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Discovery Thresholds

Michael Paul

TF Objectives Related to Discovery

IEEE P802.3da Objectives - continued

9. Specify optional plug-and-play power distribution over the mixing segment
10. Define a method to detect at least one MPD before applying full operating power
11. Specify device characteristics necessary to enable addition and/or removal of a node or set of nodes to a powered mixing segment with a bounded interruption

Source: 802d3da_objectives.pdf (ieee802.org)

State of Discovery in Clause 169

- Discovery state machines are described for MPSE and MPD
- Some MPSE discovery parameters are defined
  - Many TBDs
  - Need to update most parameters
- No MPD discovery parameters are defined
  - Subsection “169.5.4 MPD Discovery” is empty
    - Need descriptive text and a table
  - Various table references in the MPD state machine section are ‘TBD’
- Background presentation on MPoE Discovery
  - Paul_da_01_20230712.pdf

Discovery Objectives

- Gain telemetry before power up
  - Debug link issues
    - Overloaded link – Too much load
    - Shorted link
    - No MPDs connected / open link
    - Incompatible MPSE / MPDs
      - Some MPDs not accepting power after power-up
    - Back-fed power into PSE
    - Etc…
- Discovery is not mutual identification
- Discovery is not power negotiation
- Ensure remote experts can aid non-expert installers
  - Gain rudimentary knowledge on why power may not be working when data path is not available
  - Report exceptions up the stack for system logs
- Requires that compliant PDs respond to discovery

Discovery Implementation Requirements

- Discovery system must be
  - Low cost
  - Low risk
    - Keep wide margins between operating regions
- Proposed physical layer signaling is a modified version of PoE classification
  - Borrow approximate thresholds
  - Borrow approximate margins
  - Borrow approximate operation regions
- Necessary MPD discovery hardware
  - ~1mA Current source
  - State memory
    - 5 bits
  - Comparator
    - Shared with power on threshold
  - Timer
    - Shared with inrush backoff timer

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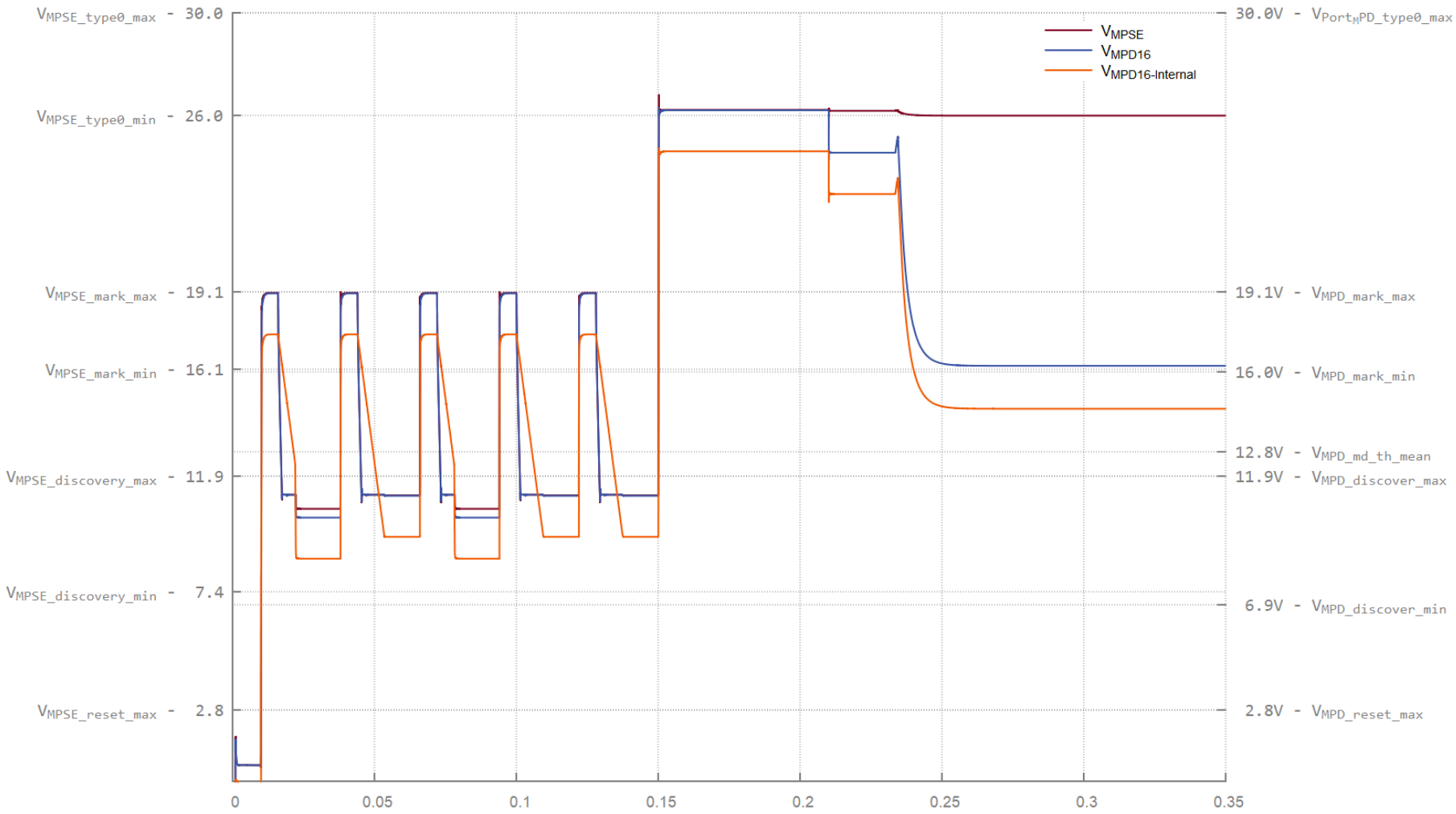
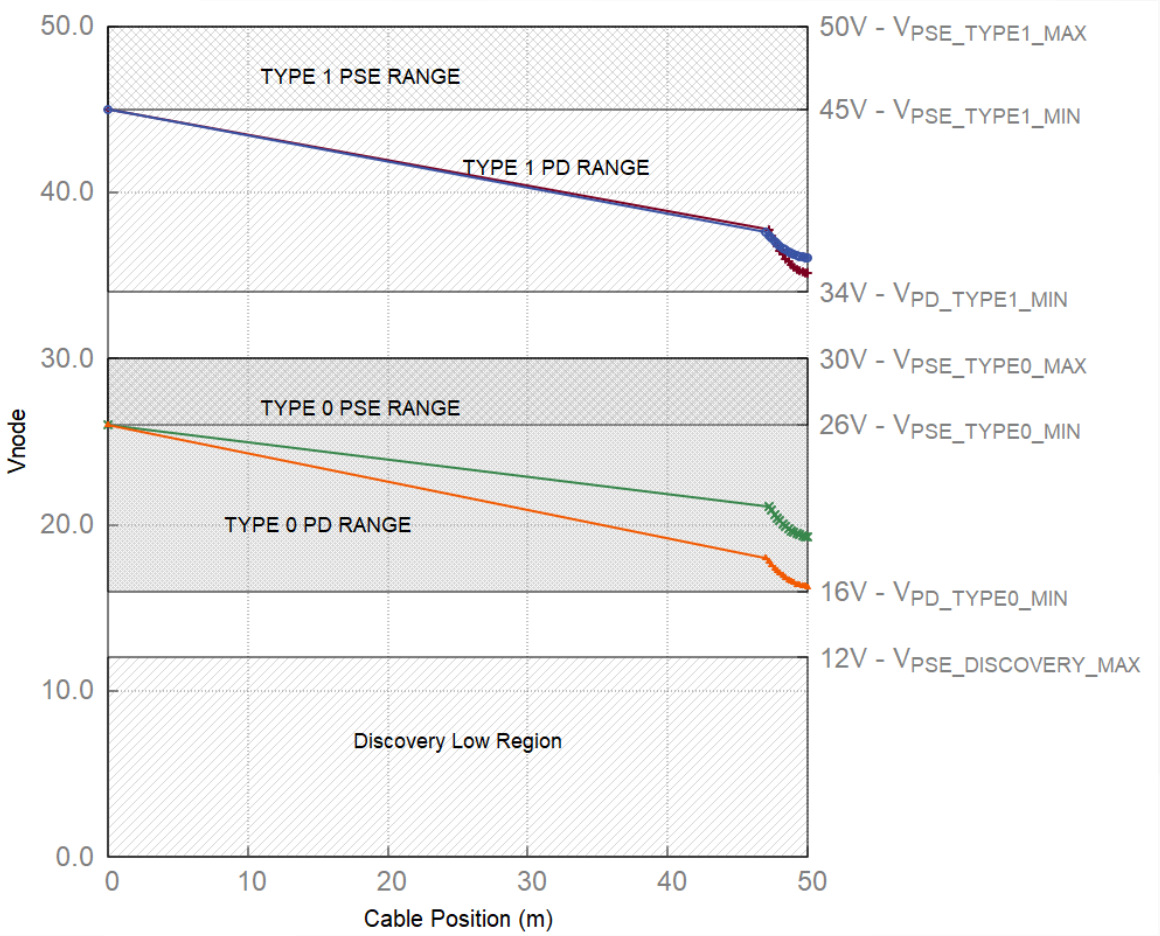
Operating Regions

