Revised Wakeup and Sleep Scheme for PoDL

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Presentation Objectives

- Propose a revised wakeup and sleep scheme for PoDL that addresses concerns of economic and technical feasibility presented at the IEEE802.3bu meeting in July 2015.
- Present changes to baseline text and state diagrams required to implement the proposal.

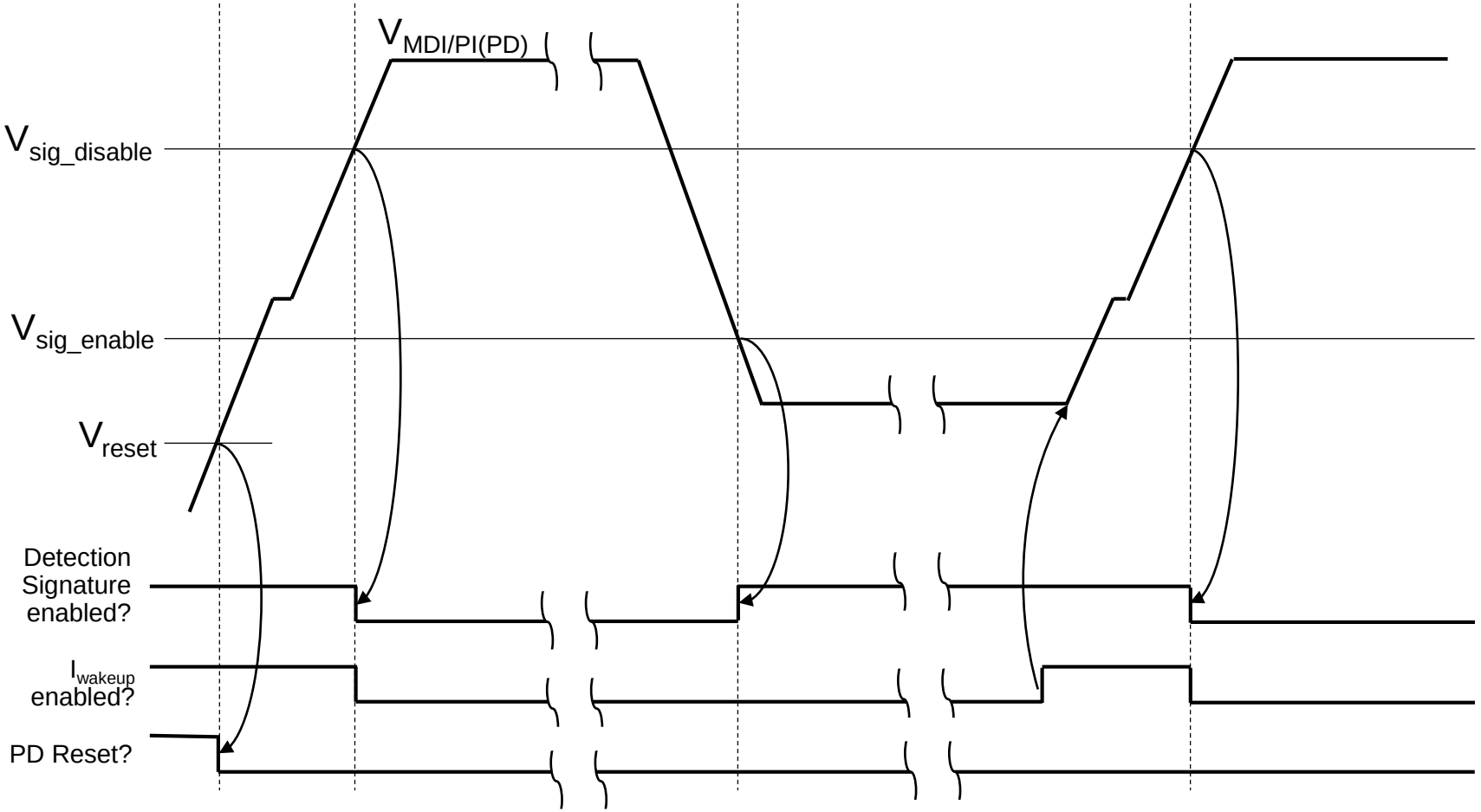
Issues with Wakeup and Sleep Scheme in D1.2

- The current sense dynamic range requirements of 500 and 300, respectively, for the proposed POWER_ON and SLEEP states are too big.
- Given the ultra-low currents that will be required by a sleeping PoDL PD, PoE style DC disconnect is not technically feasible.
- V_{Sleep} and V_{Sig} need to be defined so as to be compatible with the V_{ON} and V_{OFF} thresholds required for the unregulated 12V automotive power class.

