

# Introduction to PoE and the IEEE802.3af and 802.3at Standards

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# This Talk is about Power Over Ethernet not About Edgar Allen Poe

## The Raven

Once upon a midnight dreary,  
while I pondered, weak and weary,  
Over many a quaint and curious  
volume of forgotten lore,  
While I nodded, nearly napping,  
suddenly there came a tapping,  
As of some one gently rapping,  
rapping at my chamber door.  
"Tis some visitor," I muttered,  
"tapping at my chamber door -  
Only this, and nothing more."

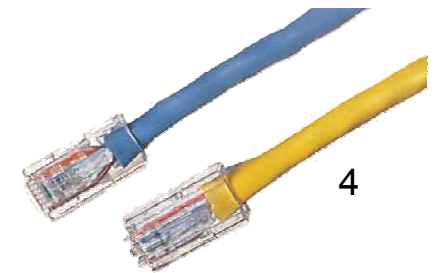


Edgar Allan Poe



# Introduction to Power over Ethernet (PoE)

- **Power over Ethernet or PoE technology describes a system to safely transfer electrical power, along with data, to remote devices over standard data cables in an Ethernet network (Cat3/Cat5/Cat5e/Cat6 ).**
- **The original IEEE 802.3af-2003 standard version of PoE supplies up to 15.4 W of DC power (minimum 44 VDC and 350 mA) to each device. Only 12.95 W is assured to be available at the powered device (PD) as some power is dissipated in the cable.**
- **No affect on network performance of 10/100/1000 Mbps links to the PD.**



# Introduction to Power over Ethernet (Cont.)

- **Power is remotely supplied from a central location (e.g. wiring closet) for distances under 100 meters without the Ethernet devices having to be individually powered by an AC outlet.**
- **PDs include IP Phones, Wireless LAN Access Points, IP Security Cameras and various other network devices**
- **IEEE 802.3af-2003 standard specifies Power over Ethernet (PoE) technology in two different methodologies:**
  - **Power-Supplying Equipment (PSE) may use either End-Span or Mid-Span**
  - **Powered devices (PD's) accept power from either type of power source**
- **Over 70 million PoE PSE ports shipped in 2008**

<http://www.poweroverethernet.com/>



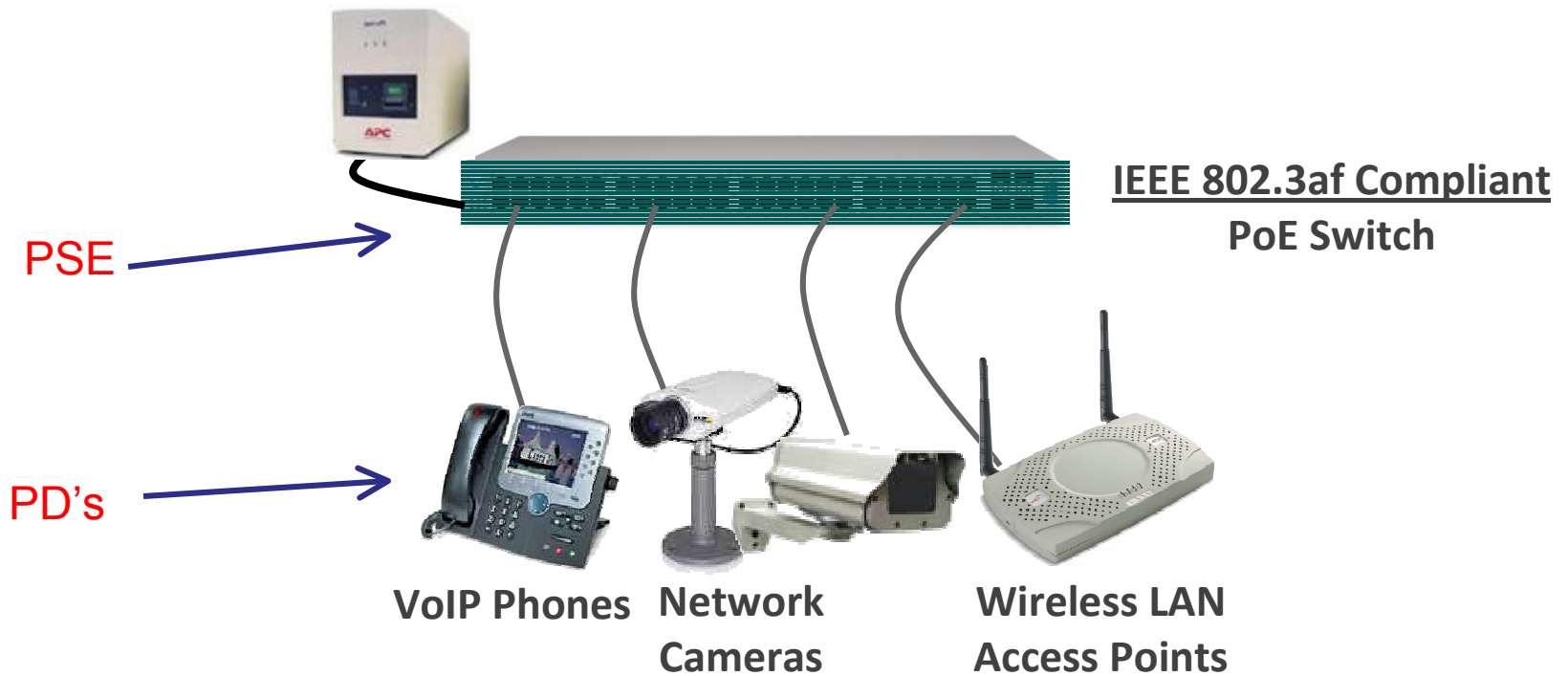
# PoE Key Benefits

- **Installation Cost Savings**
  - Eliminates the need for electrical outlet installation
  - Dramatically reduces cost of deployment – savings up to \$1,000 per PD
  - No need for bulky AC power adaptors
- **Simplifies Installation**
  - Uses a single Cat5/5e/6 cable for both data and power
- **Centralized Power Backup**
  - Continuous operation during power interruptions
- **Centralized Power Management**
  - Devices can be remotely powered down during periods of low usage or for security purposes
- **SAFE Power**
  - Will not damage Non-PoE devices or legacy peripherals



# PoE Switch = PSE End-Span

UPS – Battery Backup



# Power Originating from an End-Span (Ethernet Switch)

**End-Span technology** -Power originates from a powered port on an Ethernet Switch and is super-imposed on data transmission wire pairs 1,2,3, and 6

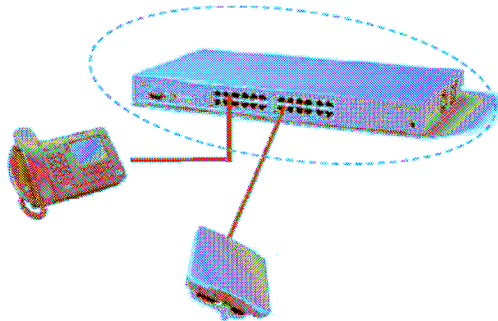
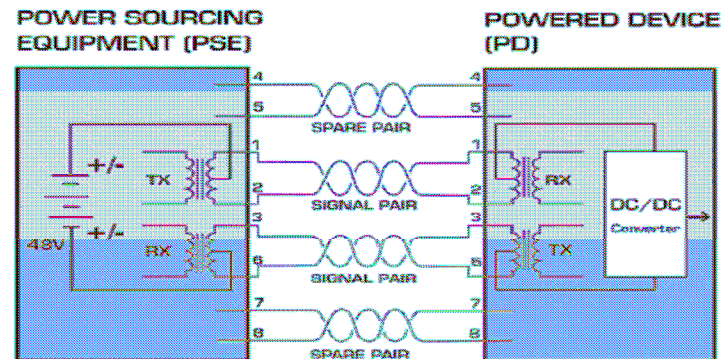