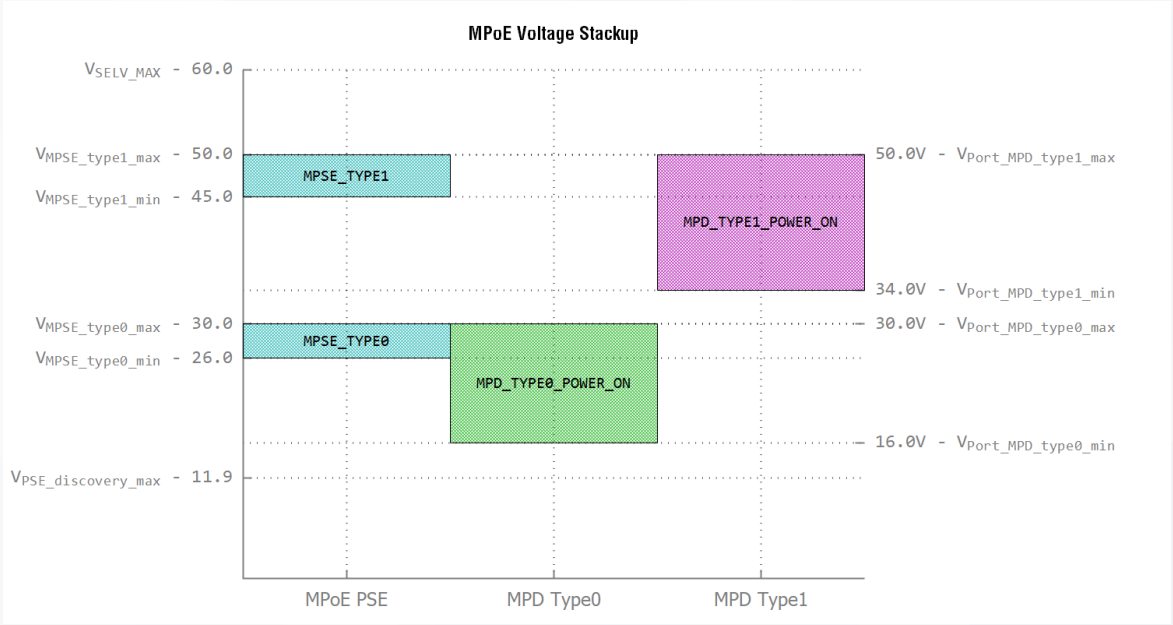
Discovery / Power-Up Transient – Type 0 System



Presently Defined Powering Regions



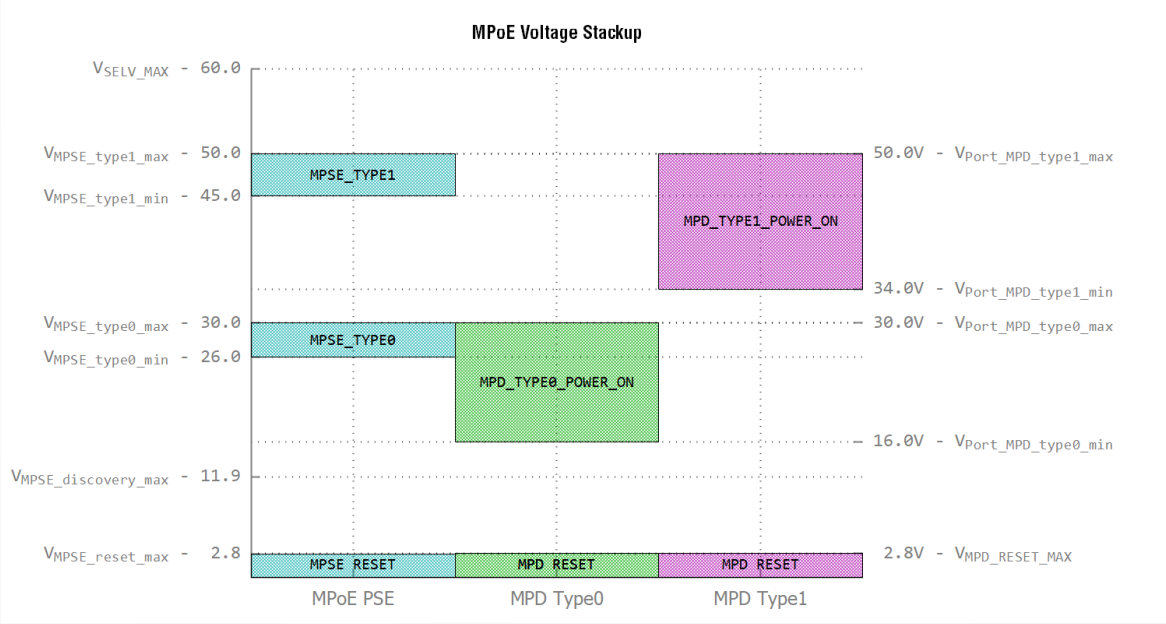
[Graph Source: mpaul-01_da_2023_11_13.pdf, slide8]



Operating regions redrawn in separate columns depending on PSE / TYPE0 MPD / TYPE1 MDP
Starting point for this presentation

