White Paper

Calculating Power for Cisco StackPower and the Cisco Catalyst 3750-X Series Switches

Power Allocation, Consumption, Dissipation, Reservation, and Power Supply Requirements

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Executive Summary

Considering power requirements is an important aspect in selecting the proper network gear for some customers. Power consumption directly impacts TCO and recurring monthly expenses. Customers are often confronted with the need to calculate a series of power characteristics to provision the service in the wiring closet.

This white paper uses a practical approach to help customers understand how to perform these power calculations while considering a set of variables. Variables to consider include what switch model to purchase, how much power is needed to scale the uninterruptable power supply (UPS), how much heat is dissipated in the wiring closet, how much power redundancy is needed, or how many power supplies to purchase for the switch or stack.

Introduction

Cisco StackPower™ and the Cisco Expandable Power System (XPS) 2200 present some interesting new alternatives in deploying Cisco® Catalyst® 3750-X and 3560-X Series Switches.

Note: Most of topics in this paper are focused on the Cisco Catalyst 3750-X Series since the Catalyst 3560-X Series does not support StackPower. See the white paper "Cisco StackPower: Efficient Use of Power" to understand StackPower operations.

The Cisco XPS 2200 is needed to form a power stack of more than four switches; for the purpose of this paper, it is irrelevant if the power stack is four switches in a ring topology or nine switches in star topology with a Cisco XPS 2200. The XPS 2200 adds power supplies to the power pool and extends the power stack from four to nine switches. If the XPS is deployed without a power supply of its own, it can power-up using the 30W global reserve.

Network personnel tasked with deployment of these switches may need to consider power issues during the network planning and prior to purchase or deployment. This white paper discusses the issues involved in the calculation of power requirements and consumption for a Cisco Catalyst 3750-X Series switch or stack of switches with or without Power over Ethernet (PoE) capabilities. The discussion includes practical examples of how to calculate power needs, power consumption, and power dissipation, and how to select the proper power supplies needed in a power stack based on customer's requirements.

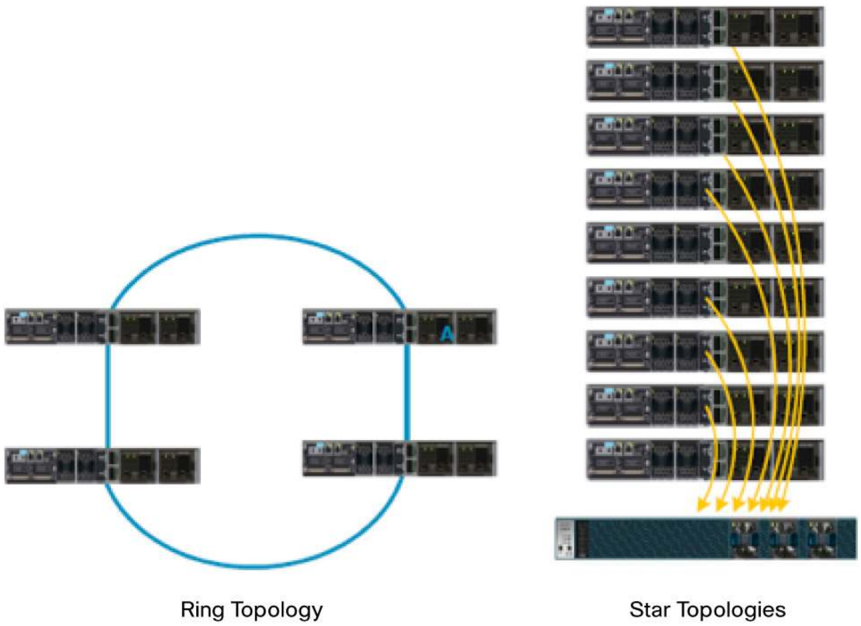
Although the topics discussed in this white paper are closely related, you can read them independently. There is no need to read the entire white paper if your interest is only a specific topic—for example, power consumption. The following topics are covered:

Understanding Power Allocation

Cisco StackPower, an innovative feature of the Cisco Catalyst 3750-X Series Switch, includes hardware and a software component that interact to provide a single power pool. (See the white paper "Cisco StackPower: Efficient Use of Power" to understand StackPower operations.)

All switches that participate in the power stack communicate and identify each other by exchanging power requirement information. As Figure 1 shows, all switches—four switches in ring a topology or 9 switches in a star topology using a Cisco XPS 2200— forming the power stack contribute to and draw power from a single power pool.

Figure 1. Cisco StackPower Topologies



The Cisco Catalyst 3750-X Series Switch boots up in two steps. First, it boots the StackPower host. Second, if power is allocated, it boots the Cisco IOS® Software.

Note that in Cisco IOS Software Release 12.2(55)SE, the allocation values for Cisco StackPower have been revised to more accurate power values, as shown in Table 1.

