# IEEE802.3at Task Force

# Vport ad hoc

## Proposal for Short Circuit Curves

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# Objectives

- Flexible Implementation in PSE.
  - PSE should limit its current sourcing capability in order not to exceed the SOA curve. (Improved margins and flexibility compared to 802.3af)
- Flexible Implementation in PD (Same concept as in 802.3af)
  - For Cpd<180uF PD is not required to limit its input current else PD is required to limit its input current.
- Meeting the objective of ~30W at the PD
  - Supporting loads and applications as presented during the CFI, Study Group and Task Force and confirmed as economical and technically feasible
    - Supporting PD low frequency AC current superimposed on the DC current to allow PD load dynamics and yet utilizing full permitted average power (29.52W) (Same concept as in 802.3af)
- Keeping the same cost per watt or lower as in 802.3af
- Supporting known system corner cases scenarios (PSE dv/dt simultaneously with PD max. peak current)

# Objectives..

- Ensuring Interoperability
- Utilizing the experience gained in 802.3af concepts and saving standard developing time
  - We don’t have to invent the wheel again
  - Reuse of 802.3af concepts whenever possible
  - Corner cases should have simple solutions and should not create problems for the main project objectives such as wide application support, utilizing max. power etc.

# Summary of System Concerns

- Can we allow long term ILIM (segment 4) to be horizontal for ever
  - Pro's: It is a corner case. Design margin is required. We would like that system will decide what to do and when.
  - Con's: In case of PD or infrastructure fault, $I_{PORT} = I_{LIM\_MAX} - \varepsilon$ for ever.
    - Cabling thermal issues.
    - PSE driver, Power supply thermal issues.
    - Clear violation of max. DC current specifications
    - Liability issues
- How to allow utilizing full available PD power as derived from 720mA number at low accuracy and resolution costs of PD circuitry
  - 720mA allows 29.5W at the PD input.
- How to support PD application load current transients and variations with low cost circuitry, and yet allowing max. 29.5W average to be used.
  - 15% circuits accuracy and max. AC load changes of 100mApp (total of Icut_max=823mA peak) at low frequency up to 50msec and 5% duty cycle max allow meeting this objective. This concept is already successfully used in 802.3af

# Summary of System Concerns..

- How to support Inrush Current due to PSE dv/dt simultaneously with PD application load peak current when PSE implements constant current limit protection.
  - Example for a corner case which the net charging current may be zero so Cpd will not be able to be charged by dv=7V within TLIM_MIN.
  - *Solution A:* Max. Load PD current should be Icut_min = 720mA peak.

    ➔ Average DC current < 720mA by ~ 15% due to circuit and application tolerances.

    ➔ Max. Power <= 25W..
  - *Solution B*: The same concept as in 802.3af: Max Load PD current should be Icut_max for 50msec. 5% duty max. PSE vendor will set its ILIM>Icut_max and TLIM_MIN to support PSE dv/dt inrush current.
  - *Solution C*: Similar to 802.3af concept i.e. ILIM_MIN=ICUT_MAX and TLIM_MIN>50msec:
  - *Solution D*: Both options B and C are valid since it is PSE vendor decision which is not PD dependent decision.

# Detailed Derivation Of the curve

# SOA

802.3at PSE/PD short circuit behavior. See separate drawing for startup behaviour