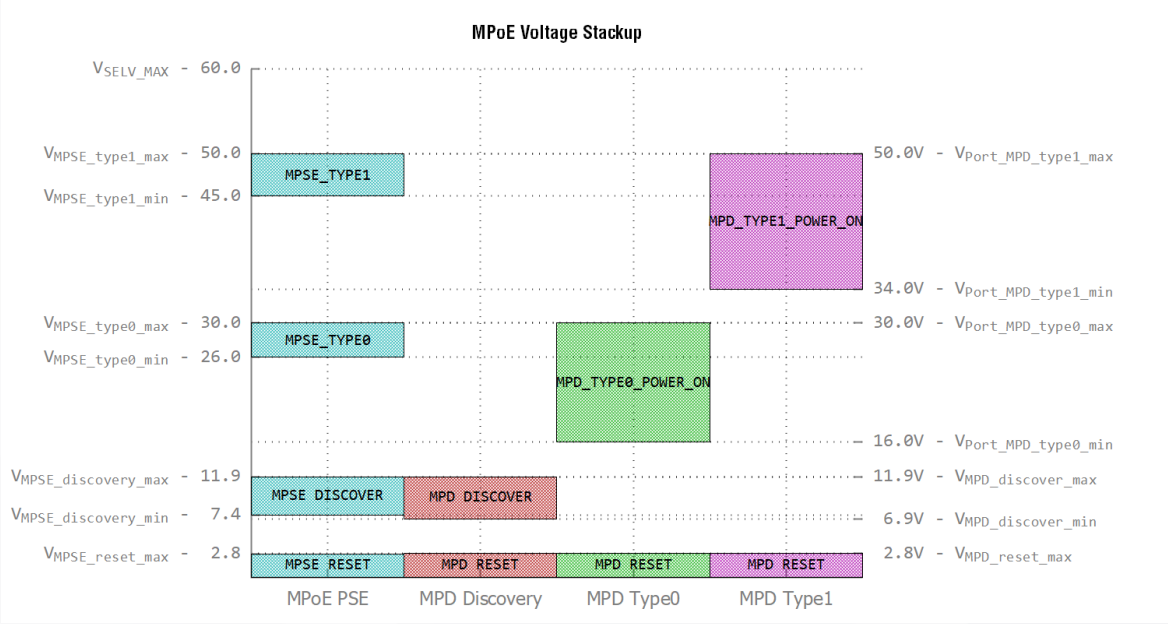
Add Reset Regions

- Use same reset thresholds as PoE
  - Clause 33 and Clause 145
- $V_{MPSE\_reset\_max}$ = 2.8V
- $V_{MPD\_reset\_max}$ = 2.8V



Add Discovery Low Region

- Add the discover low region
  - $V_{MPD\_discover}$ needs margins between $V_{Port\_MPD\_TYPE0}$ and V_{MPD_reset}
  - 4.1V Gaps to other operating regions
    - Consistent with PoE Class / Mark thresholds
- Cable Drop From PSE to MPDs
  - 16 nodes * 2mA * 12Ω = 0.288V
  - 0.5V Drop Margin allocated to cable drop in MPD_DISCOVER_LOW region



POWER_ON, HOLDOFF, and NO_POWER States (1/2)

- When MPD voltage enters $V_{Port\_MPD\_TYPE0}$ region
- MPDs wait $T_{inrush\_backoff}$ for the mixing segment voltage to settle

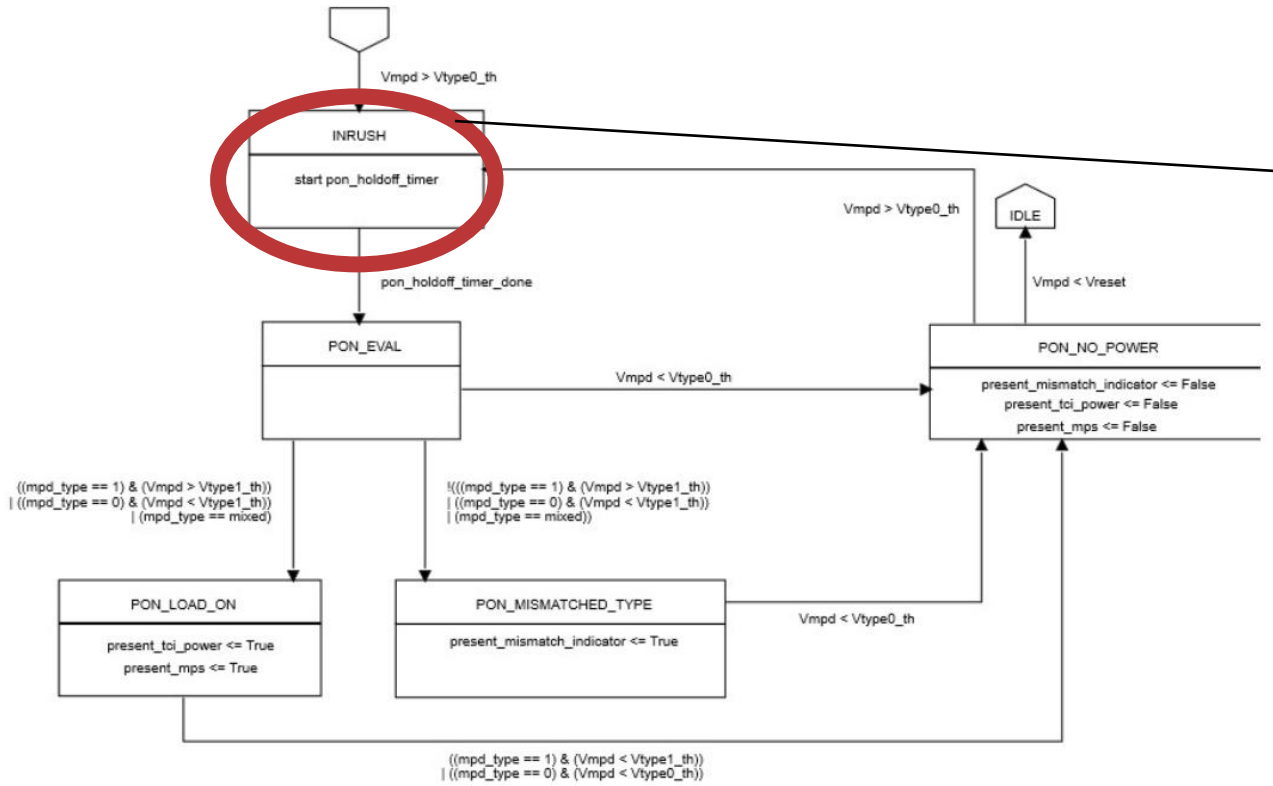
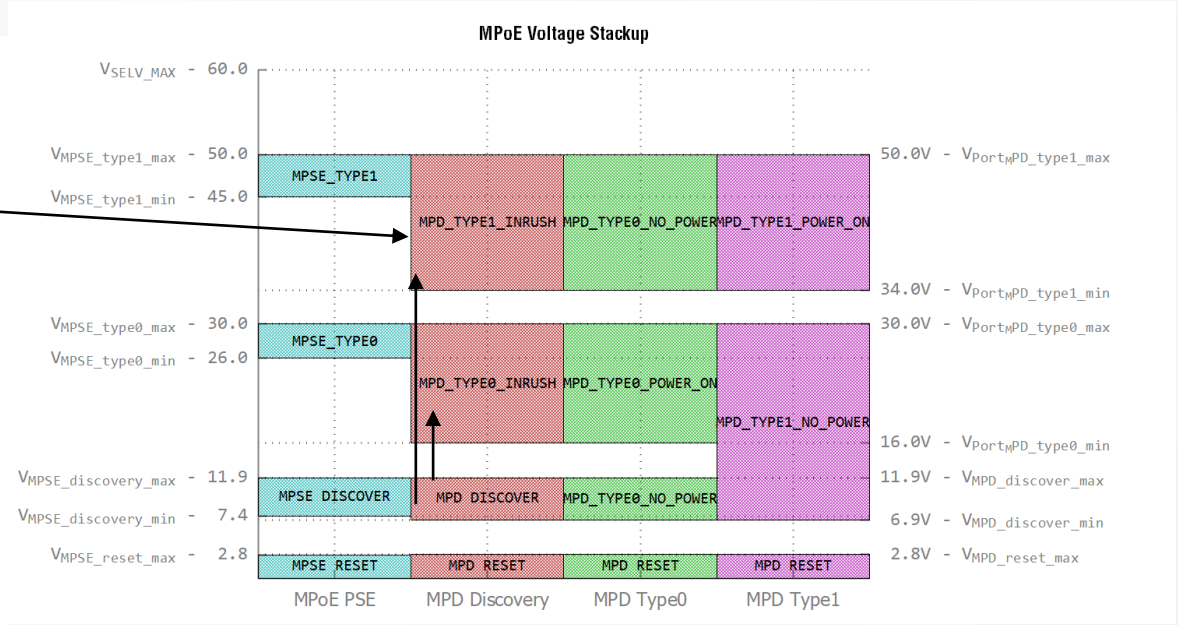
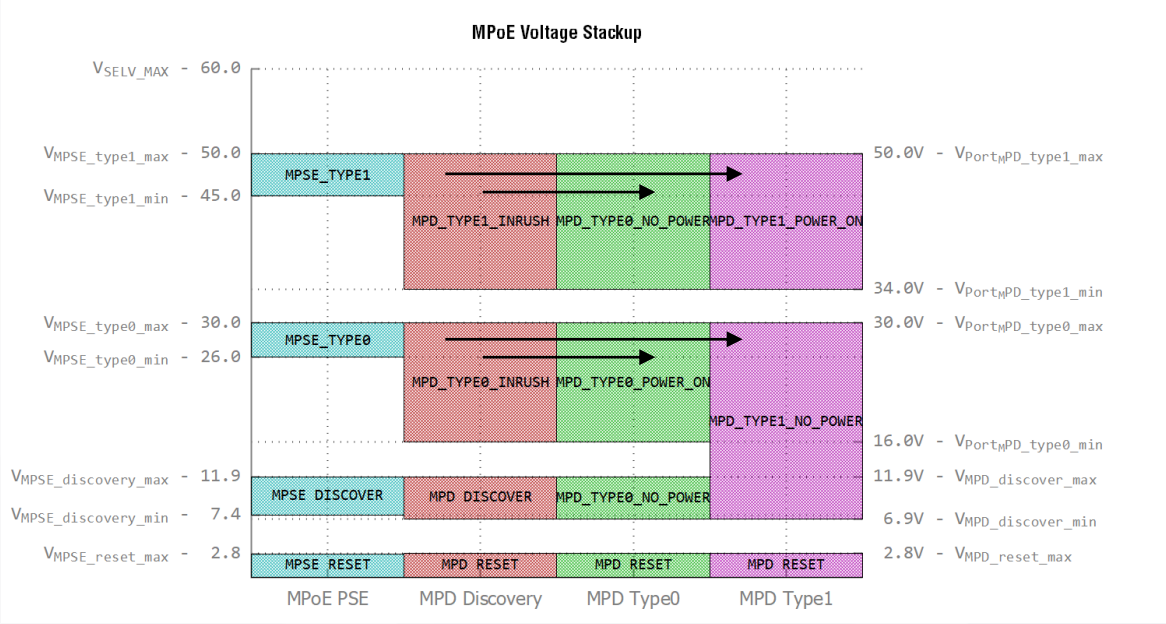