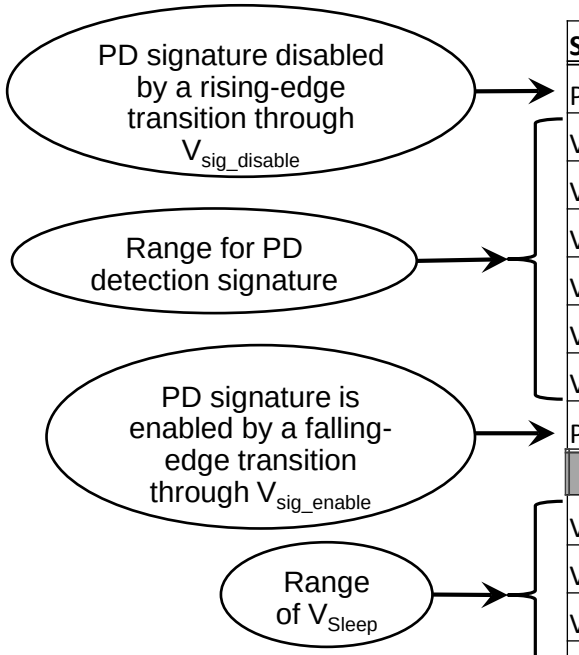
New Wakeup and Sleep Scheme Proposal

- Revert to MPS requirements that are comparable with what is currently being proposed in 802.3bt:
  - $10mA < I_{Hold}$, $T_{MPS} > 60ms$, $300ms < T_{MPDO} < 400ms$
- Instead of removing power when T_{MPDO} expires, the PSE will reduce voltage at the PI to 3.3V with limited output current.
  - This low power level should not present a hazard to the PD if it is hot-plugged.
- The PD constant voltage detection signature needs to be changed to be greater than V_{Sleep} and less than V_{ON} for the unregulated 12V class.
- The PD signature is enabled by a falling-edge through V_{sig_enable} and disabled by a rising-edge through $V_{sig\_disable}$.
- A wakeup signature current switched in shunt with the detection signature device allows a sleeping PD to request power-up.
  - A PD that is hot-plugged into a sleeping PI also presents the wakeup current when exiting RESET in order to request initial power-up.

PD Detection and Wakeup Signature Timing Waveforms



Thresholds for $V_{sig\_disable}$, V_{sig_enable}, V_{Sleep}, & Unregulated 12V Class V_{On} & V_{Off}

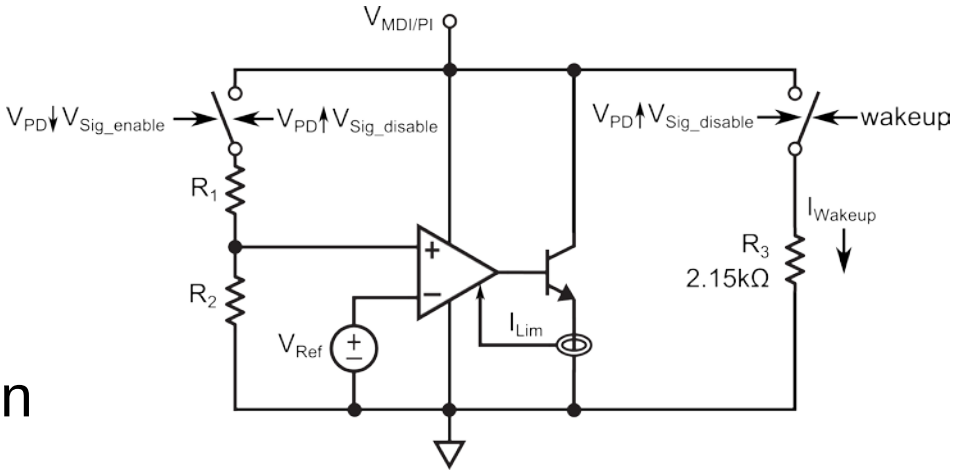


Symbol	Voltage	% from avg
PD $V_{On,max}$ 12V unreg & $V_{sig\_disable,max}$	5.75	33.7%
$V_{bad\_hi,max(PSE)}$	5.15	20%
$V_{sig,max(PSE)}$	4.7	9%
$V_{sig,max(PD)}$	4.55	5.8%
$V_{sig,nom(PD)}$	4.3	0.0%
$V_{sig,min(PD\&PSE)}$	4.05	-5.8%
$V_{bad\_low,min(PSE)}$	3.7	-9.5%
PD $V_{Off,min}$ 12V unreg & $V_{sig\_enable,min}$	3.6	-19.4%
$V_{sleep,max(PSE)}$	3.5	6.1%
$V_{sleep,nom}$	3.3	0.0%
$V_{sleep,min(PSE)}$	3.15	-4.8%
$V_{sleep,min(PD)}$	3.1	-6.1%

*See Annex A for latest power class table.

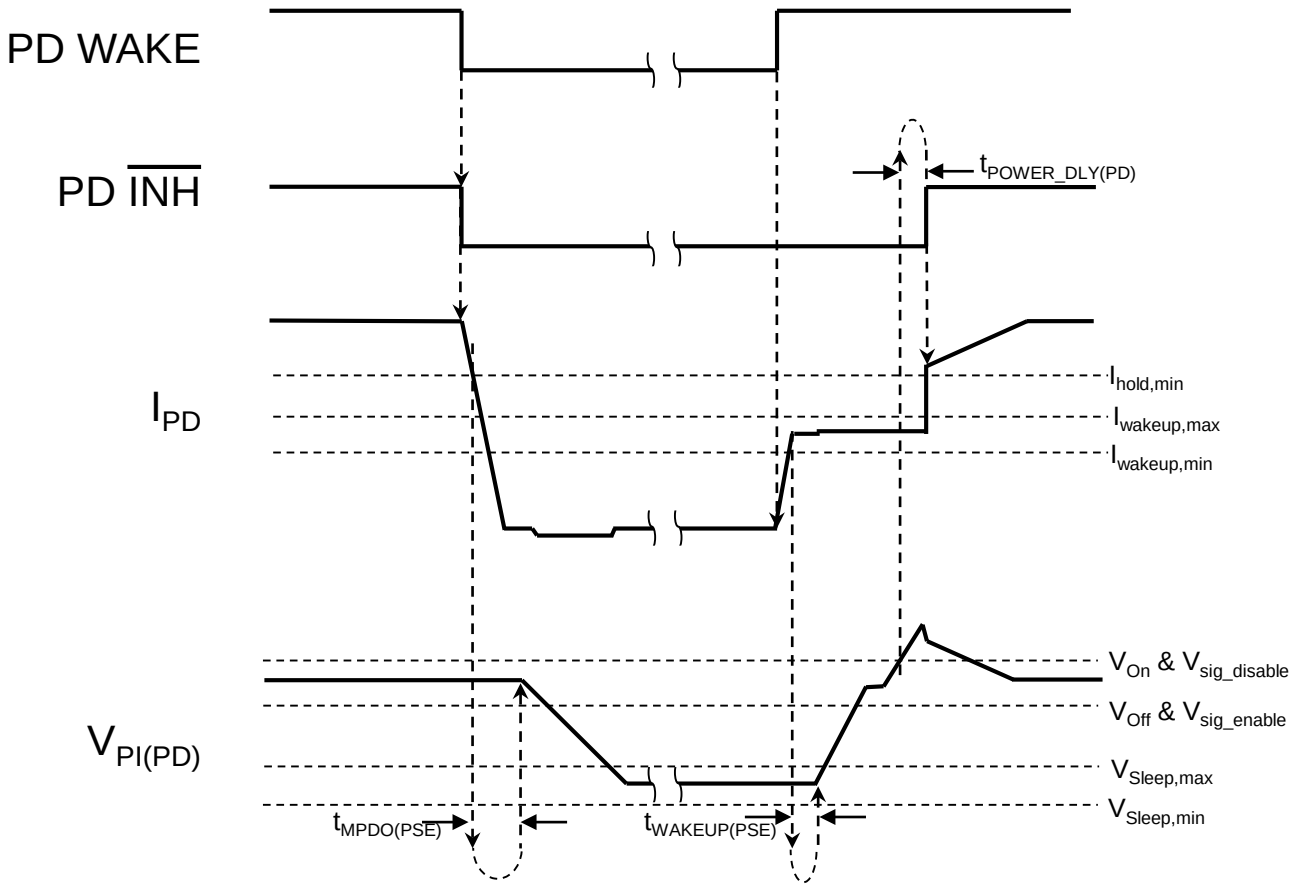
PD Detection and Wakeup Current Signatures

