



Type 3 and Type 4 short circuit protection

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Objectives

- Option 1: To show that part-2 may be deleted because part 1 already covers this fault case (D1.6 page 110 line 2)
- Option 2: OR in part 2, replace “should (TBD)” with “may” and additional text that need to be discussed in option 2 solution.

"Power shall be removed from a pairset PI of a PSE before the pairset PI current exceeds the "PSE upperbound template in Figure 33-27, Figure 33-28, and Figure 33-29.

When connected to a single signature PD, a Type 3 or Type 4 PSE should (TBD) remove power from both pairsets before the current exceeds the "PSE upperbound template" on either pairset.“

- To show that removal part 2 (option 1) or modifying part 2 (option 2) permits many applications.

Part 1

Part 2

- We already agreed in previous discussions:
 - Type 3 can work with 2-pair with SS PD class 0-4 and 4-pairs.
 - Type 4 PSEs only provide 2-pair power after a fault
- The current specification (part-1) supports short-circuit protection (and other protection) done on a pairset basis:

" Power shall be removed from a pairset PI of a PSE before the pairset PI current exceeds the "PSE upperbound template in Figure 33-27, Figure 33-28, and Figure 33-29."

- If a singled-signature PD has a short circuit on a pairset, and power is removed from that pairset, the whole current flow will shift to the second pairset if the fault persists. This second fault condition requires the second pairset power to be removed.

- There are applications for:
 - Dual-signature PDs and
 - Single-signature PDs.
- In both cases, forcing the PSE to shut off both pairs when there is a fault on one of the pairs kills the ability to support devices that can work and are designed to work over 2-pairs in case of fault.
- In addition, shutting off both pairs when there is fault on one of the pairs ***doesn't add extra protection to the PD.***

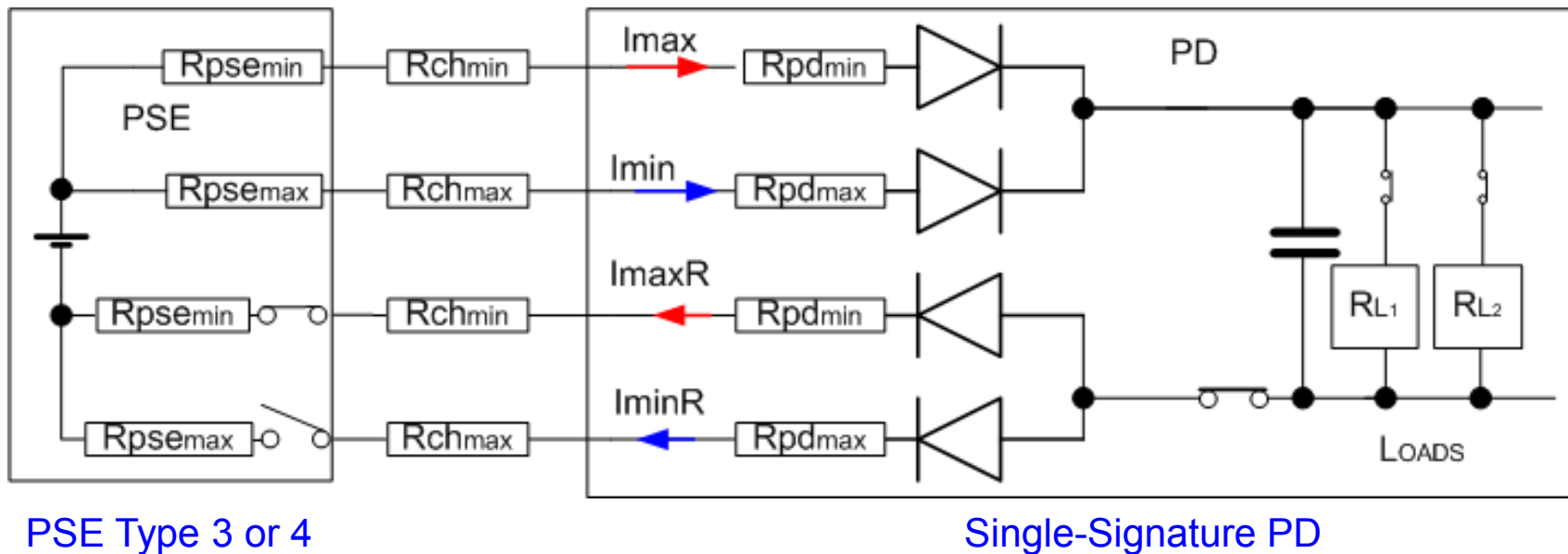
- 33.2.8 states:

“Power may be removed from both pairsets any time power is removed from one pairset.”