Table 1. StackPower Allocation Default Values

StackPower Allocation Defaults	Allocate (W)	Allocate Revised (W)
All Catalyst 3750X-48	206	223
All Catalyst 3750X-24	206	190
Global Reserve	42	30

When a single Cisco Catalyst 3750-X-48 switch is powered up, the StackPower logic discovers the power resources available—that is, checks how many and what type of power supplies are available, as well as if there is any other switch attached to its StackPower ports.

Once the power stack (consisting of one switch in this case) finishes booting, it begins to allocate power to the switch members of the power stack so they can boot the Cisco IOS Software. StackPower reserves the 223W for 48-port model and 190W for the 24-port model from the available power pool (formed by the local power supplies).

In addition, 30W are reserved as a global reserve (StackPower overhead). At this point, 253W has been requested and allocated from the power pool:

- 223W for one 48-port PoE switch
- 30W as the global reserve for StackPower

The global reserve is the power reserved by StackPower to power up a new switch member or to power up a Cisco XPS 2200 that does not have power supplies. This minimum amount of power is enough for the new device to join the power stack when its power supply or power source fails or does not have a power supply of its own.

One 350W-power supply has enough capacity to bring up any model of the Cisco Catalyst X Series switches, and has a small amount of power for PoE if needed. The 350W is the default power supply shipped with any non-PoE switch model (Sw1 in Table 2). If there is only one 350W-power supply as part of the power pool, StackPower has enough capacity to allocate 253W for the switch; hence the switch proceeds to boot up Cisco IOS Software. It is important to note that the switch does not consume 253W (30W of which are the global reserve). This amount of power is allocated for a worst-case power consumption situation resulting, for example, from new network modules, harsh environments with high operating temperatures, and so on.

Table 2. Power Allocation for a Single Non-PoE Cisco Catalyst 3750-X Series Switch

Sw1

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2:		Sw3:		Sw4:		
Global Reserve 30W →	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	
									-30
Power Supply (W) →	350	0							350
Switch Allocation →	223								-223
					Power Pool: Available (W)				97

Table 3 shows the case in which a new switch is added to the power stack. Sw2 is a Cisco Catalyst 3750-X-48-PF, a 48-port PoE switch with one 1100W power supply. This switch requires 223W allocation to boot the Cisco IOS Software. As Table 3 shows, Sw2 increases the power pool up to 1450W (350 + 1100), which is plenty of power for both switches even in the case where Sw2 draws full PoE on all 48 ports (that is, 740W). Note that more switches can be added to the stack, and while the new members request a power allocation, the global reserve remains at 30W for the entire power stack, which is why allocation is 476, not 446.

Table 3. Power Allocations for Two Cisco Catalyst 3750 Switches

Sw1  Sw2 

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2: 3750X-48PF		Sw3:		Sw4:		
Global Reserve 30W →	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	
									-30
Power Supply (W) →	350	0	1100	0					1450
Switch Allocation →	223		223						-446
					Power Pool: Available (W)				974

Table 4 shows the power allocation if we add two more switches, Sw3 and Sw4. Note that Sw3 has a 715W-power supply while Sw4 does not have a power supply at all. The four switches are as follows:

- Sw1: 48 port non-PoE and one 350W power supply
- Sw2: 48 port PoE and one 1100W power supply
- Sw3: 24 port PoE and one 715W power supply
- Sw4: 24 port PoE and no power supply

This change increases the allocation requirements to 856W just to boot up Cisco IOS Software in all four switches, leaving the power pool with 1309W of power:

- Total Pool: 2165W
- Total Reserved: 223W + 223W + 190W + 190W + 30W (global reserve) = 856W

Power Pool available for PoE: 2165W – 856W = 1309W

Table 4. Power Allocation for Four Cisco Catalyst 3750-X Series Switches

Sw1  Sw2  Sw3  Sw4 

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2: 3750X-48PF		Sw3: 3750X-24P		Sw4: 3750X-24P		
Global Reserve 30W →	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	
									-30
Power Supply (W) →	350	0	1100	0	715	0	0	0	2165
Switch Allocation →	223		223		190		190		-826
					Power Pool: Available (W)				1309

Two possible uses for the extra power available in the power pool are PoE and power redundancy:

a) Deploy PoE to the 96 PoE ports in our example (Sw2, Sw3, and Sw4), although full PoE for 96 ports requires 1478.4W and falls short 169.4W plus the PoE overhead. See "Calculating Power Needed to Deploy PoE+"

b) Provide redundancy via the Cisco Zero-Footprint Redundant Power System (RPS). This feature reserves an amount of power equal to the size of the largest supply in the power stack. In other words, if largest power supply is 1100W, 1100W is subtracted from the total power pool. The idea is to protect against the single worse power supply or power source failure. This deployment makes more sense when there is more capacity in the power pool than what is shown in this example. Bear in mind that the power is always available online. This is considered 1+N redundancy and is considered (slightly) better than 1:N redundancy; power supplies are always active and therefore less prone to latent failures. See "Cisco StackPower: Efficient Use of Power" for more details.

