



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

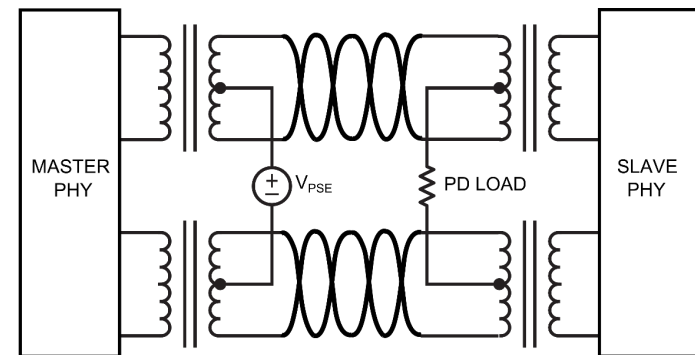
Why PoDL Matters

- 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

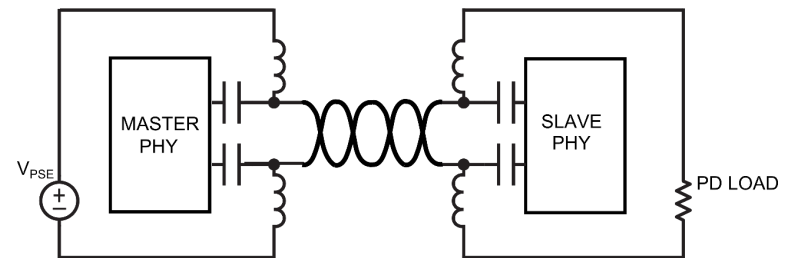


Why Can't We Use PoE?

- 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



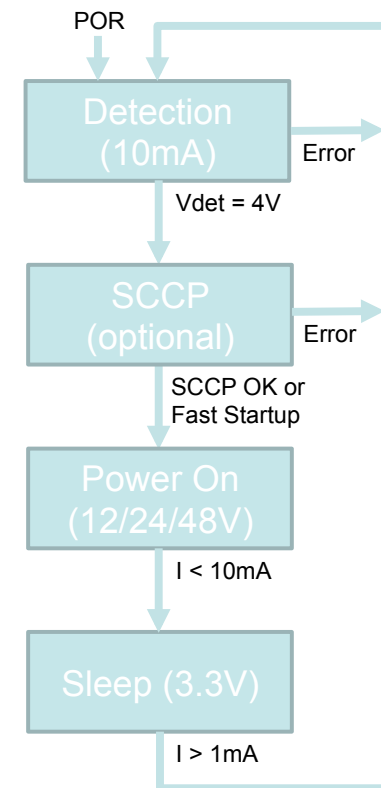
Power over Ethernet (PoE)



Power over Data Lines (PoDL)