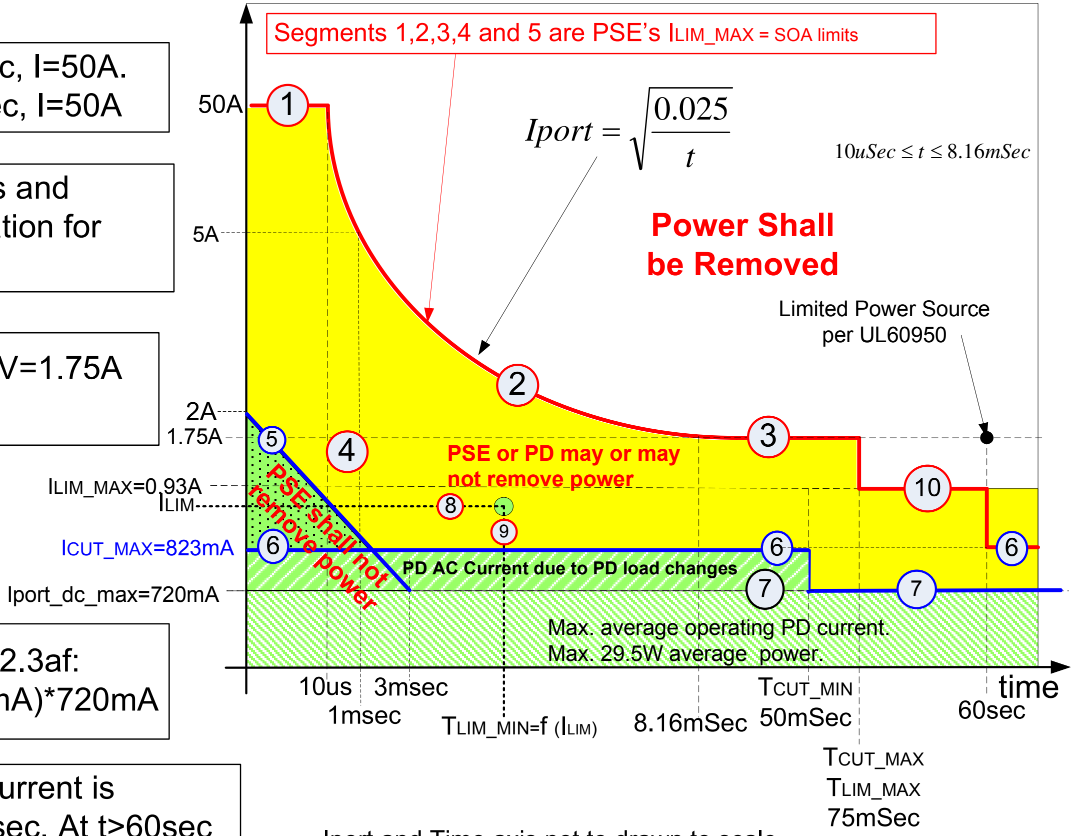
1. 33C.4 : for t=10uSec, I=50A.
   : for t<10uSec, I=50A

2. 33C.4 for 0< t <=1ms and adapting 33C.4 equation for 10us<= t <=8.16ms

