A Quick Walk Around the Block with PoDL

Dogs at the IEEE?

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Agenda

• What is PoDL?
• Why do we need another PoE?
• Quick Overview of PoDL Operation
• Summary of PAR/5C/Objectives
• Walk Through the Draft
PoDL = PoE for Single-Pair Ethernet

- Power + Data over the same cable
  - No wall warts, no AC wiring
- PoDL + 100BASE-T1: 100M and power over a single 24ga twisted pair
- PoDL + 1000BASE-T1: Same but gigabit
- PoDL is generic enough that it will work with future speeds and reaches
  - High-voltage (48V) classes enable long-reach applications
  - High power (up to 50W) classes support future high-speed PHYs with real applications
Why PoDL Matters

- Small, single-pair Ethernet devices (notably cameras) need power as well as data
- Two ways to get power to the device:
  - Send power over the same wires
  - Send power over a second pair of wires
- Second pair enables 2-pair Ethernet (10BASE-T or 100BASE-TX) but uses twice as much wire
  - Adds weight, cost, and size
  - Undesirable when the data center (i.e., the car) is moving
  - This is why we did the T1 Ethernet specs
Why Can’t We Use PoE?

• PoE requires (at least) two pairs to work
  • Connected between pair center tap

• PoDL requires only one pair
  • Connected with a lowpass/highpass bandsplitting network
  • Works with single-pair Ethernet
PoDL Overview for Data Folks

- A **PSE** puts power on the link; a **PD** draws power from the link.
- The PSE tests the link using **Detection** before turning on power:
  - It checks for a ~4V zener with a ~10mA test current.
- Found a PD? Now it asks how much power it wants using **Serial Communication Classification Protocol (SCCP)**:
  - Low-speed, self-powered, bidirectional serial protocol that operates in the low-pass power band.
  - Exception: the PSE can skip SCCP if it knows in advance what the PD is (like in an automotive wiring harness): this is Fast Startup Mode.
- If the PSE likes what it sees, it turns on the power:
  - Up to 5W at 12V or 50W at 48V.
Sleep Mode

- When not providing full power, the PSE continuously provides 3.3V to the PD at <1mA: this is **Sleep Mode**
- Sleep Mode allows battery powered systems (i.e., parked cars) to maintain minimal functionality with low power draw (with PHYs asleep or powered off)
  - PHY may use EEE or other sleep modes
- Both PSE and PD enter or leave sleep mode together
- Either the PSE or PD can cause the system to enter or leave Sleep Mode
- SCCP works in Sleep Mode
Interaction with Data

- PoDL affects the channel via the coupling network
  - Return loss and mode conversion are affected by the inductors
  - $dv/dt$, $di/dt$, and power supply noise can also affect data
  - Limits are in Clause 104
PAR and 5C

• P802.3bu meets all PAR requirements and 5 Criteria
• Technically and economically feasible for the automotive market
  • This pretty much ensures economic feasibility for any other market…
• Scalable to other applications
  • Transportation
  • Industrial
  • IoT
  • Pretty much anywhere 802.3bp or 802.3bw are useful
Objectives

- Specify a power distribution technique for use over a single twisted pair link segment. (104.1)
- Allow for operation if data is not present. (throughout Clause 104)
- Support voltage and current levels for the automotive, transportation, and industrial control industries. (Table 104-1)
- Do not preclude compliance with standards used in automotive, transportation, and industrial control industries when applicable. (104.5)
- Support fast-startup operation using predetermined voltage/current configurations and optional operation with run-time voltage/current configuration. (104.3.5, Figure 104-4)
- Ensure compatibility with IEEE P802.3bp (e.g., EMI, channel definition, noise requirements). (104.5.3)
A Brisk Walk Through the Draft

• Clause 1: New definitions
  • 5 new definitions, 1 new abbreviation

• Clause 30, 45: New management sections
  • Added oPoDLPSE and Attributes to Clause 30
  • Added MDIO registers to Clause 45

