Troubleshooting Power Over Ethernet

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This guide is for troubleshooting Power over Ethernet (PoE) in the Catalyst 3750-E, 3750, 3560-E, and 3560 switch product families. Topics related to earlier PoE switches are also included.

For precise CLI and message format, see the switch software configuration guides and command references for the specific switches.

There are minor variations in both the command-line interface (CLI) and PoE functions from the earliest to the newest switch. Characteristics unique to a specific switch family or hardware version are listed when appropriate.

This guide contains these sections:

Terminology

These terms used in this document:

- 802.3af—The IEEE standard for PoE, often referred to as *IEEE-compliant*.
- CDP—Cisco Discovery Protocol. A Cisco Layer 2 protocol that enables switches and routers to quickly identify other Cisco devices when directly connected or connected to the same VLAN.
- Cable diagnostics—A feature in specific switches that detects electrical defects in Ethernet cables. See also *TDR*.
- Endpoint PSE—Switched-based power source equipment, an Ethernet switch that provides PoE.
- FLP—Fast Link Pulse. An Ethernet protocol message used during standards-based link speed and duplex autonegotiation.
- FRU—field-replaceable unit, typically a power supply or fan module.
- Midspan PSE—power source equipment (a PoE source) in a patch panel.

- MPS—maintain power signature. The powered device must continue to be detected by a PSE in order to maintain a power feed from the PSE.

- PoE—Power over Ethernet

- PSE—power-source equipment. Typically an Ethernet switch or power patch panel that provides PoE.

- PTC—positive temperature coefficient (a self-resetting fuse)

- SNR—Signal-to-noise ratio

- TDR—time domain reflectometer. Also referred to as *cable diagnostics*, a feature used by switches to test electrical properties of Ethernet cables.

- UPS—Uninterruptible power supply

- WAP—wireless access point

Guidelines

Consider these guidelines before troubleshooting any PoE problem:

- Carefully verify the symptom. For example, does a powered device not power up at all, or does it power up briefly and then power down? Obtain as much detail as possible regarding the symptom, including any system messages from the PoE switch.

- Did the trouble occur on initial installation, or did it begin after the powered device was working normally?

- If the trouble started after the powered device was working, what changed? Were there any hardware or software changes?

- Did any specific event occur at the powered device when the problem occurred?

- Did anything occur in the local network when the problem occurred? Use the **show log** privileged EXEC command to review the switch log and SNMP traps.

- Does the problem happen at a specific time of day or night? (There could be electrical actions at the installation site possibly causing the problem.)

- If an IP phone works normally between intermittent reboots, the problem could be related to PoE or an electrical connection in the cable. It could also be caused by a temporary loss of connectivity between the IP phone and the call manager.

Troubleshooting Categories and Symptoms

No PoE On Only One Port

Follow these steps when the trouble is on only one switch port. Confirm that PoE and Non-PoE devices do not work on this port but work on other ports.

Step 1   Verify that the powered device works on other ports and that the problem is only on one port.

Step 2   Use the **show run** and **show interface status** privileged EXEC commands to verify that the port is not shut down. (Most Cisco switches turn off port power when the port shuts down.)

Step 3   Use the **show interface status** privileged EXEC command to verify that the switch port is not error disabled.

Step 4   Use the **show run** and **show power inline** *interface-id* privileged EXEC command to verify that the **power inline never** interface configuration command is not configured on the port.

Step 5   Verify that the Ethernet cable from the phone to the switch port is good. Connect a known good non-PoE Ethernet device to the Ethernet cable, and make sure that it establishes a link and exchanges traffic with another host.

Step 6   Verify that the total cable length from the switch front panel to the connected device (powered device) is not more than 100 meters. For more information, see the cable diagnostics section in the switch software configuration guide.

Step 7   Disconnect the Ethernet cable from the switch port. Use a short Ethernet cable to connect a known good Ethernet device to this switch port (not at a patch panel). Verify that the device establishes an Ethernet link and exchanges traffic with another host, or ping the port VLAN SVI. Next, connect a powered device to this port, and verify that it powers on. If it does not power on, go to Step 8.

Step 8   Use the **show inline power** and **show inline power detail** privileged EXEC commands to compare the number of connected powered devices against the switch power budget (available PoE). Verify that switch power budget can power the device.

> **Note**   If the switch power budget is depleted, additional powered devices will not power-on when connected to a PoE port. CDP (Cisco Discovery Protocol) helps identify Cisco devices and correctly establish the switch power budget.

These sections provide additional information and include command examples about troubleshooting a switch that has no PoE on one port:

No PoE On All Ports or a Group of Ports

Follow these steps when there is no power on any port or a consecutive group of ports. Confirm that nonpowered Ethernet devices can establish an Ethernet link on any port and that PoE devices *do not* power on.

Step 1 Use the **show interface status** privileged EXEC command to verify that the ports are not shut down and not error disabled.

Step 2 Use the **show env all**, **show interface status**, and **show power inline** privileged EXEC commands to review power status if no powered device on any port can power on. Use the **show log** privileged EXEC command to review alarms reported earlier by system messages.

Step 3 If the trouble is on all ports, the PoE section of the power supply might be defective if the switch works normally except for PoE and if non-PoE devices can establish an Ethernet link on any port. If the trouble is on a consecutive group of ports but not all ports, there could be a defective PoE subsection in the switch.

Step 4 If there is a persistent alarm related to power, replace the power supply if it is field-replaceable. Otherwise, replace the switch.

Step 5 If there are no alarms reported by LEDs, CLI messages, or in the output of the **show env all** privileged EXEC command, connect a powered device directly to a switch port. Do not use the existing distribution cables. Use only a short patch cord to make the connection.

Step 6 Enter the **shut** and **no shut** interface configuration commands on this port. Use the **show power inline** privileged EXEC command to verify that the powered device receives power when the port is not shut down.

