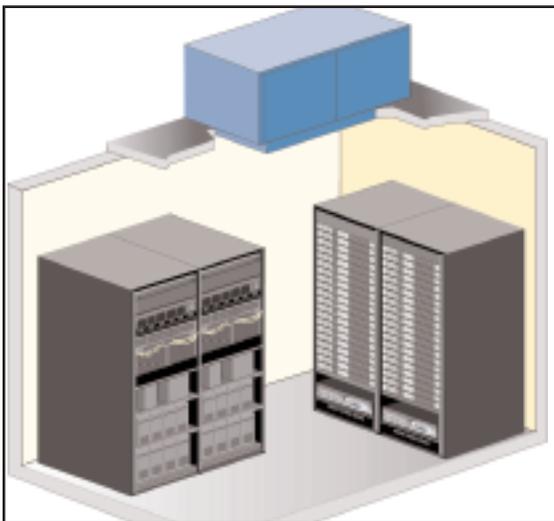


Figure 3. A ceiling-mounted precision cooling system operating in a network closet.

In combined mode, the supervisor engine manages the combined power budget of both supplies to support applications where PoE devices require more power than the redundant configuration can support. In combined mode the output power is equal to the output power of one supply times 1.67. For example, redundant 2800W power supplies operating in combined mode could provide 4676 of power. This means if one power supply fails, the switch can not continue to power all devices connected to it.

In each case, Cisco recommends that power supplies be protected by an appropriately sized UPS and that each supply be plugged into different UPS systems (Figure 4).

All Cisco power supplies have input power correction and are rated in output Watts. Input to the power supply is determined by dividing the power supply rating by the power supply efficiency. If the power supply efficiency is not known, 80 percent is used as a rule of thumb.

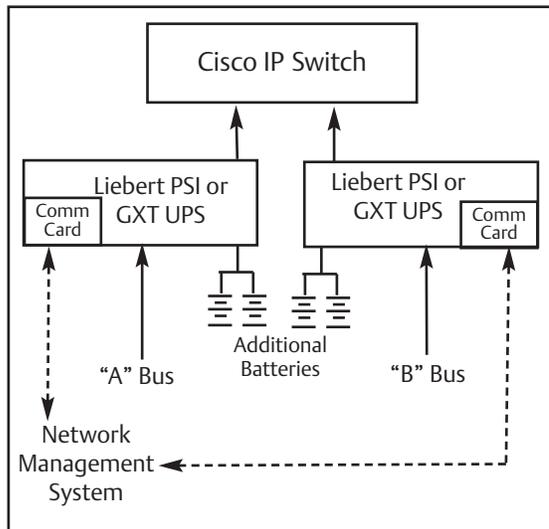


Figure 4. Redundant UPS systems increase fault tolerance and enable UPS maintenance.

Power supply options for the Cisco Catalyst 4500 switch are shown in Table 4, along with the UPS capacity required to support that supply when operating in redundant mode. Table 5 shows similar information for Cisco Catalyst 6500 switches.

AC double-conversion or DC UPS systems are typically selected for applications supporting Cisco Catalyst 4500 or 6500 switches.

For applications where rack-mount AC UPS support is preferred, the Liebert GXT system provides up to 2100 Watts of protection in a 2U configuration, 4200 Watts in a 4U configuration, 8000 Watts in a 6U configuration and 16000 Watts by paralleling two 6U devices.

Standalone UPS systems, such as the single-phase Liebert Nfinity or three-phase Liebert NX can also be used to provide UPS support for multiple racks of equipment.

All of these systems can be configured with extra battery systems to extend runtimes if generator backup is not available, and with power management software and remote monitoring capabilities.

With PoE, the majority of power being consumed by the switch is -48VDC. Consequently, DC power supplies are better able to fully power all PoE ports in larger switches. Liebert offers an AC-powered DC UPS, the NterpriseIP, that can be used to provide -48V DC power to the switch.

The NterpriseIP system (Figure 5) provides a plug-and-play solution that can deliver 4.5 kW, 6 kW or 15 kW of redundant DC power to Cisco Catalyst switches. It features hot swappable power modules for scalability, excellent efficiency and cost-effective support for extended runtimes.

DC systems like the NterpriseIP are inherently more efficient; therefore, heat loads can be up to 40 percent less compared to an AC-powered system. Figure 6 shows a block diagram of the NterpriseIP system. For more information on sizing this system, refer to the white paper, *High Availability Power Alternatives for Cisco 4500 PoE Applications* available at www.liebert.com.