• Clause 104: the heart of PoDL
  • Document structure modeled on Clause 33 (PoE)
Clause 104: Where the PoDL Lives

• Only 28 pages long (not counting PICS and Clauses 1, 30, and 45)
  • Easy reading…

• Key electrical information is in 3 sections (19 pages)
  • 104.2 Link Section (and power levels)
  • 104.3 PSE (Power Sourcing Equipment, puts power on the link)
  • 104.4 PD (Powered Device, draws power from the link)

• SCCP (analogous to PoE Classification) is broken out separately in 104.6 (7 pages)
  • SCCP is optional for Fast Mode systems (most automotive systems)
  • SCCP is a little more complicated than the rest of PoDL
    • Based on an existing industry-standard protocol
104.1: Overview

• Compatibility, relationship to the rest of 802.3
  • Specs are defined at the PI (equivalent to the MDI)
  • **All PoDL devices are compatible (they won’t damage each other)**
    • Not necessarily interoperable: see Types, below

• Definitions of PoDL Types
  • Same PoDL hardware, different coupling network bandwidth only
  • Type A: cost optimized for 100BASE-T1
  • Type B: cost optimized for 1000BASE-T1
  • Type A+B: works with both
104.2: Link Segment Section

- “Link Section” is defined in Clause 1 (originally by PoE) as a link segment that also carries power
- Specifies allowable loop resistance (matches 100/1000BASE-T1 links)
  - Compatible with 100/1000BASE-T1 links
  - PoDL isn’t sensitive to any other channel parameters
- **Table 104-1 (Class Power Requirements) lives here**
  - PoDL Class defines operating voltage and power level

<table>
<thead>
<tr>
<th>Class</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>5.5-18</td>
<td>5.5-18</td>
<td>14-18</td>
<td>14-18</td>
<td>12-36</td>
<td>12-36</td>
<td>26-36</td>
<td>26-36</td>
<td>48-60</td>
<td>48-60</td>
</tr>
<tr>
<td>Current, A</td>
<td>0.10</td>
<td>0.22</td>
<td>0.25</td>
<td>0.47</td>
<td>0.10</td>
<td>0.34</td>
<td>0.21</td>
<td>0.46</td>
<td>0.73</td>
<td>1.3</td>
</tr>
<tr>
<td>PD power</td>
<td>0.5</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>10</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>
104.3: PSE = Power Sourcing Equipment

- Puts power on the link
  - Usually located in an Ethernet switch
- .3.3, Figure 104-4: State Diagram
- .3.4: Detection details
  - How the PSE knows when to turn on the power
- .3.5: Classification overview (mostly a reference to 104.6)
  - How much power to supply
  - Classification is optional, omitted in Fast Startup mode
- .3.7: Power removal and Maintain Full Voltage Signature (MFVS)
  - When to remove power and return to Sleep or detection mode
104.3.3: PSE State Diagram

- Figure 104-4
## 104.3.6: PSE Power Details

- **Table 104-3** is the “heart” of the PSE spec: voltage, current, timing requirements

### Table 104–3—PSE output requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Min</th>
<th>Max</th>
<th>Class</th>
<th>Type</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC output voltage during POWER_ON state</td>
<td>$V_{PSE(ON)}$</td>
<td>V</td>
<td>Class $V_{PSE(min)}$</td>
<td>Class $V_{PSE(max)}$</td>
<td>All</td>
<td>All</td>
<td>See 104.3.6.1 and Table 104–1</td>
</tr>
<tr>
<td>2</td>
<td>Continuous output current capability in POWER_ON state</td>
<td>$I_{P}$</td>
<td>A</td>
<td>$P_{Class}/V_{Port-PSE}$</td>
<td></td>
<td></td>
<td></td>
<td>See Table 104–1</td>
</tr>
<tr>
<td>3</td>
<td>Output voltage dV/dt</td>
<td>$</td>
<td>dV_{PSE}/dt</td>
<td>$</td>
<td>V/ms</td>
<td>22</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
<td></td>
<td>All</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Power feeding ripple and noise:</td>
<td>$V_{p-p}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>See 104.3.6.3</td>
</tr>
<tr>
<td></td>
<td>1kHz&lt;f&lt;10MHz</td>
<td>$V_{p-p}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
104.4: PD = Powered Device

