

# Power over Ethernet Application for IP Network Camera (IPNC)

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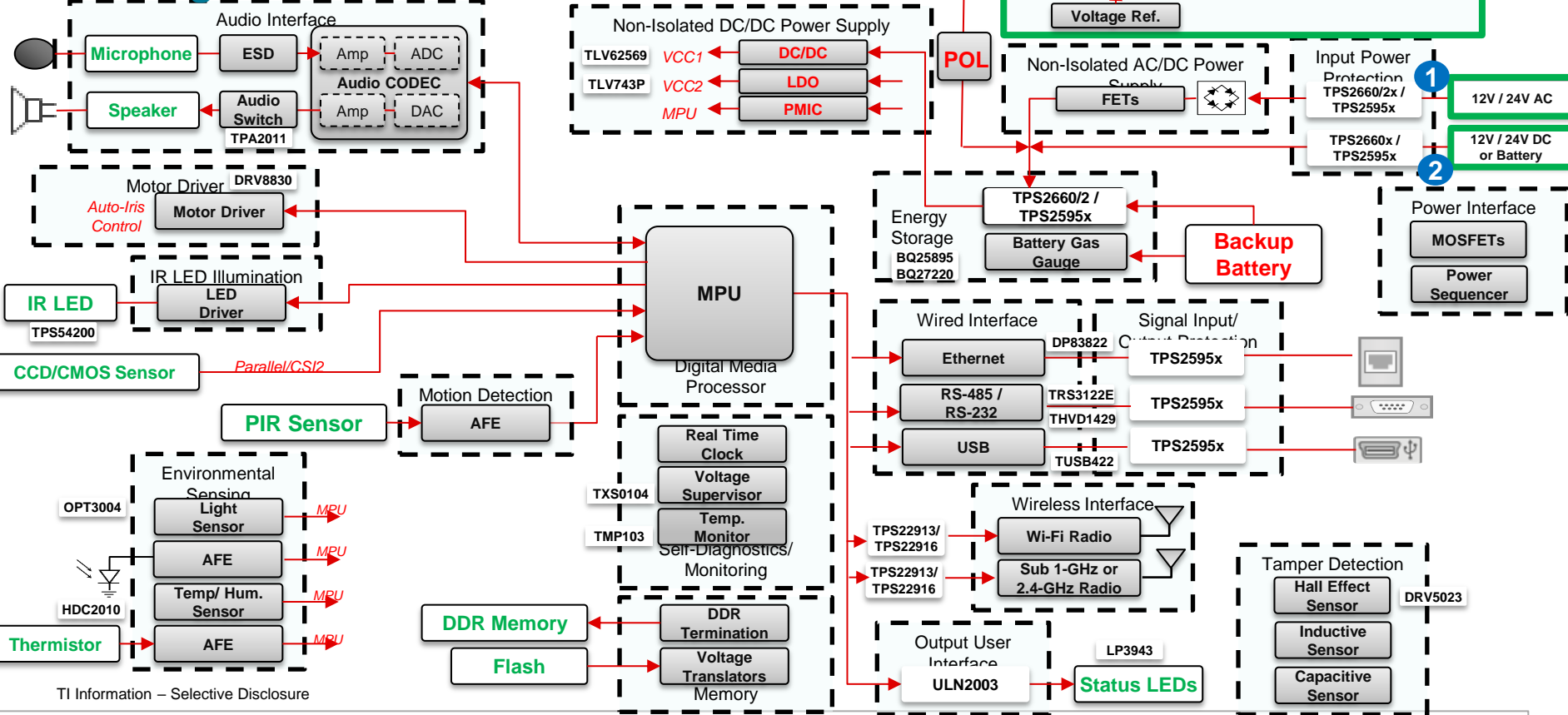
**11-13-19**

# Agenda

- IP Network Camera (IPNC) Block Diagram Overview
  - PoE Power Schematic
- Power over Ethernet (PoE) Introduction
  - What is PoE?
  - Value of PoE
  - End Equipment using PoE
- PoE Basics
  - Alternative A, Alternative B and 4 Pair PoE
  - Types & Classes
  - PSE and PD Handshake: Detection, Classification, Power on and Normal Operation.
- Ethernet Alliance (EA)
- PoE Design Block for IPNC