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Calculating the Power Needed to Deploy PoE

The Cisco Catalyst 3750-X Series has four power supply types, and all four of them can provide system power as well as PoE power at different levels. That is, even the 350W- and the 440W-DC power supplies have some extra power that can be used for PoE.

PoE models of Cisco Catalyst 3750-X Series switches come with either a 715W or an 1100W power supply, depending on the switch model. Only the 1100W power supply provides enough power to deploy full PoE on all 48 ports (15.4W per port); therefore, it might be necessary to complement the power budget by using Cisco StackPower or adding another power supply, depending on the requirements.

Consider the example shown in Table 4. The available power in the pool— 1309W— is too low for all of the switches in the power stack to deploy PoE+ or even PoE. The power pool size has to be increased by an amount of power large enough to cover the PoE requirement:

Total_PoE_PWR = Number of PoE ports x watts (15.4W or 30W) + PoE loss

Note that PoE loss is estimated to be 5 percent; hence, to add the 5 percent of PoE power loss, each case is multiplied by 1.05. In the example, switches Sw2, Sw3, and Sw4 are 48-, 24-, and 24-port PoE switches, so the requirement is enough power to support PoE on 96 ports:

Case A: Full PoE on all 96 ports (802.3af)
96 ports x 15.4W x 1.05 = **1552.32W**
Case B: Full PoE+ on all 96 ports (802.3at)
96 ports x 30W x 1.05 = **3024W**
Case C: Full PoE+ on all 96 ports plus power redundancy (Zero-Footprint RPS)
96 ports x 30W x 1.05 = 3024 + 1100 = **4124W**

In any of these cases, there is not enough available power in the power pool to support these possible deployments. Let's consider some options through three sample use cases.

Case A: Full PoE (802.3af) on All 96 Ports

Table 4 showed that the available power pool has 1309W – **1552.32W** = -243.32W deficit.

By adding one 350W-power supply to Sw4 to cover the power deficit, we can provide full PoE to all 96 ports while keeping 106.68W in the available pool, as Table 5 shows.

Table 5. Case A: **Full PoE (802.3af) on 96-ports**

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2: 3750X-48PF		Sw3: 3750X-24P		Sw4: 3750X-24P		
Global Reserve 30W →	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	**-30**
Power Supply (W) →	350	0	1100	0	715	0	350	0	**2515**
Switch Allocation →	223		223		190		190		**-826**
PoE Requirement → **add 5% PoE Loss**	N/A		776.16		388.08		388.08		**-1552.32**
					Power Pool: Available (W)				**106.68**

Case A_— Best practices recommendation: Populate the first power supply slot of each switch in the power stack before populating the second power supply in any switch. The idea is to distribute the power sources across the power stack to reduce the likelihood of causing outages in some scenarios. You reduce the amount of current required on a single StackPower cable.

In summary for case A:

- Sw1: Catalyst 3750-X-48 with one 350W- power supply
- Sw2: Catalyst 3750-X-48 with one 1100W-power supply
- Sw3: Catalyst 3750-X-24 with one 715W-power supply
- Sw4: Catalyst 3750-X-24 with **one 350W**-power supply

Adding one 350W-power supply allows StackPower to meet the PoE requirement (802.3af for 96 ports= 1478.4W). Note that StackPower has a power budget large enough to cover system power for four switches, the global reserve, and the PoE requirement only. That means no power redundancy at all. See Case C for details on providing redundancy. Also note that the 350W power supply was installed on Sw4 to follow Best practices recommendation for case A.

Case B: Full PoE+ (802.3at) on All 96 Ports

PoE+ requirement for 96 ports is 3024W. If we have 1309W available as shown in Table 4, that leaves a 1715W deficit. (Available power pool has 1309W – 3024W = -1715W deficit.)

To overcome this deficit, add one 1100W-power supply and one 715W-power supply. Power supplies get installed on Sw4 to increase the power pool size and provide full PoE+ on all 96 ports (Table 6)

Table 6. Case B: **Full PoE+ (802.3at) on 96-ports**

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2: 3750X-48PF		Sw3: 3750X-24P		Sw4: 3750X-24P		
Global Reserve 30W →	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	**-30**
Power Supply (W) →	350	0	1100	0	715	0	1100	715	**3980**
Switch Allocation →	223		223		190		190		**-826**
PoE Requirement → **add 5% PoE Loss**	N/A		1512		756		756		**-3024**
					Power Pool: Available (W)				**100**

Case B—Best practices recommendation: Deploy the larger power supplies on switches that are not adjacent to each other. Also, it is preferable to install larger power supplies in slot A to aid in balancing power across the power stack. There is nothing special to slot A; it is just a way to help ensure that larger power supplies are distributed among all switches.