Cisco Catalyst Model	PoE Ports	Data Power at switch*	PoE Class 3 at switch (at 17.3W**)	Max Input Power to PS (at .75 eff)	Cisco Power Supplies	AC UPS Capacity*** (W)
4503	48	304W	830W	1513W	1400WDC-P or 1300WAC	1733W
4503	96	304W	1661W	2620W	1400WDC-P or 4200WAC	5600W
4507R/4506	144	690W	2491W	4242W	1400WDC-P or 4200WAC	5600W
4507R/4506	192	690W	3322W	5349W	1400WDC-P or 4200WAC	5600W
4507R/4506	240	690W	4152W	6456W	1400WDC-P + power shelf	7000W
4510R	288	900W	4982W	6182W	1400WDC-P + power shelf	7000W
4510R	336	900W	5813W	7013W	1400WDC-P + power shelf	10000W
4510R	384	900W	6643W	7843W	1400WDC-P	NA

Table 4. Power requirements for Cisco Catalyst 4500 switches.

Notes:

* Data power calculated for max number of line cards.

** PoE line card efficiency is 89% so the output of the power supply to the line card has to be 17.3W.

*** Assuming redundant power supplies.

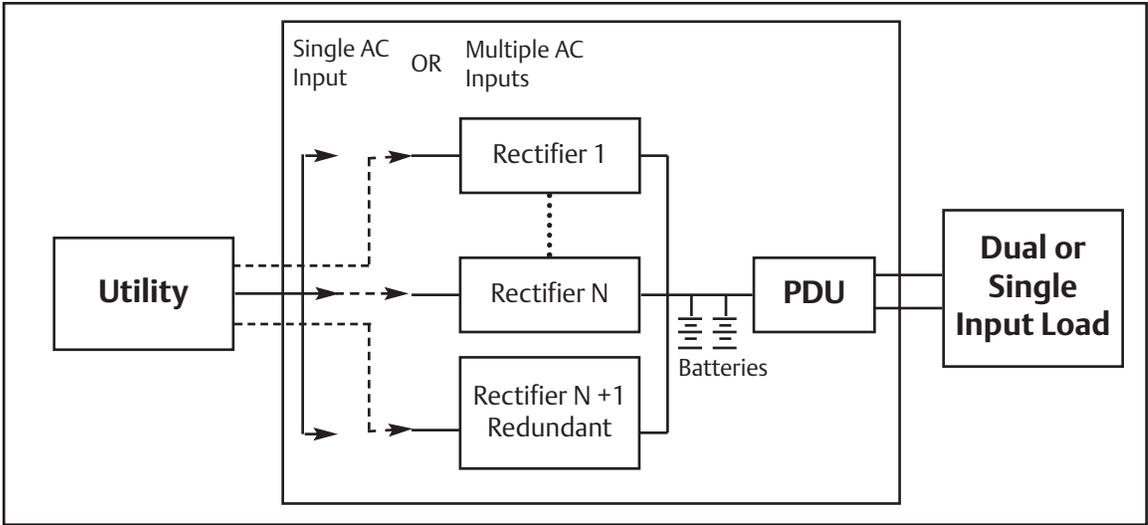


Figure 6. A DC UPS system with redundant rectifiers, batteries and load cables. Either single or multiple AC inputs can be used.



Figure 5. The NterpriseIP system



NterpriseIP has met the Cisco Technology Developer Partner Program test criteria for interoperability with with Cisco Unified CallManager 4.1 (2), Cisco Unified CallManager 4.0 (2), Cisco Unified Personal Communicator and Cisco Unity Bridge. Go to www.IPT1.Liebert.com for disclaimer.

Cooling

When deploying larger switches, it is important to understand the impact of the switch on the heat load in the environment where it will be operating. The heat generating sources at the switch point-of-use include:

1. Power used to support data and other non-PoE operations.
2. PoE processing losses (about 11 percent of total PoE power in Catalyst 4500 and 6500 switches).
3. Inefficiency of power supplies.
4. Inefficiency of external systems delivering power (AC or DC UPS).

The Cisco Power Calculator provides data on Cisco switch heat rejection for a given configuration and can be used to determine heat rejection for the first three items.