# IP Network Camera (IPNC)

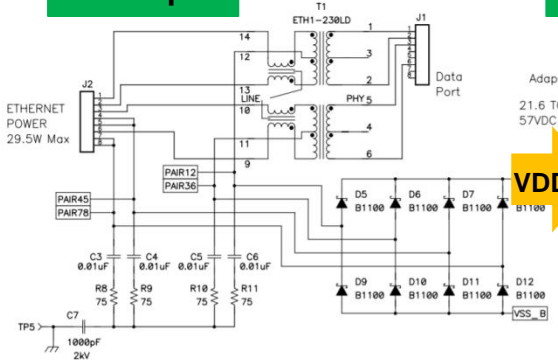
## Block Diagram Overview



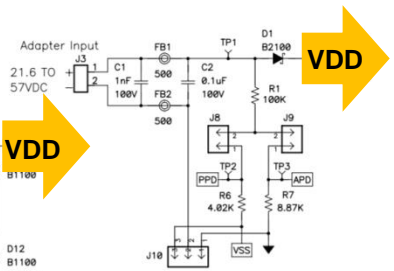
TI Information – Selective Disclosure

# PoE Power Schematic

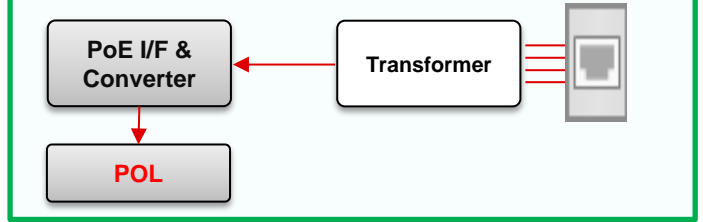
## PoE Input



## Adapter Input

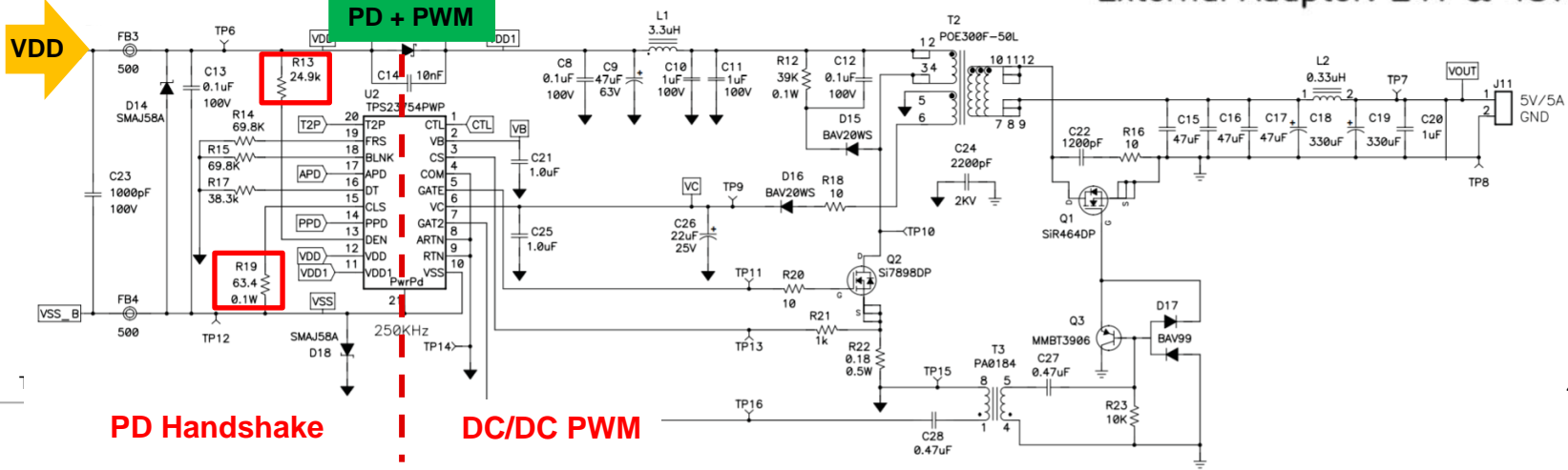


## Power over Ethernet



Type: Driven Synchronous Flyback  
 Output: 5V, 5A, 25W  
 External Adaptor: 24V & 48V

## PD + PWM



System POL

PD Handshake

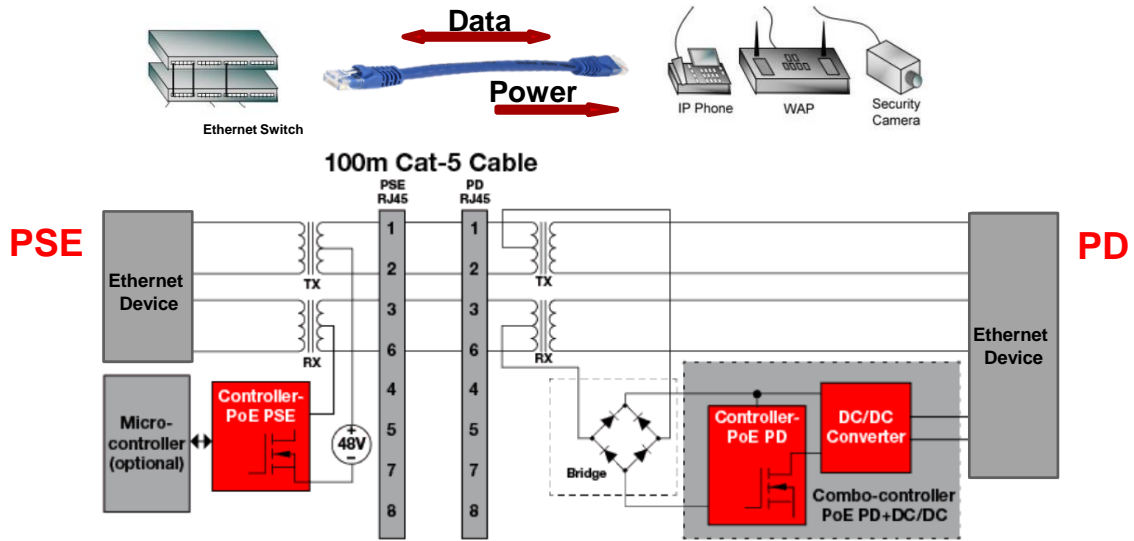
DC/DC PWM

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# What is PoE?

- **Definition:** Providing DC power (44V to 57V) over same CAT5 twisted-pair cable that carries Ethernet data.
- **Ends of the cable**
  - Power Sourcing Equipment (**PSE**): Ethernet Switch, Router, Hub
  - Powered Device (**PD**): IP Phone, Wireless Access Point, Security Camera



# Value of PoE

## 1. Convenience of installation & use

- Power & data cables combined
- The length of CAT5 cable can be up to 100m
- Ease of installation (no electricians required for install)

## 2. Reliability and longevity

- IEEE 802.3 standard based
- PoE end equipments have long lifetimes and part obsolescence is uncommon

## 3. Adjustable power levels to meet various demands

- Scalability up to 71W at the load!