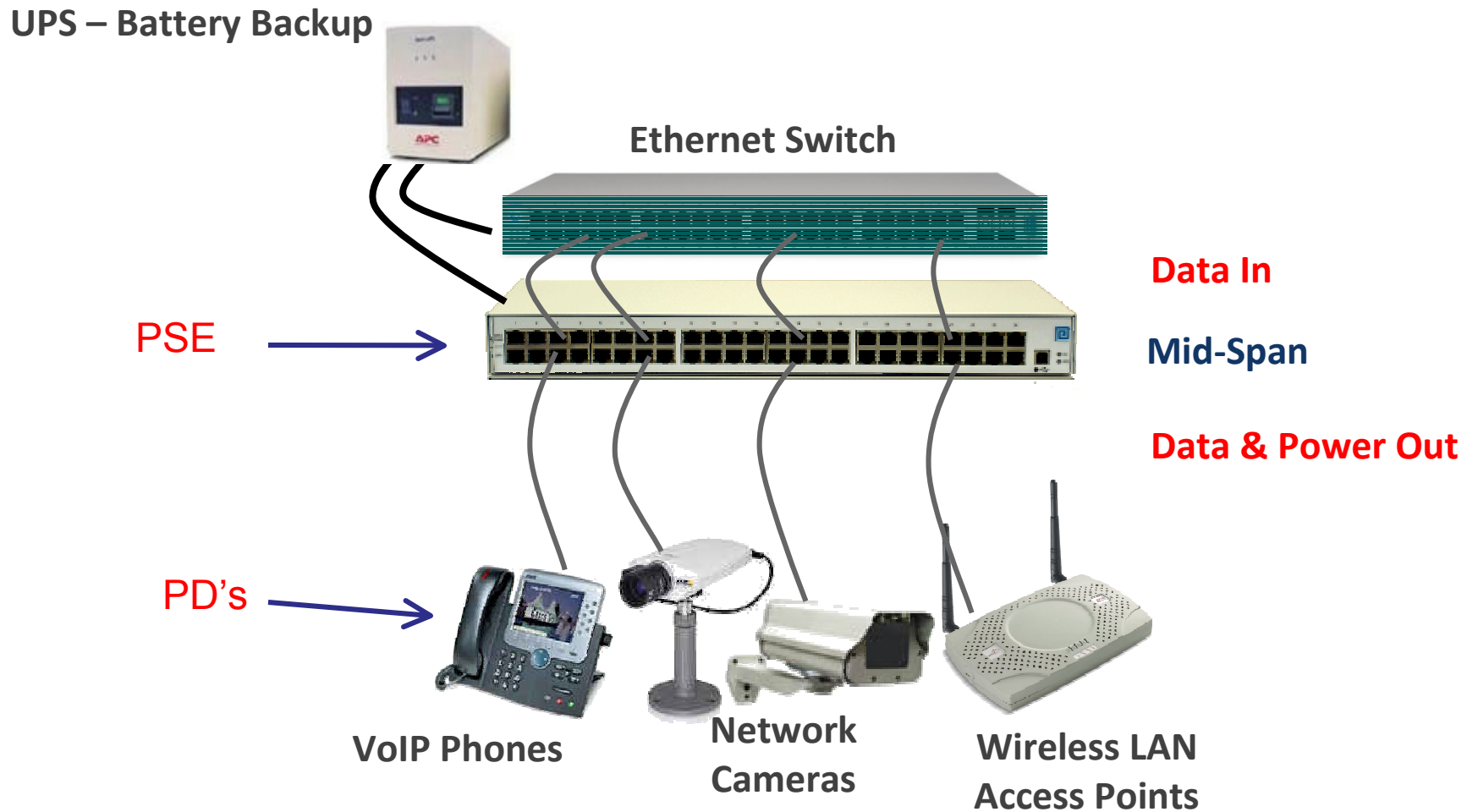
Figure 1: Endspan PoE deployment



**Option A for Midspan: Power can be sourced from the PSE through the data lines via data transformer center taps.**



# Switch + PoE Injector = PSE Mid-Span



# Power Originating from an External Mid-Span Device

**Mid-Span technology**-Power is added to the non-data wire pairs 4,5,7, and 8 from a patch-panel style hub

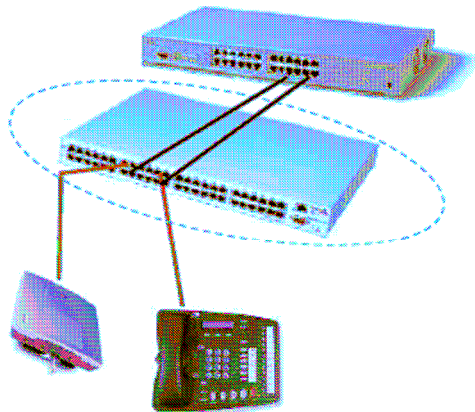
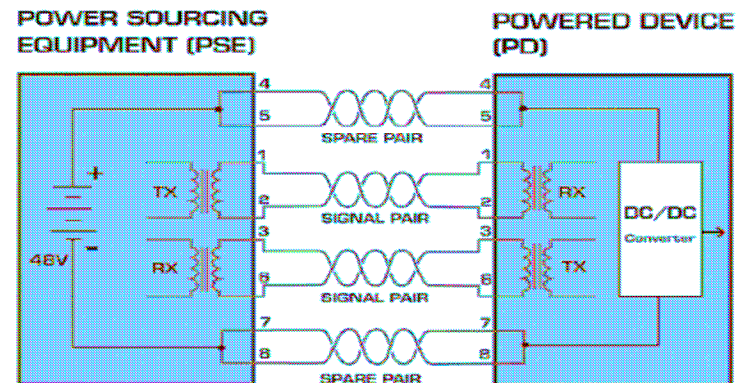


Figure 2: Midspan PoE Deployment



**Option B for Endspan:** Power can be sourced from the PSE through spare lines in the CAT-5 cable.

# Power over Ethernet PDs



Voice and Video IP Phones

WiFi Access Points a/b/g/n



Network Security Cameras – Enclosures – Heaters – Pan and Tilt



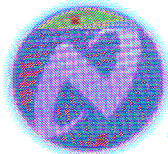
Building / Access Control – Gas and Fire Alarms – Digital Signs