In some cases, it may be appropriate to disconnect the Ethernet cables from all but one switch port, and leave a powered device connected to only that PoE port.

If this connection using a short patch cord allows the powered device to power on, verify that all intermediate patch panels are correctly connected, and that the total cable length does not exceed 100 meters. If the cable diagnostics feature is supported by the switch, temporarily disconnect the powered device, and use this feature to verify total cable length.

Step 7 If a powered device powers on when it is the only one connected to the switch, enter the **shut** and **no shut** interface configuration commands on the remaining ports. Reconnect the Ethernet lines one at a time to the switch PoE ports. Use the **show interface status** and **show power inline** privileged EXEC commands as each line and powered device is reconnected to monitor inline power statistics and port status.

Cisco IP Phone Disconnects or Resets

Follow these steps when a working Cisco IP Phone or wireless access point intermittently reloads or disconnects from inline power.

Step 1 Verify all electrical connections from the switch to the powered device. Any unreliable connection results in power interruptions and intermittent powered device operations, such as powered device disconnects and reloads.

Step 2   Verify that the total cable length from the switch front panel to the connected device (powered device) is not more than 100 meters. For more information, see the cable diagnostics section in the switch software configuration guide.

Step 3   Notice what might be changing in the electrical environment at the switch site. What is happening at the powered device when the disconnect occurs?

Step 4   Use the **show log** privileged EXEC command to review messages and events. Notice whether any other error messages are reported by the switch at the same time that a disconnect occurs.

Step 5   Verify that a Cisco IP Phone is not losing access to the call manager immediately before the reload occurs. (It might be a network problem, not a PoE problem.)

Step 6   Connect a non-PoE device to the port, and verify that it works. If a non-PoE device has link problems or a high error rate, the problem might be an unreliable cable connection between the switch port and the user.

> **Note**   If a powered device can power up when only one powered device is connected to the switch but not when all powered devices are connected, it is possible that the power budget was depleted. Connect powered devices one at a time, and enter the **shut** and **no shut** interface configuration commands as each device is connected. This clears any error-disabled states. Use the **show interface status** and **show power inline** privileged EXEC commands to monitor inline power statistics and port status as each device is connected.

These sections provide additional information and include command examples about troubleshooting a Cisco IP Phone that disconnects or resets:

- PoE Class Detection, page 8
- Overcurrent Protection and Available Power, page 15
- PoE and Cable Length , page 17

Non-Cisco Powered Device Does Not Work on Cisco PoE Switch

Follow these steps when a non-Cisco powered device is connected to a Cisco PoE switch, but never powers up, or powers up and then quickly disconnects from power (powers down). Non-PoE devices work normally.

Step 1   Use the **show power inline** privileged EXEC command to verify that the switch power budget (available PoE) is not depleted before or after the powered device is connected. Verify that sufficient power is available for the powered device type.

Step 2   Use the **show interface status** privileged EXEC command to verify that the powered device is detected by the switch when connected.

Step 3 Use the **show log** privileged EXEC command to verify that the powered device is not causing an overcurrent condition on the port. Verify the symptom precisely: Does the phone initially power on and then disconnect? If so, the problem might be an initial current surge that exceeds a current-limit threshold for the switch port.

Step 4 Verify that the powered device is compatible with the Cisco switch. For example, if both units are standards-compliant, they should interoperate. CDP cannot be used to identify a non-Cisco device, and the switch must rely on accurate detection and classification when working with a non-Cisco device.

These links provide additional information and include command examples for troubleshooting a non-Cisco powered device that does not work on a Cisco PoE switch:

Understanding PoE

Detection of Powered Devices

A switch uses *detection* to determine whether a powered device is connected to a port. PoE switches generally do not apply power to the Ethernet line unless a powered device is detected. When a powered device is connected to a PoE switch port, the switch uses one of these methods to detect the powered device:

- DC detection, sometimes called *IEEE standard* or *802.3af standard* detection. Cisco IP phones support both DC and AC detection.

- Cisco Detection, also called *prestandard* or *AC detection*. Prestandard Cisco IP phones use this method.

Cisco and non-Cisco PoE switches and powered devices are in two major categories:

- Pre-IEEE standard (for example, Catalyst 3500)
- Post-IEEE standard (for example, Catalyst 3560, 3750, 3560G, 3750G, 3560-E, and 3750-E)

Prestandard and poststandard phones might use different detection and connect or disconnect methods.

Note that powered device detection occurs when an Ethernet device is first connected to a PoE port. If a non-PoE device is connected to a PoE port, detection is deactivated. If the non-PoE device is later disconnected and replaced by a powered device, the switch might not detect it immediately. A timeout of several seconds must expire before detection is reenabled and active after a linkdown and linkup change.
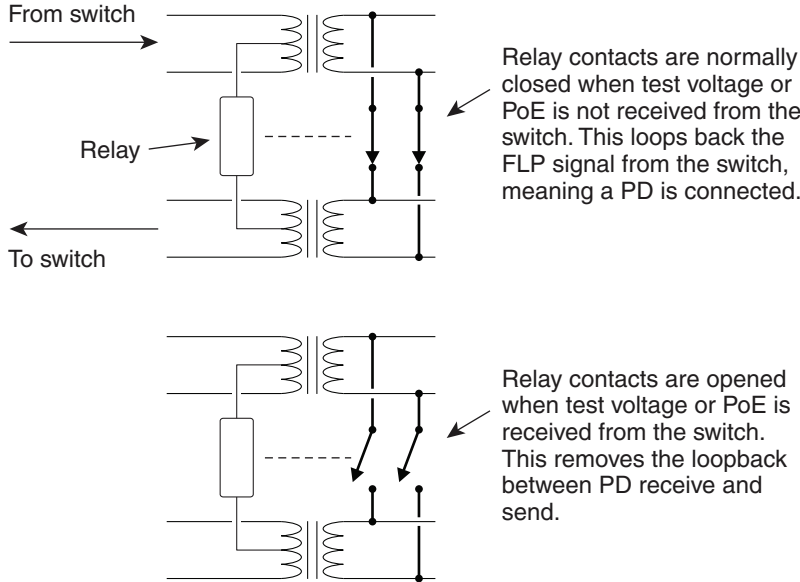
Cisco Detection (AC Discovery)

This can also be called *prestandard* detection or discovery.