- Draws power from the link
  - Usually a leaf node: camera, industrial sensor, IoT device
- .4.3, Figure 104-6: State Diagram
- .4.4: Detection Signature
- .4.5: Classification overview (pointer to 104.6)
- .4.7: Maintain Full Voltage Signature details
  - What the PD must do to stay powered
104.4.3: PD State Diagram

- Figure 104-6
- This state diagram is pretty simple
- PDs are largely voltage-driven
104.4.6: PD Power Details

- .4.6: Power details
  - Table 104-6 has key PD electrical and timing specs

Table 104–6—PD power supply limits

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Min</th>
<th>Max</th>
<th>PD Type</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input current dI/dt</td>
<td>A/ms</td>
<td>A</td>
<td>1</td>
<td>A</td>
<td>A</td>
<td>See 104.4.6.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Input voltage dV/dt</td>
<td>V/ms</td>
<td>A</td>
<td>20</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Ripple current</td>
<td></td>
<td>A_p-p</td>
<td>100Hz/f</td>
<td>A</td>
<td>See 104.3.6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1kHz&lt;f&lt;10MHz</td>
<td></td>
<td></td>
<td>1000Hz/f</td>
<td>B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
104.5: Additional Electrical Specs

- **.5.1: Isolation requirements**
  - PD isolated from chassis ground
  - PSE isolation is optional

- **.5.2: Fault tolerance**
  - Short circuits can’t blow anything up

- **.5.3: T1 MDI Spec Modifications**
  - Revised lower limits for 100/1000BASE-T1 Return Loss specs
  - Allows for practical, compact PoDL coupling networks (smaller, lower value inductors)
  - These specs ended up in Clause 104 because the data clauses were complete when this was added
104.6: SCCP

- SCCP = Serial Communications Classification Protocol
  - Indicates PD voltage and power requirements to the PSE before it turns on the power
  - PoDL equivalent of PoE Classification pulses
  - Only works when power is off or in Sleep Mode
- Fairly comprehensive low-speed (333bps) serial protocol
  - Based on a subset of the 20-year-old Maxim 1-Wire™ serial protocol
- SCCP is optional for Fast Startup Mode (engineered network) systems
104.7: PICS

- No surprises here...

104.7.4.2 Power sourcing equipment (PSE)

<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Subclause</th>
<th>Status</th>
<th>Support</th>
<th>Value/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE1</td>
<td>Voltage and power</td>
<td>104.3.2</td>
<td>M</td>
<td>Yes [ ]</td>
<td>As defined in Table 104–1 for each relevant system class</td>
</tr>
<tr>
<td></td>
<td>requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE2</td>
<td>PSE behavior</td>
<td>104.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>In accordance with state diagram shown in Figure 104–4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE3</td>
<td>external_wakeup variable</td>
<td>104.3.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>Re-detect the PD before re-applying the full operating voltage to the PI after request is received</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE4</td>
<td>pd_wakeup variabale</td>
<td>104.3.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>Re-detect the PD before re-applying the full operating voltage to the PI after valid current signature at the PI is detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE5</td>
<td>pi_powered variable</td>
<td>104.3.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>If false, do not apply power to the PI. If True, apply power to the PI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE6</td>
<td>sleep_detected variable</td>
<td>104.3.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>Transition to SLEEP state when the average value of $I_{port}$ is less than or equal to $I_{sleep}$ threshold</td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSE7</td>
<td>wakeup_detected variable</td>
<td>104.3.3.3</td>
<td>M</td>
<td>Yes [ ]</td>
<td>TRD</td>
</tr>
</tbody>
</table>

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