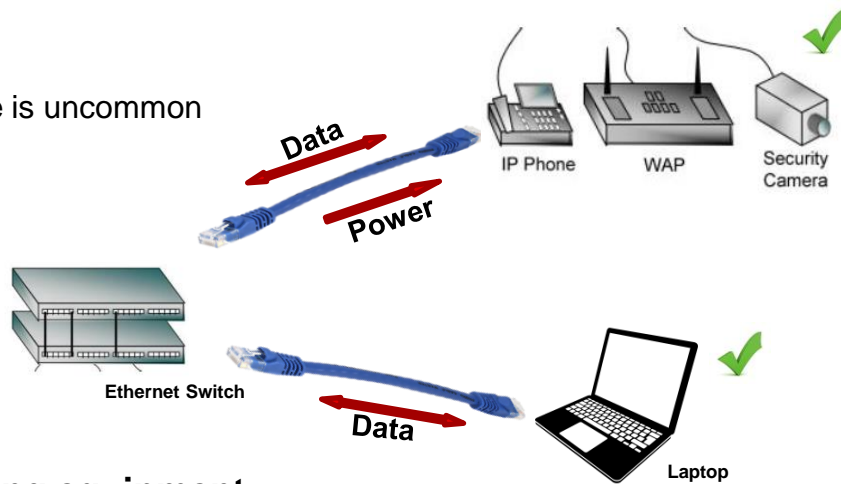
## 4. Power Redundancy

- Data and power
- Battery packs, AC/DC power, etc.

## 5. Plug into any RJ-45 port without concern for damaging equipment


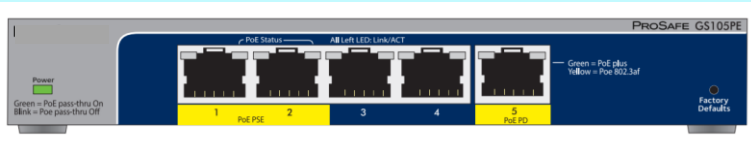

- For IEEE802.3 compliant devices, the PSE will not supply power to non-compliant PD devices or data only ports.