- Constant voltage detection signature moves from 3V to 4.3V to make room for V_{Sleep}.
- A resistor connected in shunt with the detection signature creates a wakeup current signature when a sleeping PD needs to be powered-up or when a PD exits RESET.
- Detection signature is enabled by a falling edge through V_{Sig_enable}.
- Detection signature and wakeup current signature are disabled by a rising edge through $V_{Sig\_disable}$.

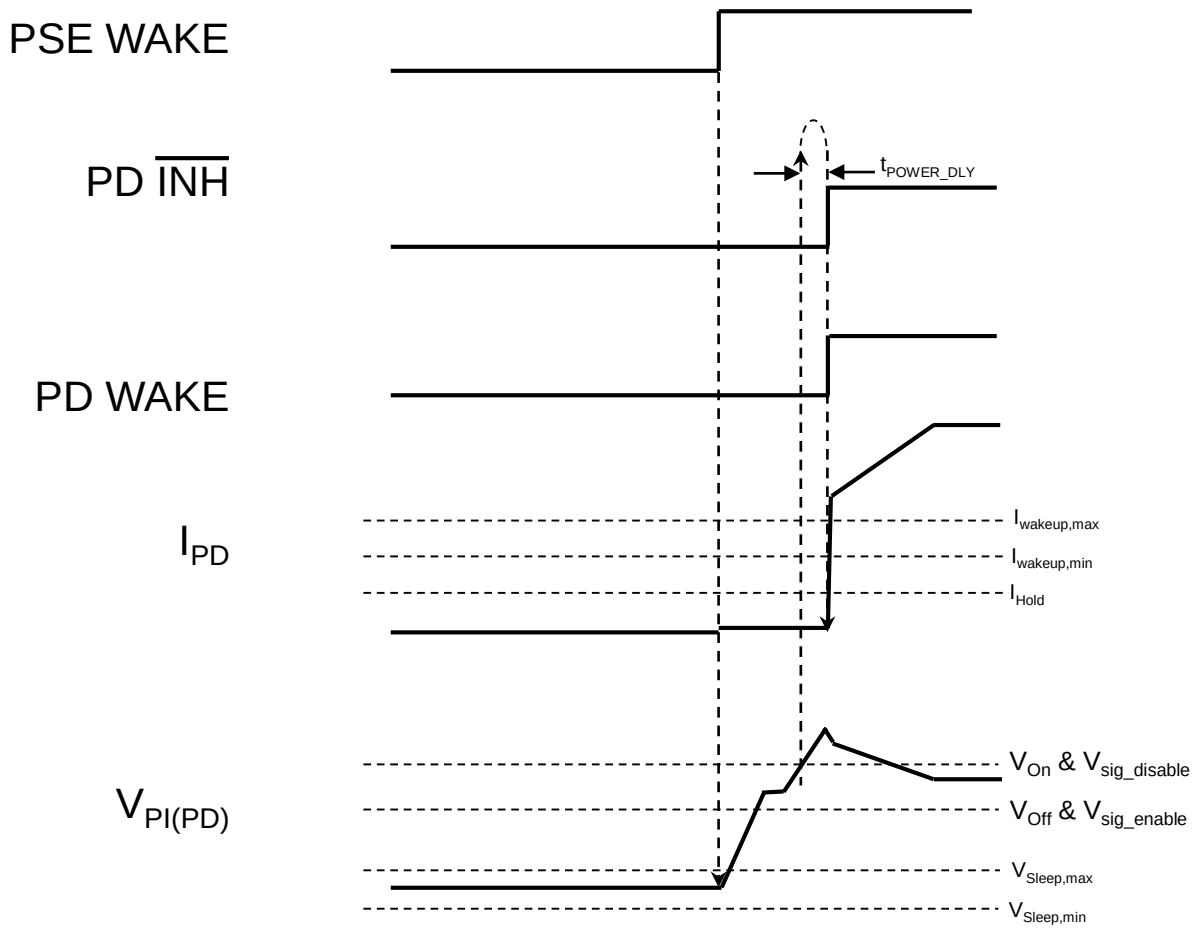


Simplified Schematic of Proposed Detection and Wakeup Signature

PD Initiated Sleep and Wakeup Transition Waveforms (Unregulated 12V Class)



PSE Wakeup Forwarding Waveforms (Unregulated 12V Class)



Proposed Changes to Baseline Text

- 104.1 Overview

  f) A method of scaling supplied ~~power~~ voltage back to the ~~detect~~ sleep level when normal operating ~~power~~ voltage is no longer requested or required.