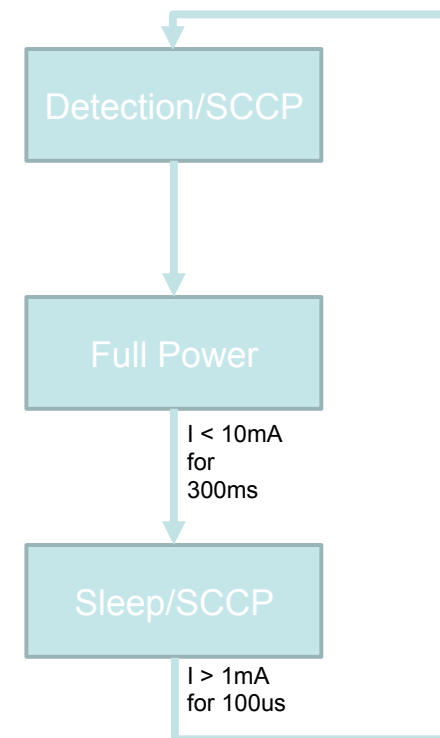
PoDL Overview for Data Folks

- 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



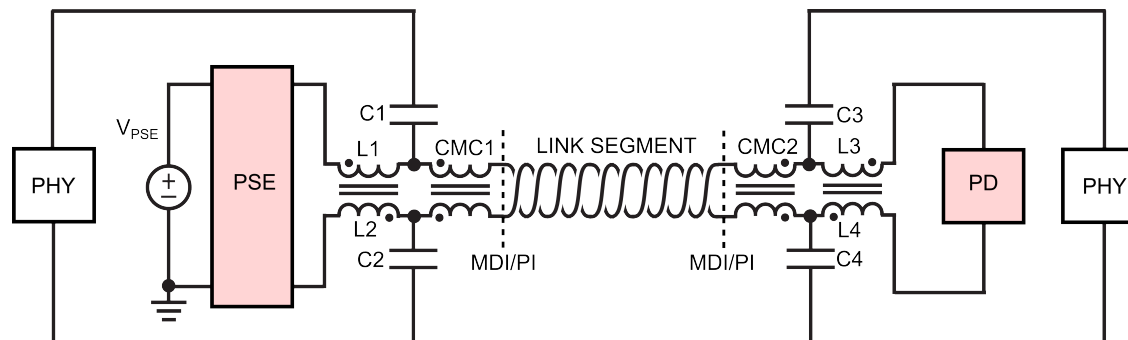
Sleep Mode

- When not providing full power, the PSE continuously provides 3.3V to the PD at <math><1\text{mA}</math>: 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

- ▶ 1. Introduction
- 30. Management
- 45. Management Data Input/Output (MDIO) Interface
- ▼ 104. Single-Pair Power over Data Lines (PoDL)
 - ▶ 104.1 Overview
 - 104.2 Link segment
 - ▶ 104.3 Power sourcing equipment (PSE)
 - ▶ 104.4 Powered Device (PD)
 - ▶ 104.5 Additional electrical specifications
 - ▶ 104.6 Serial communication classification protoc...
 - ▶ 104.7 Protocol implementation conformance stat...
- ▼ Annex 104A
 - ▶ PSE-PD Stability

- 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

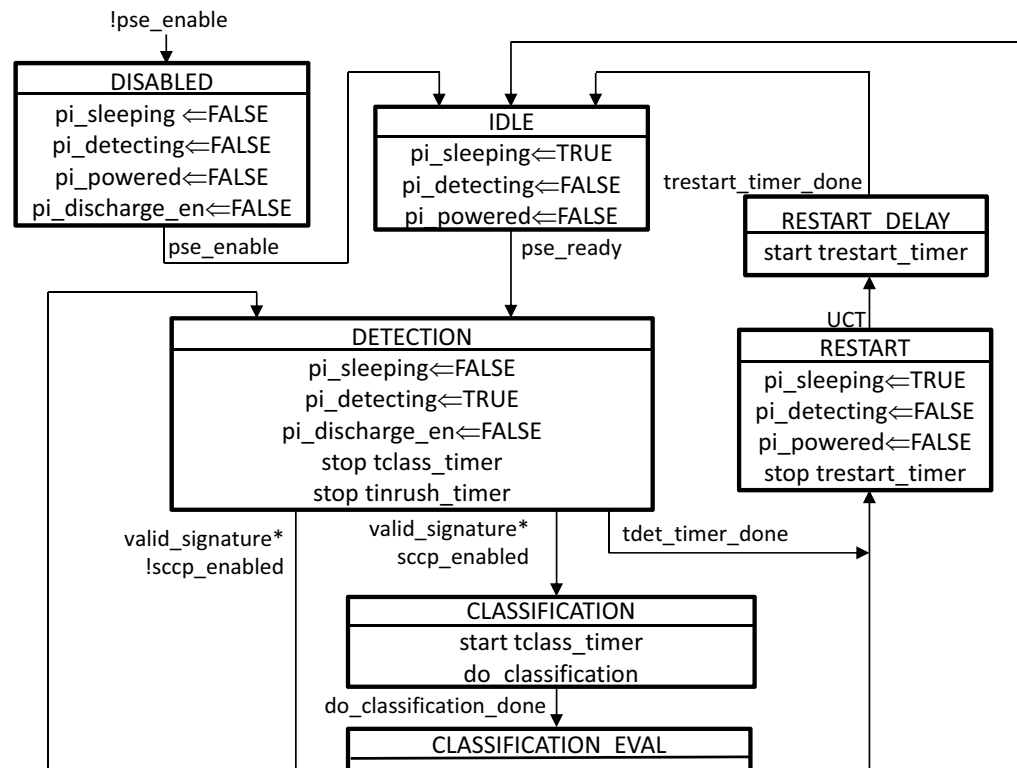
Class	0	1	2	3	4	5	6	7	8	9
Voltage	5.5-18	5.5-18	14-18	14-18	12-36	12-36	26-36	26-36	48-60	48-60
Current, A	0.10	0.22	0.25	0.47	0.10	0.34	0.21	0.46	0.73	1.3
PD power	0.5	1	3	5	1	3	5	10	30	50