TI Information – Selective Disclosure



# Primary Applications using PoE

PoE helps to reduce power cabling where CAT5 is already needed for Data

- PSE**
  - Enterprise Switch  

  - PoE Pass Through  

  - PoE Injector  


- PD**
  - IP Phone  

  - Small Cells  

  - IP Camera  

  - Wireless Access Point  




# Emerging PoE Applications

## PoE Lighting



## Digital Signage



## Building Automation



## Access Control



## POS Terminals



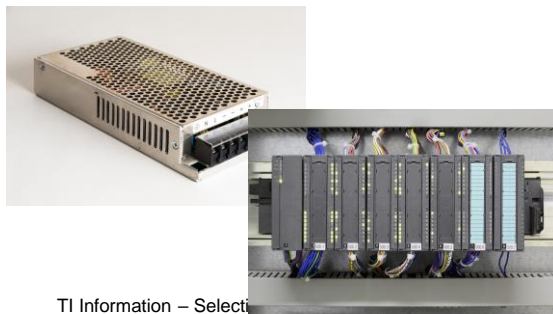
## Satellite Dish



## Entertainment



## Industrial Controls

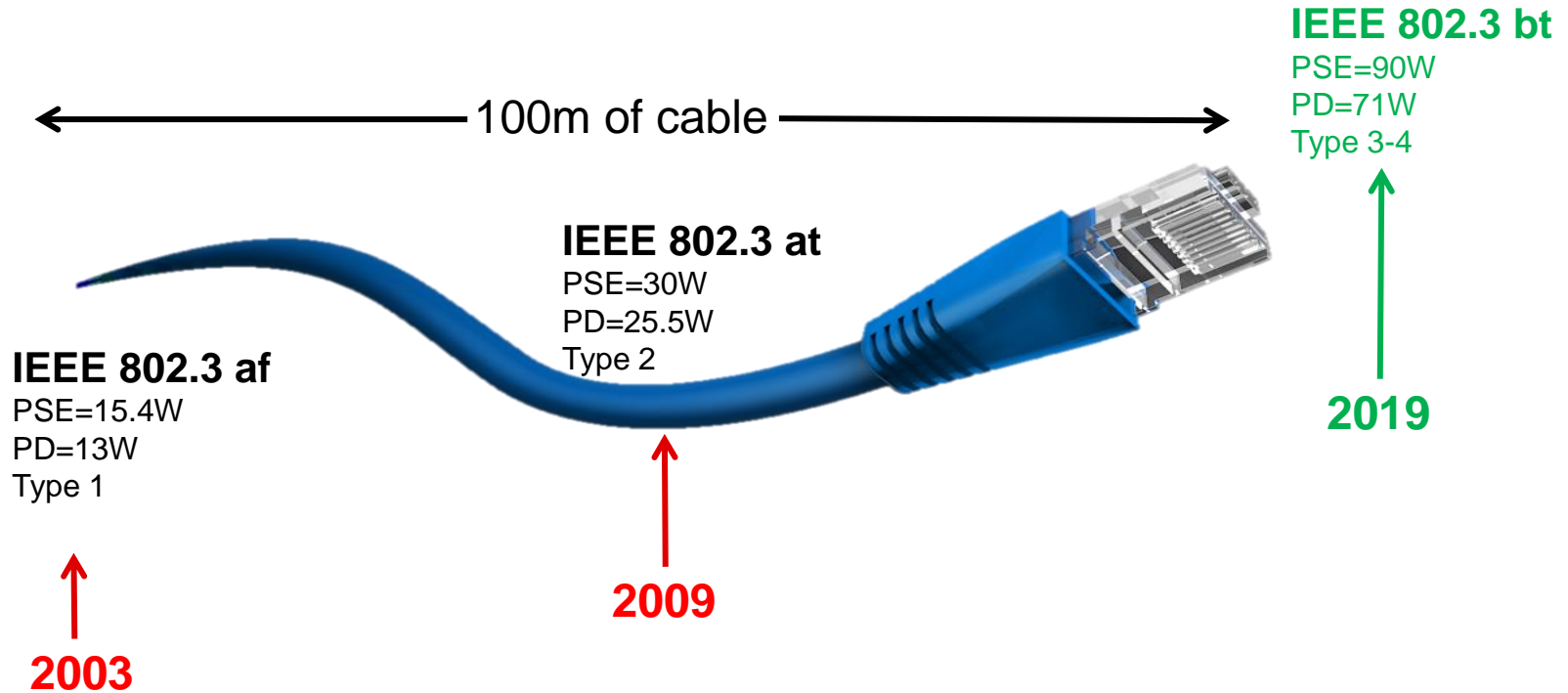


TI Information – Select

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- **PoE Basics**
  - **Alternative A, Alternative B and 4 Pair PoE**
  - **Types & Classes**
  - **PSE and PD Handshake: Detection, Classification, Power on and Normal Operation.**
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# PoE Basics | How Much Power can I send?



**PoE evolution driven by desire for more Power!**

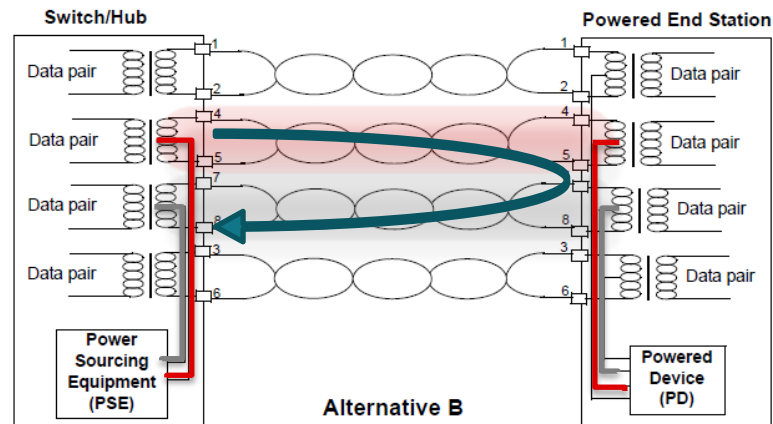
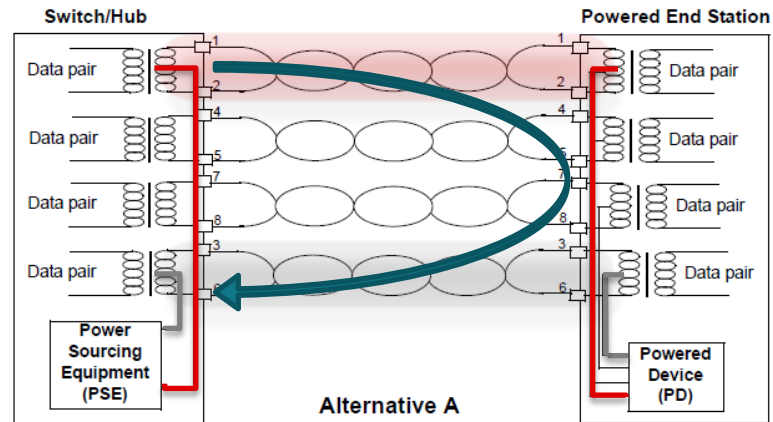
# IEEE802.3at 2-Pair Wiring

1. There are 4 pairs in an Ethernet cable
  - Each pair consists of 2 twisted wires.
2. We use 2 pairs to deliver power in AT standard.

There are 2 options for wiring:

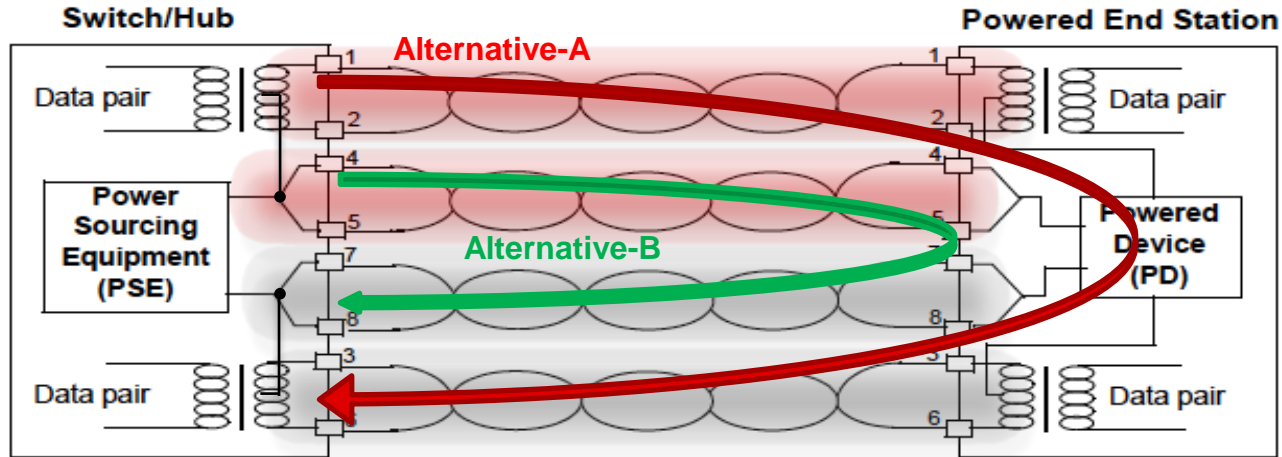
- Alternative A: Wires 1&2 + Wires 3&6
- Alternative B: Wires 4&5 + Wires 7&8