- 104.3 Power sourcing equipment (PSE)

  - To remove normal operating voltage ~~power~~ when no longer requested or required, ~~returning to the searching state~~ transitioning to the SLEEP state

  An unplugged link segment is one instance when normal operating voltage ~~power~~ is no longer required. In addition, voltage and power classification mechanisms exist via SCCP to provide the PSE with detailed information regarding the requirements of the PD and vice versa.

Proposed Changes to Baseline Text Cont'd

- 104.3.3.1 Overview

  Prior to application of ~~power~~ of normal operating voltage at the PI, the PSE ~~shall~~ performs detection in order to verify that a valid PD is present. A PSE may communicate with the PD prior to the application of normal operating voltage using SCCP.

  After normal operating voltage has been applied, the PSE monitors the PI for a valid maintain power signature (MPS) from the PD. In the event a valid MPS is not present, the PSE reduces the voltage at the PI to the range of V_{Sleep}. If an external wakeup request is received or if a valid wakeup current signature is detected at the PI, the PSE confirms that a valid PD is still present by re-performing detection before re-applying normal operating voltage to the PI.

Proposed Changes to Baseline Text Cont'd

- 104.3.6.4 Output Current

~~A PSE operating in the POWER_ON state shall consider a PD sleep request valid if I_{Port} averaged over a sliding window t_{Sleep} wide is less than or equal to I_{Sleep} min.~~

A PSE operating in the POWER_ON state shall enter the SLEEP_SETTLE state if a valid MPS is not present at the PI.

A PSE operating in the SLEEP_SETTLE state shall discharge the PI to the range of V_{Sleep} with a current greater than $I_{discharge}$.

104.3.6.4.1 Wakeup current signature detection

A PSE operating in the SLEEP state shall consider a PD wakeup request valid if I_{Port} is ~~greater than I_{Wakeup} min~~ is in the valid range of I_{wakeup} for a minimum of t_{Wakeup} (see Table 104-3).

A PSE operating in the SLEEP state shall consider a PD wakeup request invalid if I_{Port} is greater than $I_{wakeup\_bad\_hi}$ or less than $I_{wakeup\_bad\_lo}$. A PSE may consider a PD wakeup request valid or invalid if I_{port} is in the band between $I_{wakeup\_bad\_hi}$ and I_{wakeup} max or the band between I_{wakeup} min and $I_{wakeup\_bad\_lo}$.

Proposed Changes to Baseline Text Cont'd

- 104.3.6.6 Turn off time

  The specification for T_{Off} in Table 104–3 shall apply to the discharge time from V_{PSE} in the POWER_ON state to ~~V_{Off}~~ V_{Sleep} ~~with a test resistor of *TBD* kΩ ±1% attached to the PI~~. In addition, it is recommended that the PI be completely discharged when the PSE is not enabled ~~turned off~~. T_{Off} starts when V_{PSE} drops 1 V below the steady-state normal operating voltage value after the pi_powered variable is cleared. T_{Off} ends when $V_{PSE} \leq$ ~~V_{Off}~~ V_{Sleep} max. ~~The PSE remains in the IDLE state as long as the average voltage across the PI is V_{Off}. The IDLE state is the state when the PSE is not in detection, classification, or normal powering states.~~

- 104.3.7 PSE power removal

  ~~Power shall be removed from the PSE PI in the absence of the PD Maintain Power Signature while the PSE is operating in the SLEEP state~~.

  ~~Power~~ Normal operating voltage shall be removed from the PSE PI in the absence of the PD Maintain Power Signature while the PSE is operating in the ~~SLEEP~~ POWER_ON state.

Proposed Changes to Baseline Text Cont'd

- 104.3.7.1 PSE Maintain Power Signature (MPS) requirements

~~A PSE shall consider the MPS to be present if I_{Port} averaged over a sliding window T_{MPS} wide is greater than or equal to I_{Hold} max.~~ A PSE shall consider the MPS to be present if I_{Port} is greater than or equal to I_{Hold} max for a minimum of T_{MPS}.

~~A PSE may consider the MPS to be either present or absent if I_{Port} averaged over a sliding window T_{MPS} wide is in the range of I_{Hold}.~~ A PSE may consider the MPS to be either present or absent if I_{Port} is in the range of I_{Hold}.

~~A PSE shall consider MPS to be absent if I_{Port} averaged over a sliding window TMPS wide is less than or equal to I_{Hold} min.~~ A PSE shall consider MPS to be absent if I_{Port} is less than or equal to I_{Hold} min. ~~Power~~ Voltage shall be ~~removed from~~ reduced to the range of V_{Sleep} at the PI when the MPS has been absent for a duration greater than T_{MPDO}.

Proposed Changes to Baseline Text Cont'd

Item	Parameter	Symbol	Unit	Min	Max	Class	Type	Additional Information
~~1a~~ 1	DC output voltage during POWER_ON state	$V_{PSE(PON)}$	V	Class $V_{PSE(min)}$	Class $V_{PSE(max)}$			See 104.3.6.1 and Table 104-1
~~1b~~	~~DC output voltage during sleep~~	~~$V_{PSE(SLP)}$~~	~~V~~	~~4~~	~~$V_{off(min)}$~~			
11	~~Turn off voltage~~ DC output voltage during SLEEP state	~~V_{OFF}~~ V_{Sleep}	V	~~*TBD*~~ 3.15	~~*TBD*~~ 3.5			~~*TBD*~~ See 104.3.6.6
13	PD Maintain Power Signature dropout time limit	T_{MPDO}	s	0.3	0.4			See 104.3.7.1
14	Maintain Power Signature window time limit	t_{MPS}	ms	~~90~~ 60	~~110~~			
15	MPS Current Threshold	I_{Hold}	A	0.005	0.010			
~~16~~	~~Sleep current threshold~~	~~I_{Sleep}~~	~~uA~~					
~~17~~	~~Sleep current threshold sliding window~~	~~t_{Sleep}~~	~~ms~~	~~90~~	~~110~~			
16	Valid wakeup current signature range	$I_{wakeup\_}$	mA	1.25	1.85			See ~~104.3.6.5~~ 104.3.6.4.1
17	Invalid wakeup current signature high range	$I_{wakeup\_bad\_hi}$	mA	2.5				
18	Invalid wakeup current signature low range	$I_{wakeup\_bad\_lo}$	mA		0.5			
19	Restart timer delay	$t_{Restart\_timer}$	ms	100				