In summary for case B:

- Sw1: Catalyst 3750-X-48with one 350W-power supply
- Sw2: Catalyst 3750-X-48with one 1100W-power supply
- Sw3: Catalyst 3750-X-24 with one 715W-power supply
- Sw4: Catalyst 3750-X-24 with **one 1100W-power supply and one 715W**-power supply

Notice that both power supplies were installed on Sw4.

Switch Sw4 did not have any power supply and Sw1 has small power supply in slot A. To comply with the best practices for case A and case B, the first power supply must go on Sw4 and the second power supply can go on any second slot of any switch in the power stack. Also, it would be preferable to exchange the 715W-power supply in Sw4 slot B with Sw1 slot A to balance the large power supplies across all switches in the stack.

Case C: Full PoE+ (802.3.at) on all 96 ports with Power Redundancy (Zero-Footprint RPS)

Expanding on case B, let's add redundancy to increase the resiliency of the power stack. That is, provide RPS functionality through StackPower and Zero-Footprint RPS. Zero-Footprint RPS allows for the failure of a single power supply without any impact to the operation of the switch and the PoE power it is providing.

See the white paper "Cisco StackPower: Efficient Use of Power" for more details.

Access the switch console and enter the following commands in configuration mode:

```
#configuration Terminal <cr>
Cat3k(config)#stack-power stack TME-XPS   <cr>    ← Configure a name the power stack
Cat3K(config-stackpower)#mode redundant  <cr>  ← Configure StackPower in "redundant" mode
```

By default, when you configure StackPower redundant mode, StackPower chooses to reserve an amount of power equal to the size of the largest power supply available in the power stack. Refer to Table 6 and notice that the largest power supply deployed is 1100W; hence, StackPower reserves 1100W in this case.

The logic is that the worse case possible is to lose one of the largest power supplies; therefore, StackPower is protecting against the worse possible failure of a single power supply or power source. Of course, this reservation will protect against the loss of any of the power supplies or power source and not just the 1100W-power supply or power source. Table 7 shows the power allocations.

Table 7. Case C: Full PoE+ with Zero-footprint RPS

	Power stack Members (W)								StackPower Pool (W)
	Sw1: 3750X-48		Sw2: 3750X-48PF		Sw3: 3750X-24P		Sw4: 3750X-24P		
	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	Slot A	Slot B	
Global Reserve 30W →									-30
Power Supply (W) →	350	350	1100	0	715	0	1100	350	3965
Switch Allocation →	223		223		190		190		-826
PoE Requirement → add 5% PoE Loss	N/A		1512		756		756		-3024
Zero-Footprint RPS →	Reserve								-1100
					Power Pool: Available (W)				-1015

As Table 7 shows, the full PoE+ requirement and power redundancy force the power pool to go negative, at –1015W. This is no longer enough to support the full PoE+ requirement from the example in case B (3024W).

The answer is to go back to case B and calculate what is needed. You are likely to need one 1100W-power supply to overcome the deficit shown in Table 7.

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Calculating Power Consumption

The previous sections covered calculating power allocation in Cisco StackPower and how to calculate the amount of power needed to provision PoE and PoE+ in a switch or stack. This section discusses how much of that power is consumed by a switch and how much power is wasted.

Power Supply Efficiency

To calculate power consumption on a Cisco Catalyst 3750-X Series Switch, it is important to understand the characteristics and requirements of the power supplies available. The Cisco Catalyst 3750-X and 3560-X Series can utilize any combination of four different power supplies: 350W, 715W, 1100W, and 440WDC.

Each power supply type has an efficiency factor that indicates how much energy is wasted while passing power from the wall to the load (the switch). The energy wasted is the cost of transforming energy through the power supplies, which is transforming 120/240v AC into 56v DC. The loss of energy should be accounted for, at least for the purpose of calculating power dissipation, since it is dissipated in the wiring closet. The formula for calculating the loss of energy is:

$$\%\text{Efficiency} = \frac{Output\ (W)}{Input\ (W)} \times 100$$

These Cisco Catalyst 3750-X Series power supplies reach 80 percent efficiency at very low loads, typically 15 percent. The efficiency curve starts to level off once the load reaches 40 percent (Table 8).

Table 8. Power Supply Efficiency

Efficiency @ 40% Load	Product ID	Product Description
87%	C3KX-PWR-350WAC	Catalyst 3K-X 350W AC Power Supply
89%	C3KX-PWR-715WAC	Catalyst 3K-X 715W AC Power Supply
88%	C3KX-PWR-1100WAC	Catalyst 3K-X 1100W AC Power Supply
81.50%	C3KX-PWR-440WDC	Catalyst 3K-X 440W DC Power Supply

Another aspect often inquired about is “power factor.” By definition, the power factor is a ratio between the “real” power measured in watts delivered to the power supply and the “reactive” power drawn by the load and measured in volt ampere (VA) units. A value of 1 is ideal.

