Commnent (#167):
(TDL #385 D2.2)

Comment: Do we need the spec for Irms in 145.3.8.4?

YES if we will not guarantee that:

-Pclass_PD is the maximum average power for 1sec sliding window including in the presence of Ppeak.

(Currently it is not 100% the case in the spec thus Irms spec is protecting us.)

As a result, any current value under overload conditions has to be treated as RMS current due to the fact that PClass_PD is the true power consumed by the PD.

Overview

1. **We care for the true power consumed in the PD. It is always Paverage** (See Annex A).
2. **Prms is by definition equal to Pavg.** (See conditions and example in Annex A and B).
3. **Prms is used for time variant signals to describe true power loss**
4. **VRMS or IRMS gives the equivalent DC value for an AC or DC+AC signal for the same power that a pure DC value would give.**
5. **Our spec is defined in terms of Average Power, Peak power and current.**
6. **We need to guarantee that the maximum average power includes operation under peak power conditions which is not 100% guarantee in D2.3.**

The objective of this work is to get rid of the detailed RMS spec and to ensure that when input currents are measure at the PD, their maximum limits will be treated as per RMS current and not Average current.

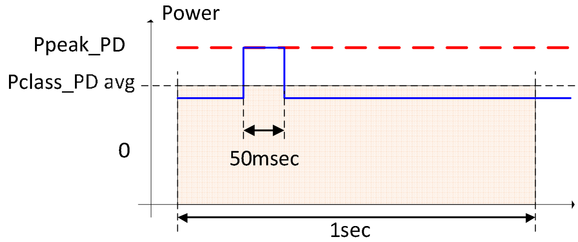
Starting first with the basics.

145.3.8.2 on Input average power says the following:

P_{Class_PD} is the maximum average PI power and applies to single-signature PDs.
$P_{Class\_PD\text{-}2P}$ is the maximum average power on a pairset and applies to dual-signature PDs.

The maximum average power, P_{Class_PD} or $P_{Class\_PD\text{-}2P}$ in Table 145-24, Table 145-25, and Table 145-28 or PDMaxPowerValue in 145.5.3.3, including any peak power drawn per 145.3.8.4 ~~is~~ shall be calculated over a 1 second ~~interval~~sliding window.

~~NOTE - Average power is calculated using any sliding window with a width of 1 s.~~



Problem #1:

The note "NOTE - Average power is calculated using any sliding window with a width of 1 s." is correct for PClass_PD and PClass_PD-2P and is redundant. It appears in the text above.

Problem #2:

There is a missing "shall" that limits Pclass_PD and and PClass_PD-2P to be the maximum average power over a 1sec sliding window.

Without it, it is impossible to guarantee that under Ppeak conditions (see 145.3.8.4), the maximum average power will stay Pclass_PD and and PClass_PD-2P

145.3.8.4 Peak operating power

At any static voltage at the PI, and any PD operating condition, with the exception described in 145.3.8.4.1, the peak power for single-signature PDs shall not exceed P_{Class_PD} for more than $T_{CUT\text{-}2P}$ min, as defined in Table 145-16 and 5% duty cycle. Peak operating power shall not exceed P_{Peak_PD}.

Problem #3:

Missing instructions that "The maximum average power, P_{Class_PD} or $P_{Class\_PD\text{-}2P}$ shall be calculated over a 1 second interval including when operating under the conditions of 145.3.8.4" which is the peak power conditions

Without the above changes we can't get rid of most of the RMS spec.

Proposed concept for solution.

1. **Update 145.3.8.2 per the proposed changes.**
2. Delete all the RMS equations and related text
3. To add informative text that for accurate measurements of Icon-2Punb and Icon-2P under overload conditions, to measure the RMS current and not the average current.

[Baseline starts here]

Suggested Remedy:

Make the following changes:

[Ensuring that Pclass_pd and Pclass-PD-2P is the maximum average power over a 1sec sliding window]

145.3.8.2 on Input average power says the following:

P_{Class_PD} is the maximum average PI power and applies to single-signature PDs.
P_{Class_PD-2P} is the maximum average power on a pairset and applies to dual-signature PDs.

The maximum average power, P_{Class_PD} or P_{Class_PD-2P} in Table 145-24, Table 145-25, and Table 145-28 or PDMaxPowerValue in 145.5.3.3, including any peak power drawn per 145.3.8.4 ~~is~~ shall be calculated over a 1 second ~~interval~~sliding window.
~~NOTE - Average power is calculated using any sliding window with a width of 1 s.~~

145.3.8.4 Peak operating power

$V_{Overload-2P}$ is the PD PI voltage when the PD is drawing the permissible P_{Peak_PD} for single-signature PDs, or P_{Peak_PD-2P} for dual-signature PDs.