Table 104-3 PSE output requirements

Proposed Changes to Baseline Text Cont'd

Item	Parameter	Symbol	Unit	Min	Max	Additional Information
1	Open circuit voltage	V_{OC}	V	~~3.5~~	~~4.5~~ 5.5	
2	Short circuit current	I_{SC}	mA	~~20~~	30	
3	Valid test probe current	I_{Valid}	mA	~~1~~ 4	10	
7	Valid PD detection range measured at PSE PI	V_{good_PSE}	V	~~2.8~~ 4.05	~~3.2~~ 4.7	
8	Invalid PD detection signature high range measured at PSE PI	$V_{bad\_hi\_PSE}$	V	5.15		
9	Invalid PD detection signature low range measured at PSE PI	$V_{bad\_low\_PSE}$	V		3.7	

Table 104-2 PSE PI detection state electrical output requirements

Proposed Changes to Baseline Text Cont'd

- 104.4.3.1 Overview

~~If the PD input voltage is less than $V_{sig\_disable}$, the PD shall present a constant voltage signature, defined in Section 104.4.4. SCCP may be used for communication between the PD and PSE when $V_{PD} < V_{sig\_disable}$.~~

~~When the input voltage exceeds $V_{sig\_disable}$, the PD shall remove the constant-voltage signature from the PI and shall wait t_{pwr_delay} before drawing power from the MDI. In the event of a PD fault or removal of the MPS, a rising V_{PD} edge through the V_{on}(max) threshold shall cause the PD to re-enable MDI power after a delay of t_{pwr_delay}.~~

A falling-edge of the PD input voltage through V_{sig_enable} enables a constant voltage signature, defined in Section 104.4.4. When the input voltage rises through the $V_{sig\_disable}$ the PD disables its constant-voltage signature.

A PD requests detection and wakeup while the constant voltage signature is enabled by presenting a valid wakeup current signature. SCCP may also be used for communication with the PD by the PSE when the constant-voltage signature is enabled.

A rising edge through the V_{On} threshold causes the PD to enable MDI power after a delay of t_{pwr_delay}. A falling edge through the V_{Off} threshold causes the PD to disable MDI power.

Proposed Changes to Baseline Text Cont'd

- 104.4.4 PD signature

  A PD shall present~~s~~ a valid detection signature when V_{PD} ~~is less than~~ drops below V_{sig_enable} ~~while it is in the DO_DETECTION state when it is requesting power via the PI, but is not powered via the PI per Figure 104–6~~. When V_{PD} rises through $V_{sig\_disable}$, a PD shall remove the current draw of the detection signature.

  ~~A PD shall present a detection signature, either valid or non-valid, at the PI.~~

  The detection signature shall consist~~s~~ of a current limited, constant voltage per Table 104–4 when measured by the PSE.

- 104.4.6.1 PD input voltage

  The PD shall operate in the ~~SLEEP and WAKEUP states~~ PD_SLEEP state with an input voltage ~~in the range of~~ greater than V_{Sleep_PD} min as specified in Table 104-6.

Proposed Changes to Baseline Text Cont'd

- 104.4.6.5 Input current

  During operation in the ~~SLEEP_PENDING and~~ SLEEP state~~s~~, the PD shall not draw current ~~averaged over a sliding window t_{Sleep} seconds wide in the range of I_{Sleep}~~ in excess of I_{Sleep} as specified in Table 104-6.

  ~~During operation in the WAKEUP state, the PD~~ A PD that requires detection and power-up shall draw current in the range of I_{Wakeup_PD} for at least t_{Wakeup_PD} as specified in Table 104-6.

- 104.4.7 PD Maintain Power Signature

  In order to maintain ~~power~~ full input operating voltage, the PD shall provide a valid Maintain Power Signature (MPS) at the PI. ~~The MPS shall draw current averaged over a sliding window TMPS wide equal to or above IHold_PD(min).~~ The MPS shall consist of current draw equal to or above I_{hold_PD} for a minimum duration of T_{MPS_PD} measured at the PD PI followed by an optional MPS dropout for no longer than T_{MPDO_PD}. PDs that do not require ~~power~~ full input operating voltage shall remove the current draw of the MPS from the PI.

Proposed Changes to Baseline Text Cont'd

Parameter	Conditions	Unit	Min	Max
V_{good}	~~1~~ 3mA<$I_{connector}$<~~10~~ 11mA, ~~$I_{connector}$ rising from 0~~ PD exiting RESET	V	~~2.9~~ 4.05	~~3.1~~ 4.55
$I_{signature\_limit}$	~~$V_{connector}$ >3.5V~~ $V_{connector}$<5.15V	mA	~~20~~	~~50~~ 20
$V_{sig\_disable}$	$V_{connector}$ rising	V	~~3.9~~	5.75
V_{sig_enable}	~~Hysteresis~~ $V_{connector}$ falling	V	~~3~~ 3.6	

Table 104-4 Valid PD detection signature characteristics, measured at PD connector

Parameter	Conditions	Unit	Min	Max
V_{bad_hi}		V	~~3.2~~ 5.15	
V_{bad_lo}		V		~~2.8~~ 3.7