Figure 169–7—Top Level PD state diagram (continued)



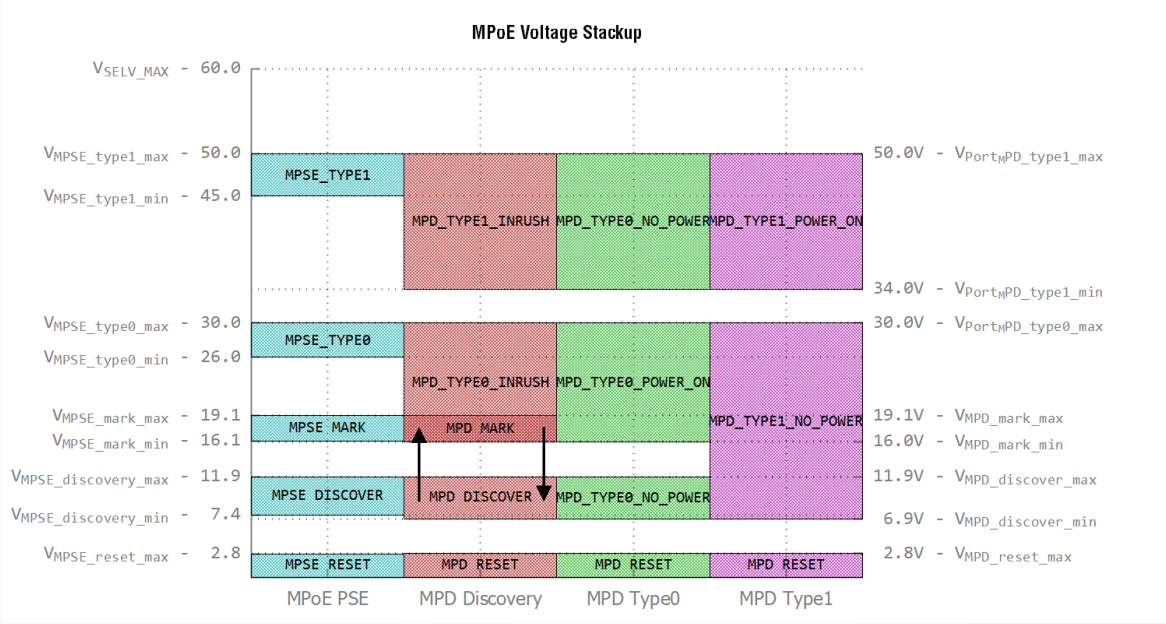
POWER_ON, HOLDOFF, and NO_POWER States (2/2)

- After $T_{inrush\_backoff}$,
  - MPDs may enter POWER_ON region and begin sourcing power
  - If the MPSE and MPD types are incompatible, the MPD enters a NO_POWER state
- Hot added MPDs will immediately enter MPD_TYPEn_INRUSH state and will not participate in Discovery



MARK region

- V_{MPD_MARK} overlaps $V_{Port\_MPD\_TYPE0}$
- Use same current draw in both states
  - I_{MPD_mark}
- $V_{MPD\_mark\_min} = V_{Port\_MPD\_TYPE0\_min}$
  - Maintain wide separation between POWER_ON and MPD_DISCOVER regions
  - Transition from MPD_MARK to MPD_TYPE0_POWER_ON after $T_{inrush\_backoff}$
- Reuse DISCOVER->POWER_ON comparator