3. UL60950 : 100VA/57V=1.75A max up to 75ms.

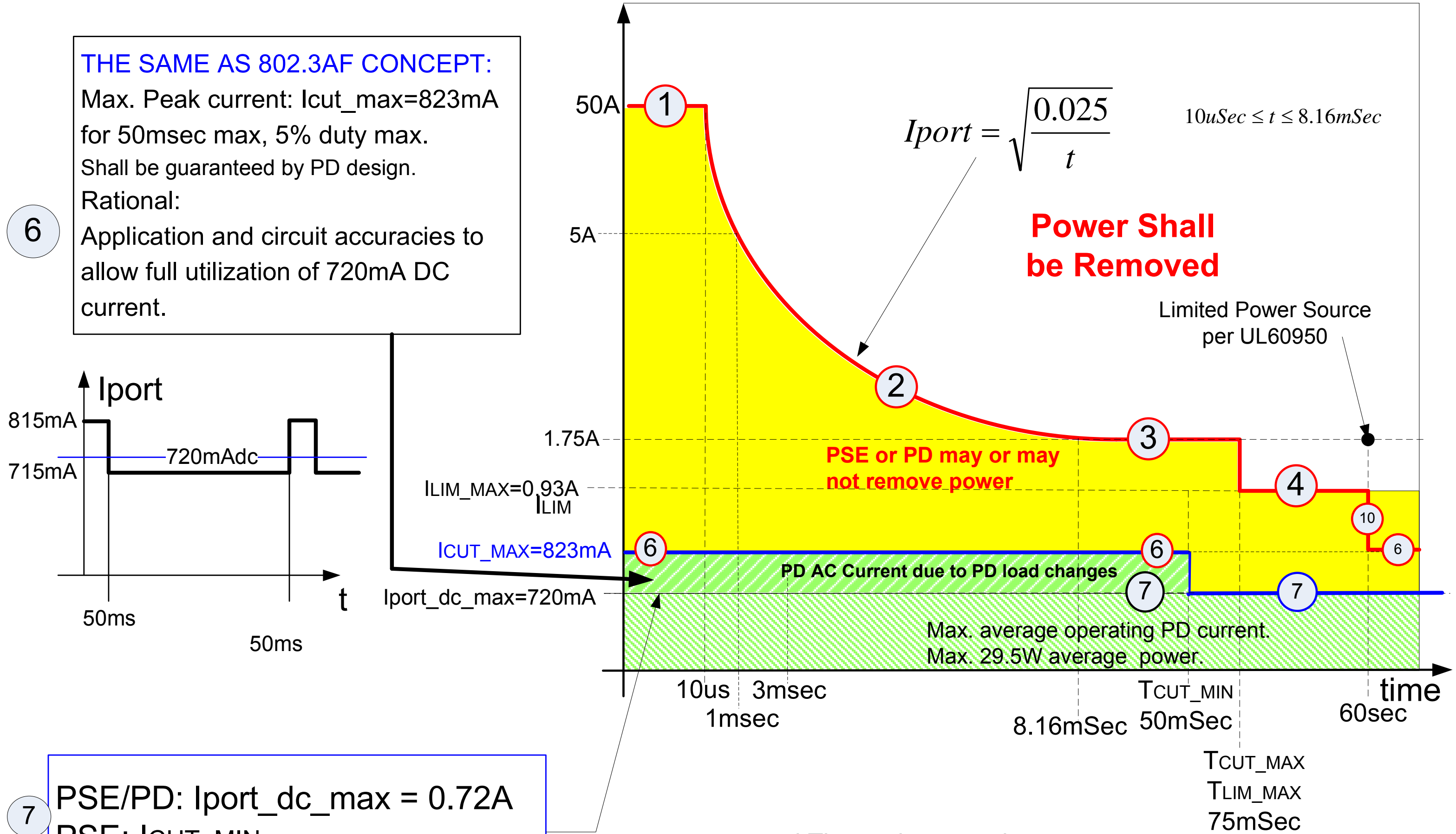
4. Same ratios as in 802.3af: 0.93A=(400mA/350mA)*720mA