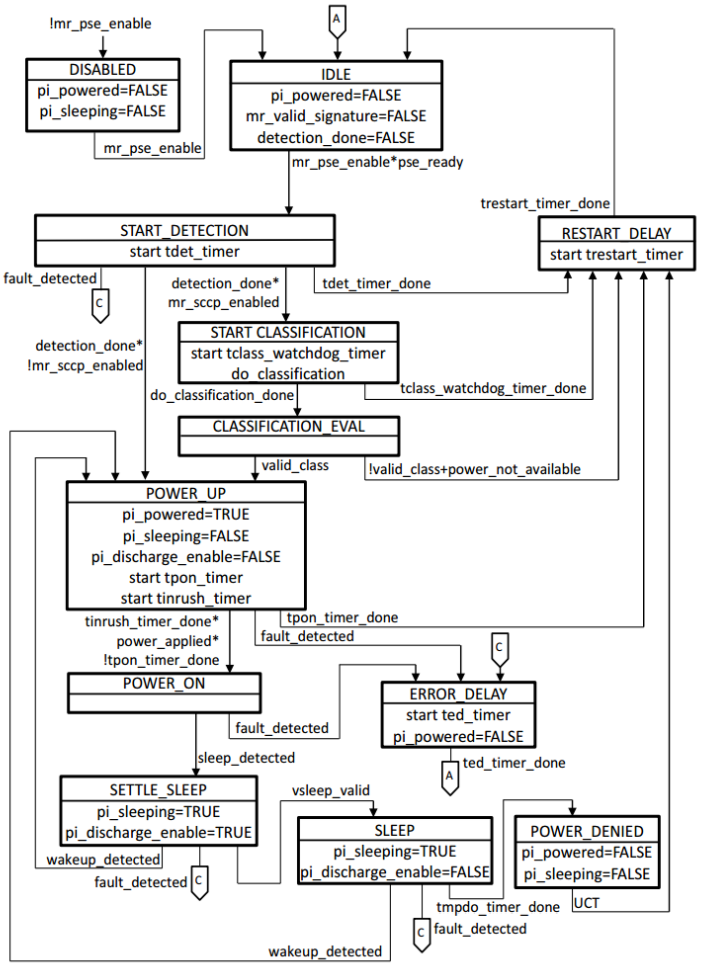
Table 104-5 Non-valid PD detection signature characteristics, measured at PD connector

Proposed Changes to Baseline Text Cont'd

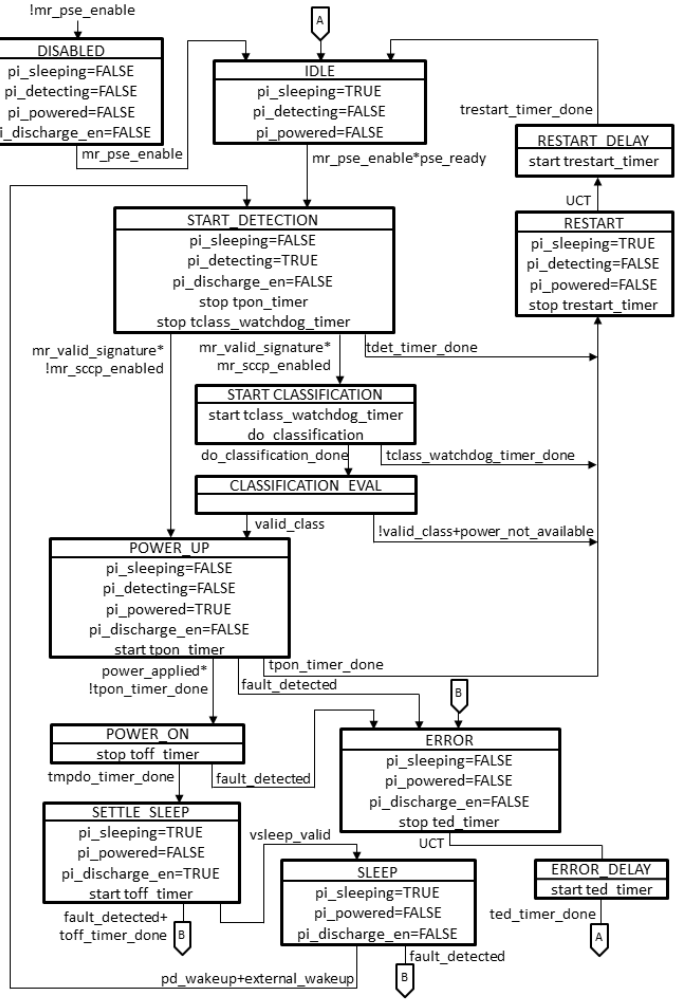
Item	Parameter	Symbol	Unit	Min	Max	PD Type	Additional Information
8	PD Maintain Power Signature time	T_{MPS_PD}	ms	75			See 104.4.7
~~8~~ 9	PD Maintain Power Signature dropout time limit	T_{MPDO_PD}	ms		250		
~~9~~ 10	MPS current threshold limit	I_{hold_PD}	mA	11			See ~~104.3.7.1~~ 104.4.7
~~10~~ 11	Power supply voltage during SLEEP ~~and WAKEUP states~~	V_{Sleep_PD}	V	~~3.9~~ 3.1	~~$V_{off(min)}$~~		See 104.4.6.1
~~11~~ 12	SLEEP state current limit	I_{Sleep_PD}	µA		100		See 104.4.6.5
~~12~~ 13	Wakeup current	I_{wakeup_PD}	mA	~~3~~ 1.3	~~10~~ 1.8		$3.1V<V_{PD}<3.5V$