Digital and School Clocks – SIP IP Paging – Door locks - Gateways

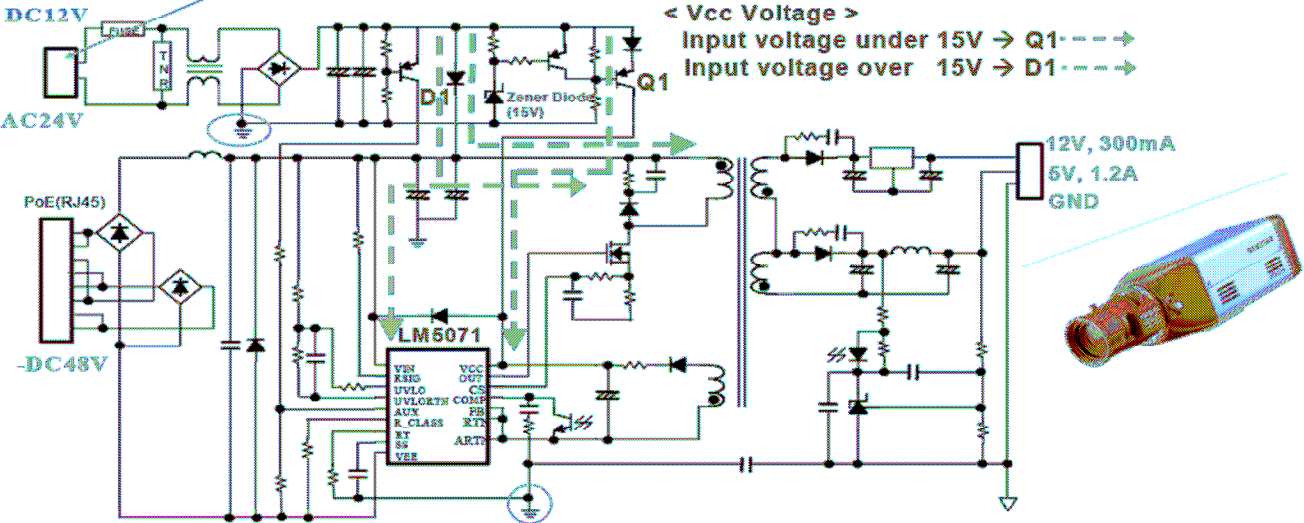
# Sample PD Circuit

## LM5071 - Power Over Ethernet PD Controller with Auxiliary Power



### Design PoE Power for IP Camera with LM5071 Supporting Aux Input

Support popular 12 Vdc or 24Vac Adapter to power IP Camera with LM5071 Aux input feature



- Vin => DC-48V, DC12V, AC24V
- Vout ==> DC12V 300 mA, 5V 1.2A.

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Fully Compliant 802.3af Power Interface Port

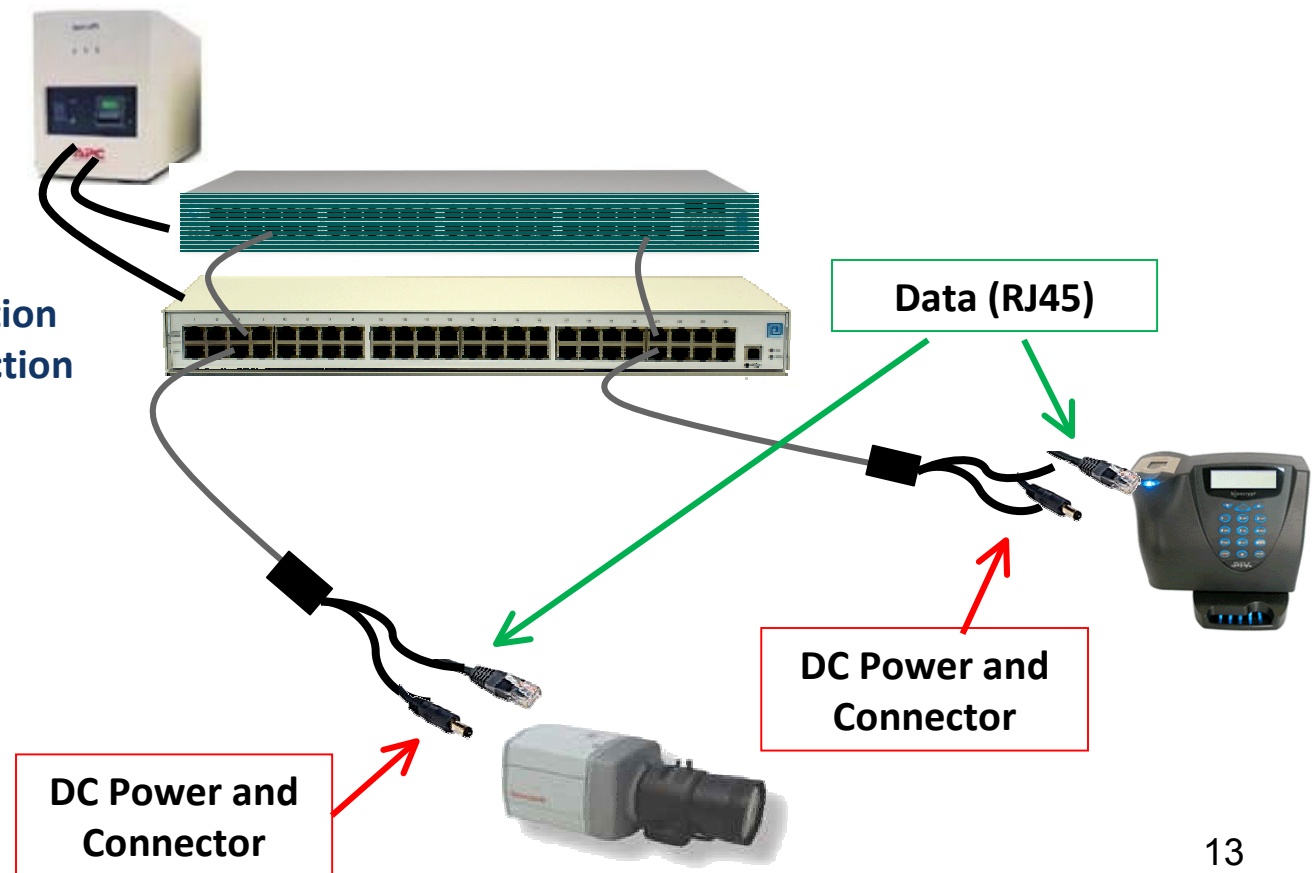
<http://www.national.com/analog/power/hv/poe>