- It is already allowed to remove power from a pairset if there is a fault on the other pairset.
- We do not want to make it illegal to power down both pairsets when there is a fault on one pairset. We believe this should be optional behavior.
 - Power down of both pairsets will happen automatically with PDs that were not designed to support reduced power mode after fault on one pairset.

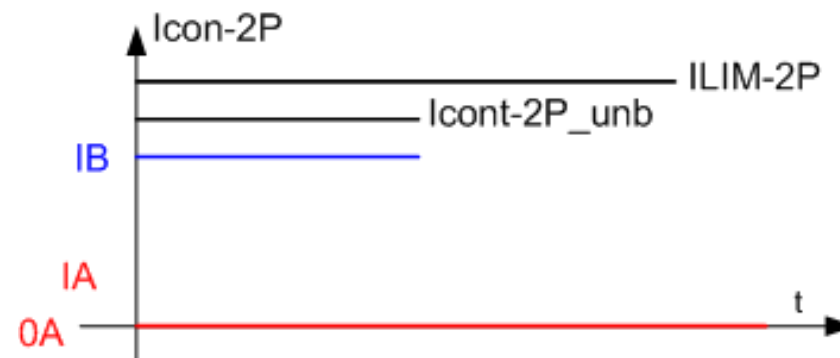
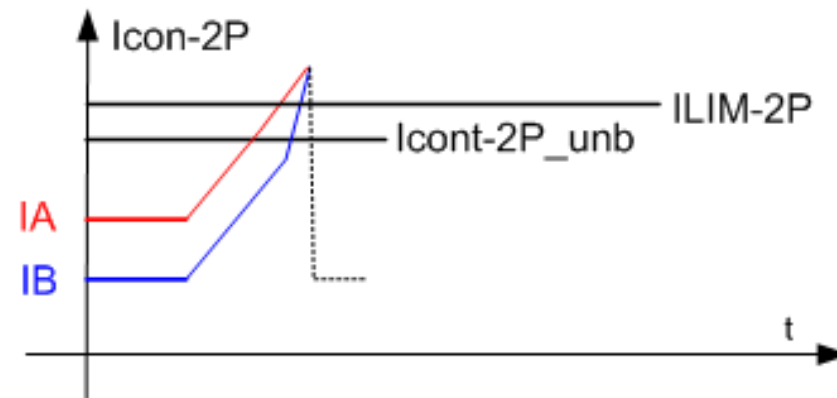
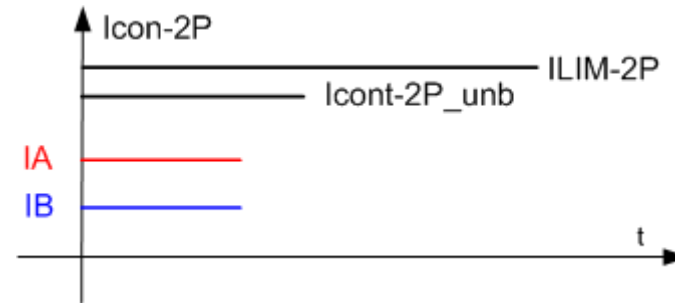
Single-Signature PD Inherent 4-pairs protection -1

- The use case under discussion:
 - There is a short circuit on one of the pairs and power is removed from that pair.
if short still persists, the whole current will flow through the 2nd pair and that per will shut off too.
If short disappear due to the ability of the PD to work with lower power,