What Cpd is really required

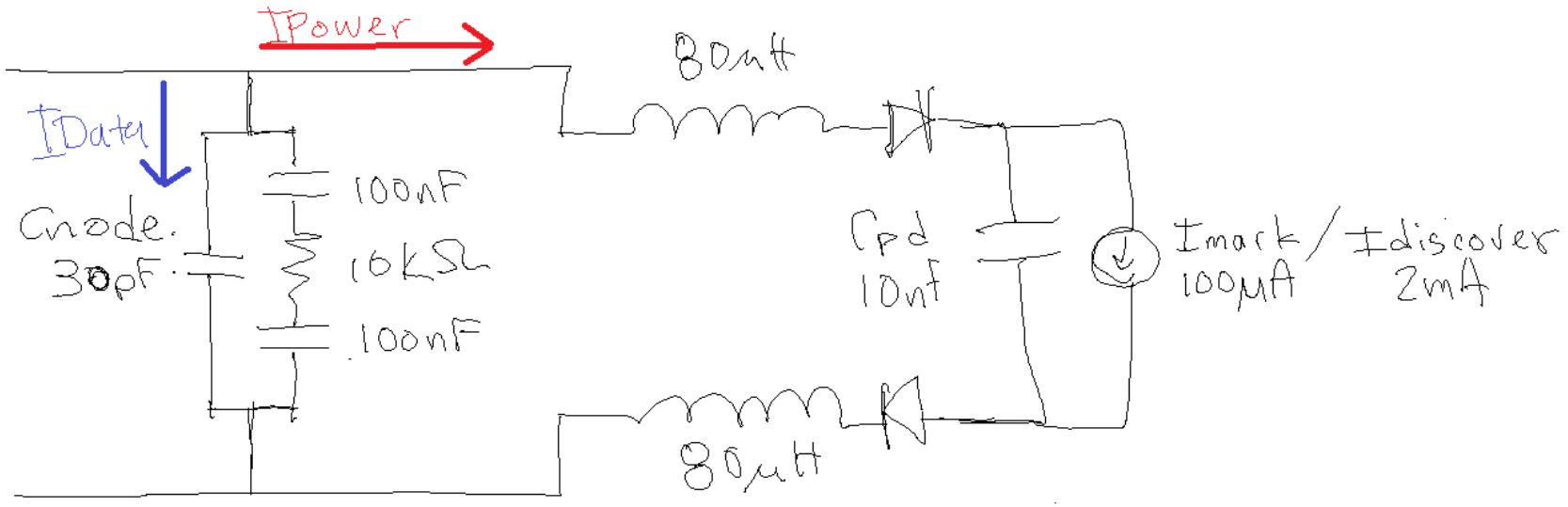
- 100nF value comes from rule of thumb
  - Really Required?
- Use 10nF instead?
  - Speed MPD Mark – Discovery discharge
  - Disturb the system less during a hot-plug event
    - Help with TF Objective 11

Discovery Settling Time

Discovery Settling Time

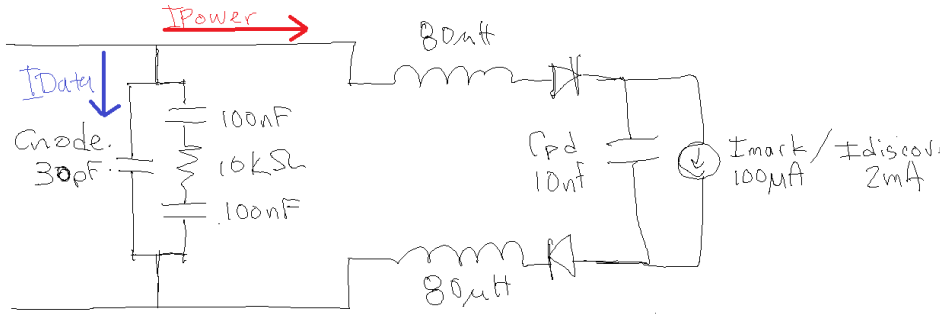
Discovery Settling Time Factors

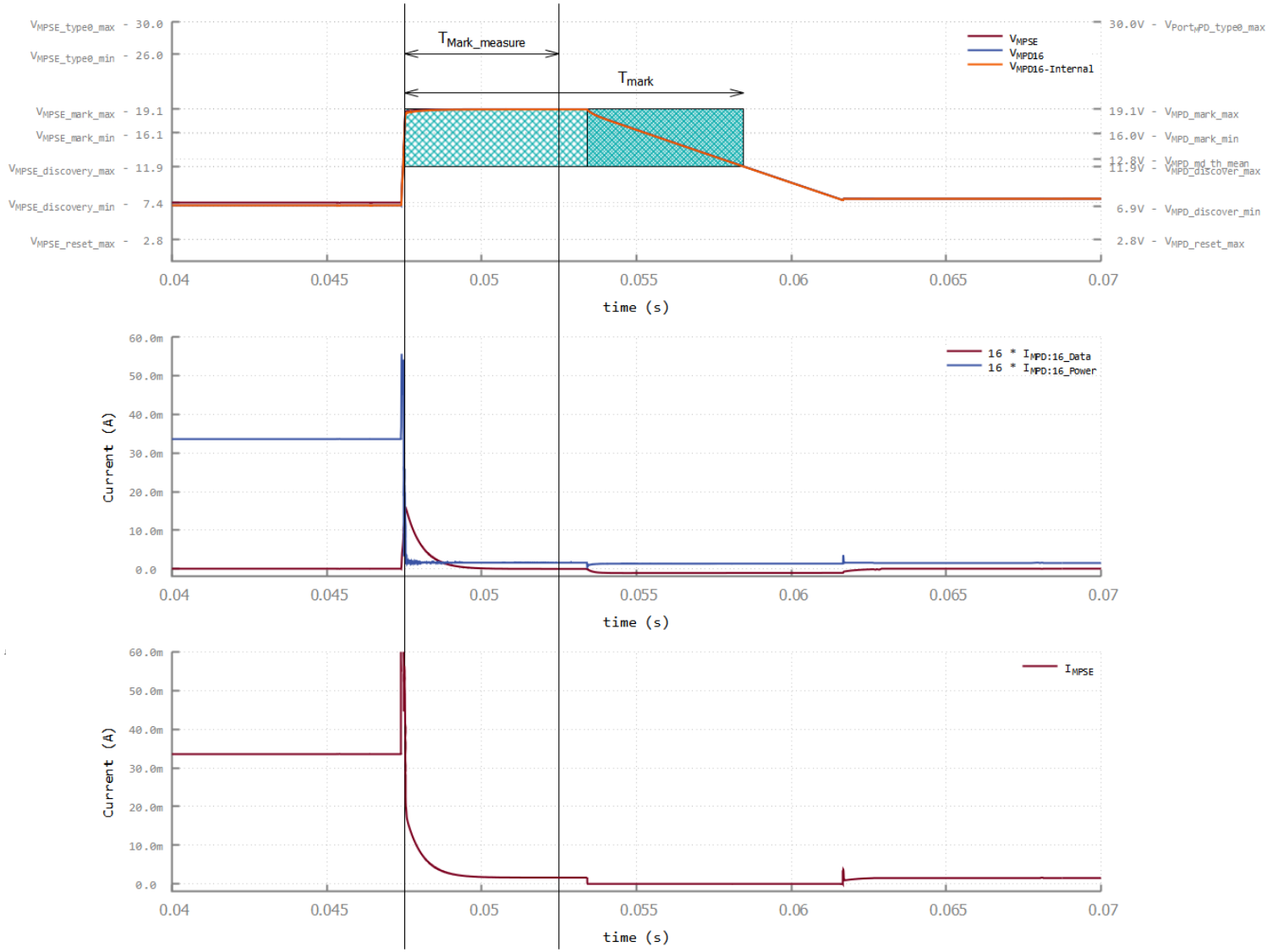
- Power Path Current
  - Cpd (10nF)
  - I_{MPD_mark} / $I_{MPD\_discover}$
  - V_{Mark} – $V_{discover}$
- Data Path Current
  - MDI Resistance (10k Min)
  - Phy Coupling Capacitance
    - 2x 100nF in series = 50nF
  - Cnode is negligible