The Catalyst 3500 and earlier PoE switches use Cisco prestandard discovery to detect IP phones or other powered devices.

- The switch sends a special Fast Link Pulse (FLP) signal to any device connected to the port.
- The switch port determines if the special FLP signal is looped back by the powered device receive pair to the send pair. The only devices that loop back the FLP signal are those that would use inline power.
- When the switch detects the looped-back FLP signal and determines that it should provide inline power to the port, the switch determines if there is power available for the connected device. The switch might use a default power allocation to check available power. It can then adjust this allocation based on CDP information from a Cisco powered device.
- The switch port then applies power to the connected device, and the relay inside the phone releases the loopback, as shown in .
- If the powered device is a Cisco device, it boots, and CDP becomes active. The power budget in the switch can be adjusted by power requirement information in CDP messages from the powered device.

Figure 1   *Powered Device*

From switch

Relay

To switch

Relay contacts are normally closed when test voltage or PoE is not received from the switch. This loops back the FLP signal from the switch, meaning a PD is connected.

Relay contacts are opened when test voltage or PoE is received from the switch. This removes the loopback between PD receive and send.

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PoE Class Detection

Standards-based Cisco PoE equipment conforms to the IEEE standards for five power classifications for powered devices.

When the switch detects a powered device and grants a power request, the switch can adjust the power budget (available power) according to the powered-device IEEE classification.

PoE classes describe a range of power used by a specific powered device. Some powered devices require more power than others, and power classes allowed switches to manage a *power budget* or available power. When a powered device is detected and its class is identified, the switch *allocates* (reserves) the appropriate power range.

The switch can determine the IEEE power class of the powered device by applying approximately 20 VDC to the line and measuring the resulting current flow. IEEE-compliant powered devices will produce a very specific current flow in response to the 20 VDC applied by the switch.

Table 1 shows the IEEE standard power classes.

Table 1   *IEEE Standard Power Classes*

IEEE 802.3af Power class	Power delivered by switch port	Maximum power used by powered device	Class signature current (typical and maximum)
0	15.4 W	12.95 W	0–4 mA, 6 mA max.
1	4 W	3.84 W	9–12 mA, 14.5 mA max.
2	7 W	6.4 9W	17–20 mA, 23 mA max.
3	15.4 W	12.95 W	26–30 mA, 33 mA max.
4	–	–	36–44 mA, 48 mA max.

Some of the power from the switch port is dissipated in the cable due to wire resistance, especially on cables as long as 100 meters. The remaining power is available to the powered device.

Most powered devices do not use the maximum power of their classes. For example, some IP phones are in the class 3 category, but consume less than 15.4 W.

If the powered device is Class 0 (class status unknown or prestandard) or Class 3, the switch must initially budget 15.4 W for the device, regardless of the actual amount of power needed by the powered device. If the powered device reports a higher class than its actual power consumption or does not support power classification (defaults to Class 0), the switch can power fewer devices if it uses the IEEE class information to establish and track the power budget. (Cisco switches and Cisco powered devices can also use CDP to establish the correct power usage for the powered device, but this occurs after the powered device is powered-up and fully operational.) Some switches can measure the actual power used on a per-port basis.

After classification, the switch applies 48 to 52 VDC to the line, which is the operational voltage of telephones and wireless access points. The powered device is now fully powered and should be operational (or registering with the call manager if the powered device is an IP phone).

Most earlier prestandard switches such as the Catalyst 3500 can not provide full power to newer devices such as IP phones with a color display. Bringing the phone up in reduced power mode at least allows it to operate, even though possibly with reduced features or reduced display brightness.

Maintain Power Signature and Disconnect

The switch uses maintain power signature (MPS) to detect the continued presence of a powered device after detection and after power is applied. As long as a power signature is present, the switch provides PoE. Cisco switches and Cisco IOS use various MPS versions as described in these sections:

- DC Current MPS and DC Disconnect, page 9
- 100-Hz MPS and AC Disconnect, page 10
- Ethernet Link MPS and Disconnect, page 11

The powered device must maintain its power signature to maintain a PoE feed from the switch. PoE is typically removed within 500 milliseconds after the switch no longer detects a power signature. All disconnect methods occur at the physical layer.

DC Current MPS and DC Disconnect

Catalyst 3750-E, 3750, 3560-E, and 3560 switches support DC current MPS. The switch port removes power if the DC current in the current loop to the powered device is below a specific threshold for 300 to 400 milliseconds. When a powered-up device is disconnected, the current between the switch port receive and send pairs drops to 0.

As long as DC current is flowing between minimum and maximum thresholds, the switch determines that a powered device is connected, powered, and should continue receiving power, as shown in Figure 2 on page 10. An unreliable connection at some point between the switch and powered device can cause a false disconnect.

Figure 2 **DC Current Flowing Between Switch and Powered Device**

PoE Switch Port   Powered Device

Sending Pair

DC +

DC -

Receiving Pair
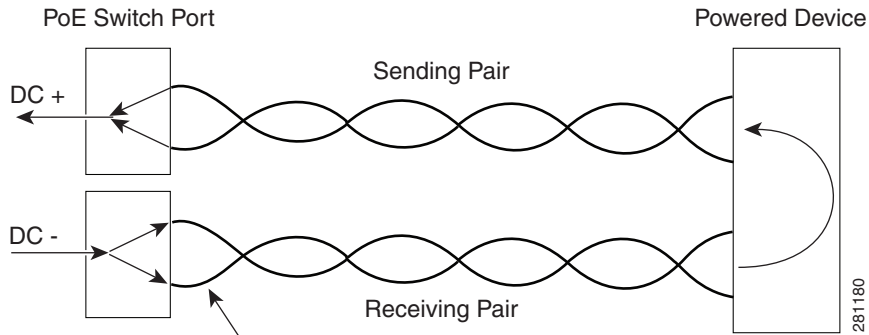
PoE power is applied at the switch port interface.