# Splitters for PoE

Active PoE Splitters allow PoE power on non-PoE devices

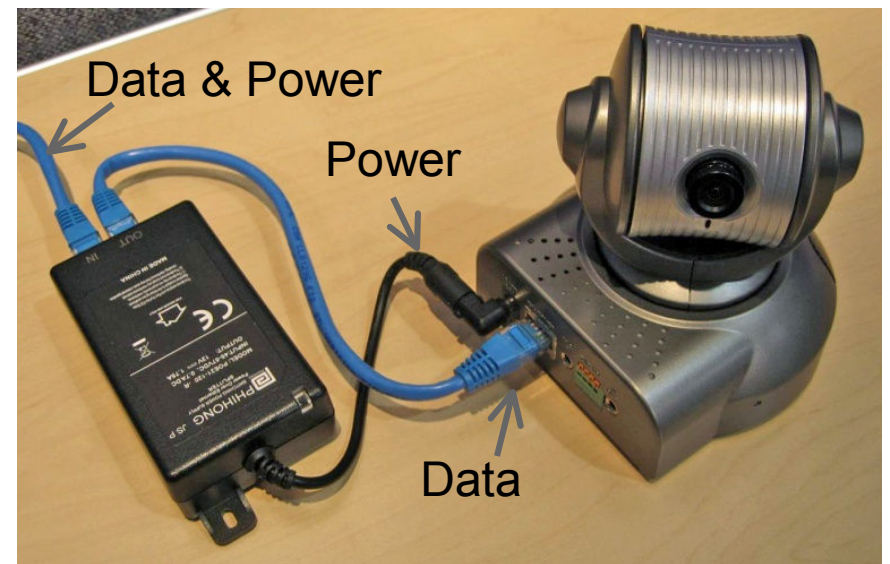
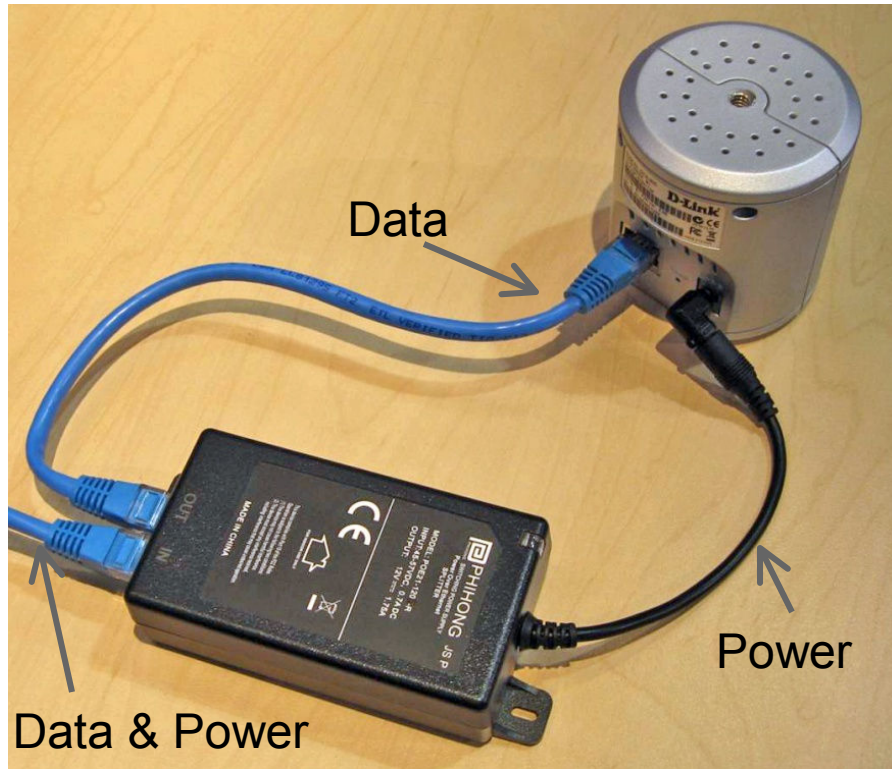
## Typical Splitters Feature