3. Power is injected by the PSE on the isolated side of the transformer
4. The PD receives power on the isolated side of the transformer



# IEEE802.3bt 4-Pair Wiring

1. All 4 pairs of the Ethernet cable are used to deliver power at all power levels
2. To reduce power loss due to cabling and increase overall system efficiency
  - 100m CAT5 Cable resistance is typically 12.5ohm with 2 pairs
3. 1Ch = 2 Pairs



# PoE Basics | IEEE802.3af (2003) Types & Classes

Class	Type	# Pairs	Power Sourced at PSE	Power at PD after 100m of cat5e cable
0	1	2	15.4W	13.0W
1	1	2	4W	3.84W
2	1	2	7W	6.49W
3	1	2	15.4W	13.0W

# PoE Basics | IEEE802.3at (2009) Types & Classes

Class	Type	# Pairs	Power Sourced at PSE	Power at PD after 100m of cat5e cable
0	1	2	15.4W	13.0W
1	1	2	4W	3.84W
2	1	2	7W	6.49W
3	1	2	15.4W	13.0W
4	2	2	30W	25.5W

# PoE Basics | IEEE802.3bt (2019) Types & Classes

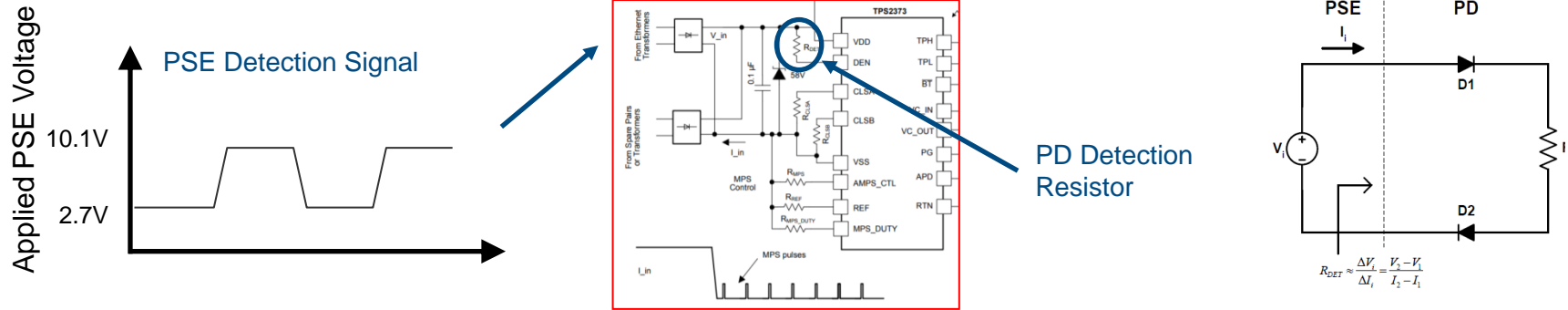
Class	Type	# Pairs	Power Sourced at PSE	Power at PD after 100m of cat5e cable
0	1	2	15.4W	13.0W
1	1 or 3	2 or 4	4W	3.84W
2	1 or 3	2 or 4	7W	6.49W
3	1 or 3	2 or 4	15.4W	13.0W
4	2 or 3	2 or 4	30W	25.5W
5	3	4	45W	40.0W
6	3	4	60W	51.0W
7	4	4	75W	62.0W
8	4	4	90W	71.3W

The new IEEE802.3bt standard add Types 3 and 4 & Classes 5-8 to accommodate sourced power levels up to 90W



# PoE Basics | Detection

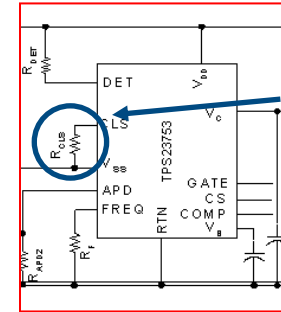
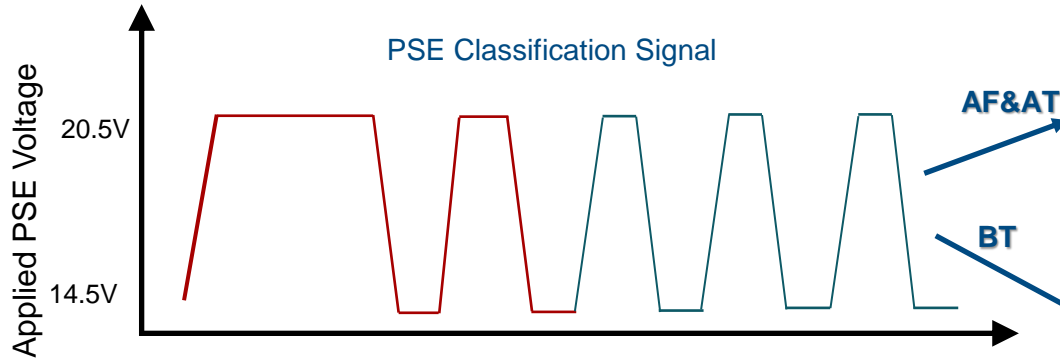
- The IEEE802.3 standards define a method of safely powering a PD (powered device) over a cable, and then removing power if a PD is disconnected.