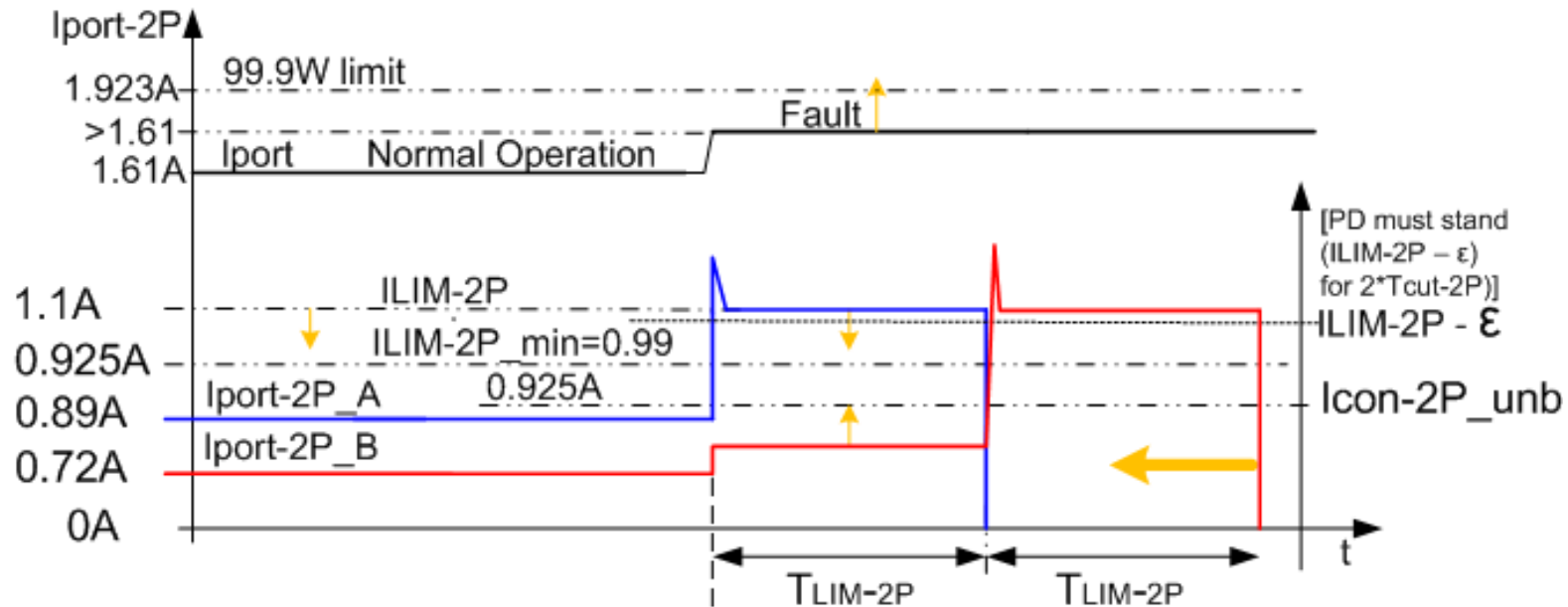
Single-Signature PD Inherent 4-pairs protection -2

- Currents status before fault
- Currents status at fault of the 1st pair and 2nd pairset if PD can't work in reduced power mode after fault
- Currents status at fault of the 2nd pair if PD can work on 2-pairs after fault.



Single-Signature PD Inherent 4-pairs protection

See simulation results in Annex A and B



- PD must be design to stand in both pairs ($ILIM-2P-\epsilon$) for the maximum time allowed by the upper bound template in figure 33-28/29. See Annex C. It can be done by PD to put its protections per pairset just above I_{con-2P_unb} max to guarantee operation and below PD $ILIM-2P$ per its max class/Type (see international standards).
- Total T_{LIM-2P} will decreases (both pairsets will be in $ILIM$ at the same time) when:
 - Unbalance is decreased
 - Short load current is increased so the pair with minimum current hits $ILIM-2P$.
 - $ILIM-2P$ is set near to $ILIM-2P_{MIN}$ and load current at short load is increased.

