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
PoE Power Schematic

Power over Ethernet

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

PD + PWM
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.
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
  - Wireless Access Point
  - IP Camera
Emerging PoE Applications

- PoE Lighting
- Digital Signage
- Building Automation
- Access Control
- POS Terminals
- Industrial Controls
- Satellite Dish
- Entertainment

TI Information – Select
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PoE Basics | How Much Power can I send?

PoE evolution driven by desire for more Power!

IEEE 802.3 af
PSE=15.4W
PD=13W
Type 1

2003

IEEE 802.3 at
PSE=30W
PD=25.5W
Type 2

2009

IEEE 802.3 bt
PSE=90W
PD=71W
Type 3-4

2019

100m of cable
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

<table>
<thead>
<tr>
<th>Class</th>
<th>Type</th>
<th># Pairs</th>
<th>Power Sourced at PSE</th>
<th>Power at PD after 100m of cat5e cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>15.4W</td>
<td>13.0W</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4W</td>
<td>3.84W</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>7W</td>
<td>6.49W</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>15.4W</td>
<td>13.0W</td>
</tr>
</tbody>
</table>
### PoE Basics | IEEE802.3at (2009) Types & Classes

<table>
<thead>
<tr>
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<td>2</td>
<td>4W</td>
<td>3.84W</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>7W</td>
<td>6.49W</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>15.4W</td>
<td>13.0W</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>30W</td>
<td>25.5W</td>
</tr>
</tbody>
</table>
### PoE Basics | IEEE802.3bt (2019) Types & Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Type</th>
<th># Pairs</th>
<th>Power Sourced at PSE</th>
<th>Power at PD after 100m of cat5e cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>15.4W</td>
<td>13.0W</td>
</tr>
<tr>
<td>1</td>
<td>1 or 3</td>
<td>2 or 4</td>
<td>4W</td>
<td>3.84W</td>
</tr>
<tr>
<td>2</td>
<td>1 or 3</td>
<td>2 or 4</td>
<td>7W</td>
<td>6.49W</td>
</tr>
<tr>
<td>3</td>
<td>1 or 3</td>
<td>2 or 4</td>
<td>15.4W</td>
<td>13.0W</td>
</tr>
<tr>
<td>4</td>
<td>2 or 3</td>
<td>2 or 4</td>
<td>30W</td>
<td>25.5W</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>4</td>
<td>45W</td>
<td>40.0W</td>
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<tr>
<td>6</td>
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<td>4</td>
<td>60W</td>
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<td>75W</td>
<td>62.0W</td>
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<tr>
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<td>4</td>
<td>4</td>
<td>90W</td>
<td>71.3W</td>
</tr>
</tbody>
</table>

The new IEEE802.3bt standard add Types 3 and 4 & Classes 5-8 to accommodate sourced power levels up to 90W.
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 $\frac{dV}{dl}$ 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.

- 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**

**Detection**
- If PD shows Class 4, PSE responds with 2nd finger if it is capable of supplying 30W.

**Classification**
- PD shows Class 0-4 during 1st finger
- 1st Class
- 2nd Class

**Hardware Classification**
- Low: Can support Type2 Power
- High: Only support Type1 Power

To let load know if PSE is Type1 or Type2 power level
PD & PSE Handshake | BT. Standard

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

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**TI Information – Selective Disclosure**

- BT: Type1-2 or Type3-4 PSE
- TPH/TPL: Presents the numbers of fingers
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 $T_{\text{start}}$ (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
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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%)

**IEEE 802.3 bt**
- PSE=60W
- PD=40W
How to get familiar with TI portfolio (TI.com/PoE)
Thank you