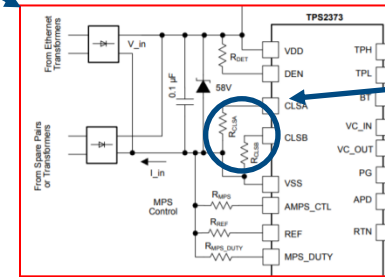
- The PSE leaves the cable unpowered while it periodically looks to see if something has been plugged in. This is called **Detection**.
- How does Detection work?
  - PSE sends 2 low voltage signals to PD (2.7V–10.1V) → 2-point Detection
  - Measures  $dV/dI$  across  $R_{det}$
  - Acceptable detection if  $23.75k\Omega < R_{det} < 26.25k\Omega$
  - 4-point Detection → 2-point Detection twice

# PoE Basics | Classification

- If a valid PD signature is present, the PSE may inquire how much power the PD requires. This is referred to as **Classification**.



1 Classification Resistor on PD

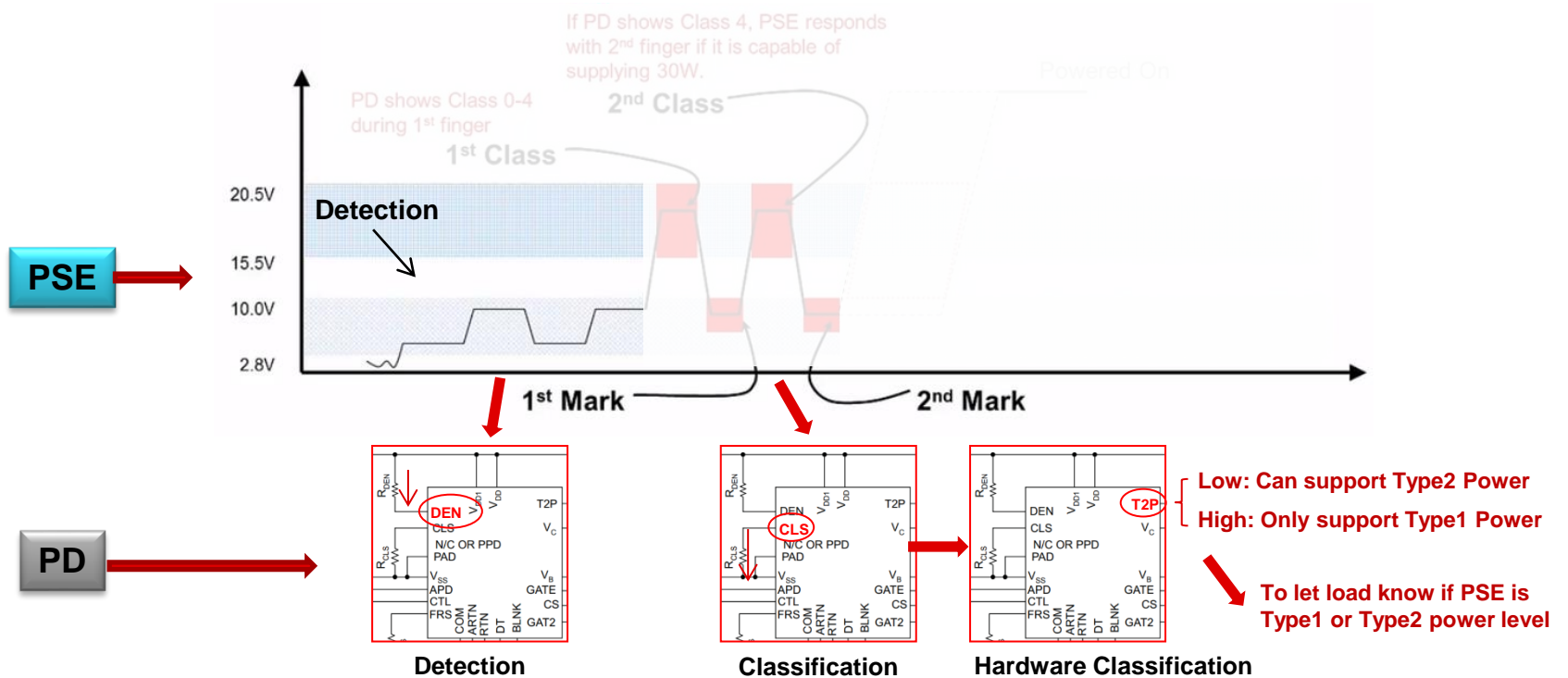


2 Classification Resistors on PD

- **How does classification work?**
  1. PSE sends voltage signals to PD (14.5V - 20.5V)
  2. PD removes  $R_{det}$  and turns on internal LDO which applies 2.5V across the  $R_{class}$
  3. PSE Measures current through  $R_{class}$
  4. Classification determines power allotment from PSE