10. After 75msec max current is ILIM_MAX until t<=60sec. At t>60sec PSE shall turn OFF the port if I>ICUT_MAX




Iport and Time axis not to drawn to scale.
Drawing segments are defined by their current, time coordinates.
Note: The term ILIM doesn't force any particular implementation. It only indicates that the current should not deviates from the value defined by ILIM.

# PD input current due to PD load

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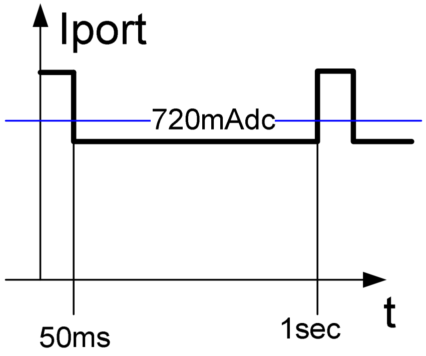
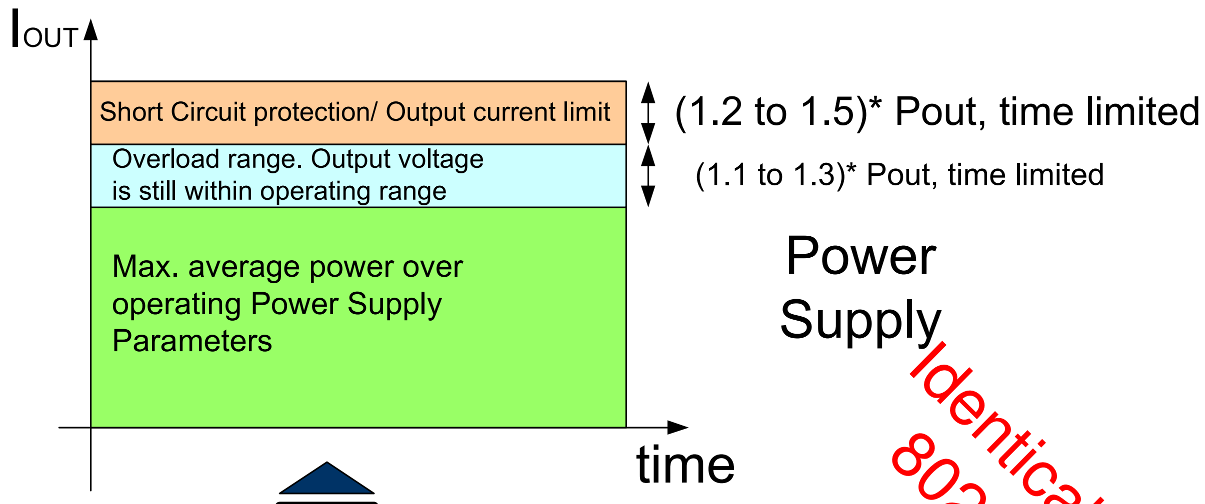
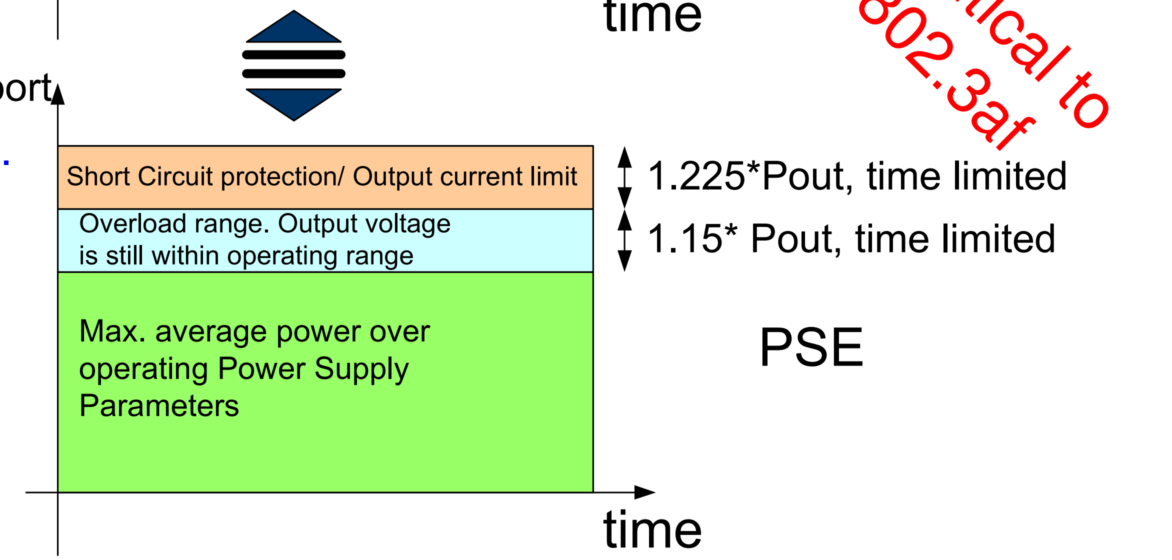


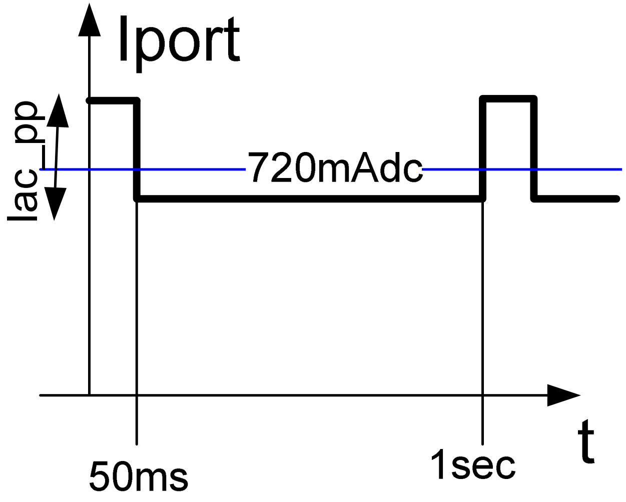




- Power supply is tested at Pmax.
- Cost is according to $/Pmax[W]
- Overload Margins are already included in Pmax cost otherwise yield, MTBF and operation reliability are impaired.
- Pavg=Iavg*Vport

- No thermal effects at overload range for 5% duty for 50msec duration.