At any static voltage at the PI, and any PD operating condition, with the exception described in 145.3.8.4.1, the peak power for single-signature PDs shall not exceed P_{Class_PD} for more than T_{CUT-2P} min, as defined in Table 145–16 and 5% duty cycle. Peak operating power shall not exceed P_{Peak_PD}.

At any static voltage at the PI, and any PD operating condition, with the exception described in 145.3.8.4.1, the peak power for a dual-signature PD shall not exceed P_{Class_PD-2P} for more than T_{CUT-2P} min, as defined in Table 145–16 and 5% duty cycle. Peak operating power shall not exceed P_{Peak_PD-2P}.

NOTE—The duty cycle of the peak current is calculated using any sliding window with a width of 1 s.

~~For single-signature PDs, ripple current content (I_{Port_ac}) superimposed on the DC current level (I_{Port_dc}) is allowed if P_{Peak_PD} requirements are met and the total input power is less than or equal to P_{Class_PD}.~~

~~.For dual-signature PDs, ripple current content (I_{Port_ac-2P}) superimposed on the DC current level (I_{Port_dc-2P}) is allowed if P_{Peak_PD-2P} requirements are met and the total input power is less than or equal to P_{Class_PD-2P}.~~

~~The RMS, DC and ripple current shall be bounded by Equation (145–26):~~

$$I_{Port\_RMS} = \left\{ \begin{array}{ll} \sqrt{(I_{Port\_dc})^2 + (I_{Port\_ac})^2} & \text{single-signature PD} \\ \sqrt{(I_{Port\_dc-2P})^2 + (I_{Port\_ac-2P})^2} & \text{dual-signature PD} \end{array} \right\}_A \quad (145–26)$$

where

I_{Port_dc}	is the DC component of the input current for a single-signature PD
I_{Port_ac}	is the RMS value of the AC component of the input current for a single-signature PD
I_{Port_dc-2P}	is the DC component of the input current for a dual-signature PD
I_{Port_ac-2P}	is the RMS value of the AC component of the input current for a dual-signature PD

~~The maximum I_{Port_RMS} value for all PDs except those described in 145.3.8.2.1 and 145.3.8.4.1, over the operating V_{Port_PD-2P} range shall be defined by Equation (145–27):~~

$$I_{Port\_RMS\_max} = \left\{ \begin{matrix} \frac{P_{Class\_PD}}{V_{Port\_PD\text{-}2P}} & \text{single-signature PD} \\ \frac{P_{Class\_PD\text{-}2P}}{V_{Port\_PD\text{-}2P}} & \text{dual-signature PD} \end{matrix} \right\}_A \qquad (145\text{–}27)$$

where

$V_{Port\_PD\text{-}2P}$ is the minimum specified input voltage at a PD pairset
P_{Class_PD} is the maximum power at the PD PI per the PDs assigned Class, as defined in Table 145–24
$P_{Class\_PD\text{-}2P}$ is the maximum power at the PD PI for a pairset per the PDs assigned Class as defined in Table 145–25

145.3.8.4.1 Peak operating power exceptions

For Class 6 and Class 8 single-signature PDs and for Class 5 dual-signature PDs, when additional information is available to the PD regarding actual channel DC resistance between the PSE PI and the PD PI, in any operating condition with any static voltage at the PI, the peak power shall not exceed PClass_PD for single-signature PDs and PClass_PD-2P for dual-signature PDs at the PSE PI for more than TCUT-2P min, as defined in Table 145–16 and with 5% duty cycle. Peak operating power shall not exceed 1.05 × PClass_PD for single-signature PDs and shall not exceed 1.05 × PClass_PD-2P for dual-signature PDs on each pairset. Operating under 145.3.8.4.1 conditions is allowed if PPeak_PD and PPeak_PD-2P requirements are met and the total input power is less than or equal to PClass and PClass-2P at the PSE PI respectively when calculated over a 1 second interval.

~~For single-signature PDs ripple current content (I_{Port_ac}) superimposed on the DC current level (I_{Port_dc}) is allowed if P_{Peak_PD} requirements are met and the total input power is less than or equal to P_{Class} at the PSE PI.~~

~~For single-signature PDs, the maximum I_{Port_RMS} value over the operating $V_{Port\_PD\text{-}2P}$ range shall be defined by Equation (145–28):~~

$$I_{Port\_RMS\_max} = \left\{ \frac{P_{Class}}{V_{PSE}} \right\}_A \qquad (145\text{–}28)$$

where

P_{Class} is the allocated Class power as defined in 145.2.7 and Equation (145–2)
V_{PSE} is the voltage at the PSE PI as defined in 145.1.3