Mark Settling Time

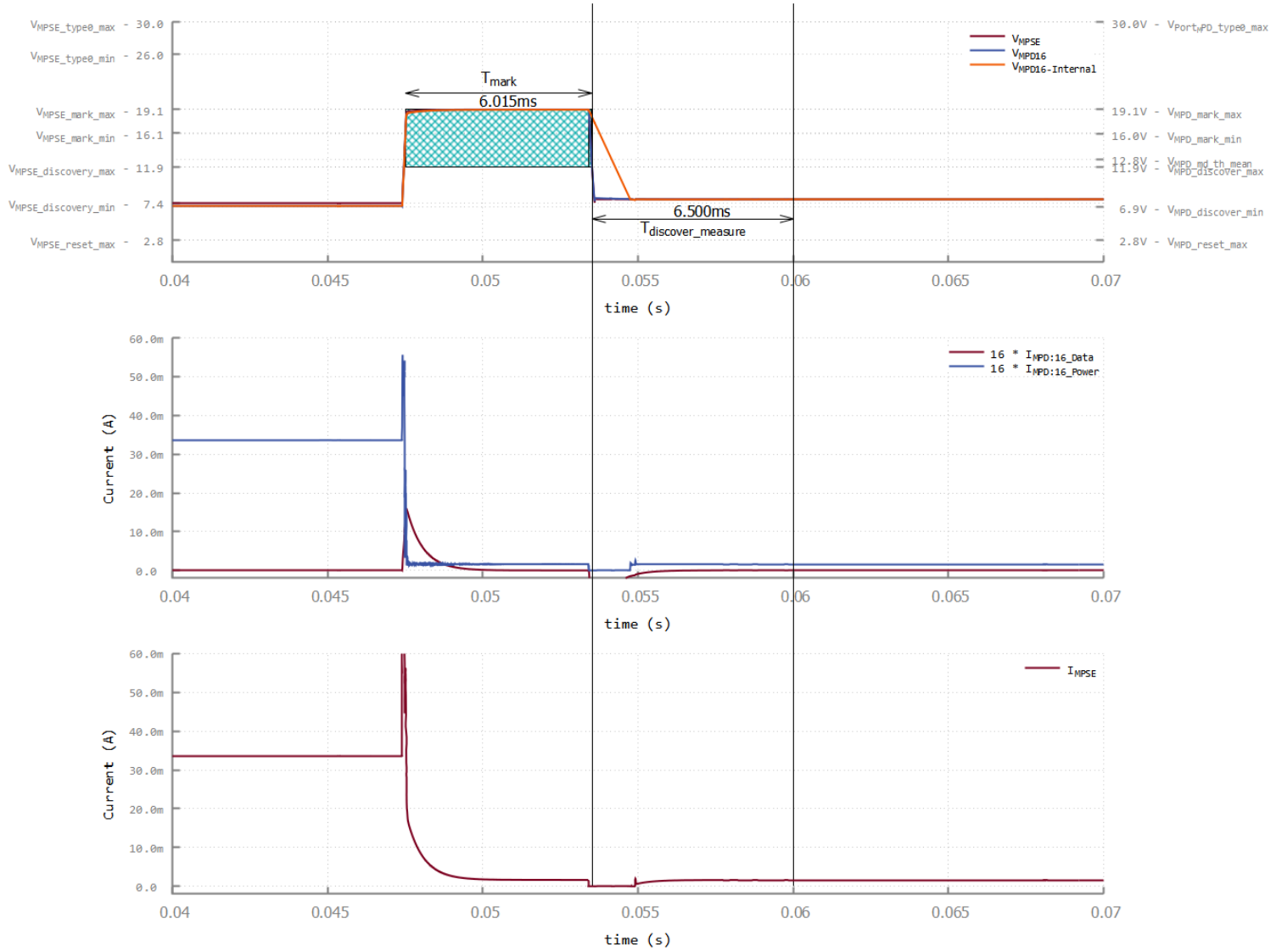
- Dominated by data path
  - t = 10kΩ * 50nF = 500us
  - Require at least 10*t so data current does not affect mark measurement
  - $T_{Mark\_measure}$ > 5ms





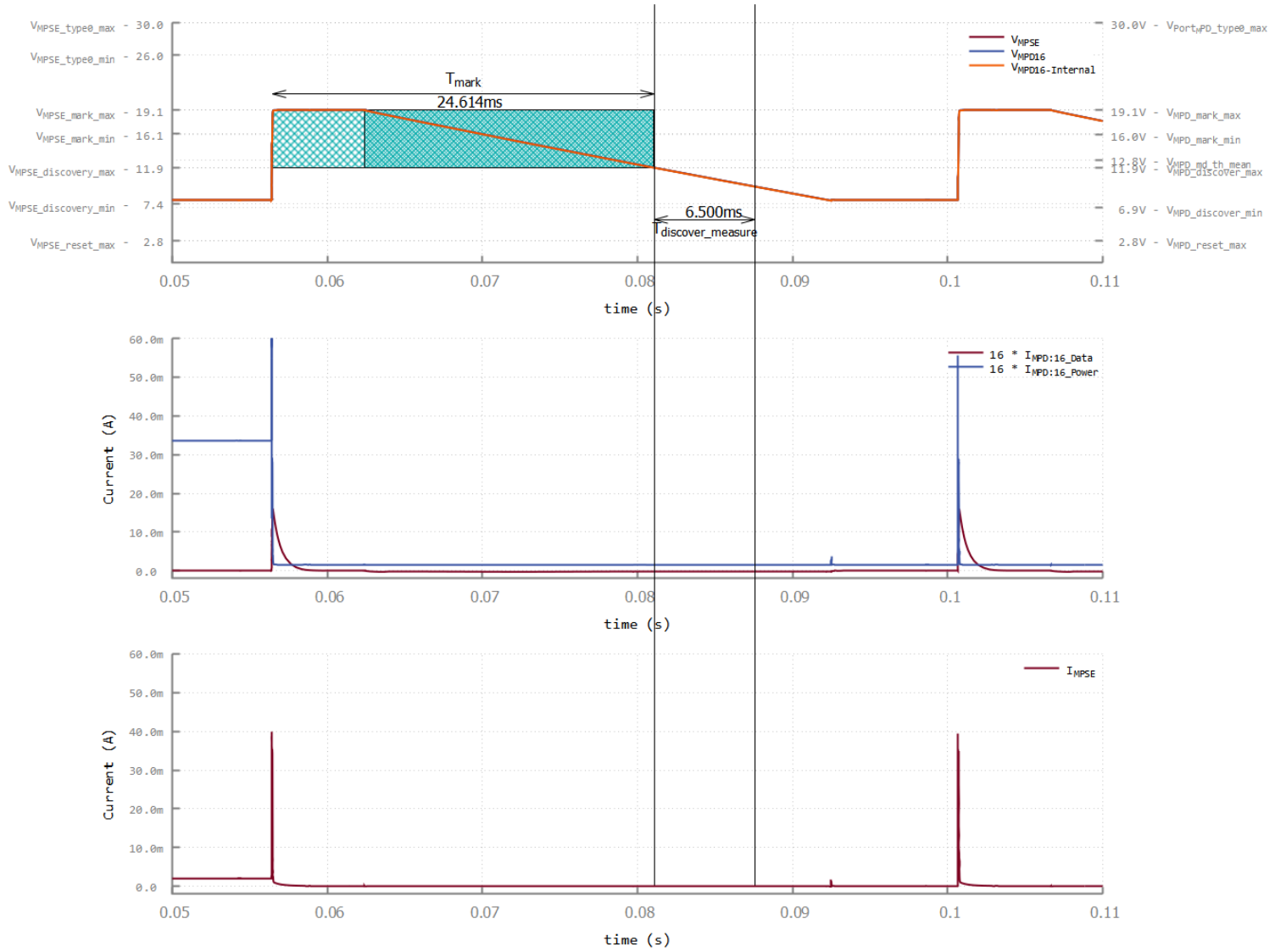
Discovery Settling Time (1/3)