- Safe Power with IEEE detection
- IEEE connect and disconnection
- 10/100/1000



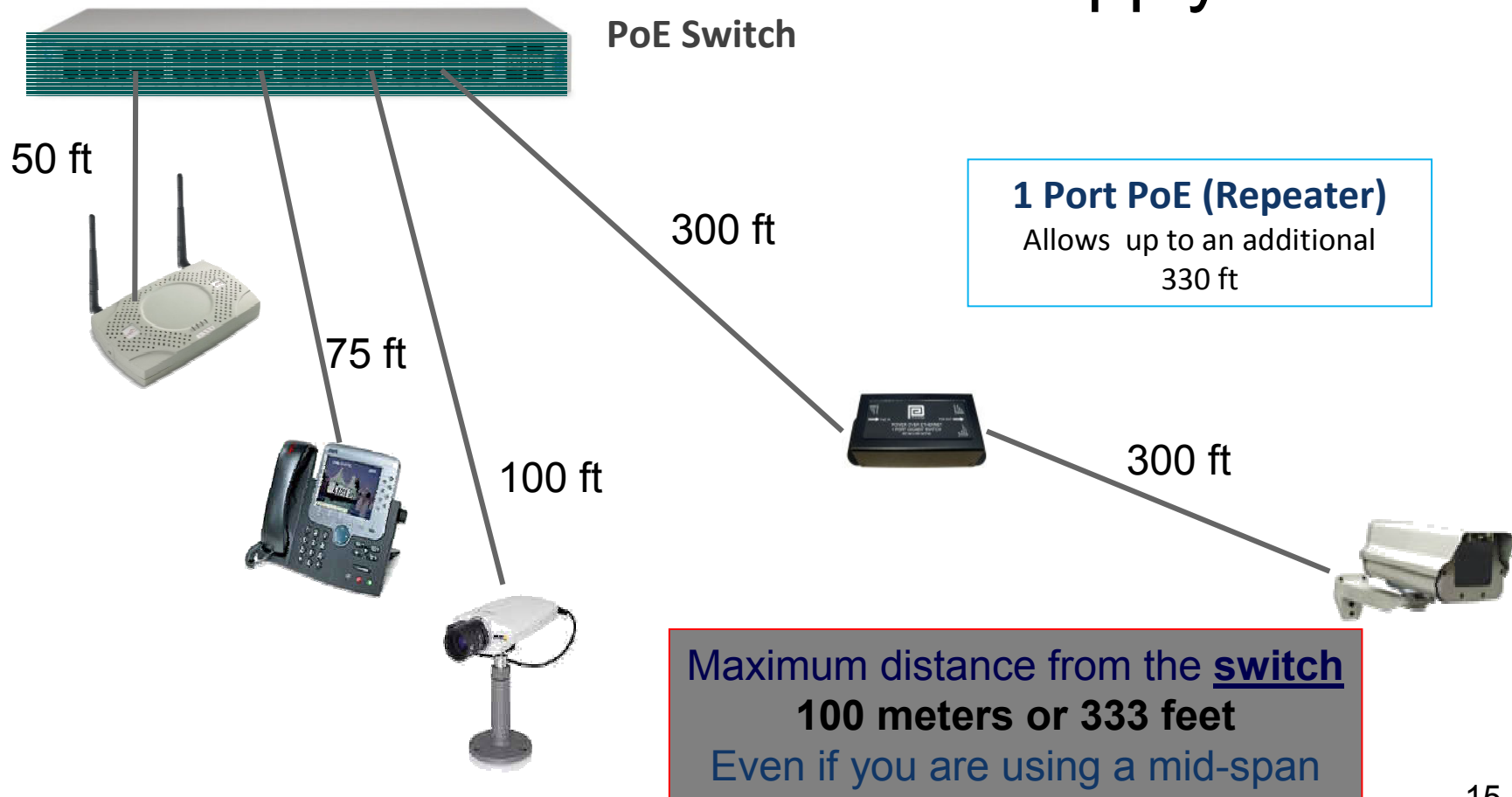


# PoE Splitters Application Example



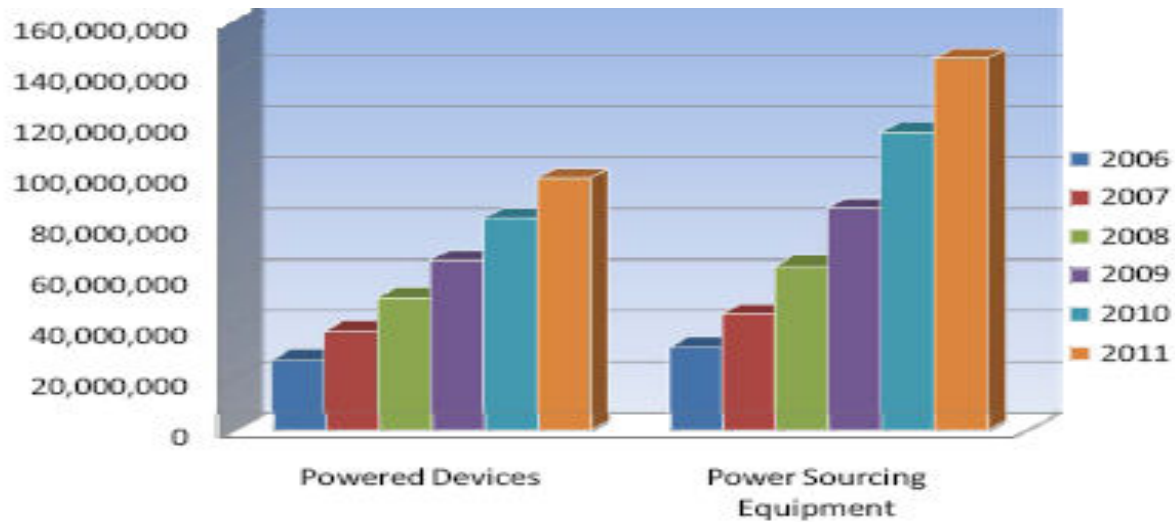
# IEEE802.3af Distance Limitations

Standard Ethernet distance rules apply



# PoE Market Size

Projected 25+% growth rates for PDs and PSEs



**Number of PoE Ports**





# Market and Competitive Analysis

- **Ethernet Switch Ports:** This report estimates that global shipments of PoE-enabled ports in enterprise switches are expected to reach over 132 million ports in 2012. By 2012, PoE ports will represent one quarter of all enterprise Ethernet ports.
- **Mid-Spans:** Mid-Span shipments will be healthy over the next several years as people who have not yet deployed PoE or PoE-Plus switches will still want to take advantage of PoE benefits without having to purchase new switch gear.
- **PDs:** In 2007, shipments of PoE-enabled business IP phones exceeded 10 million units. VDC expects shipments of enterprise wireless LAN access points to grow to 11.2 million units in 2012.
- **PoE Controllers:** There are only two vendors who have any significant market share of PSE controllers, Linear Technology and Microsemi. The PD controller market is a bit more fragmented, with several companies having significant market share in 2007.

# Partial PoE Vendor List

- 3COM CORPORATION
- AKROS SILICON, INC
- ARUBA NETWORKS, INC
- AVAYA
- AXIS COMMUNICATIONS
- BROADCOM CORPORATION
- CISCO SYSTEMS, INC
- DVTEL, INC
- ENTERAYS NETWORKS, INC
- HEWLETT-PACKARD COMPANY
- HID GLOBAL
- LINEAR TECHNOLOGY CORPORATION
- **MICROSEMI, INC** (PowerDsine)
- MITEL NETWORKS
- MOTOROLA, INC
- **NATIONAL SEMICONDUCTOR CORPORATION**
- PANDUIT CORPORATION
- **PHIHONG**
- POLYCOM, INC
- **SIFOS TECHNOLOGIES**
- SILICON LABORATORIES, INC
- SILVER TELECOM
- TEXAS INSTRUMENTS,



Special thanks to slides and material from Microsemi, Phihong, Sifos, Cisco and National Semiconductor.

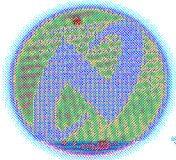
# PoE Original Standard (802.3af-2003)

- IEEE802.3af (15.4W/port)
  - Approved in 2003 for PDs up to 12.95W (350mA) at 48V DC
  - PoE requires handshake before applying power
  - Power Sourcing Equipment (PSE) transmits power over 2 pairs (4 of 8 wires) on Cat5/5e/6 cable
  - Connect/disconnect protocol for applying/disconnecting power
    - Detect device that needs power
    - Determines power needed
    - When to turn on power
    - Detect device disconnect (AC and DC disconnect)
    - When to remove power
  - Physical layer mechanism for PSE's to characterize power demands of individual PD's and thus manage power delivered per port.

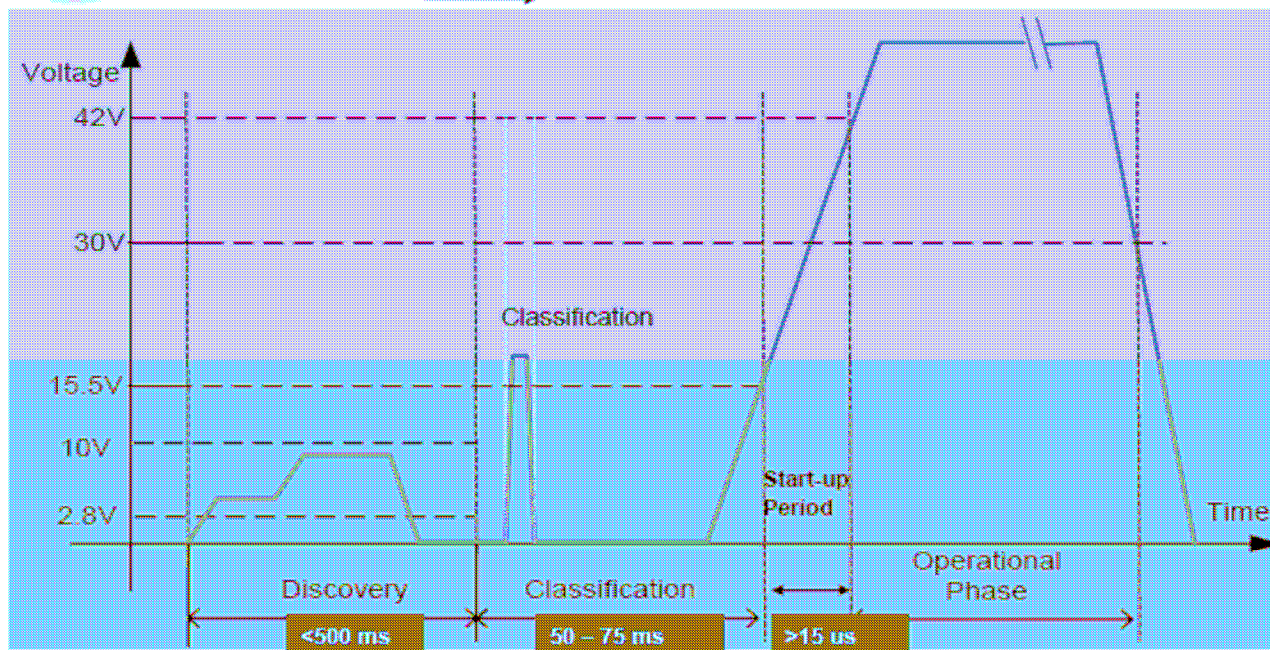


<http://www.ieee802.org/3/af/index.html>

# PoE Operation Modes with Respect to Input Voltage



## PSE's Signal during PoE Process



Discovery: 25K Ohm Signature Impedance  
Classification: Constant Current, 4 Ranges, Max 30 mA

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# 802.3af Power Classification

In the start-up process when a PoE connection is made, the PD can advertise its power class which is an indication of how much power is required

Class	Min. PSE Power	Max. PD Power	Sample PD's
1	4 Watts	3.84 Watts	IP Phones
2	7 Watts	6.49 Watts	IP Camera
3,4, or 0	15.4 Watts	12.95 Watts	Wireless AP

“Power cannot be forced down the cable” - *a common misconception* -

The PD presents a load to the cable and draws as much as it needs. Most PoE powered devices will draw a fixed level of power.