The powered device completes the current loop. DC current within specific minimum and maximum thresholds means that a PoE-powered device is connected and requires continued PoE.

A device that is locally powered by an AC power module is detected by the PoE switch when connected to a port. However, the switch either provides or removes power based on a low current threshold (for example, the powered device is not using power from the switch.)

When powered devices are locally powered (no PoE), it might be appropriate in some cases to use the **power inline never** interface configuration command:

```
Switch(config)# int g0/1
Switch(config-if)# power inline never
```

100-Hz MPS and AC Disconnect

Some early Catalyst 3750 and 3560 switches apply a 100-Hz signal between the receive and send pairs of the Ethernet port. A low-pass filter in the powered device *loads* (attenuates) the 100-Hz signal level below a specific threshold. The low-pass filter works only at 100 Hz and does not loop back normal traffic or Ethernet control signals.

The switch does not detect the attenuated 100-Hz signal when the powered device has the low-pass filter between the receive and send pairs. This means that a powered device is still connected and powered on, and that power to the device should continue, as shown in .

Figure 3   *100-Hz Amplitude*

100 Hz is applied at the switch port. The amplitude is measured to determine whether a powered device is connected at the other end of the cable.

PoE Switch Port   Powered Device

Sending Pair

100 Hz

Low-Pass Filter

Receiving Pair

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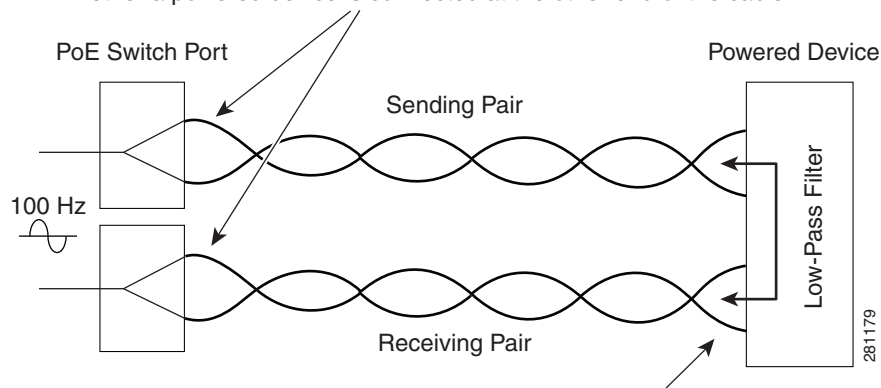
The low-pass filter provides a line termination at the signal frequency of 100 Hz. This causes a higher current at 100 Hz and lowers the amplitude of the signal measured at the switch port. Other frequencies and DC are not affected by the filter.

When the powered device is disconnected, the100-Hz signal loading is removed from the line and the 100 Hz signal goes up beyond a specific threshold. The switch detects the signal level increase and recognizes that a powered device has been disconnected. The switch removes PoE from the Ethernet port.

Some early Catalyst 3560 and 3750 PoE switches use the 100-Hz MPS method with early Cisco IOS versions, but later Cisco IOS versions on these switches change the MPS mode to DC current.

Ethernet Link MPS and Disconnect

If Cisco detection is used, a Cisco PoE switch generally removes PoE from a port if the switch port detects loss of Ethernet link. (If IEEE detection is used, DC or AC MPS methods detect disconnects. Power to a device can continue when an MPS signal is present, even if the Ethernet link is down.) The disconnect method depends on the connected powered device.

A Cisco switch reports when a powered device is connected or disconnected and when an Ethernet link state changes. This example shows a Cisco IP phone that was disconnected from the Ethernet port and then reconnected. The switch then detects a powered device, applies PoE, and detects MPS (Ethernet link).

```
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/3, changed state to
down
%ILPOWER-5-IEEE_DISCONNECT: Interface Gi1/0/3: PD removed
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/3, changed state to down
%ILPOWER-7-DETECT: Interface Gi1/0/3: Power Device detected: IEEE PD
%ILPOWER-5-POWER_GRANTED: Interface Gi1/0/3: Power granted
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/3, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/3, changed state to up
```

Note   Unreliable plugs or jacks at any point between the phone and switch can cause the same disconnections.

Cisco Discovery Protocol and PoE

CDP (Cisco Discovery Protocol) is a Cisco-proprietary Layer 2 protocol that runs on most Cisco equipment and shares information about directly connected Cisco equipment.

Cisco PoE switches using CDP can recognize Cisco powered devices such as IP phones and wireless access points. The actual power requirement can be advertised by the powered device, and the unused *class power* is returned to the switch power budget.

To use CDP for powered device discovery, enable it on the switch and on the PoE ports. (CDP is typically enabled by default.)

When a Cisco powered device (phone or WAP) powers on, CDP sends a message that tells the switch how much power the powered device actually needs. The switch CPU adjusts the power allocation for the port and adjusts the power budget.

Without CDP, if a powered device is connected but the class is 0 (default) or cannot be identified, the switch must reserve the maximum per-port PoE for the powered device. This can quickly deplete the power budget and, in a worst case, could result in a total *artificial* power budget depletion. Then the switch might not allocate power to a detected powered device even though power is still available.

For example, if a non-Cisco IEEE 802.3af Class 3 powered device is detected which requires only 9 W, but the actual requirement is not known by the PoE switch, the switch must initially budget the full per-port *class power* of 15.4 W even though the device will use only 9 W. This wastes 6.4 W, and this quickly adds as multiple similar devices are connected to the switch. An improper classification signature in the powered device can cause the same problem. This might prevent all intended devices from receiving power. Catalyst 3750, 3560, and newer switches monitor the actual per-port power used after powered device detection is complete and PoE is applied.