Table 104-6 PD power supply limits

PSE, State Machine Changes for Proposed Wakeup and Sleep Scheme

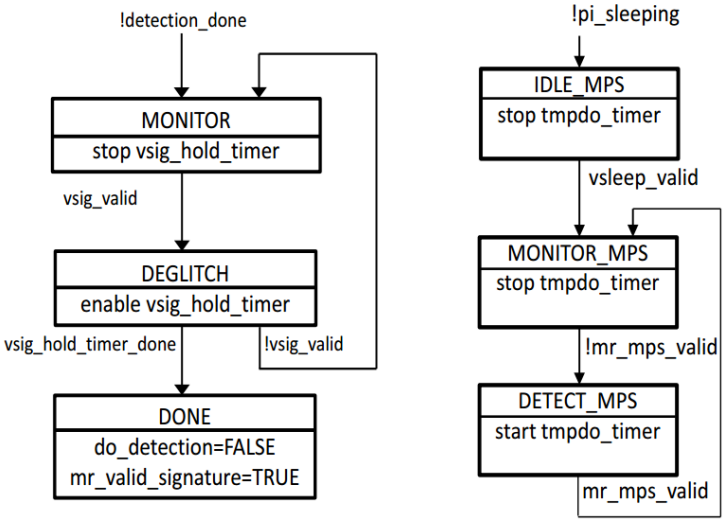


D1.2 PSE Port State Machine

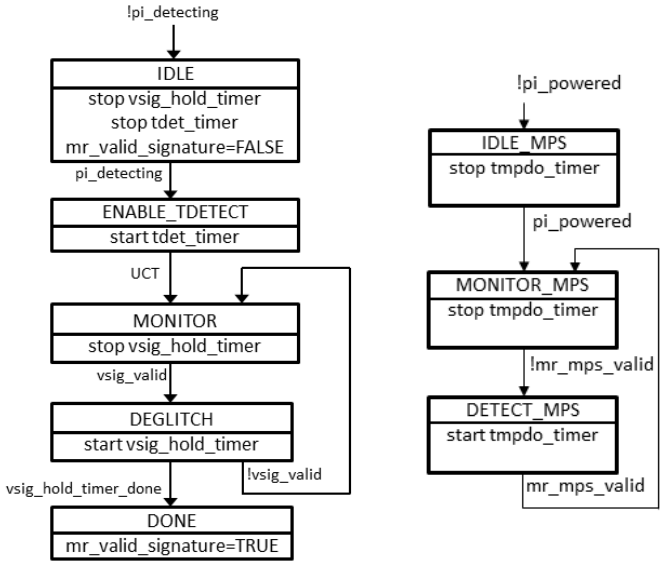


Proposed PSE Port State Machine

PSE, Detection, and MPS State Machines for Proposed Wakeup and Sleep Scheme



D1.2 Detection and MPS State Machines



Proposed Detection and MPS State Machines

New and Modified Variables for Proposed PSE State Machines

- ~~detection_done~~

  ~~A Boolean variable indicating that a valid detection sequence has been completed prior to entering the POWER_UP state. True when a valid detection sequence has been completed.~~

- external_wakeup

  A Boolean variable that indicates the PSE has received an external wakeup request and shall re-detect the PD before re-applying the full operating voltage to the PI.

- pd_wakeup

  A Boolean variable that indicates the PSE has detected a valid wakeup current signature at the PI and shall re-detect the PD before re-applying the full operating voltage to the PI.

- pi_detecting

  A Boolean variable that controls the circuitry the PSE uses to detect a valid PD signature. If true, the PSE forces a voltage limited detection current and senses the voltage at the PI in order to determine if a valid PD signature is present.

New and Modified Variables for Proposed PSE State Machines

- pi_powered

  A Boolean variable that controls the circuitry the PSE uses to power the PD. If false, the PSE shall not apply ~~power~~ the normal operating voltage to the PI (default). If true, the PSE is applying ~~power~~ normal operating voltage to the PI.

- pi_sleeping

  A Boolean variable that controls the circuitry the PSE uses to power the PD. ~~True when the PSE applies V_{Sleep} at the PI.~~ If true, the PSE is applying V_{Sleep} at the PI.

- ~~sleep_detected~~

  ~~A Boolean variable indicating that the average value of IPort is less than or equal to the ISleep threshold current and that the PSE shall transition to the SLEEP state. See 104.3.6.4.~~