# IEEE802.3at Project Milestones

- Nov-2004: Study Group Created
- Jul-2005: IEEE802.3 recommended creation of Task Force
- Sep-2005: IEEE802.3at Power over Ethernet Enhancements Task Force Created
- Jan-2009: New Orleans, LA (interim) – last meeting
  - All comments on draft 3.3 addressed, draft 4.0 created, sponsor ballot
- Mar-2009: Vancouver, BC (plenary)
- Sep 11 2009: Ratification



# IEEE802.3at Objectives

- At least 24W power supplied to the PD
  - As much as economically feasible
- Backwards compatible with IEEE802.3af-2003
  - Type 2 PD's that cannot operate with less than 12.95W must give indication to user when connected to Type 1 PSE
  - Type 2 PD's that can operate with less than 12.95W must be able to be powered by a Type 1 PSE
- PD MIB to be created
- Support for Gigabit Midspan

Type 1: "low power"

Type 2: "high power"



# Devices Evolve and Require More Power

- Access Points migration to 802.11n
  - Cisco AP-1200 with g radio : 802.3af (6.5W)
  - Cisco AP-1200 with a+g radios : 802.3af (11.6W)
  - Cisco AP 1250 for 802.11n : ~ (20+W)
- Migration to Advanced Network Cameras
  - Sony SNC-Z20N Zoom Camera : 802.3af (<12.95W)
  - Sony SNC-RZ30N Pan/Tilt/Zoom : (21.6W)
  - Sony SNC-RZ30N Pan/Tilt/Zoom/Heated Enclosure : (50W)
- IP Phones evolving into Video Phones
  - Wooksung Video Phone : 18.4W
  - Packet8 Video Phone : 25W
  - Leadtek IP Broadband Video Phone : 25W
  - WorldGare Video Phone : 36W





# IEEE 802.3af Enhancements

The 802.3at specification expands upon 802.3af in several key areas:

<http://www.ieee802.org/3/at/>

- Enable higher power PD's such as wireless access points, panning security cameras, video phones, and audio appliances requiring continuous power to 25.5 watts up to 100M from the PSE.
- High Power PSE's must furnish at least 30.0 Watts at the PSE port.
- Provide full backward compatibility and interoperability to existing 802.3af compliant PSE's and PD's.
- Enable Mid-Span PSE's to support 1000BaseT connections.
- Restrict cost increases for PSE ports and PD equipment in areas such as PSE controller devices and PoE capable magnetics such that PoE+ (high power) could become ubiquitous.
- Improve potential power management granularity and power budgeting capability over time.
- Resolve well known issues of specification clarity inherent in the 802.3af specification



# IEEE802.3at Specifications



- **Cabling:** CAT5E required
- **Voltage:** PSE voltage from 44V to 57V (50V for Type-2 PSEs)
- **Current level:** 600mA assuming cable temperature is 50C or lower
- **Polarity:** End-Spans can use MDI or MDI-X (Positive or Negative Polarity)
- **Pulse transformer inductance:**
  - End-Span PSE (Switch) & PDs: 120 $\mu$ H (allows usage of IEEE802.3af magnetics)
  - Mid-Span: 350 $\mu$ H, Midspan Alternative-A 10/100 installations require regulation
- **Power Feeding:** 2-pairs and 4-pairs possible
  - Focus on 2-pairs Medium Power: PSE 30W output, **PD 25.5W** input
  - 4-pairs High Power should be based on 2x2-pairs: PSE 60W output, **PD 51W** input

# IEEE802.3at Specifications (cont.)

- **Power Detection & Removal Essentially Unchanged**
  - 25K signature resistance will not be changed
- **Classification**
  - Classic Method enhancement: 2-Event Classification (two pulse) that is transparent to 802.3af but allows Type-2 PD presents Class 4 to request maximum power.
  - Type-2 PSE may use either single-event or 2-event classification
  - PD must support Layer 1 and Layer 2 classification
  - PSE must support either Layer 1 or Layer 2 classification
  - Layer 2 Classification Method: Using a data link layer protocol such as Link Layer Discovery Protocol (LLDP).
- **1000Base-T Mid-Span in scope of IEEE802.3at**
  - Any Mid-Span power interface can be Type A (4,5,7,8) or Type B (1,2,3,6)

# 802.3at Power Classification

Category	PSE Power	PD Power	L1 Classification	L2 Classification
Type-1	15.4 Watts	.44 - 13 Watts	PSE: Optional PD: Required	PSE: Optional PD: Optional
Type-2	30.0 Watts	13 - 25.5 Watts	PSE: Required PD: Required	PSE: Optional PD Required

PSE Type	Classification	Guaranteed Power at PSE Output	Minimum Power at PSE Output	Units
Type-1	Class 0	15.4	~ 0.5	Watts
	Class 1	4.0	~ 0.5	
	Class 2	7.0	~ 4.0	
	Class 3	15.4	~ 7.0	
Type-2	Class 4	30.0	~ 15.4	

# All Possible PSE/PD Combinations

PSE TYPE	PD TYPE	COMMENTS
Type 1(.af)	Type 1(.af)	Existing 802.3af system, class 0, 1, 2, or 3.
Type 1(.af)	Type 2(.at)	Type 1(.af)PSE sees class 4 and powers per 802.3af specification, i.e. 15.4W. Type 2(.at) PD can only assume Type 1 PSE and must operate with 15.4W and alert user not enough power.
Type 2(.at) L1 i.e. high power midspan	Type 1(.af)	Type 2(.at) PSE sees class 0, 1, 2, 3 and powers per 802.3af specification.
Type 2(.at) L1 i.e. high power midspan	Type 2(.at)	Type 2(.at) PSE sees class 4 and powers with maximum allowable 802.3at power level. Type 2(.at) PD sees two class pings and knows Type 2 PSE connected. Power information is known before PD is powered.
Type 2(.at) L2 i.e. end point PSE	Type 1(.af)	Type 2(.at) PSE sees class 0, 1, 2, 3 and powers per 802.3af specification. Layer 2 communication fails to establish. Power level is maintained at .af levels. PD sees af behavior and operates under .af specs.
Type 2(.at) L2 i.e. end point PSE	Type 2(.at)	Type 2(.at) PSE sees class 4 and powers with 15.4W. Layer 2 communication is established and mutual identification is established. High power operation begins.