A Cisco IEEE+CDP powered device such as the 7970G IP phone initially powers up in low-power mode (6.3 W), then sends a CDP message with the actual power requirements of the device. If the required power is less than the default 15.4 W for a Class-3 device, the switch updates its power budget. If the requested power exceeds the power budget available for the switch, power is either be denied, or the port remains in low-power mode (typically 7 W).

Use the **show power inline** privileged EXEC command to review these factors:

- PoE power available per switch
- PoE power used by all ports in the switch
- PoE power used by each connected powered device
- PoE power classification

Monitoring Detection and Allocated Power

To see connected Cisco devices, use the **show cdp neighbor** or **show cdp neighbor detail** privileged EXEC commands:

```
Stack-1# show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone
Device ID       Local Intrface   Holdtime  Capability  Platform  Port ID
SEP001121116D78 Gig 1/0/2        167            H P     IP Phone  Port 1

Stack-1# show cdp neighbor detail
-------------------------
Device ID: SEP001121116D78
Entry address(es): IP address: 192.168.1.249
Platform: Cisco IP Phone 7970,  Capabilities: Host Phone
Interface: GigabitEthernet1/0/2,  Port ID (outgoing port): Port 1
Holdtime : 150 sec
```

Note The maximum required power for this phone is 10250 milliwatts (10.25 W), but the phone can operate with reduced screen brightness at 6.3 W.

```
Version :  SCCP70.8-0-0-74S
advertisement version: 2
Duplex: full
Power drawn: 10.250 Watts
Power request id: 28024, Power management id: 3
Power request levels are:10250 6300 0 0 0
```

This example shows the allocated and power budget for two switches in a Stackwise stack. Switch 1 (Module 1) is a 3750-E, and switch 2 is a 3750G.

```
Stack-1# show power inline
Module    Available    Used     Remaining
(Watts)     (Watts)   (Watts)
------    ---------   --------  ---------
1           420.0      22.2      397.8
2           370.0      18.2      351.8
```

This example shows per-port power usage:

```
Interface Admin  Oper        Power  Device              Class Max
                             (Watts)
--------- ------ ----------- ------- ------------------- ----- ----
Gi1/0/1   auto   on          6.3     IP Phone 7960        0    15.4
Gi1/0/2   auto   on          10.3    IP Phone 7970        3    15.4
Gi2/0/1   auto   on          15.4    IP Phone CP-7970G    3    15.4
Gi2/0/2   auto   on          8.5     AIR-AP1220-IOS       n/a  15.4
```

Note This 7970 is a Class-3 phone, but uses only 10.3 W (maximum) in this configuration. The 7970G is using 15.4 W due to maximum screen brightness.

In this example, some of the phones are early prestandard units. The indicator of standard or nonstandard varies depending the switch model and Cisco IOS version. Failing to identify a specific class is typically a sign of a prestandard powered device.

The **show power inline c**ommand offers port-specific information containing elements of the **show cdp neighbor detail** and **show inline power** privileged EXEC commands:

```
3750# show power inline g2/0/14
Interface Admin  Oper        Power   Device               Class Max
                             (Watts)
--------- ------ ----------- ------- ------------------- ----- ----
Gi2/0/14  auto   on          10.3    IP Phone CP-7970G      3   15.4


Interface  AdminPowerMax   AdminConsumption
           (Watts)         (Watts)
---------- --------------- ------------------
Gi2/0/14       15.4             15.4
```

Non-Cisco Powered Device Problems

- Detection and Classification, page 14
- Surge-In Current, page 14
- Overcurrent Protection and Available Power, page 15

Detection and Classification

It is possible that some of the prestandard non-Cisco powered devices might not be detected by a Cisco switch, but later IEEE-compliant powered devices should not have this problem when connected to a IEEE-compliant Cisco switch.

CDP identifies Cisco powered devices and establishes the appropriate power budget, but non-Cisco devices do not have the advantage of CDP. If a non-Cisco powered device can be detected but the power class cannot be identified, the switch must default to class 0 and allocate the maximum power for the port. This can cause a premature depletion of the power budget.

For example, unidentified devices might need only 6 W, but they are allocated maximum PoE power (up to 15.4 W), and the power budget can be depleted before all available ports on the switch have been provided power. This results in a symptom where a known-good powered device is connected to a known-good PoE port on a switch, but the powered device does not power on.

Some of the newer switches, such as the Catalyst 3750-E and 3560-E can adjust the power budget according to actual measured power usage.

Surge-In Current

Some non-Cisco devices might have an excessive *surge in* current when first connected to a PoE port. The switch initially provides power to the port, then quickly removes power due to a momentary, overcurrent condition. The powered device appears to power on, but then quickly powers down.

This error message from a Catalyst 3750 is possibly caused by an overcurrent condition:

```
%ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi1/0/1: inline power denied
```

This error message from a Catalyst 6000 is possibly caused by an overcurrent condition:

```
%C6K_POWER-SP-1-PD_HW_FAULTY: The device connected to port 3/21 has a hardware problem.
Power is turned off on the port.
```

Overcurrent Protection and Available Power

Any current over 450 mA is usually considered an overcurrent condition.

All PoE switches have electronic voltage and current regulators that detect an overcurrent threshold and disconnect DC power from the line to prevent damage.

Cisco PoE switches have two levels of overcurrent protection:

- Electronic regulation (per port)
- Fuses (per switch)

This prevents excessive current from being delivered by the PoE port, which could possibly result in damage to port-level components.

Earlier PoE switches such as the Catalyst 3524PWR support a nominal 6 or 7 W per port. If the line current on a particular port increases to approximately 9 W, the switch removes power to prevent circuit damage due to overheating.