# How P.S. cost and power are not affected

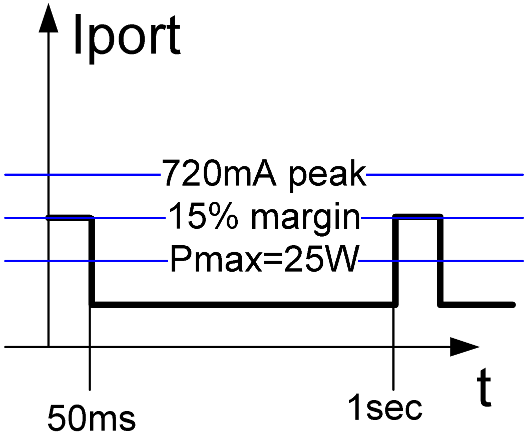
$$Iport\_rms = \sqrt{\left(Idc^2 + Iac\_rms^2\right)}$$




- From 802.3: Iport shall not exceed
  - 350mA (720mA) rms or
  - 350mA (720mA) DC
- Hence
  - P.S. average power is not increased
  - No additional resistive loses due to RMS current
  - 5% Duty Cycle allows 95/5 ratio of cooling time for 15% current peak above DC level while 95% of the time DC current<720mA…

# PD input current due to PD load..

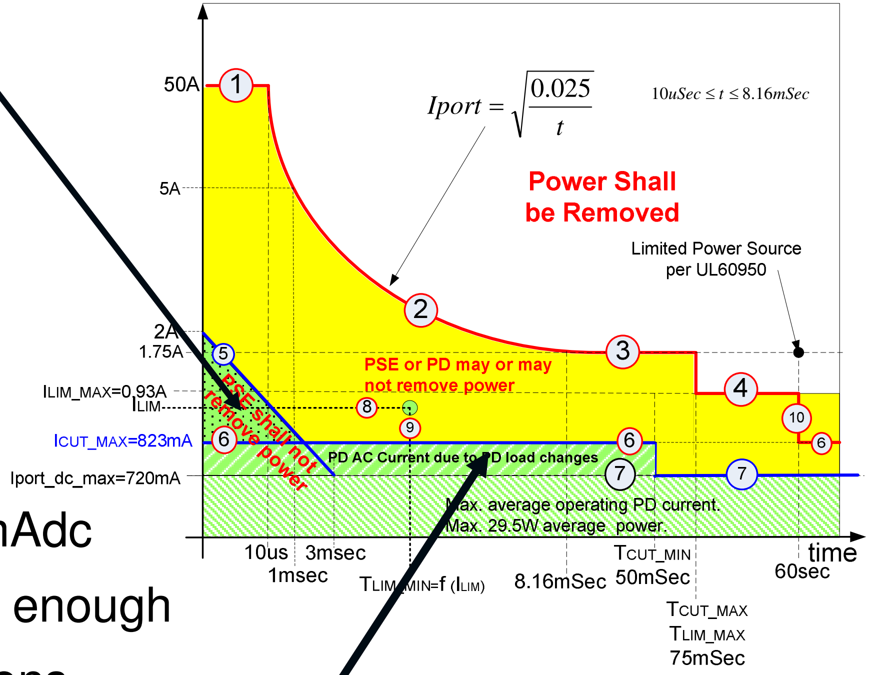
- What happen if Iport=720mA peak max ?




- Practical power at PD input will be <25W
- Less potential applications
- Reduced cost effectives of the standard in terms of $/Watts
- Giving up precious watts w/o gaining anything..
  - (See how we handle PSE dv/dt next slides)