[http://www.ieee802.org/3/at/public/2007/03/stanford\\_3\\_0307.pdf](http://www.ieee802.org/3/at/public/2007/03/stanford_3_0307.pdf)

Clay Stanford Linear Technology

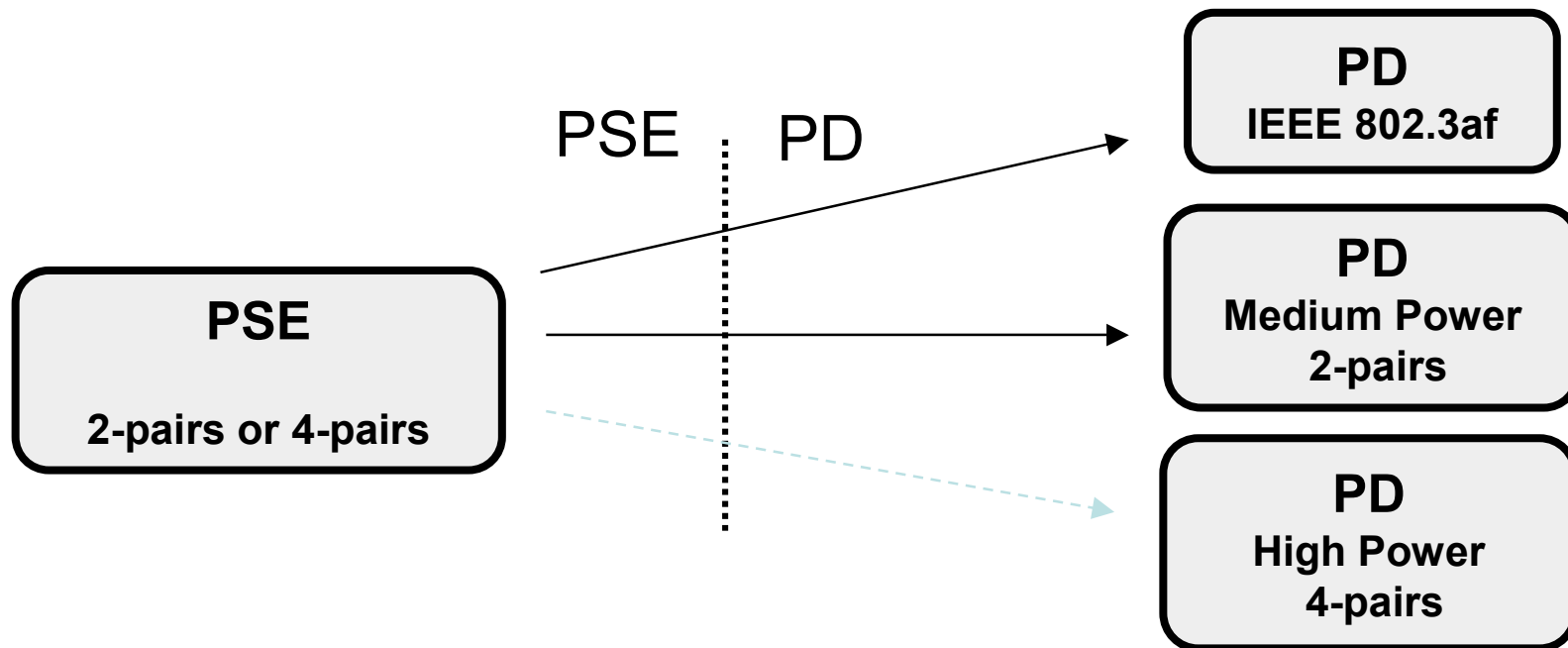
# 802.3at Use of LLDP

- 802.3at has moved in the direction of supporting both layer 1 PD classification as well as layer 2 PD classification that will offer both very high power management granularity and will enable dynamic negotiation of power levels between PSE and PD.
- The Layer 2 scheme will use a link layer discovery protocol (LLDP) as currently defined in the new IEEE 802.3BC standard with additional protocol rules defined in IEEE 802.3at. LLDP is a link (point-to-point) MAC protocol historically used to allow switches and routers to automatically “discover” what is around them and to populate and maintain a MIB that can be used for viewing a network architecture.
- The 802.3at standard was contingent on the adoption of the new IEEE 802.3BC Standard which covers Ethernet Organizationally Specific Type, Length, Values (TLVs)



# IEEE 802.3at Specification Latitude

- The 802.3at standard allows for the following PSE/PD Topologies
  - High Power, over 4-pairs (two 802.3at PDs per device)
  - Medium Power 802.3at, over 2-pairs
  - 802.3af complaint, over 2-pairs
- 2-pairs End-Span can support 4-pairs PD with Mid-Span
- Standard and Proprietary Detection Schemes



# Sample 15.4W and 30W Mid-Span Products

- **POE125U-8C (15.4W/Port)**
  - 8 Port Legacy Power 15.4W
  - 19" Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant
  - Native Cisco legacy support
  - SNMP (optional)
  
- **POE125U-4AT (30W/Port)**
  - 4 Port 802.3at PoE Plus Power
  - 19" Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant



[http://www.phihong.com/midspans\\_website/](http://www.phihong.com/midspans_website/)



# Sample 30W End-Span Cisco Products - Line Card

## Upcoming PoEP Standard and Devices

New Standard—IEEE802.3at for 30W/Port







Next Gen PoEP Devices Expected CY2009 Onwards



# Sample 30W End-Span Cisco Products - Power Supplies

## Catalyst 4500 PoE Power Supplies

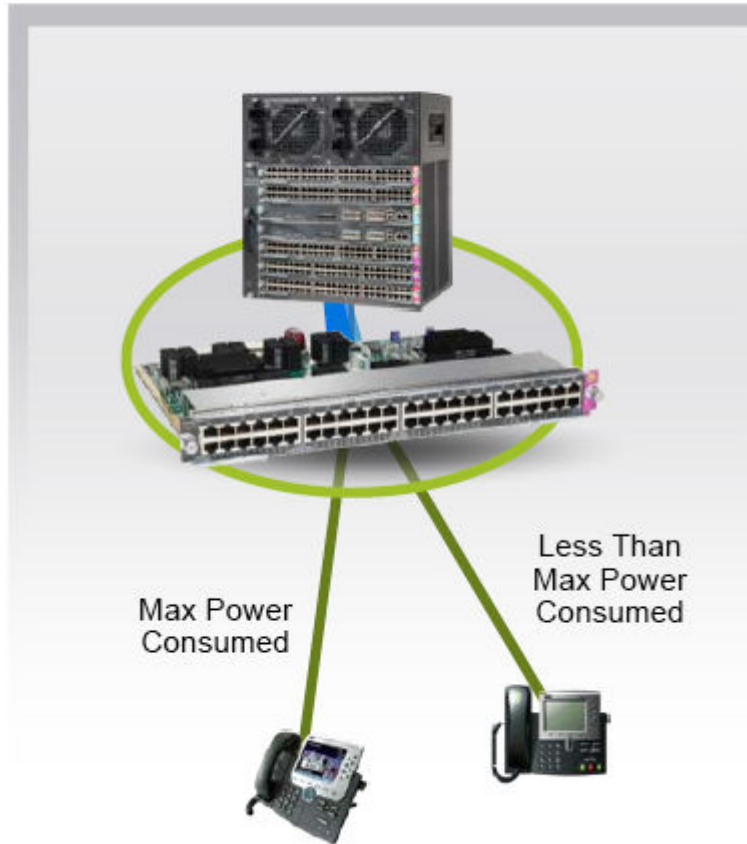
	Input Circuits	Voltage	Circuit Power	PoE Power	Class 3 PD (Max)	30W PD (Max)
 PWR-C45-1300ACV	Single	110V/220V	1000W	800W	48	48
 PWR-C45-2800ACV	Single	220V	1360W	1400W	84	43
 PWR-C45-4200ACV	Dual	110V/220V	1383W	3700W (220V) 1850W (110V)	223 (220V) 111 (110V)	114
 PWR-C45-6000ACV	Dual	110/220V	2200W	(220V) 1850W (110V)	289 (220V) 111 (110V)	148

Compatible with E-Series and Classic Chassis  
All Catalyst 4500 Chassis support 1+1 Power Redundancy