~~For dual-signature PDs ripple current content (IPort_ac-2P) superimposed on the DC current level (IPort_dc-2P) is allowed if PPeak_PD-2P requirements are met and the total input power is less than or equal to PClass-2P at the PSE PI.~~

~~For dual-signature PDs, the maximum IPort_RMS-2P value over the operating VPort_PD-2P range shall be defined by Equation (145–29).~~

$$I_{Port\_RMS\text{-}2P\_max} = \left\{ \frac{P_{Class\text{-}2P}}{V_{PSE}} \right\}_A \qquad (145\text{–}29)$$

where

$P_{Class\text{-}2P}$ is the allocated Class power on a pairset as defined in 145.2.7 and Equation (145–3)
V_{PSE} is the voltage at the PSE PI as defined in 145.1.3

~~NOTE—The duty cycle of the peak current is calculated using any sliding window with a width of 1 s.~~

End of baseline

Annex A: What is the definition of RMS value?

The definition of average value for time varying signal X(t) is :

$$X_{AVG} = \frac{1}{T}\int_0^T X(t)\cdot dt$$ Eq-1

The definition of RMS value for time varying signal X(t) is :

$$X_{RMS} = \sqrt{\frac{1}{T}\int_0^T (X(t))^2 \cdot dt}$$ Eq-2

The definition of average power is

$$Pav = \frac{1}{T}\cdot\int_0^T V(t)\cdot I(t)\cdot dt$$ Eq-3

And we can show that it will be always equal to the RMS power **<u>only if it will be calculated per Eq-3</u>**:

$$Pav = \frac{1}{T}\cdot\int_0^T V(t)\cdot I(t)\cdot dt = \frac{1}{T}\cdot\int_0^T (I(t)\cdot R)\cdot I(t)\cdot dt = \frac{R}{T}\cdot\int_0^T I(t)\cdot I(t)\cdot dt = \frac{R}{T}\cdot\int_0^T (I(t))^2\cdot dt = R\cdot Irms^2 = P_{RMS}$$

$$Pav = \frac{1}{T}\cdot\int_0^T V(t)\cdot I(t)\cdot dt = R\cdot Irms^2 = \frac{Vrms^2}{R} = P_{RMS}$$ Eq-4

Equation 3 is correct always for any load including time varying loads.
Equation 4 is correct for constant load only i.e. the load is not changed over time HOWEVER, RMS calculation <u>can be used if done correctly</u> by treating separately each time segment that has different load and calculating its Prms_i=Vrm_i*Irms_i and sum up all duty_i*Prms_i.

The RMS is used in other areas e.g.: if $\overline{X}$ is the arithmetic mean and σ the standard deviation of a population or a waveform then $X^2{}_{rms} = \overline{X}^2 + \sigma^2 = \overline{X^2}$ (Note 1).

Note 1: $X^2{}_{rms} = \overline{X^2}$. $\overline{X^2}$ Is Pavg is the load is constant i.e. $Pavg = \overline{X^2} = \mathrm{Pr}\,ms$.

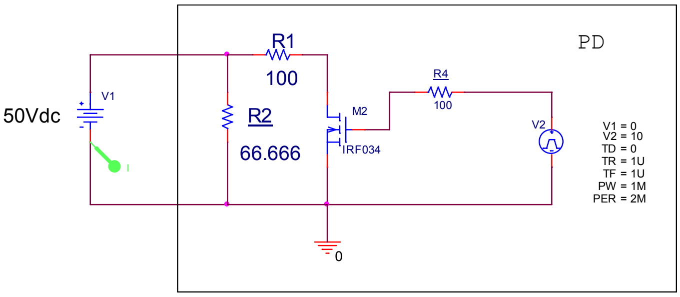
The RMS value, *I*$_{RMS}$, of the function *I(t)* is a constant that yields the same power dissipation as DC current would.