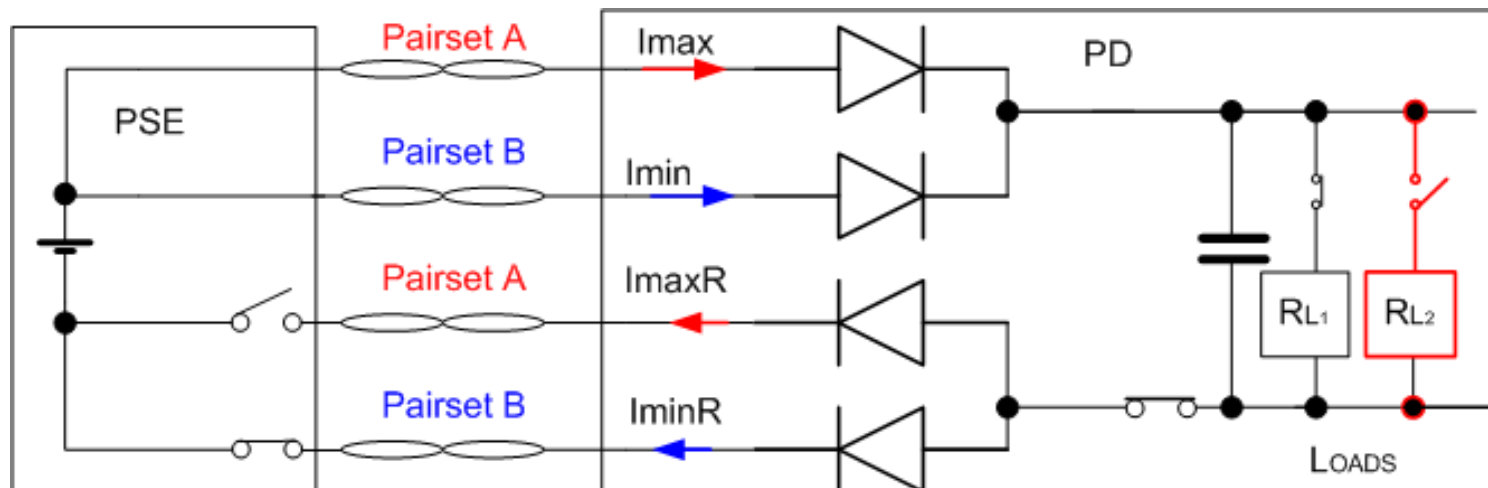
Protection summary

Shutting off both pairsets if only one pairset is faulty doesn't add extra protection to PDs.

- PSEs and PDs needs to be designed to work at I_{con-2P_unb} per pairset.
- PSEs and PDs needs to be designed to not be damaged at $(I_{LIM-2P} - \epsilon)$ per pairset.
- $(I_{LIM-2P} - \epsilon)$ per pairset can be anywhere between:
 - 1.3A to 1.75A for T_{CUT-2P_MAX}
 - ILPS to 1.3A for 4sec
 - I_{LIM-2P_MIN} to $(ILPS - \epsilon)$ for ever
- As a result, PDs need to meet $(1.75A - \epsilon)$ for $t \gg T_{LIM-2P_MIN}$ per pairset any way. **(before current hits the current limiter threshold per pairset)**
- No need to force PSE to shut off both pairsets if there is a fault on one pairset.
 - it will happen automatically in single signature PD if fault is persists after the faulty pair is turned off.

Supporting PDs with reduce operating power mode during faults

- There are single-signature applications that under fault can work at lower power or with one of the pairsets used as backup power so they can work over 2-pairs under fault **with half the load**.
- The objective is to transition between 4-pairs to 2-pairs in case of fault without going through IDLE state, which saves time and keep the system up and running.
- Such a PD will consume the same current (or lower) over a pairset (2P) as it did when operating over two pairsets (4P).
 - Otherwise the PSE will remove power from the remaining pairset.



- Option1: Remove the marked text [Preferred].

"Power shall be removed from a pairset PI of a PSE before the pairset PI current exceeds the "PSE upperbound template in Figure 33-14, Figure 33-14a, and Figure 33-14b.

~~When connected to a single signature PD, a Type 3 or Type 4 PSE should (TBD) remove power from both pairsets before the current exceeds the "PSE upperbound template" on either pairset.~~

See discussion on Option 2 in next slide

Reasons why to choose option 1 or 2:

1. Per pairset protection is maintained. Part 1 covers all our needs.
2. Shutting off all 4-pairs in case of fault in one pairs does not provide additional protection to the PD. PDs must be protected for the worst case ILIM-2P and timings anyway.
3. If we leave Part 2 as it is, it will preclude many PD applications for no technical reason.

We do not want to make it illegal to power down both pairsets when there is a fault on one pairset. We believe this should be optional behavior and it is covered already by 33.2.8.

Discussion on Option 2

- Option 2 : To be discuss by the group if to modify the marked text in option 1 to:

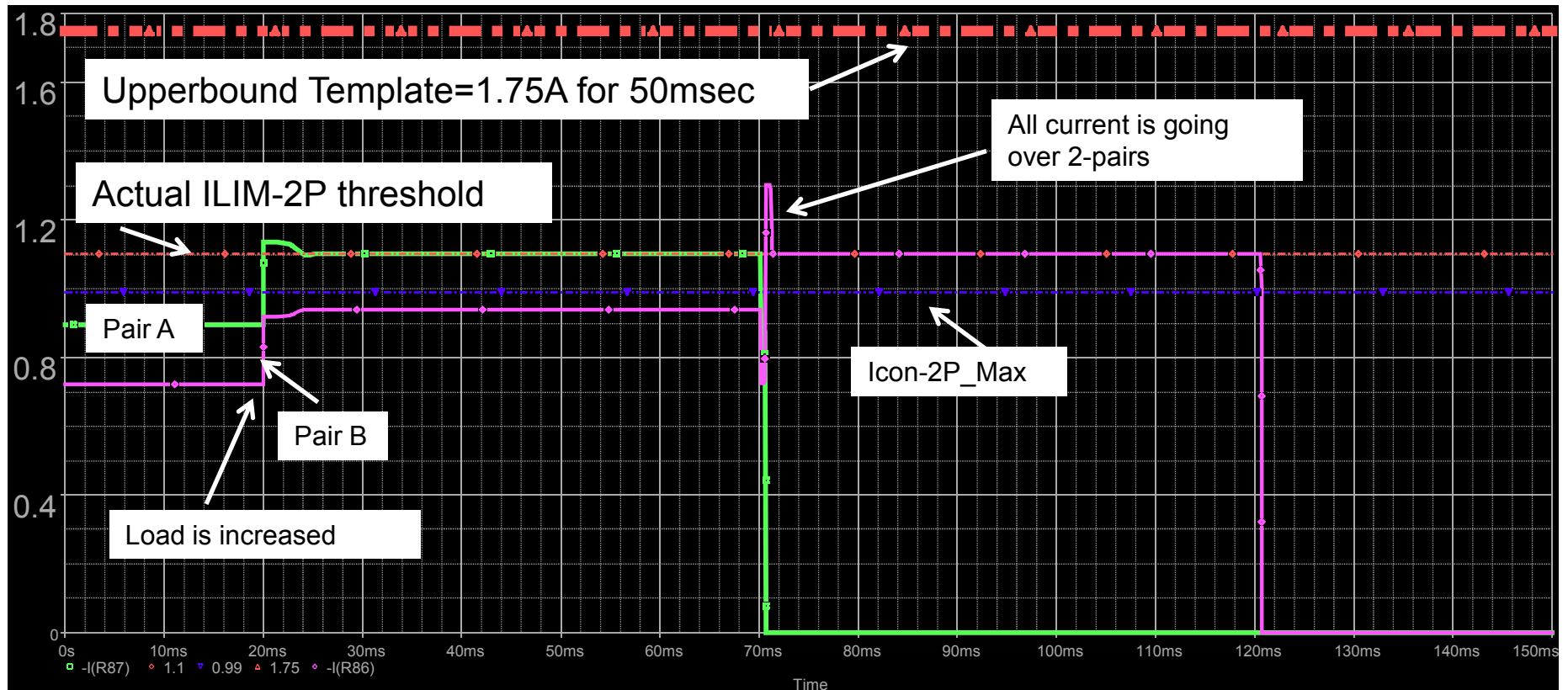
“When connected to a single signature PD, a Type 3 or Type 4 PSE may decide to remove power from one pairset and maintain power on the other pairset only if Iport-2P of that pairset is below **TBD**.”

TBD	implications
ILIM-2P	no additional requirement to PSE/PD. No more power dissipation then it was with 4-pairs over 2-pairs. Actually it is the same as option 1.
ILIM-2P_max	To set ILIM-2P_max value which is lower that the upper bound by having $ILIM-2P_max=1.15*ILIM_2P_min$ which is a new requirement but practically it is being implemented in most PSEs.
Icut-2P	no additional requirement to PSE/PD. Allows protecting at lower current.
Icon-2P_unb	Additional requirement to PSE.

- To consider to add to the PD section: “PDs that are designed to work over 2-pairs after short load or overload fault shall consume up to half of their assigned Pclass-PD when working over 2-pairs” or equivalent. ***It is not a must since Type N PD connected to Type (N-1) PSE has to work at reduced load if wants to operate which is already permitted behavior.***