Newer switches such as the Catalyst 3750-E, 3560-E, and 3750G support up to 15.4 W per port. Some earlier switches might not be able to provide 15.4 W on all ports, and the maximum power delivered to all ports is limited by a power budget. The power budget is usually related to the switch power-supply capability and the amount of delivered power. All newer switches can power a mix of 7.5 W and 15.4 W powered devices until the power budget is depleted.

The Catalyst 3750-E and 3560-E switches support 15.4 W per port up to 48 ports depending on the FRU power supply installed. Switches that provide 15.4 W per port typically remove power from the port if power dissipation reaches approximately 17 W.

Normally the automatic electronic current regulation is completely effective, and fuse action is very seldom necessary or observed. Fuses can either be self-resetting (replacement not required) or a basic, fast-acting fuse that requires replacement after burning open. Fuses are included in the PoE power supply as a safeguard, but the port-level electronic regulators are the primary method of overcurrent protection.

The self-resetting fuses are PTC (positive temperature coefficient) resistors. These components are a polymer-based temperature-dependent resistor, not actually a fuse. When activated by heat, PTC units increase in resistance.

PTC fuses are also sensitive to high ambient temperature (inside the Ethernet switch chassis), so these devices might appear to activate more quickly when exposed to higher temperatures. The actual current threshold is a factor of both heat from circuit current and heat from ambient temperature inside the chassis. The advantage of a self-resetting fuse is, if activated, power is restored to the line when the overcurrent condition is corrected. The disadvantage of these devices is after the first time they are activated, they usually exhibit a slightly higher resistance thereafter, even when the device temperature returns to normal or ambient.

The standard, fast-acting fuses used in some switch power supplies open if a circuit in the switch fails and causes excessive current. This is unusual, but if it occurs, replace the power supply (if it is replaceable) or replace the switch.

In normal operation, the electronic regulators limit the per-port PoE current to safe levels. The fuses are a second level of safety. If an overcurrent condition occurs on one port, it does not affect other ports.

Some Cisco switches allow manual adjustments to the power budget and per-port control of the maximum PoE power delivered to a powered device.

In this example, the **power inline consumption** interface configuration command adjusts the switch power budget to 7 W when the actual power required by a powered device is known but cannot be determined by IEEE classification. This prevents artificial depletion of the switch power budget:

```
3750E(config-if)# power inline consumption 7000
3750E# show power inline consumption
```

A powered device might use more power than set by the **power inline consumption** command, so you must carefully make adjustments to the power budget. An accurate power budget protects the switch from an overcurrent condition.

In this example, the power budget is manually adjusted to 4 W on a specific port. When a Class 3 phone was connected, it required more power than 4 W:

```
Switch(config-if)# power inline consumption 4000
%ILPOWER-4-LOG_OVERDRAWN: Interface Gi1/0/1 is overdrawing power. it is consuming 4794
milliwatts where as maximum configured power is 4000 milliwatts.
```

In this case, there was remaining available power at system level, so power was delivered to the powered device. The syslog message was an alert to report the powered device exceeding the configured power budget for the port. However, the powered device did not exceed the maximum power delivery capability of the switch.

When the power budget has been manually adjusted at port-level, the **show power inline** privileged EXEC command shows the administratively assigned power, not the actual power used by the powered device:

```
Switch# show power inline
Interface Admin  Oper       Power   Device             Class Max
                            (Watts)

--------- ------ ---------- ------- ------------------ ----- ----
Gi5/0/1   auto   on         4.0     IP Phone 7970        3    15.4
```

To see the power used by the powered device, use this command:

```
Switch# show cdp neighbors g5/0/1 detail
-------------------------
Device ID: SEP001121116D78
Platform: Cisco IP Phone 7970,  Capabilities: Host Phone
Interface: GigabitEthernet5/0/1,
Power drawn: 6.300 Watts
Power request levels are:10250 6300 0 0 0
```

The power request levels for this powered device (a Cisco 7970 phone) are 10.25 W and 6.3 W. The phone can operate at 6.3 W with reduced screen brightness. Full screen brightness requires 10.25 W. The phone in the example is operating at 6.3 W.

The Catalyst 3750-E, 3750, 3560-E, and 3560 series PoE switches allow maximum power delivery to a powered device on a per-port basis. This allows an override of the powered device classification. In this example, the **inline power static** interface configuration command sets an absolute limit of 5 W on a specific port. The powered device requires more power than is allowed by the 5 W limit, and inline power is denied:

```
Switch(config-if)# inline power static max 5000
%ILPOWER-7-DETECT: Interface Gi5/0/1: Power Device detected: IEEE PD
%ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi5/0/1: inline power denied
```

An under-powered condition can result in a permanent loopback from a Cisco-powered device, which also error disables the port. This is usually the result of an inappropriate option error when entering the **inline power static max** interface configuration command. (Set a more appropriate power limit and then enter the **shut** and **no shut** interface configuration commands on the port to clear an error-disabled state and to restore the port to service.)

Enter the **show interface status** privileged EXEC command to review the operational state of the port:

```
Switch# show interface status
Port       Name       Status        Vlan      Duplex  Speed Type
Gi5/0/1               err-disabled 7          auto    auto 10/100/1000BaseTX
```

In this example, port G5/0/1 was set to a static limit of 5 W, less than the minimum power required by the powered device. Power was denied by the switch port. The admin PoE status of port G5/0/1 is static, and the maximum allowed power is 5 W:

```
Switch# show power inline
Interface Admin  Oper        Power   Device              Class Max
                             (Watts)
--------- ------ ---------- ------- ------------------ ----- ----
Gi5/0/1   static off        5.0     n/a                 n/a  5.0
Gi5/0/2   auto   on         10.3    IP Phone CP-7970G   3    15.4
```

Class 3 powered devices are allocated 15.4 W by default. After power is applied and a Cisco-powered device boots up, CDP is enabled, and the power budget can be adjusted from CDP. Some non-Cisco class-3 phones (no CDP) use considerably less than 15.4 W maximum, although 15.4 W is budgeted if a switch can not measure the actual power consumption. For example, an Avaya 2620SW uses approximately 8 W maximum. If power consumption (allocated power) is limited to 8 or 9 W, more phones can be powered because the switch power budget is not quickly and artificially depleted. Some powered devices can operate at reduced power, but this usually limits the features or capability of the powered device. For example, a Cisco 7970 phone can operate with reduced screen brightness, using less power than the maximum *advertised* power requirement.