Inductive loads are the culprit in reactive power, but reactive power can be cancelled with a special circuitry called -power factor correction (PFC). The presence of reactive power makes the real power appears to be lower than it is; hence, the concern of some power utilities to have PFC.

This should not be a concern with the Cisco Catalyst 3750-X Series switches because all the power supplies have built-in active PFC circuitry that brings the PF close to 1. Normally any power supply rated over 75W will have a PFC built-in.

Power Consumption Variables

Two variables can affect power consumption: operating temperature and packet switching.

As the operating temperature in the wiring closet rises, the fan modules consume more power by increasing the fan speed to cool down the system, which increases power consumption. Packet switching and full-line-rate transmitting of frames on all ports puts more energy in the application-specific integrated circuit (ASIC) and wires, which increases power consumption as well.

It is worth noting that process variations in the internal ASIC, as well as other manufacturing variations (for example, internal bus voltages), also cause variations in power consumption from system to system.

Table 9 shows some of the power supplies characteristics that can be used to provision the service needed from the power utility or uninterruptible power system(UPS). These characteristics shown should not be confused with power consumption.

Table 9. Maximum Input and Output Per Power Supply

Power Supply Characteristics Maximum Input & Output Power in Watts & BTU/hr	350W		715W		1100W		440WDC	
Efficiency (<40% Load, 25°C)	87.0%		89.0%		88.0%		81.5%	
Power Unit	Watt	BTU/HR 1W=3.412BTU	Watt	BTU/HR 1W=3.412BTU	Watt	BTU/HR 1W=3.412BTU	Watt	BTU/HR 1W=3.412BTU
Maximum Input Power From the wall	402.29	1372.61	803.37	2741.10	1250.00	4265.00	539.88	1842.07
Maximum Output Power Into the system	350.00	1194.20	715.00	2439.58	1100.00	3753.20	440.00	1501.28

Note: Some values in Table 9 may differ slightly from the information provided in the Catalyst 3750-X and 3560-X Switch Hardware Installation Guide and the Cisco Catalyst 3750-X and 3560-X Series Switches data sheet. The subtle differences are caused by rounding of efficiency factors and/or efficiency readings under different test conditions such as input voltage, load and temperature.

All models of the Cisco Catalyst 3750-X Series Switches have different power requirements, and each of the available power supplies have different power efficiency curves. For example, a switch drawing 150W from a 350W-power supply represents a 43 percent load to the power supply; hence the efficiency is in the high 80 percent range. In contrast, the same switch drawing 150W from an 1100W-power supply would only represent a load of 13 percent, which translates to lower power supply efficiency and higher power consumption than the 350W supply. When you add another power supply to the same switch, power supplies share the power draw, which reduces the utilization of each power supply and further impacts the efficiency of the power pool.

In general, if the power supplies have a power draw greater than 40 percent of their capacity, they are at or close to peak efficiency. In addition, the peak efficiency of the different power supplies types also varies.

Power Consumption Exercise: Cisco Catalyst 3750-X-48PF Full PoE Allocation

Let's assume the following:

- Assume a Cisco Catalyst 3750-X-48PF switch with one 1100W-power supply. From Catalyst 3750-X data sheet, we know that the switch consumes 137.2W at 100 percent of line rate of all 48 ports, based on ATIS test criteria. This is the data-only power draw.
- Assume normal operating temperature of 25℃.
- Assume full PoE deployment on 48 ports (15.4W x 48-ports).
- Assume that 50 percent of allocated PoE power is being drawn.

The total power consumption is more than what the switch consumes. For this reason, the next step considers the power used for PoE as well as power loss related to the generation of PoE power, which is estimated at 5 percent. Note that the calculation provides the entire power draw from the power supply, which is consumption but not dissipation. See Calculating Power Dissipation.

The formula includes switch power consumption, PoE actual draw, and PoE loss. Note that switch power consumption is taken from the data sheet.

First adjust the data sheet ATIS power consumption of the switch since it already factors in the power supply efficiency. This way, all power drawn from the power supply can be added:

Switch Power Consumption = ATIS Switch_Power_Draw x 88% (efficiency, see assumptions)

Switch Power Consumption = 137.2W x 0.88

Switch-P_ Consumption = 120.74W

This is the power output from the power supply into the system board. Need to subtract the power inefficiency since this data comes from ATIS test results from the data sheet.