# PD input current due to PD load..

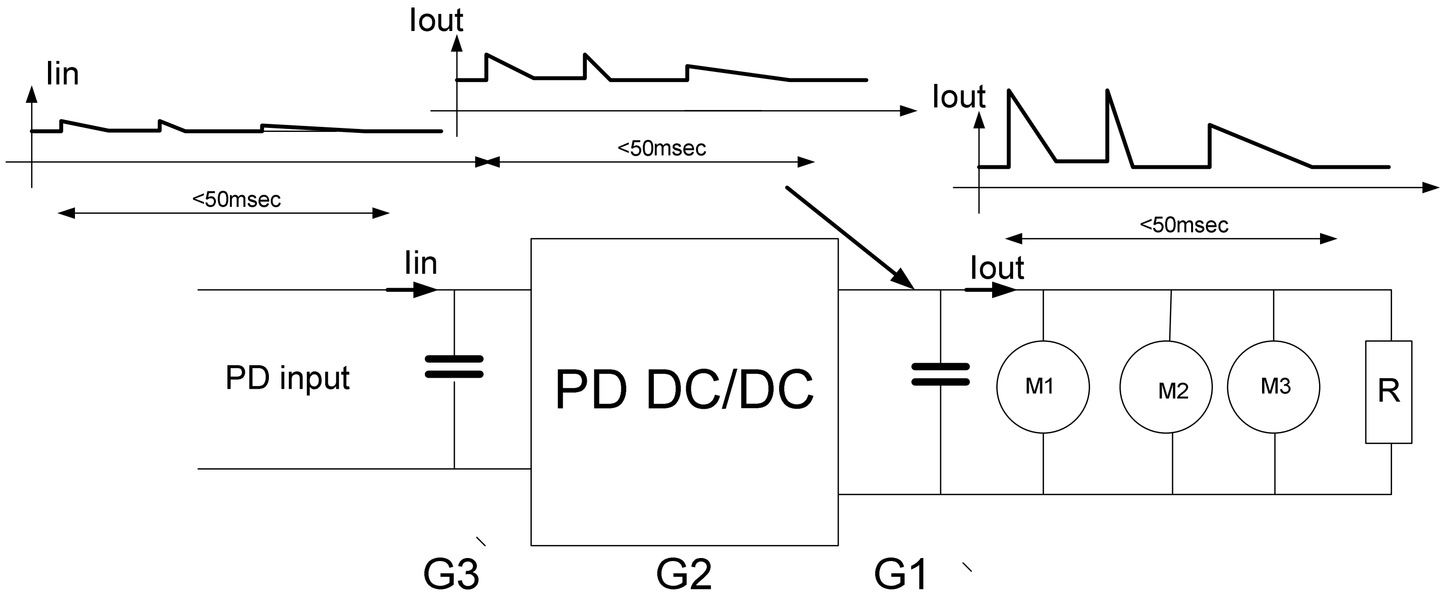
- Why the additional triangle area 2A,3msec doesn't add value to handle load variations?




- It is limited to 3msec max. while low frequency variations are at the 20-50Hz ➔ <=50msec..
- It adds only 2A*3msec/2=3mAdc to the average while (823mA-720mA)*50ms/1sec=~5mAdc
- In this concept Ipeak=720mA, not enough margin to circuit accuracy limitations..
- This concept is more practical to all applications (823mA, 50msec, 5%)
- *…And there is no need to support 2A peak at PD input due to PD load changes*

# PD load examples

- PTZ / security camera generate current transients at the PD DC/DC output for 0.5A to 1.5A (other values possible) and for 0.3msec, 6.3msec and 10msec time constants pending on type etc. At Iin, Ipeak is kept by design of Cin/Cout,Iout_peak, Vout etc.