In newer switches, per-port power can be increased from 15.4 W to 20 W for special-purpose powered devices. Multiple ports can provide this increased power at the same time, but the switch power budget is more quickly depleted.

```
Switch(config-if)# power inline port maximum 20000
```

PoE LEDs

Some switches have a PoE LED in the system status group of LEDs. This LED indicates the per-port and system PoE status, as shown in Table 2.

Table 2   Port LEDs

| PoE LED Color	Status
Off	PoE display mode is not selected by the mode button. When this LED is off, none of the 10/100/1000 ports have been denied power, and none are in a fault condition.
Green	PoE mode is selected by the mode button, and the PoE status is shown on the port LEDs. A green port LED means that the port is supplying PoE.
Blinking amber	PoE mode is not selected by the mode button. At least one of the 10/100/1000 ports has been denied power, or at least one of the 10/100/1000 ports has a PoE fault.

PoE and Cable Length

A stable Ethernet link can sometimes be established on Category-5 cable lengths up to 130 meters, especially for 10Base-T, but the standard maximum Category 5 or Category 6 cable length for all 10/100/1000Base-T Ethernet types is 100 meters.

Category 5 and Category 6 defines the high-frequency transmission characteristics of cable over distance, which is important for 100Base-T and Gigabit Ethernet. However, PoE relies mainly on the total DC resistance of a specific length of cable, and much less on the high-frequency transmission characteristics of the cable.

PoE is delivered as a current loop through the powered device, with current flowing on both wires of the send pair and both wires of the receive pair. Both wires of each pair are required to reduce DC circuit losses and prevent excessive voltage and current drop on cables up to 100 meters long. Using both wires of each pair is the same as using a larger wire size for DC current delivery to the powered device.

An unreliable connection in a jack or at a patch panel can disrupt both Ethernet and PoE. In this case, insufficient current might be delivered to the powered device on longer cables, as shown in Figure 4.

Figure 4   *Open Connection*
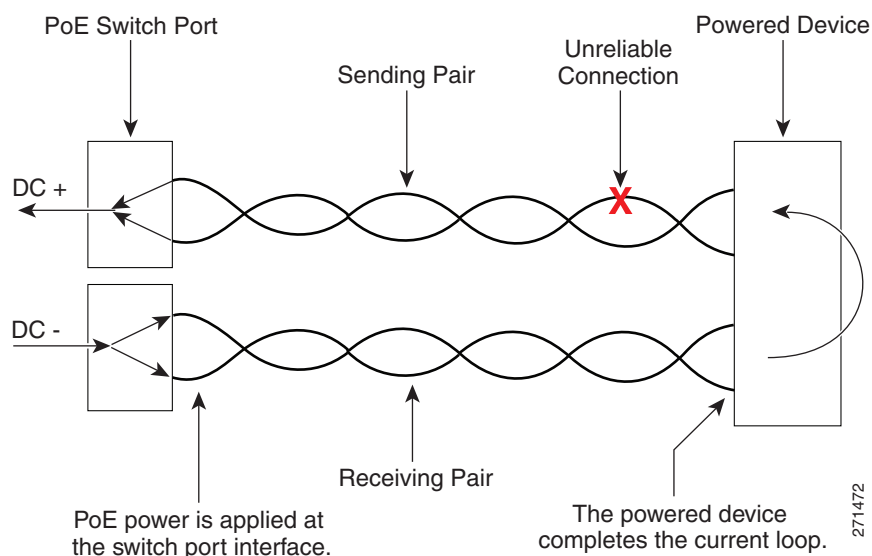
PoE requires both conductors of the send and receive pairs in order to deliver PoE power at 100 meters cable length, as shown in Figure 5 on page 19. On shorter cables with one wire of the send or receive pair open, it might be possible to have powered device detection and classification, but no Ethernet link. On longer cables with an open wire in one of the pairs, it might not be possible to detect or power-up a powered device.

The 100-meter limit for twisted-pair Ethernet cable assumes:

- Not more than four RJ-45 connection points in the transmission path
- 90 meters of solid-strand Category 5 or 5e
- 10 meters of flexible multistrand cable (2-to-5 meters of multistrand Category 5 patch cords)

Figure 5 Cable Limitations
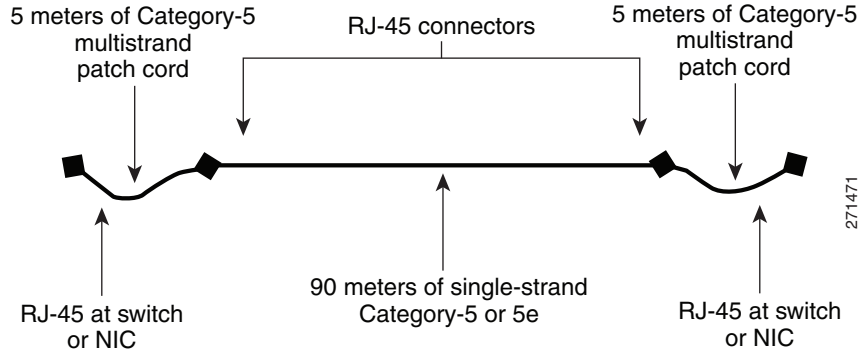
If multistrand wire (flexible patch cord) is used for the entire cable length, it might not be possible to establish a stable Ethernet link on more than 60 to 70 meters of cable (depending on the transmission line characteristics). The multistrand cable can deliver adequate power to almost any powered device at 100 meters, but multi-strand cable does not have optimum transmission characteristics for Ethernet at 100 meters. Each RJ-45 connector in the signal path introduces a small amount of signal loss and might also become an unreliable DC connection point.