Thank You

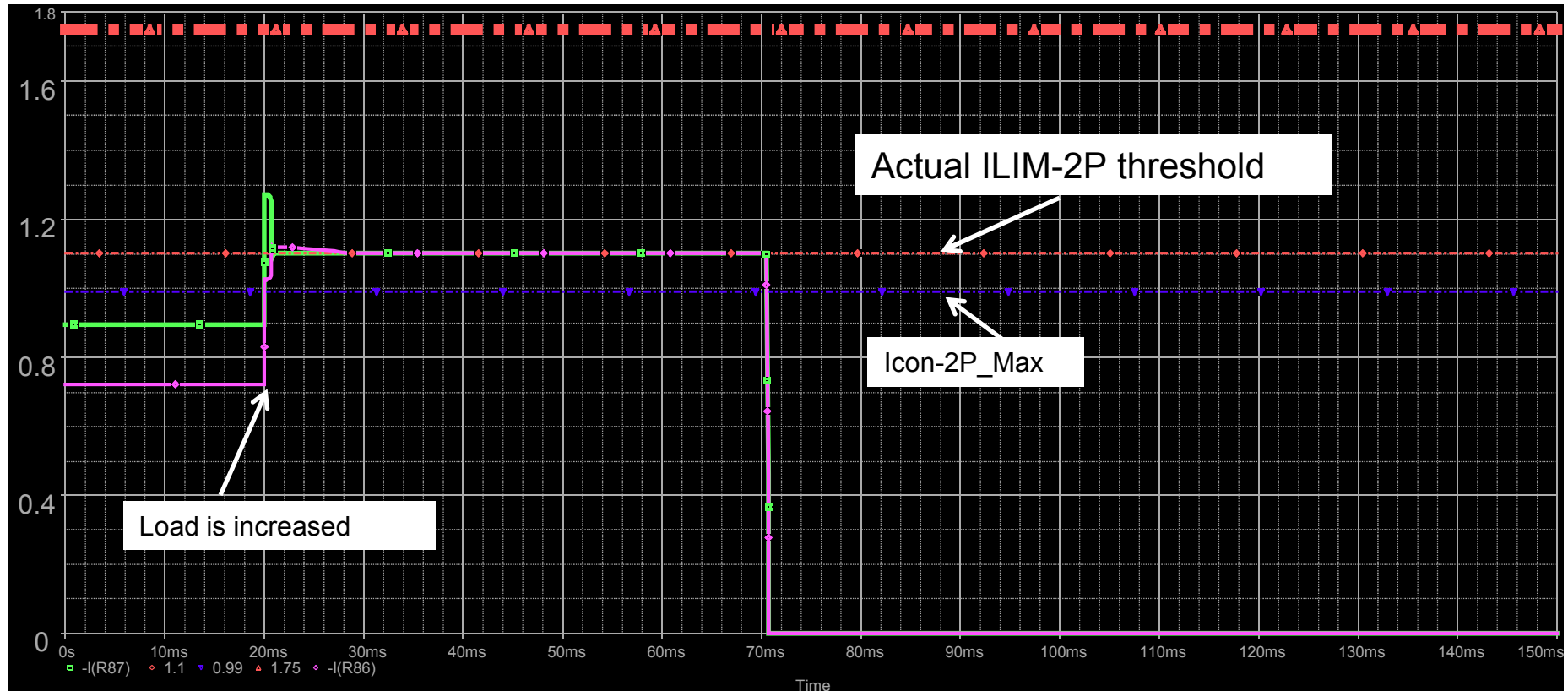
Annex A- Simulation results for Type 4 system at worst case conditions. Short load condition: pair A is in current limit and Pair B is not yet...



- Per pairset current limit is set to 1.1A. ($ILIM_MIN=0.99A$, $ILIM_2P_MAX<1.75A$ for 50msec max.)
- $I_{cont-2P_A}=0.89$, $I_{cont-2P_B}=0.72$. ($I_{con-2P_unb_MAX}=0.925A$)
- Under short load condition in which the pair with I_{con-2P_max} hits the current limit protection and the 2nd pair is not, we can see that after 50msec that pair is off and as a result all the current is going to the 2nd pair but its current limit is activated too and after 50msec this pair is power off too.

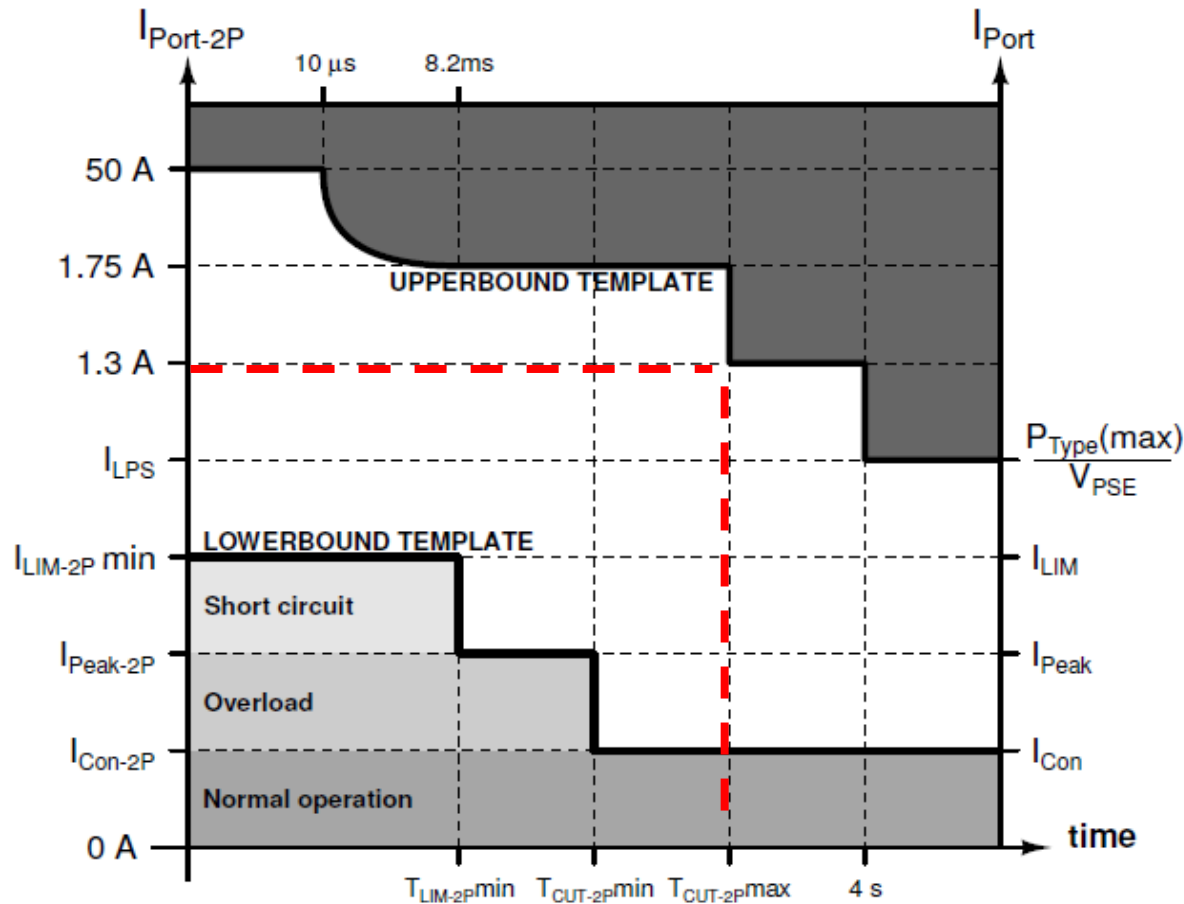
Annex B: Simulation results for Type 4 system at worst case conditions.