$$\frac{Iin(s)}{Iout(s)} = \frac{1}{G1 \cdot (s)G2(s) \cdot G3(s)}$$

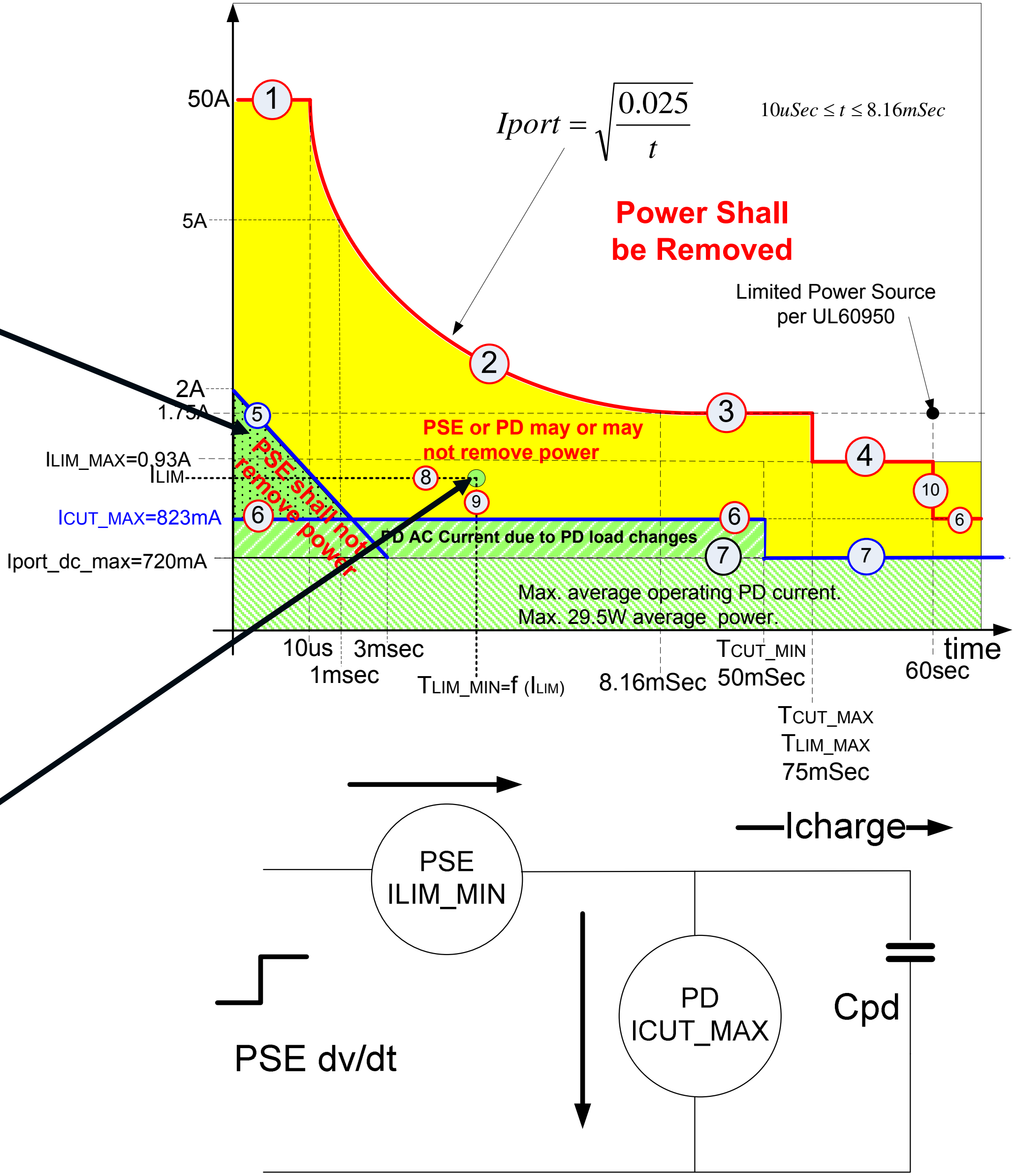
# PD input current due to PSE dv/dt

**•With energy power limiter:**

- •PSE shall not remove power at the triangle zone
- •2A/3msec for a given Cpd<=180uF, dv=7V max. with PSE S.R=TBD

**•With constant current limit:**

- •PSE shall not remove power For ILIM / TLIM_MIN.
- •Values are implementation specific. TLIM is a function of ILIM.
- •ILIM_MIN – ICUT_MAX > Icharge_min **or** TLIM_MIN>50msec <u>both options are valid</u>



# Summary - PSE/PD Current limit Curve Derivation

## 802.3at PSE/PD short circuit behavior. See separate drawing for startup behaviour

1 — 33C.4 : for t=10uSec, I=50A.
: for t<10uSec, I=50A

2 — 33C.4 for 0< t <=1ms and adapting 33C.4 equation for 10us<= t <=8.16ms

3 — UL60950 : 100VA/57V=1.75A max up to 75ms.