# Sample 30W End-Span Cisco - Products Features

## Catalyst 4500 Linecards

Intelligent PoE Delivery and Control

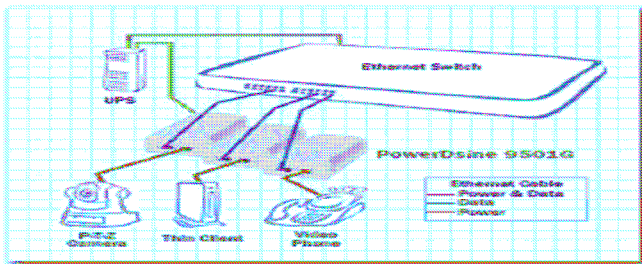


Available on Catalyst 4500 with IOS 12.2(50)SG

- **PoE Monitoring** lets you display the true power consumption of inline powered devices attached to the switch, so you have an idea of your actual power consumption
- **PoE Policing** protects a switch from faulty inline powered devices that may draw more current than they were designed for
- **CDP and LLDP** used to negotiate power per port
  - Allocation based on device needs
  - Maximize number of devices
  - Right-size the power supply

# Sample 4 Wire 802.3at Mid-Span Product 60W

## PowerDsine® 9501G Family High Power, Gigabit Single Port PoE Midspan



### Overview

The PowerDsine 9501G is a single port, high-power solution for remote powering of current and emerging high power applications.

Generating a maximum of 60W, the PD-9501G enables remote power for a new range of applications including pan-tilt-zoom (PTZ) cameras, video-phones and thin-clients. It complies to IEEE 802.3af PoE standard parameters, while doubling the power available from prior midspans. It can power both existing 10/100Base-T network devices and such emerging wireless gigabit devices as Wi-MAX and remote distance wireless IEEE 802.11n access points.

### PD-9501G Features

- Up to 60W of Power on 4-pairs
- IEEE 802.3af Compliant—With Higher Power
- Compatible With All IEEE pre 803.3at, 802.3af or Legacy Powered Devices
- Safe: Low Power Devices Receive Only the Power They Need, 2-pair PDs receive power on 2-pairs
- Safe and Reliable Power over Ethernet
- Automatic Detection and Protection of Non-standard Ethernet Terminals
- Supports 10/100/1000BaseT applications
- Compact Design Fits Easily in WLAN Access Point Installations

### 9501G Specifications

No. of Ports	1
Pass Through Data Rates	10/100/1000 Mbps
Power over Ethernet Output	Pin Assignment and Polarity: Data Pairs 1/2 (-) and 3/6 (+) Spare Pairs 7/8 (-) and 4/5 (+) Output Power Voltage: 55Vdc User Port Power: 60Watts Max.
Input Power Requirements	AC Input Voltage: 100 to 240 Vac AC Input Current: 1.6A @ 100-240 Vac AC Frequency: 50 to 60 Hz
Dimensions (W x H x L)	57.9 mm x 51.3 mm x 166 mm
Weight	.381 lbs (400g)
Indicators	System Indicator: AC Power (Green) User Indicator: Channel Power (Green and Orange)
Connectors	Shielded RJ-45, EA 568A and 568B
Environmental Conditions	Operating Ambient Temperature: 32° to 104°F (0 to 40°C) Operating Humidity: Maximum 90%, Non-condensing Storage Temperature: -4° to 158°F (-20° to 70°C) Storage Humidity: Maximum 95%, Non-condensing Operating Altitude: -1000 to 10,000 ft. (-304.8 to 3048 m)
Reliability	MTBF: 100,000 hrs. @25°C
Warranty	1-year
Regulatory Compliance	IEEE 802.3af (PoE), RoHS Compliant WEEE Compliant, CE
Electromagnetic Emission & Immunity	FCC Part 15, Class B EN 55022 Class B (Emissions) EN 55024 (Immunity), VCCI
Safety Approvals	UL/CUL Per EN 60950 GS Mark Per EN 60950

### Ordering Information



Part Number	Name	Description
PD-9501G/AC	PowerDsine 9501G	High Power 1-port 4-pair, AC Input



# IEEE Interoperability Testing

- 802.3af and 802.3at PSEs and PDs should be tested and evaluated by vendors and third party labs.
- The University of New Hampshire Interoperability Lab (IOL) tests compliance to the standards and interoperability between devices and also verifies that all data remains uncorrupted.

<http://www.iol.unh.edu/services/testing/ethernet/tools/poe/>

- Some PSE vendors perform free but limited PD compatibility testing
  - <http://www.microsemi.com/PowerDsine/Products/SelectionGuide.asp>
  - [http://www.phihong.com/midspans\\_website/pages/selector.php](http://www.phihong.com/midspans_website/pages/selector.php)
- Other vendors sell automated conformance testing solutions designed to assess PSE compliance to 802.3af and to the emerging 802.3at specification at a very detailed level.

<http://www.sifos.com/Products/PSEConformanceTestSuite/tabid/133/Default.aspx>

# PD Compliance Testing at UNH-IOL

- The Power over Ethernet consortium offers a PD compliance test suite based on the specifications defined in Clause 33 of the IEEE Std 802.3af™-2003. This test suite investigates the conformance of a Powered Devices.
- Several areas are covered including signature characteristics, pin-out, polarity insensitivity and classification.
- The testing is performed using methodologies developed by the UNH-IOL, using UNH-IOL developed hardware and software, thus providing unbiased, independent, third-party test results.
- The test suite for this service is available and may be viewed online.

# Conclusions and Recommendations

The IEEE 802.3at is a gradual evolutionary improvement to the IEEE 802.3af standard.

In the near term, this market will continue it's 20% annual growth and continue to focus on VOIP terminals, Wireless APs and IP Cameras.

The migration to the IEEE802.3at will be slow but steady as more vendors determine how to take advantage of 25 - 50 W of power delivered over Ethernet and design and test new PDs that can take advantage of the higher power.

A new PoE standard will be required and completed in the next 6-7 years.



# Power Requirements by Solution



<b>13 to 20 W</b>	802.11n	<b>40 to 50W</b>	PTZ IP Cameras / With heaters
	Biometric Access Control		Thin Clients
	Thin Clients		Point of Sales
<b>20 to 30W</b>	RFID Readers	<b>50 to 80W</b>	Information Kiosks
	Video IP Phones		Laptops
	PTZ IP Cameras		Thin Clients
	Alarm Systems		Point of Sales
	Thin Clients		Information Kiosks
<b>30 to 40W</b>	Industrial Sensors	<b>80W to 120W</b>	PTZ IP Cameras / With heaters
	Access Controls		Desktops
	Video IP Phones		Laptops
	PTZ IP Cameras		High Power Wireless
	Workgroup switches		Thin Clients
	Point of Sales		Point of Sales
	Information Kiosks		Information Kiosks



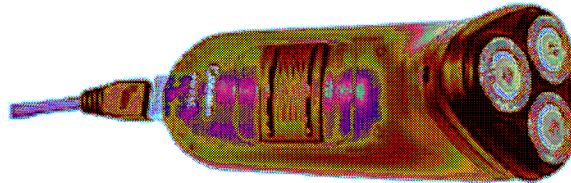


# The Ultimate PoE Vision

PoE Powered Notebooks, Netbooks, Thin Clients and Kiosks  
PoE at Every Conference Room, Hotel Room & Home



# The PoE Challenge



Engineers created this Power over Ethernet Shaver!

What PoE Device can you Design?

**Thank You**