System P_ Consumption = Switch-P_Consumption + 50% x Allocated_PoE + 5% x Drawn_PoE

= 120.74W + 50% x 739.2W + 5% x Drawn_PoE

= 120.74W + 0.5 x 739.2W + 5% x (50% X 739.2W)

= 120.74W + 369.6W + 0.05 x (0.5 X 739.2W)

= 120.74W + 369.6W + 18.48W

System Power Consumption =	**508.82W**

Or

System Power Consumption =	**1736.09 BTU/Hr**

Based on the assumptions, this is the power consumed by one Cisco Catalyst 3750-X-48PF with 1100W-power supply running at 25℃ and drawing 50 percent of al located full PoE (739.2W).

This conversion uses a multiplier of 1 watt = 3.412BTU/Hr

The last piece of power consumption is the power loss in the power supply itself. Replace that value in the following formula and use the efficiency values from Table 9.

$$Power\ Supply\ Efficiency\ Loss = PS_{\ Input-Power} - PS_{\ Output-Power}$$

$$= \frac{PS\ Output\_Power}{PS\ Efficiency} - PS_{\ Output-Power}$$

$$\text{Power Supply Efficiency Loss} = \frac{508.82W}{88\%} - 508.82W$$

Power Supply Efficiency Loss = 68.45W

Calculated at 88 percent efficiency

Now, calculate total power consumption by the system, which includes power consumption by the switch, power supply efficiency loss, PoE consumption, and PoE loss. Note that PoE power is part of the total system consumption, but it is consumed and dissipated outside of the wiring closet.

Total Power Consumption = System Power Consumption + Power Supply Efficiency Loss

Total Power Consumption = 508.28W + 68.45W

Total Power Consumption = 577.27W

Or

Total Power Consumption = 1969.65 BTU/Hr

This conversion uses a multiplier of 1 watt = 3.412BTU/Hr

To this calculation, you can add a second power supply. Power supplies share the load, so as long as the load on the power supplies remains at 40 percent or higher, there is no change in the calculation in terms of power supply efficiency and power loss.

If you add a second power supply of different type, just average the efficiency of the power supplies. For example, for one 1100W-power supply and one 350W-power supply, the efficiency is 88 percent and 87 percent, respectively, based on the numbers in Table 9.

The resulting efficiency would be: $Avg\ Efficiency = \frac{\mathrm{PS1eff} + PS2eff}{2}$

Avg Efficiency = (88 + 87) / 2 = 87.5%

This formula calculates efficiency for multiple power supplies, either power supplies in one switch or across a power stack.

The following formula is summary of the previous exercise on how to calculate the total power consumption for a system:

Total Pwr Consumption = (Switch-P_Consumption X Efficiency) + Actual_PoE + PoE Loss + PS Loss

Total Pwr Consumption:

This is the overall power drawn by a switch from the power source—in other words, the total power consumption by the switch. It includes switch power consumption, actual drawn PoE power, PoE power loss, and power supply loss.

Switch-P Consumption:

This is the power consumed by a switch without consideration for the power supply efficiency. The value is given by the Catalyst 3750-X data sheet and includes the switch's board and components power consumption except for PoE. The data sheet reports consumption including power supply efficiency; hence, the need to multiply by the efficiency factor.

Efficiency:

This is the efficiency of the power supply based on load and operating temperature.

Actual_PoE:

This is the actual power draw by the attached Powerable Device (PD). Actual PoE can be estimated as a percentage of the allocated PoE.

PoE Loss:

This is the power loss due to the generation of PoE power. Assume 5 percent of the actual PoE draw.

PS Loss:

This is the power loss due to the power supply efficiency.

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Calculating Power Dissipation

In the discussion of power consumption, calculations included the power consumed by the switch and the power loss by PoE, as well as the power supply itself, but not all of this power is dissipated in the switch. PoE power is dissipated outside the switch, and therefore outside the wiring closet.

Refer back to the Switch Power consumption calculation and note that includes the power drawn by PoE and PoE loss. The exercise assumed 50% of the allocated power being actually drawn. Since PoE power is dissipated outside of the wiring closet, then deduct actual power drawn by PD from the calculation to obtain power dissipated in the wiring closet

$$Power\ Dissipation_{Inside\_Wiring\ Closet} = \text{Switch-P\_Consumption} + 5\% \times \text{Drawn\_PoE} + Power\ Supply_{Loss}$$

From previous section (Calculate Power consumption):

Switch-P_ Consumption = 120.74W

This is power output from the power supply into the system board.