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

Item	Parameter	Symbol	Unit	Min	Max	Class	Type	Additional Information
1	DC output voltage during POWER_ON state	$V_{PSE(PON)}$	V	Class $V_{PSE(min)}$	Class $V_{PSE(max)}$	All	All	See 104.3.6.1 and Table 104-1
2	Continuous output current capability in POWER_ON state		A	P_{Class}/V_{Port_PSE}				See Table 104-1
3	Output voltage dV/dt	$ dV_{PSE}/dt $	V/ms		22	All	A	See 104.3.6.1
					200	All	B	
4	Power feeding ripple and noise:							
	1kHz<f<10MHz		V_{p-p}		$\frac{0.2}{\sqrt{1 + \left(\frac{f}{50kHz}\right)^2}}$		A	See 104.3.6.3

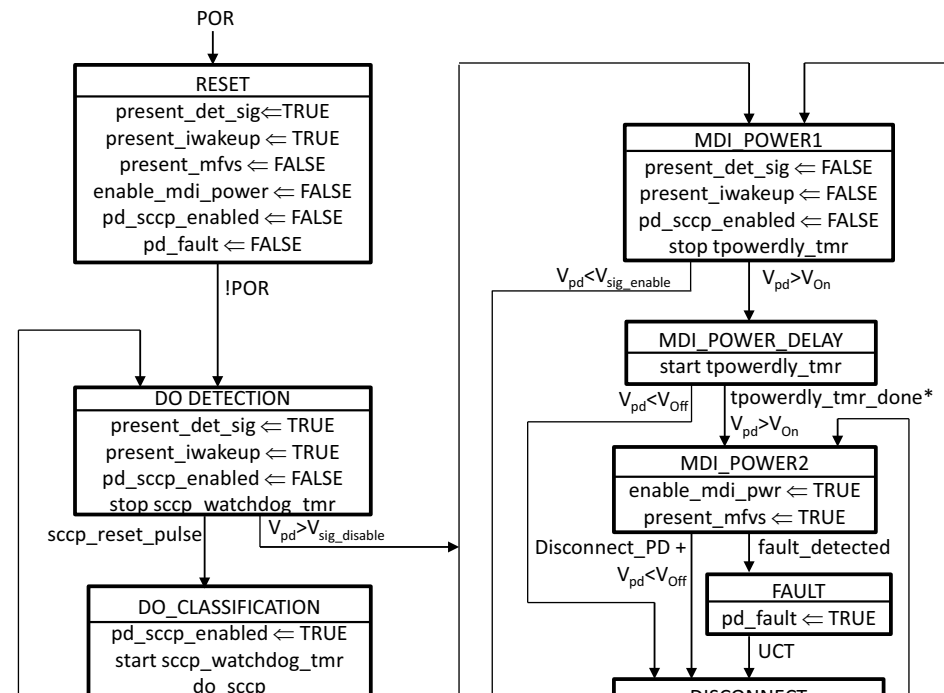
104.4: PD = Powered Device

- 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—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

Item	Parameter	Symbol	Unit	Min	Max	PD Type	Additional Information
1	Input current dI/dt		A/ms		1	A	See 104.4.6.3
					10	B	
2	Input voltage dV/dt		V/ms		20	A	
					200	B	
3	Ripple current						
	1kHz<f<10MHz		A _{p-p}		100Hz/f	A	See 104.3.6.3
				1000Hz/f	B		

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)

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

Thank You and Happy Commenting!