Sometimes Ethernet performance and PoE performance problems are related, but Ethernet links can often be established on cables too long for effective PoE delivery. For example, some transceiver pairs can establish an Ethernet link on 120 meters of good quality Category 5 or Category 6 cable, but a powered device that requires 15 Watts may not power up on 120 meters of cable. Maximum functional Ethernet cable length usually depends on the capability of the connected transceivers. Maximum delivery length of PoE usually depends on the powered-device power requirements.

These factors significantly affect Ethernet reliability and performance:

- Cable type, typically Category 5, 5e, 6
- The amount of single-strand and multistrand wire in the signal path.
- The number of connectors in the signal path and the reliability of all mechanical connections.
- Any shorts or opens in the signal path
- Amount of electrical noise induced into the Ethernet cable and the resulting degradation to SNR.

These factors significantly affect PoE reliability:

- The total end-to-end DC resistance between the switch port and powered device.
- The reliability of all mechanical connections (connectors)
- Any intermittent shorts or opens in the signal path.
- For AC detection and AC disconnect, the amount of electrical noise in the Ethernet cable

The cable diagnostics (or TDR) feature, in most of the newer Ethernet switches can be valuable when measuring cable length to an open or shorted cable pair. Cable length is usually measured to an open (nothing connected at the powered device end of the cable). Refer to the switch software configuration guide to determine cable diagnostics TDR availability and related commands.

Debug and PoE

Several debug functions are available for PoE troubleshooting. You can monitor debug functions for all PoE states and events.

To see powered device detection and PoE states on a specific port, use **debug ilpower port** privileged EXEC command:

```
Switch# debug ilpower port
%ILPOWER-7-DETECT: Interface Gi5/0/1: Power Device detected: IEEE PD
%ILPOWER-5-POWER_GRANTED: Interface Gi5/0/1: Power granted
%LINK-3-UPDOWN: Interface GigabitEthernet5/0/1, changed state to up
```

This **debug ilpower powerman** (inline power management) example shows information about power requests from a powered device that has been granted inline (PoE) power:

```
Switch# debug ilpower powerman
%ILPOWER-7-DETECT: Interface Gi5/0/1: Power Device detected: IEEE PD
Ilpower interface (Gi5/0/1) power status change, allocated power 15400
%ILPOWER-5-POWER_GRANTED: Interface Gi5/0/1: Power granted
%LINK-3-UPDOWN: Interface GigabitEthernet5/0/1, changed state to up
power_consumption = 6300
power_request_level[] = 10250 6300 0 0 0
Interface (Gi5/0/1) select power 10250
req id 28024, man id 2, pwr avail 15400, pwr man 10250
```

Note that 15.4 W was initially allocated before classification was complete and CDP messages were processed. This powered device (a Cisco 7970 phone) has an actual power requirement of 10.25 W for screen full brightness, but can operate with reduced screen brightness on less than 10 W.

If the port is administratively shut down while PoE is applied and powerman debug is active, these messages (or equivalent) appear:

```
ilpower delete power from pd linkdown Gi5/0/1
Ilpower interface (Gi5/0/1), delete allocated power 10250
```

The power is no longer allocated and is returned to the switch power budget.

This debug example shows the sequence and result of powered device detection:

```
Switch# debug ilpower event
%ILPOWER-7-DETECT: Interface Gi5/0/1: Power Device detected: IEEE PD
ILP uses AC Disconnect(Gi5/0/1): state=ILP_IEEE_PD_DETECTED_S, event= IEEE_PWR_GOOD_EV
%ILPOWER-5-POWER_GRANTED: Interface Gi5/0/1: Power granted
ILP uses AC Disconnect(Gi5/0/1): state=ILP_LINK_UP_S, event=PHY_LINK_UP_EV
%LINK-3-UPDOWN: Interface GigabitEthernet5/0/1, changed state to up
```

In this example, inline power is denied because the powered device is requesting more power than is available in the switch power budget:

```
3w4d: %ILPOWR-7-DETECT: Interface Gi5/0/1: Power Device detected: IEEE PD
3w4d: %ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi5/0/1: inline power denied
```

Several additional PoE debug commands are available for monitoring specific events or functions related to detection, classification, and power grants.

AC Power and PoE Problems

Various disturbances on the AC power line (mains) can cause unusual PoE problems. The power supplies in various switches and powered devices sometimes have unique reactions to AC input disturbances. Problems caused by AC disruptions are usually temporary or one-time occurrences. For example, a specific switch or powered device might reboot due to an AC power problem, while other switches or powered devices might exhibit a greater immunity to the problem.

This is a typical occurrence during lightning storms or AC power maintenance. In a worst-case situation, a PoE power supply might appear to shut down (no PoE output voltage to any port). It is possible the Ethernet functions in the switch appear normal, and only the PoE functions are disrupted or degraded, or the switch might power-down completely in response to the AC disturbance. Powered devices might exhibit unusual behavior.

In such cases, power cycle the switch (unplug the switch, wait at least 3 seconds, then plug it back in). This ensures a total system reset and should restore normal operation.

When several or all PoE ports in a switch cannot provide power to powered devices, and entering the **shut** and **no shut** interface configuration commands does not clear the problem, verify that a power cycle restores the switch to normal operation. If it does, suspect an AC power disturbance as the source of the problem.

Sometimes an AC power disturbance can be so brief that it is missed by site personnel but detected by the switch or other electronic systems. If this happens frequently on multiple switches, carefully determine the stability and reliability of AC power. If it often occurs on only one switch, and other switches in the same location do not exhibit the symptom, contact Cisco TAC for guidance.