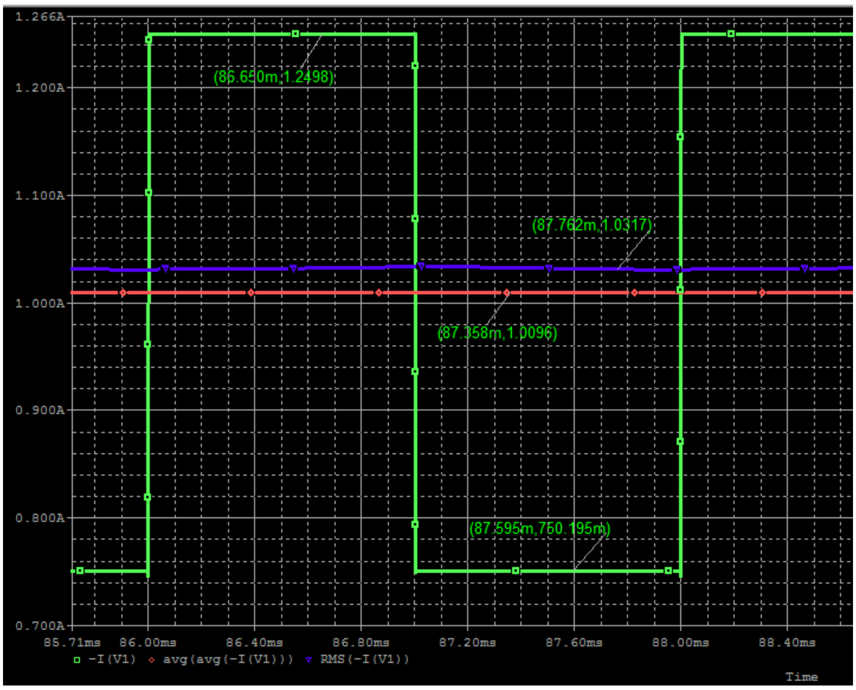
Our problem is:
If we measure only the DC current when we test Icon or Icon-2P under overload conditions for compliance we will not know if PD is cheating or not.
PD can be designed to generate average current that will meet Pclass_PD/Vport_PD-2P value but the actual RMS current will be higher and will cause excessive power loss on PSE. See Annex B for examples.

The ways to ensure 100% compliance are:
Measure average power in power meter that follows Equation 3) and Peak power and duty cycle timing.
RMS current may be used <u>to verify that Irms≤Iavg</u> ~~if time segments of each load level is calculated separately as described above,~~ and verified against with Peak Power ~~time and duty cycle~~ limits.

Annex – B: Why if Iavg is met, It desn’t guarantee that Irms is met.
Calculation techniques

- The following “PD” is consuming 0.75A plus additional 0.5A pulses at duty cycle of 50%.
- Resulting with peak current of 1.25A and valley value of 0.75A.





1. The average current is:
   Iavg=0.5*(0.75A+0.5A)+0.5*0.75A=1A
2. The RMS current is:
   Irms= (0.5*(0.75A +0.5A)^2+(0.5*0.75A ^2))^0.5=~1.03A
3. The average power delivered from the source equal to the average power deliver to the load:

$$Pavg = \frac{1}{T}\cdot\int_0^T V(t)\cdot I(t)\cdot dt =$$

$$\frac{1}{T}\cdot\int_0^T 50V\cdot I(t)\cdot dt = \frac{50V}{T}\cdot\int_0^T I(t)\cdot dt =$$

$$50V\cdot Iavg = 50W$$

4. The RMS power dissipated at the PD is:
   Prms=R1*Duty*Irms1^2+R2*Irms2^2=
   0.5*100Ω*(0.5^2)+66.666Ω*(0.75^2)=50W (*)

(*) Please note that calculating by Prms=Vrms*Irms=50V*1.03A=51.5W**≠**50W will lead to error. This is due to the fact that in this case the load is not constant over time and Vrms at the input of the device can’t be used without piecewise calculations. The RMS calculation need to be based on separate calculation of each Vrms*Irms for each load when it is connected.

In the above case Prms=Pavg only because the calculation done correctly by paying attention to the details.

Using Prms=Vrms*Irms at the black box terminals is correct only for constant loads unless the above technique is used.

Annex – C: In the following text there is an error. Anyway, this text goes away in this proposal.

$$I_{\text{Port\_RMS\_max}} = \left\{ \begin{array}{ll} \dfrac{P_{\text{Class\_PD}}}{V_{\text{Port\_PD-2P}}} & \text{single-signature PD} \\ \dfrac{P_{\text{Class\_PD-2P}}}{V_{\text{Port\_PD-2P}}} & \text{dual-signature PD} \end{array} \right\}_{\text{A}} \qquad (145\text{–}27)$$

where

$V_{\text{Port\_PD-2P}}$ is ~~the minimum specified~~ input voltage at a PD pairset

$P_{\text{Class\_PD}}$ is the maximum power at the PD PI per the PDs assigned Class, as defined in Table 145–24

$P_{\text{Class\_PD-2P}}$ is the maximum power at the PD PI for a pairset per the PDs assigned Class as defined in Table 145–25

In the above text in D2.3, Voprt_PD_2P is defined as the minimum specified input voltage at the PD pairset.

This is an error. Vport_PD-2P is defined as a range in many places explicitly.
See:
Table 145-28
P75, L21
P183, L51
145.3.8.1
P87, L6
P186, L52

The intent was that Iport_RMS_max will be Pclass_PD/Vport_PD-2P for the entire operating range resulting with lowers current at high input voltage and vice versa.