# PD & PSE Handshake | AF&AT Standard

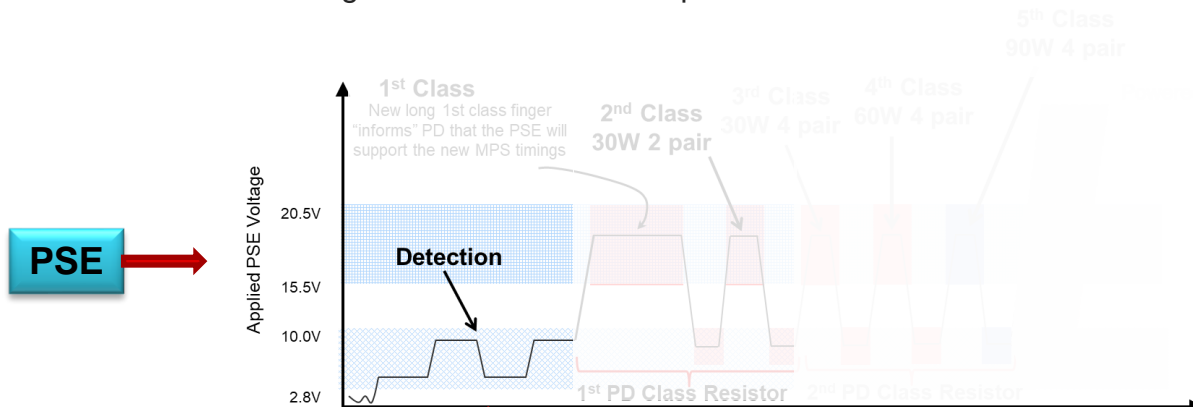
- AT Standard



# PD & PSE Handshake | BT. Standard

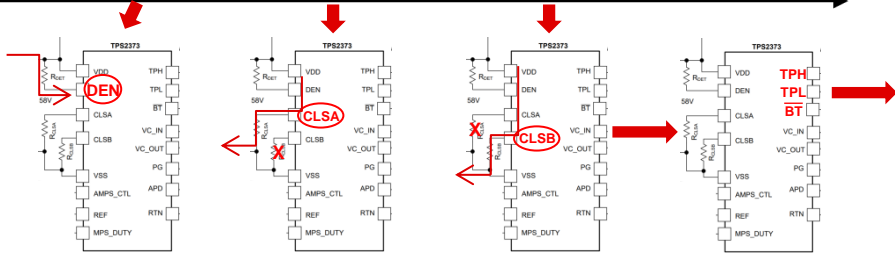
- BT Standard**

- PSE sends longer 1<sup>st</sup> finger to inform PD that it's Type3 or Type4 PSE.
- PD uses 2<sup>nd</sup> Rclass to identify higher power level.
- PSE sends total 5 fingers for maximum 90W power



**BT: Type1-2 or Type3-4 PSE**  
**TPH/TPL: Presents the numbers of fingers**

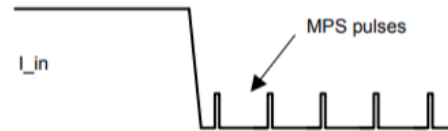
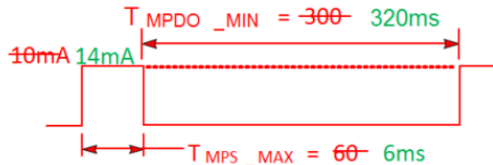
**PD**



PSE Type	PD Class	NUMBER OF CLASS CYCLES	PSE ALLOCATED POWER AT PD (W)	TPH	TPL	BT
1-2	0	1	12.95	HIGH	HIGH	HIGH
1-2	1	1	3.84	HIGH	HIGH	HIGH
1-2	2	1	6.49	HIGH	HIGH	HIGH
1-2	3	1	12.95	HIGH	HIGH	HIGH
2	4	2	25.5	HIGH	LOW	HIGH
3-4	0	1	12.95	HIGH	HIGH	LOW
3-4	1	1	3.84	HIGH	HIGH	LOW
3-4	2	1	6.49	HIGH	HIGH	LOW
3-4	3	1	12.95	HIGH	HIGH	LOW
3-4	4	2-3	25.5	HIGH	LOW	LOW
3-4	5	4	40	LOW	LOW	LOW
3-4	6	4	51	LOW	HIGH	LOW
4	7	5	62	LOW	LOW	LOW
4	8	5	71	LOW	LOW	LOW

# PoE Basics | Inrush and Normal Operation

- After a valid classification result (not overcurrent or class mismatch), PSE will turn on the port and start monitoring inrush current.
  - At this time, 48V typically (could be in the range of 44V to 57V) is sent from the PSE to the PD across the Ethernet cable.
- Inrush Current Limiting
  - Once 48V is applied by PSE to PD, PSE will turn on the port and start monitoring inrush current. At the same time, PD takes the control to limit the inrush current. If the current keeps below PSE's inrush current limit during  $T_{start}$  (maximum allowed overcurrent time during inrush) period, PD will pull full load and the port starts normal operating.
- Normal Operation
  - During normal operation, the PSE checks to see if amount of power sent down the cable is within the allocated power class and current limits if needed to prevent the PD from drawing more power than was allocated.
  - PSE must also continually detect Maintain Power Signature (MPS) from PD to stay connected during light load operation.



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# What does the Logo Mean?

- Meets Ethernet Alliance Certification Test Plan
  - Based on IEEE Std 802.3™-2015 PoE Specifications
- Confidence of interoperability between certified products
- PSE / PD Logo Distinction
- Class Number indicates maximum class supported
- Easy Interoperability: PSE Class must be greater than or equal to PD Class
- Initial rollout (called ‘GEN1’) limited to Class 4 and lower; ‘GEN2’ is in definition and will go up to Class 8
- Read more [here](#) in our Blog