Short load condition: both pair A and pair B are in current limit.



- Per pairset current limit is set to 1.1A. (**ILIM_MIN=0.99A, ILIM_2P_MAX<1.75A for 50msec max.**)
- Icont-2P_A=0.89, Icont-2P_B=0.72. (**Icon-2P_unb_MAX=0.925A**)
- **Under short load condition in which BOTH pairs are in current limit, both of them automatically will power off after maximum 50msec.**

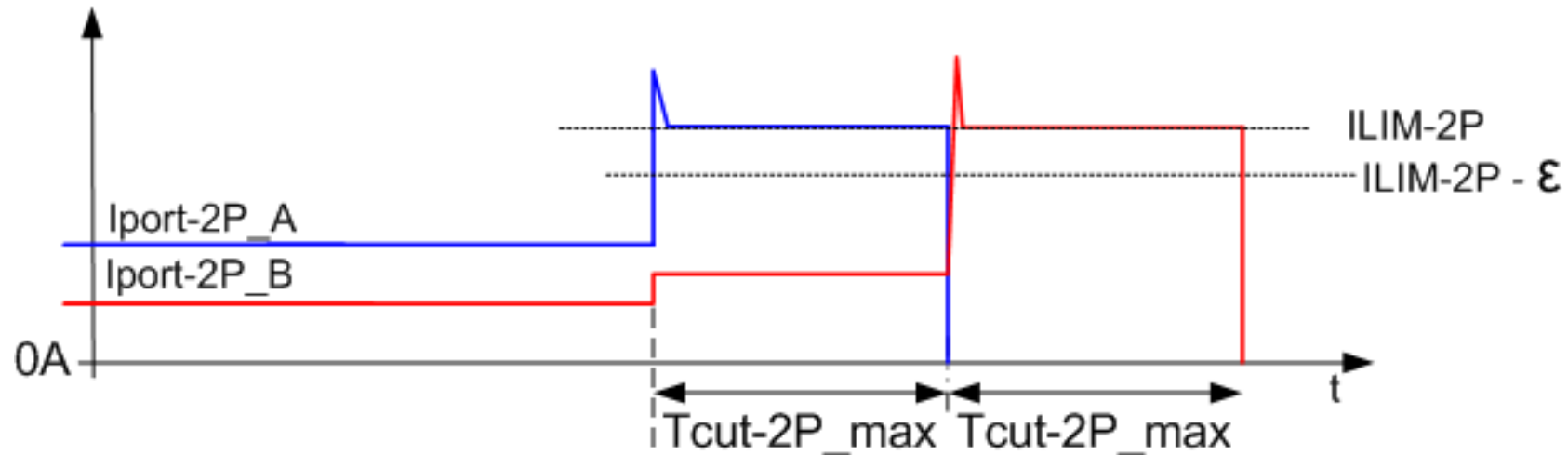
Annex C: Figure 33-29- Figure 33–29—POWER_ON state, per pairset operating current template for Type 4PSEs



$(I_{LIM-2P} - \epsilon)$ per pairset can be anywhere between:

- 1.3A to 1.75A for T_{CUT-2P_MAX}
- I_{LPS} to 1.3A for 4sec
- I_{LIM-2P_MIN} to $(I_{LPS} - \epsilon)$ for ever

Annex D: What $I \cdot t$ must PD endure during normal operation?