4 — Same ratios as in 802.3af: 0.93A=(400mA/350mA)*720mA

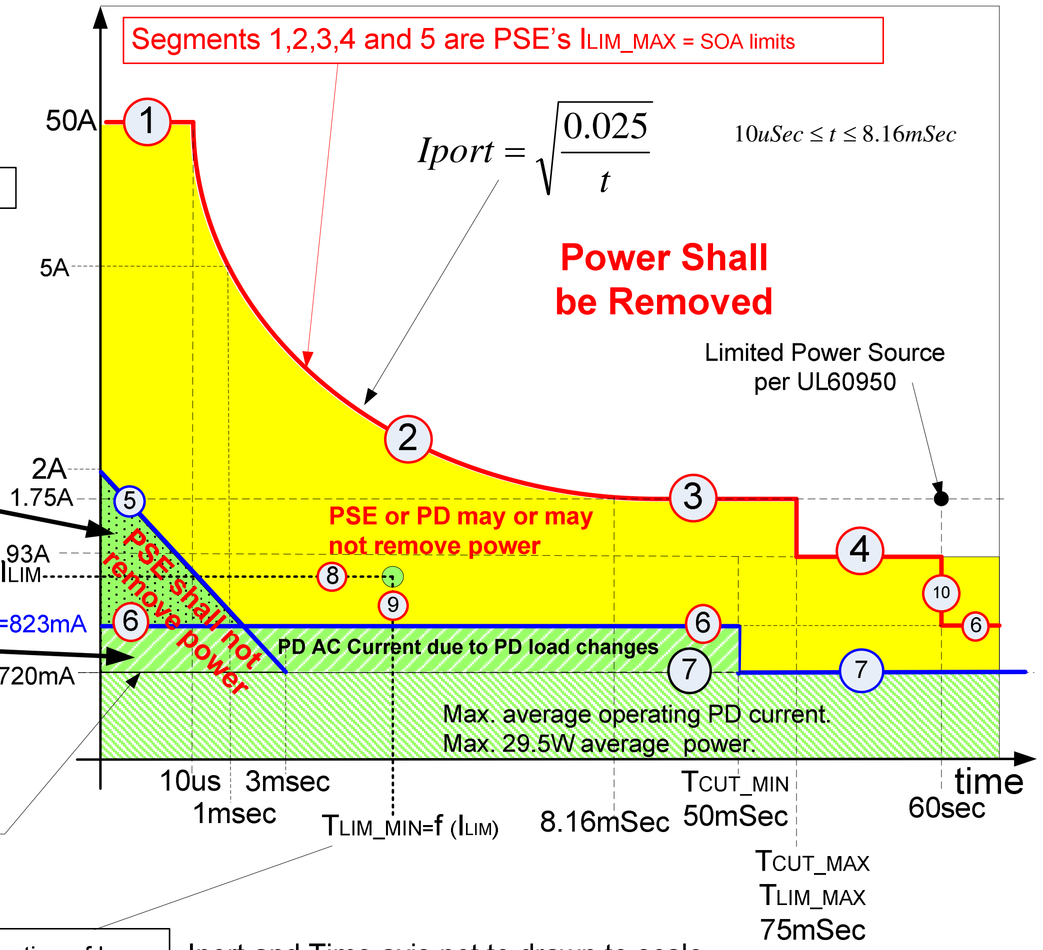
5,6,7 — PSE shall not remove power within the GREEN zone.

5 — Support current transients due to PSE dv/dt and low cost limited bandwidth current limit circuits.

6 — PD shall not exceed Icut_max for more then 50ms, 5% duty cycle. Policing it is not required by the PD. It may be done at PSE. Allows utilizing PDs max. average available power by using 720mA max. DC current with optional additional low frequency ac ripple current due to PD load variations.

7 — PSE/PD: Iport_dc_max = 0.72A
PSE: ICUT_MIN

8,9 — If constant current limit is used, TLIM_MIN is a function of ILIM. ILIM and TLIM_MIN shall be determined by the PSE vendor to supply sufficient energy for charging Cpd<=180uF and keep the port ON for the zone enclosed by 8,9 in addition to segments 6 and 7.

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# Translating Curve to Standard's Language

- PSE shall remove power if current exceeds SOA curve.
  - (To define each segment by equation and/or current / time coordinates)
- PSE $I_{CUT\_MAX}$ = 823mA
- PSE $I_{CUT\_MIN}$ = 720mA
- PSE shall not remove power up For I=Icut for 50msec min.5% duty min.
- $T_{LIM\_MIN}$ should be adjusted by PSE vendor to be higher then 3msec if
  - If PSE vendor is using constant current limit within the triangle area (2A, 3msec)
  - $T_{LIM\_MIN}$ in this case will be function of ILIM.
- PSE $I_{LIM\_MAX}$= 930mA at t>=75mSec up to 60sec max and then it is $I_{CUT\_MAX}$.
- PD max peak current =823mA for 50msec max, 5% duty max.
- PD max DC or RMS current =720mA
- PD max average power =29.5W

# Discussion