***PSE Class “4” Logo***



***PD Class “1” Logo***

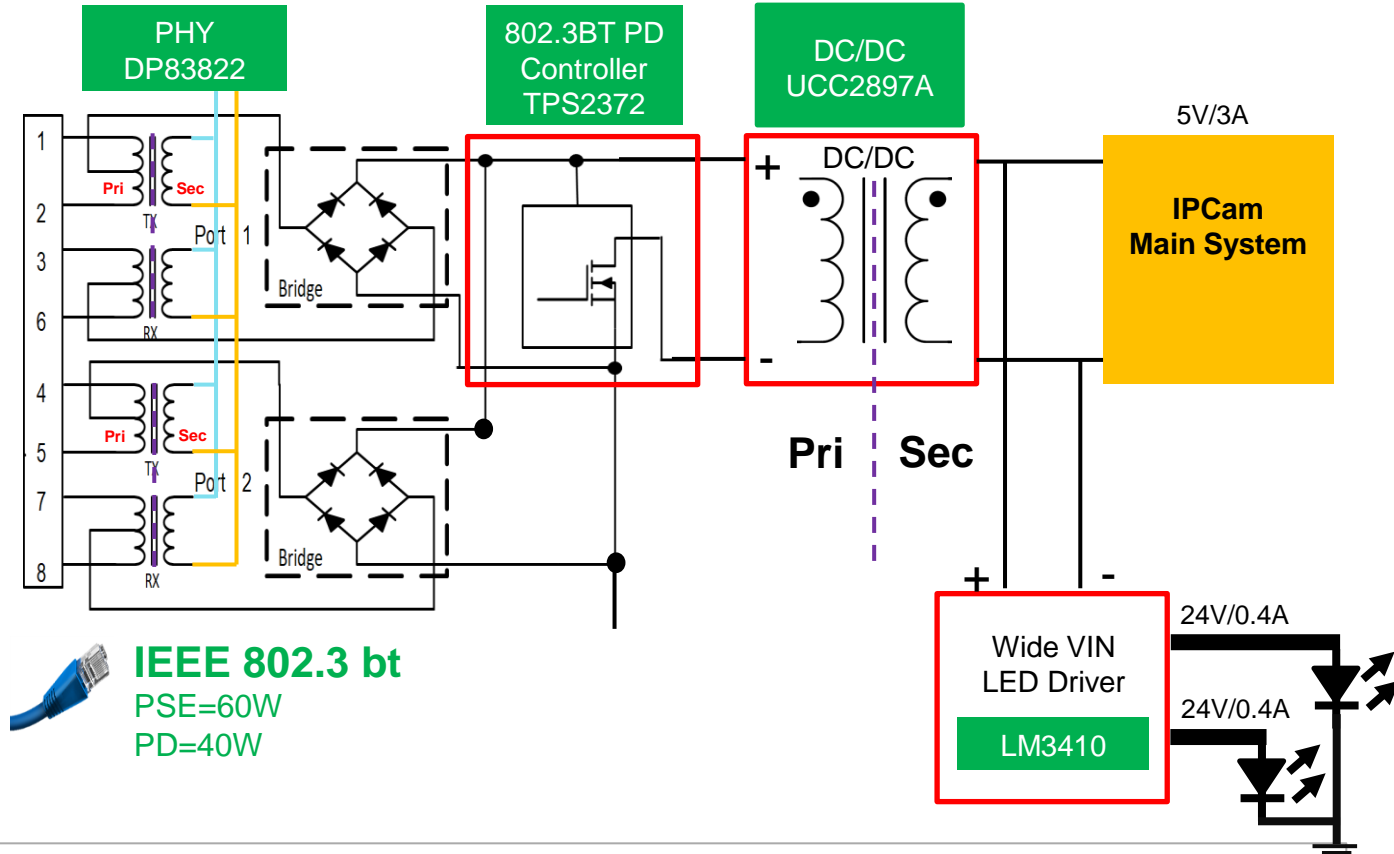
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# PoE Design Block for IPNC

- Using **UCC2897A** for the DC/DC conversion (ACF)
- LED driver is designed in secondary side
- So the conversion efficiency for the main system is **~ 90% at 5V/3A without LED driver**
- And the conversion efficiency of the LED lamp is **~ 82% (DC/DC = 90%, LED driver = 92%)**



# How to get familiar with TI portfolio (TI.com/PoE)

Overview | **Featured products** | Reference designs | Tools & software | Technical documents | Support & training

## Power over Ethernet (PoE) solutions

PSEs and PDs for PoE design interoperability and flexibility

Our power over Ethernet (PoE) ICs offer high interoperability, reliability, convenience, and complete system solutions to those wanting to easily deliver power through Ethernet cables. The IEEE Committee has ratified a new PoE standard (IEEE 802.3bt). We have been involved in the standard's development since inception, and have a full IEEE802.3bt-ready end-to-end portfolio of interoperable powered devices (PD) and power sourcing equipment (PSE) controllers, which will enable power up to 90W at the source (PSE) and 71.3W at the input to loads (PD), making it ideal for end equipment requiring more power than previous standards could support. Examples of new applications include professional audio, digital signage, 5G small cell radio units, industrial access control, and connected lighting.

### Learn more about IEEE 802.3bt

Get a head-start on compliance with the below resources from our PoE experts. Learn at your own pace with our chapter-style .bt training page, or check out our blog or video on how to transition from IEEE 802.3 at to the new standard.

[Browse our .bt training page](#)

[Read the blog](#)

[Watch a short video](#)

### PoE powered devices (PD)

A PD-only device manages and protects the PoE power system at the load.  $V_{in}=V_{out}$ . A PD + DC/DC does all that and performs the DC/DC conversion to provide the required load voltages.

[TPS2372-3: IEEE 802.3bt-ready PD](#)

[TPS23754: Class 4 EA Certified](#)

[TPS23755: Up to Class 3 PD](#)

[Search products](#)

### PoE power sourcing equipment (PSE)

PSE devices protect and manage the power as it is being put into the CAT-5 cable. Classification, identification, and overload protection are among the standard functions.

[TPS23880: New .bt ready PSE](#)

[TPS2388: 8-channel EA certified](#)

[TPS23861: 4-channel EA certified](#)

[Search products](#)

# Thank you