Different approaches to cooling can be deployed for switches operating in remote

locations depending on the size of the room, other heat-generating equipment in the room and existing cooling systems. Options include:

- Enclosed systems. Systems such as the Liebert XDF provide a plug-and-play power and cooling solution for remote locations that can support up to 14.4 kW of equipment in a single enclosure.
- Ceiling mount precision cooling. Available in a wide variety of configurations, ceiling-mount systems can provide precise environmental control for up to 10 kW of equipment in a small room or closet.
- For larger rooms, floor-mounted precision cooling systems can be configured to ensure proper environmental conditions for Cisco switches.

A Liebert power and cooling specialist can help configure power and cooling support to the switch's configuration and environment.

Conclusion

Network convergence brings higher densities, capacities and availability requirements to critical facilities. An adaptive, mission-critical power and cooling infrastructure is essential to dealing with the changes that come with convergence. Evaluating existing systems in terms of their ability to deliver the power availability, power quality and cooling required by IP telephony and PoE technology will help ensure a successful transition and create the foundation for expanded IP communications in the future.

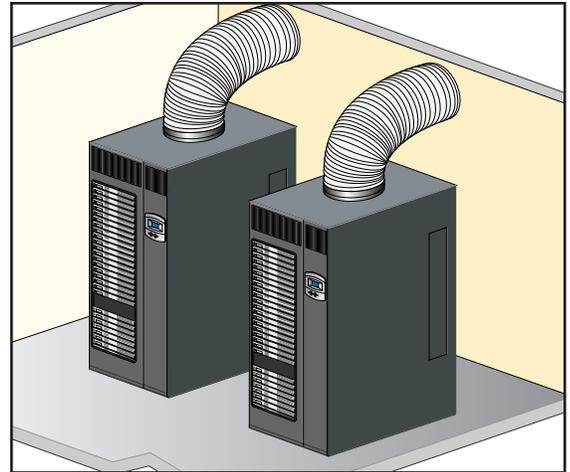


Figure 7. High-density cooling enclosures.

Cisco Switch Config	No. of Devices Supported	Efficiency	Max input Power	AC UPS Capacity
Cisco Catalyst 6506 single Supervisor Engine 2 with PCF2				
2500W redundant	107, 112	.7	3571 W	4000 W
4000 W redundant	185, 186	.75	5400 W	7000 W
6000 W redundant	240 ^{*/**} , 283	.85	7034 W	7000 W
Cisco Catalyst 6509 single Supervisor Engine 2 with PCF2				
2500W redundant	107, 112	.7	3571 W	4000 W
4000 W redundant	185, 186	.75	5400 W	7000 W
6000 W redundant	279, 283 ^{**}	.85	7034 W	7000 W
Cisco Catalyst 6513 single Supervisor Engine 2 with PCF2				
2500W redundant	104, 95	.7	3571 W	4000 W
4000 W redundant	184, 174	.75	5400 W	7000 W
6000 W redundant	285, 271	.85	7034 W	7000 W
Cisco Catalyst 6506 redundant Supervisor Engine 2 with PCF2				
2500W redundant	101, 105	.7	3571 W	4000 W
4000 W redundant	179, 181	.75	5400 W	7000 W
6000 W redundant	192 ^{*/**} , 248 ^{*/**}	.85	7034 W	7000 W
Cisco Catalyst 6509 redundant Supervisor Engine 2 with PCF2				
2500W redundant	101, 105	.7	3571 W	4000 W
4000 W redundant	179, 181	.75	5400 W	7000 W
6000 W redundant	273 ^{*/**} , 272 ^{*/**}	.85	7034 W	7000 W
Cisco Catalyst 6513 redundant Supervisor Engine 2 with PCF2				
2500W redundant	97, 87	.7	3571 W	4000 W
4000 W redundant	178, 167	.75	5400 W	7000 W
6000 W redundant	279, 263	.85	7034 W	7000 W

Table 5. Number of PoE Devices that can be supported for various configurations of the Cisco Catalyst 6500 switch.

* Indicates that the configuration supports inline power on all possible inline power ports.

** Indicates that enhanced chassis is required to support the configuration.



Liebert IP Telephony Availability System, version 1.0 has tested compatible with Cisco Unified CallManager, Unified CallManager Express and Unity. The Cisco Compatible logo signifies that Liebert products have undergone interoperability testing by Liebert together with Cisco and a third-party test house based on test criteria set by Cisco. Liebert is solely responsible for the support and warranty of its products. Cisco makes no warranties, expressed or implied, with respect to Liebert's products or its interoperation with the Cisco listed products and disclaims any implied warranty of merchantability, fitness for a particular use or against infringement.

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