- Best Case Scenario
  - Strong MPSE pull-down
- Power Path settle time
  - T = 12nF * 12.2V / 100uA =~ 1.5ms
- Data Path Settle time
  - 5ms (from previous slide)
- Set $T_{Discover\_measure}$ > 6.5ms



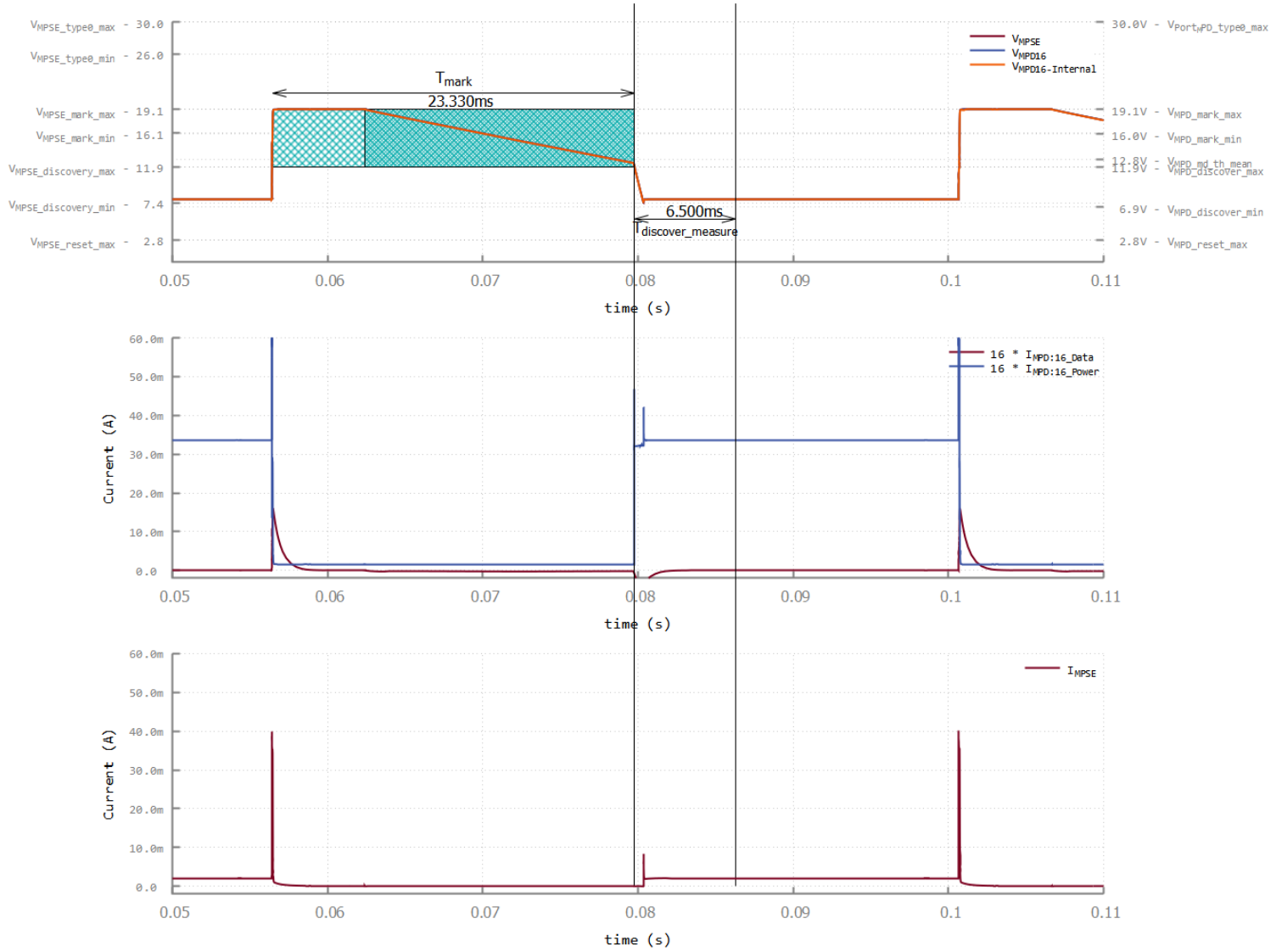
Discovery Settle Time (2/3)

- Worst Case Scenario
  - Weak MPSE pull-down
    - 1MOhm
  - 1x MPD
  - MPD sinks I_{MPD_mark}
- Power Path settle time
  - MPD discharges
    - Cpse (100nF)
    - Data Path Caps (50nF)
    - Cpd (12nF)
  - T = 162nF * 12.2V / 100uA =~ 20ms
- $T_{Discover\_measure}$ is a min. limit
  - MPSEs with weak discovery pulldown must allocate more time before measuring discovery



Discovery Settle Time (3/3)

- For Comparison
  - Weak MPSE pulldown
    - 1MOhm
  - 1x MPD
  - MPD sinks $I_{MPD\_discover}$



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Clause 169 Updates

Update "Table 169-3—MPSE Discovery Parameters"

Item	Parameter	Symbol	Min	Max	Units	Additional Information
1	Discovery high mark voltage	V_{Mark}	16.1	19.1	V	
2	Discovery low mark voltage	V_{Discovery}	7.4	11.9	V	
3	Discovery current limit	I_{Discovery_LIM}	50	100	mA	
4	Discovery high event time	T_{Discovery_high}	7	-	ms	
5	Discovery low event time	T_{Discovery_low}	20	TBD	ms	MP_NOTE: 18ms for 100nF PD settling + 2ms for measurement stabilization
6	Discovery time	T_{Discovery}	-	TBD	ms	MP_NOTE: finalize after other timing parameters are solid
7	Discovery backoff time	T_{Backoff}	150	-	ms	
8	Mark short circuit threshold	I_{Mark_short}	3	4	mA	
9	Discovery all MPD present range	I_{MPD_present}	0.8	40	mA	I_{Discovery}-I_{Mark}
10	MPD type present	I_{Type_present}	0.8	40	mA	I_{Discovery}-I_{Tare}
11	Mark Measurement Delay	T_{Mark_measure}	5	-	ms	MP_NOTE: 1ms longer than MPD mark stability time
12	Discovery Measurement Delay	T_{Discover_measure}	6.5	-	ms	Based on Mark-Discover Fall time (10nF Cpd)
13	Discovery Reset	V_{MPSE_reset}	0	2.8	V	

- Green values are changes in the table
- Using LaTeX notation where _{xx_yy} means xx_yy is subscript

Add New Table in Subsection “169.4.5 MPD Discovery”