PD must stand $(I_{LIM-2P} - \epsilon)$ for $t \gg T_{LIM-2P_min}$.

As a result, it must stand $\sim I_{LIM-2P}$ for $2 \cdot T_{LIM-2P}$.

PD can do it by placing its protections just above I_{con-2P_unb} in order to optimize its component size. PD is required to it anyway by international standards.

Annex E1: Defined behavior of PSE and PDs

- PSE that is connected to single-signature PD and has a short circuit on one of the pairs can do one of the following:
 - A) turn off the faulty pairset. If as a result the 2nd pairset is in short too, it will turn off the 2nd pairset.
 - B) turn of both pairsets even if there is a fault on only one pairset.
 - C) If PD equipped with the ability to work with reduced mode or power back etc. it can continue working on the good 2-pairs and the faulty one is OFF.
- All are defined behavior for the PSE and PD. It depends on PD construction if it can support reduced operating modes.
- Examples of precedencies of defined behavior or not, that we are OK with it. See next slide:

Annex E2: Defined behavior of PSE and PDs

- Examples of precedencies of defined behavior or not, that we are OK with it:
 - PD Type 2 connected to PSE Type 1:
 - May work or not, depends on PD capability to work at reduced operation mode
 - PD class N connected to PSE class N+1:
 - May work or not, depends on PD capability to work at reduced operation mode
 - Depends on PSE power available budgets
 - Depends on PSE power supply size.
 - Depend on power management algorithm – if better use of available power
 - Depends if using LLDP, Autoclass (which is optional) or just the typical mutual identification that has limited resolution in power management.
 - Extended power: The race who will use the power budget: PSE or PD?
 - Autoclass: Not all PSEs will support it. It is optional. Different behavior is expected for same PD with different PSE due to available power and power management efficiency.
 - Different PSE power management schemes. The same PD will not get the same service at each PSE.
 - And more...

Annex F: What if after short circuit on one pairset when the power was removed from that pairset, at the same time, that PD is drawing less power so the 2nd pair will not go short also, and when it is operating on 2-pairs, the PD will suddenly increase power to maximum?

- The same protection mechanism will work again.
- When the 1st pairset had a short, it was disconnected.
- When the 2nd pairset got a short it was disconnected again after TBD time that it was working within the operating limits.
- All is good.

- But from fault reporting point of view how I will now at reasonable time that I has a fault and will not have to wait until it happen?
 - See Annex G for details

Annex G: How can fault be identified immediately?

- How can a fault be seen immediately?
- How can we know that there is a fault at max power but now the PD works at low power after fault?
- Answers:
 - When the first pairset goes off, we already know that we have a fault. So the host knows and can report by SMS to the installer/ technician etc.
 - Also not all faults can be known to the installer/ technician immediately without checking host report e.g. wire faults when load power is low AND MANY OTHERS.
 - Regarding the whole PD: You can send command to e.g. the lighting fixture to operate it at max power and then we will see the fault. It take couple of milliseconds.
 - There are many solutions for this question but all of these do not justifies to force all 4-pairs off in case of fault and killing huge markets of single-signature PDs with the ability to work with half the power under fault.

Annex H: Does the PD after fault is still a PD?

- It depends if this PD can function after a fault with reduced operation modes or can't.
- PD after fault is still a PD if it can continue to function...ONLY a PD that after fault can't function anymore is not PD.
 - PD with reduces operating modes is still a PD
 - The fault could be in the cable over 2-pairs and not necessarily the PD which doesn't change the PD status..

Annex J1: PSE protection circuits objectives

- PSE Protection circuits Icut-2P, ILIM-2P, TLIM-2P etc. are meant to protect the PSE equipment and the cabling infrastructure.
- It may protect the PD but it is not PSE job to protect the PD.
 - If PD is connected to PSE injector it may not be protected by the PSE to the maximum current level that this PD was designed to.
 - Same is if PD is connected to wall adapter
 - What if Type 1 PD is connected to Type 3 multiport system and one of the PSE ports where the PD is connected to is ON due to a fault? In this case the PD will be exposed to $N \times 30W = 24 \times 30 = 720W$...if the PD has failure or there is wire fault....
- PD has to protect itself from ANY power supply it is connected to. This is a required by international mandatory standards.

Annex J2: PSE vendors don't want to be liable for purely designed PDs

- PSE system vendors don't want to be liable for purely designed PDs
- PD system vendors don't want to be liable for purely designed PSEs
- As a result each system must be protected individually per their mandatory standards and others such IEEE...