New and Modified Timers for Proposed PSE State Machines

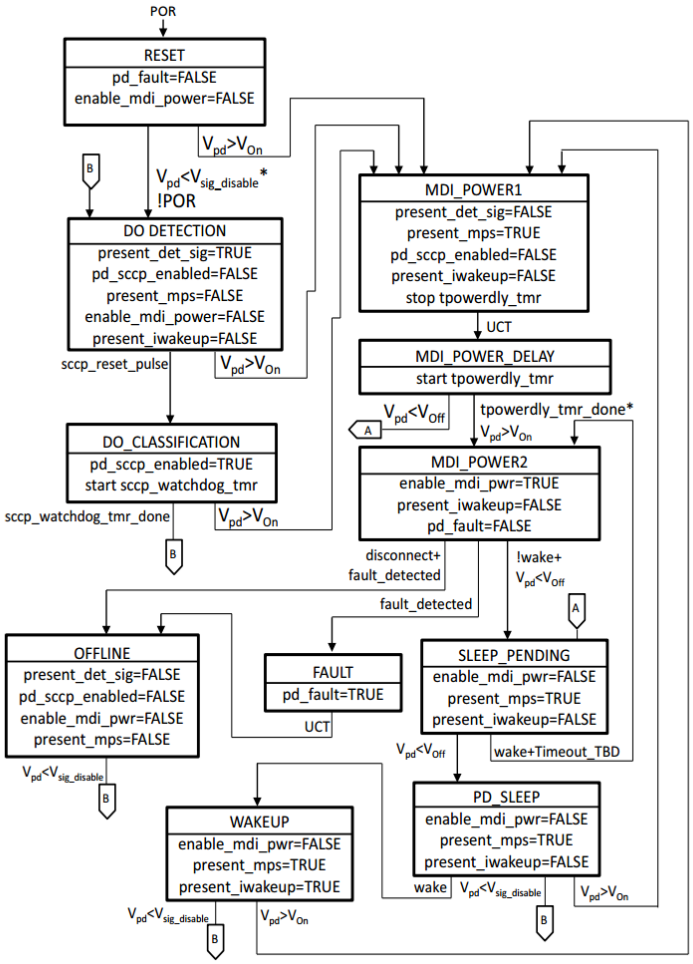
- ~~tinrush_timer~~

  ~~A timer used to monitor the duration of the inrush event.~~

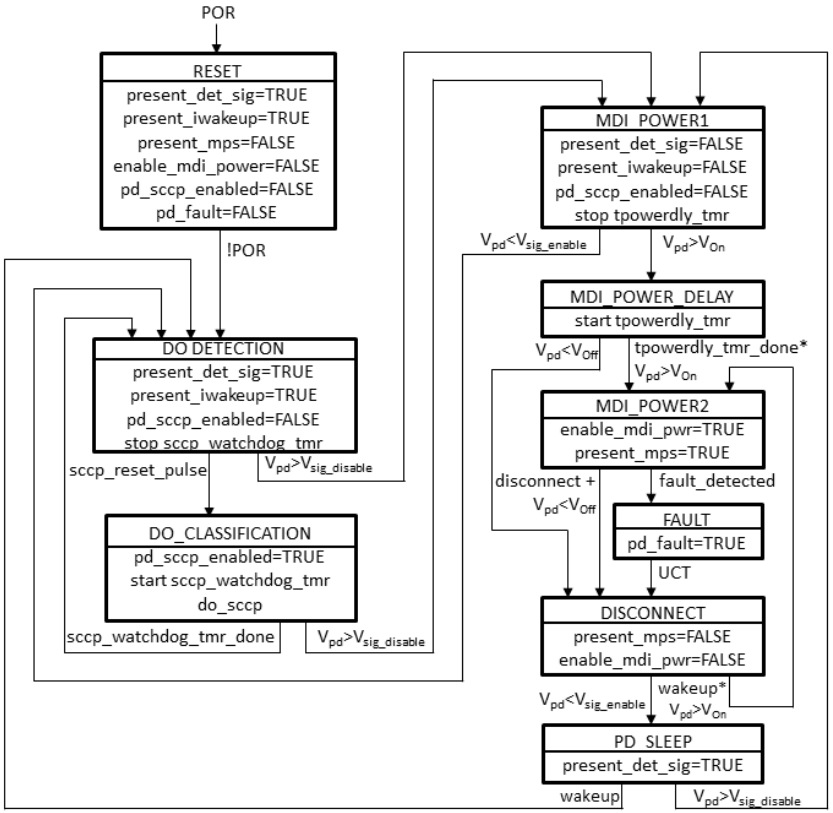
- toff_timer

  A timer used to limit the time the PSE attempt to discharge the PI to the range of V_{sleep}. If toff_timer expires during the SETTLE_SLEEP state, an error condition exists, and the port state machine enters the ERROR state.

PD State Machine Changes for Proposed Wakeup and Sleep Scheme



D1.2 PD State Machine



Proposed PD State Machine

New and Modified Variables for Proposed PD State Machine

- disconnect

  A Boolean variable that indicates a PD no longer requires ~~power~~ the normal operating voltage from the PI and has reduced its port current below the MPS threshold current, I_{Hold}.

- ~~wake~~ wakeup

  A Boolean variable that indicates when a PD requires full power at the PI and when it is ready to go to sleep. True when full power is required and false when ready for sleep.

Summary

- A proposal for a revised wakeup and sleep scheme that addresses issues raised at the July plenary meeting was proposed.
- Changes to baseline text and state diagrams were presented.

Questions?

Annex A – Proposed Power Class Table

System Class														
	12V unreg		12V reg		24V unreg		24V reg		48V unreg		48V reg		(Open)	Show in table 104-1?
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)		
$V_{PSE\_PI(max)}$ (V)[1]	18	18	18	18	36	36	36	36	60	60	60	60	-	yes
$V_{PSE(min)}$ (V)	6	6	14.4	14.4	12	12	26	26	24	24	48	48	-	no
$V_{PSE\_PI\ (min)}$ (V)[1]	5.59	5.76	14.4	14.4	11.6	11.8	26.0	26.0	23.1	23.5	48.0	48.0		yes
$R_{PSE}(\Omega)$	4	1	0	0	4	1	0	0	4	1	0	0	-	no
$I_{PI(max)}$ (A)	0.101	0.237	0.149	0.431	0.091	0.189	0.203	0.431	0.232	0.492	0.443	1.25	-	yes
$R_{Loop(max)}$ (Ω)[2]	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	-	no
$V_{PD(min)}$	4.94	4.23	13.4	11.6	11.05	10.58	24.7	23.2	21.6	20.3	45.1	39.84	-	yes
P_{VPSE} (W)	0.61	1.42	2.14	6.21	1.09	2.27	5.27	11.21	5.56	11.82	21.28	60.24	-	no
P_{PSE} (W)[3]	0.57	1.36	2.14	6.21	1.05	2.23	5.27	11.21	5.35	11.58	21.28	60.24	-	no
P_{PD} (W)[4]	0.50	1.00	2.00	5.00	1.00	2.00	5.00	10.00	5.00	10.00	20.00	50.00		yes
$K=(P_{VPSE}-P_{PD})/P_{PSE}$	0.18	0.30	0.07	0.19	0.08	0.12	0.05	0.11	0.10	0.15	0.06	0.17		no
worst case K	0.73	0.77	0.25	0.36	0.69	0.71	0.31	0.36	0.64	0.66	0.25	0.34		no
SCCP Class Code (binary)	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100-1111	no
(decimal)	0	1	2	3	4	5	6	7	8	9	10	11	12-15	no

[1] V_{PSE_PI} is the voltage measured at the PSE PI for all load conditions.

[2] R_{Loop} is the round trip link segment resistance.

[3] P_{PSE} is the maximum power the PSE is required to source as measured at the PI.

[4] P_{PD} is the power available at the PD PI.