Power Supply Efficiency Loss = 68.45W

$$Power\ Dissipation_{Inside\_Wiring\ Closet} = 120.74W + 5\% \times 739.2 + 68.45$$

$$\boldsymbol{Power\ Dissipation_{Inside\_Wiring\ Closet}} = \mathbf{242.31W}$$

Or

$$\boldsymbol{Power\ Dissipation_{Inside\_Wiring\ Closet}} = \mathbf{838.64\ BTU/Hr}$$

All power, except PoE, is dissipated inside the wiring closet including the PoE power loss.

$$Power\ Dissipation_{Outside\_Wiring\ Closet} = \text{PoE power drawn by PD}$$

$$\boldsymbol{Power\ Dissipation_{Outside\_Wiring\ Closet}} = \mathbf{369.6W}$$

Or

$$\boldsymbol{Power\ Dissipation_{Outside\_Wiring\ Closet}} = \mathbf{1261.08\ BTU/Hr}$$

This conversion uses a multiplier of 1 watt = 3.412 BTU/Hr

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How to Select the Right Power Supply for Cisco Catalyst 3750-X Series Switch

All Cisco Catalyst 3750-X Series Switch models have one default power supply that was determined based on the power needs foreseen for that model. That is, the default power supply has enough capacity to support the switch itself, the fans, the network module, and PoE.

All data-only models come with a 350W-power supply, while the PoE models (except one) come with a 715W power supply. One PoE model, the Catalyst 3750-X-48PF, comes with one 1100W power supply to provide full PoE on all 48 ports—that is, 15.4W per port (802.3af).

There might be situations where you need to add a second power supply to a switch or a power stack. Some examples of these situations include:

- Upgrading PoE to full PoE
- Deploying full PoE+
- Adding power redundancy

Upgrading PoE to Full PoE

By default, the PoE switch comes with a 715W power supply and full PoE requires 739.2W.

A 48-port switch reserves 223W from the power budget before Cisco IOS Software can boot up. Therefore, the total power requirement is:

Switch Reserve	= 223W	(See: Understanding Power Allocation)
Global Reserve	= 30W	StackPower overhead
Full PoE	= 739.2W	15.4W times 48-ports)
PoE Loss	= 36.96W	(5% of PoE, see Calculating Switch Power Consumption)

Total requirement = 1029.16W

Since the switch already comes with one 715W power supply, only 314.16W are needed to cover the deficit. Adding a 350W power supply to the second slot will meet the requirements. Note that there is no redundancy thus far in this example.

Deploying Full PoE+

Note that a full PoE+ deployment requires 1440W which is larger than any power supply available for the Cisco Catalyst 3750-X Series switches. The solution is to complement the power budget with the second power supply or Cisco StackPower. Complementing the power budget with StackPower is the same as adding a second power supply to the switch in question, since the location of the power supply is irrelevant to StackPower and all power is shared across all members of the power stack.

From the example of upgrading PoE to full PoE, we have:

Switch Reserve = 223W (See: Understanding Power Allocation)

Global Reserve = 30W StackPower overhead

Full PoE+ = 1440W (30W times 48-ports)

PoE Loss = 72W (5% of Catalyst 3750-X data sheet PoE, see Switch Power Consumption)

Total requirement = 1765W

Since our example uses a Cisco Catalyst 3750-X-48PF, the switch already has an 1100W-power supply, and the deficit is only 665W, which can easily be covered with one 715W power supply.

On the other hand, if the switch were a Catalyst 3750-X-48P with a 715W-power supply, you can just add an 1100W-power supply to meet the 1765W power requirement.

Adding Power Redundancy

Neither of the first two scenarios accounts for adding power redundancy. Once power supplies are chosen, power redundancy should be considered. There are three ways to achieve this redundancy on a Cisco Catalyst X-Series switch:

- Add a second power supply
- Cisco Zero-Footprint RPS functionality
- Use a Cisco Expandable Power System (XPS) 2200

Adding a second power supply is the first and easiest way to provide redundancy to a standalone switch or a switch whose overall power requirement does not exceed one time the size of the maximum power supply size available for the X-Series switches. That is, if the switch meets its power requirements with one 1100W power supply, add another 1100W-power supply in the second slot. The second power supply must be of the same size of the first power supply.

The Zero-Footprint RPS functionality requires Cisco StackPower. The minimum Cisco IOS Software feature set required is IPBase. StackPower provides power redundancy by adding extra power supplies in any switch member of the power stack (and you must do a little bit of configuration to change the StackPower mode from sharing, the default, to redundant. See "Cisco StackPower: Efficient Use of Power" for more details on how this feature works and how to deploy Zero-Footprint RPS functionality.

Note: StackPower is very efficient because one power supply can back up as many as four switches. Also, StackPower is a way to provide power redundancy to a full PoE+ deployment. For power redundancy to work as expected, however, the extra power supply installed on any member of the power stack must be equal or larger to the largest power supply in the power stack.

The third option is to deploy a Cisco XPS 2200 to build a larger power stack of up to nine switches that can share power across the XPS 2200 power bus and can also provide full power redundancy to a full PoE+ deployment.