Item	Parameter	Symbol	Min	Max	Units	Additional Information
1	Mark Event Voltage	V_{MPD_mark}	16	19.1	V	
2	Discovery Event Voltage	V_{MPD_discover}	6.9	11.9	V	
3	Mark Event Current	I_{MPD_mark}	100	200	uA	
4	Discovery Event Current	I_{MPD_discover}	1	2	mA	
5	Discovery reset threshold	V_{MPD_reset}	2.8	6.9	V	
6	MPD discovery stability time	T_{MPD_discover}	-	6	ms	MP_NOTE: Data Path and Power Path Settling
7	MPD mark stability time	T_{MPD_mark}	-	3	ms	MP_NOTE: 6*tau Data Path Settling time

Conclusion

- Discovery mark region can overlap Type 0 power region
  - Use timers to differentiate state
  - Wide margin make system easier to implement
- Settling time is dependent on power path capacitance and data path capacitance
- MPSEs with weak pull down need to budget extra settling time in discovery

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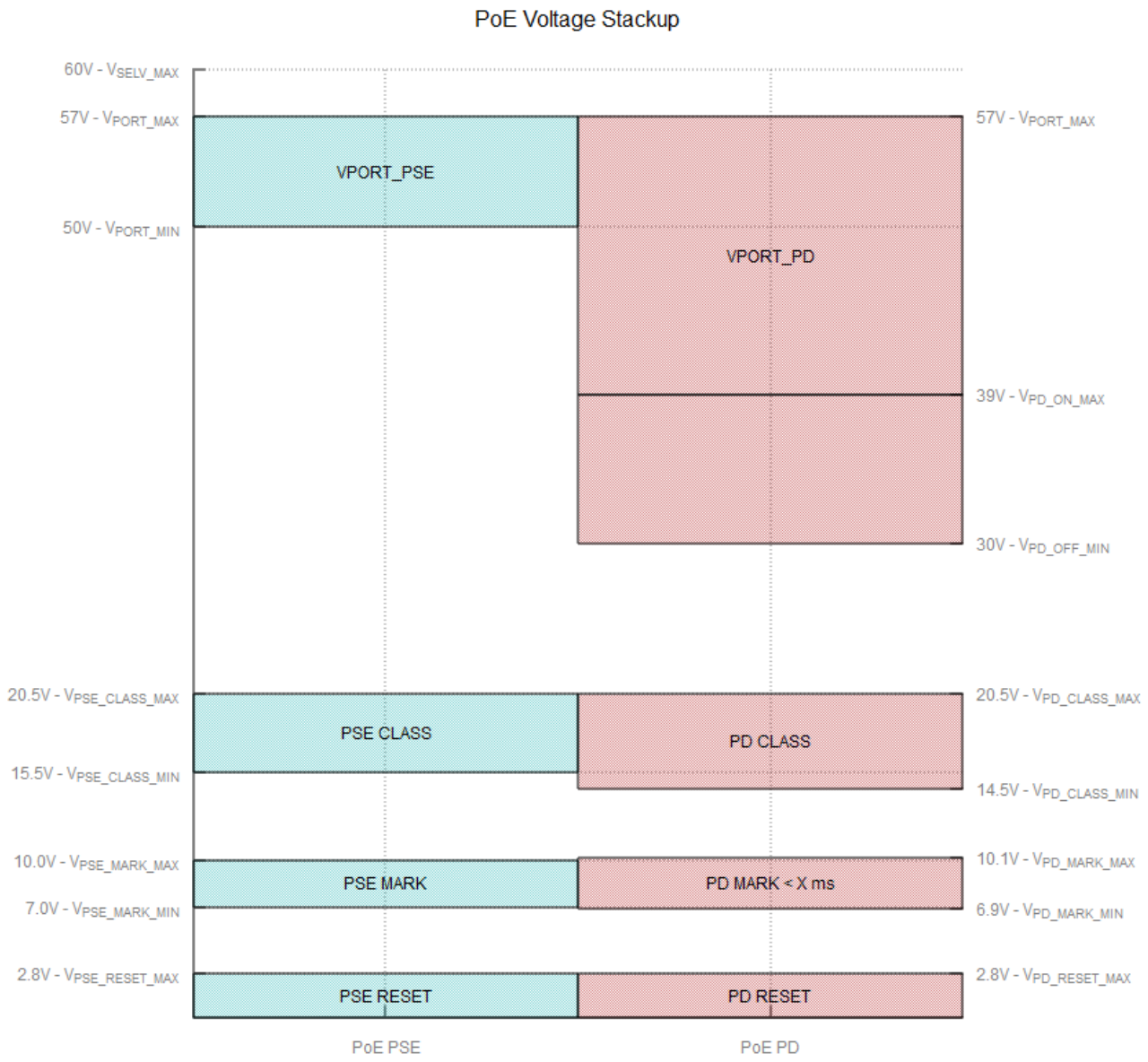
Appendix Slides

PoE Voltage Stackup (Clause 145)



Offset Sources

- Diodes
  - S1B @ -40C, 100mA
    - Vf =~ 0.9V
    - 2*Vf = 1.8V

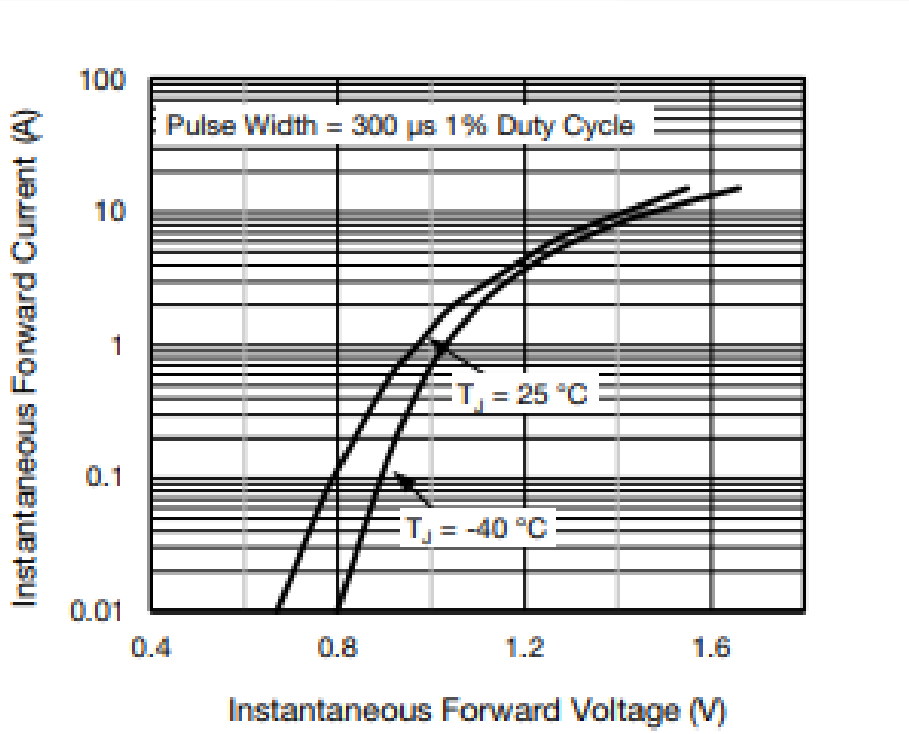


Fig. 3 - Typical Instantaneous Forward Characteristics

- Cable Offset
  - 30mA @ 12Ω
  - 0.36V
- Diodes
  - S1B @ -40C, 100mA
    - Vf =~ 0.9V
    - 2*Vf = 1.8V
- 2*Vf + Vcable = 2.26V