Power redundancy is achieved through the XPS 2200 but the power can come from extra power supplies in any of the Cisco Catalyst 3750-X Series Switches attached to the XPS or from power supplies installed directly in the XPS. The XPS uses the exact same power supplies as the 3750-X Series Switches.

The same rules apply when the power available in the entire power stack is just enough to meet the power requirement. In this situation, you can add redundancy by adding at least one power supply equal to the largest power supply in the entire power stack.

Of course, if full PoE+ is deployed, both power supplies must be used on the XPS to provide redundancy. Again, the power supplies must be the same size as the largest power supply used in the entire power stack in order to provide power redundancy.

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Frequently Asked Questions

Q. I see the power consumption listed in the data sheet for every switch model and I don't understand where the 223W power reservation comes from in the "Calculating Power Consumption" section.

A. The data sheet lists power consumption per switch model based on predefined criteria such as traffic load and PoE load (ATIS). The 223W is a general power reservation that a switch makes to Cisco StackPower. There are two hosts in a switch: the StackPower host (Hardware & Software components) and the IOS host (the switch itself). At power-on, the StackPower software boots up (only uses 30W). Once the first host is up and running, the logic requests 223W from StackPower, if power is available and allocated to the switch, Cisco IOS boots up.

The switch does **not** consume 223W. The switch only reserves 223W or 190W (worst-case power requirements) depending on the switch model.

Q. It seems that reserving 223W and not using it is a waste of power. Why do this?

A. The StackPower software requests from the power pool the maximum amount of power that the switch may need for system power consumption, the global reserve (30W), and enough power to power up any newer uplink module that may be inserted in the network module slot. Also, StackPower host considers the worst possible operating temperature and assumes that fans may be running at full speed drawing even more power.

The Catalyst 3750-X-48 requests an allocation of 223W. The Catalyst 3750-X-24 requests an allocation of 190W. The global reserve is always 30W single switch or for an entire power stack. See "Understanding Power Allocation"

Q. If a switch requests 223W from the power pool, does this means that a single 350W-power supply can support only one switch?

A. Yes, that is true. Only one switch can be turned on and boot up. Since 223W only fits once within 350W, only one switch can boot up Cisco IOS from a cold start. StackPower allows a the power pool to go into a negative budget—that is, the power supply gets overcommitted as long as the actual power drawn from the power supply is below the available power pool size.

Typically, a switch would only consume anywhere from 92.8W up to 142.9W. These ranges easily fit within 350W two to three times; hence, a 350W-power supply can keep two to three switches up and running as long as those switches are consuming the minimum amount of power (see data sheet). Obviously this condition oversubscribes the power supply and StackPower would send plenty of log messages to the console port to warn about the oversubscription of power.

Note that a single 350W-power supply can only get oversubscribed after the switches have already booted up Cisco IOS and not before due to the 223W/190W requirement to boot up from a cold start.

Q. If the power supply is rated for 1100W, does that mean that my switch is consuming 1100W?

A. No. 1100W is the capacity of the power supply and a switch only draws the actual power needed.

Q. Why is the power consumption described in the data sheet is different from the values provided in the Hardware Installation Guide?

A. The values are very close; the difference is in the factor used to convert watts into BTU/Hr. Some use 3.45 but the more precise factor should be 3.412. That is, 1W is equal to 3.412 BTU/Hr. Also; do not confuse the following values:

- Power supply rating either in watts or BTU/Hr
- Power reservation made from the power pool
- Power consumption – the power actually used to run the switch

Q. Would a single 350W-power supply be able to support two switches in a power stack?

A. Engineering has optimized the power allocation requirements for all switches and the global reserve. See the StackPower allocation default values in Table 1.

In case of a 350W-power supply and two switches, one 350W-power supply cannot boot up Cisco IOS on two switches. The reason is that 350W is not enough to allocate power to both switches unless both switches are already running IOS and one switch loses its power supply; in that case, one 350W-power supply can hold both switches up and running. This is the case when you are running the default power sharing mode (loose mode) of StackPower. Of course, if you run power sharing mode (strict mode) or redundant mode, load shedding will occur and you lose one switch.

Q. According Table 12 in Cisco Catalyst 3750-X and 3650-X Series Switches data sheet, a 3750-X-48T (with no PoE) draws an average of 126W. Will the default 350W-DC be able to provide power to a stack of two switches if one of them fails?
http://www.cisco.com/en/US/prod/collateral/switches/ps5718/ps6406/data_sheet_c78-584733.html

A. Yes, the 350W power supply can support a second data-only switch in case of a power supply failure. The 440W-DC will do the same when available.

Two switches will not be able to boot up while only one 350W-power supply is available because a each switch reserves 190W or 223W (depending on whether it is the 24- or 48-port model), plus a 30W global reserve, which pushes the power requirement to boot up two switches to 430W. Obviously, this is well above the 350W available with one 350W power supply.

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