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 is the maximum average[1] power for 1sec 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 is the true power consumed by the PD, measure in W_{RMS} and not $W_{average}$ In case of time varying load.

Overview

1. **We care for the true POWER LOSS. It is always Power loss=Prms=Vrms*Irms**
2. **Prms is by definition the average of the squared function f (t) but it is not always equal to Paverage. See examples in Annex B.**
   If used *correctly* then Prms=Pavg[1].
   e.g. in 220V AC network, the 220V is rms value and the power will be RMS power and it is always defined as RMS power and not average power. The use of average power will be incorrect here (i.e. some of the power is real and some imaginary).
3. **Prms is used for time variant signals to describe true power loss**
4. **Pavg is uded for DC signals to describe true power loss for constant loads.**
5. **VRMS or IRMS gives the equivalent DC value for a DC+AC signal for the same power that a pure DC value would give.**
6. **Our spec is defined mostly in terms of Average Power and Peak power**
7. **We need to guarantee that the maximum average power includes operation under peak power conditions which is not 100% guarantee in D2.3.**

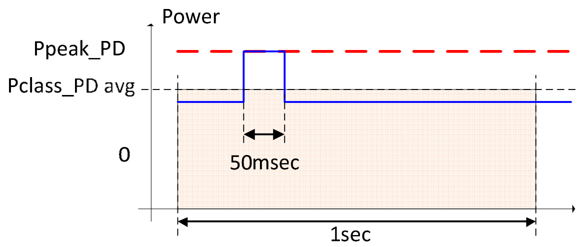
So if we agree that in our case, Pavg[W_{RMS}][1]=Prms=Vrms*Irms
Then: Irms=PClass/Vport_PD-2P

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 RMS current and not Average current.

Note 1: Average power is not equal to RMS power unless:
(a) The load is constant.
(b) The average power was calculated or measured by true RMS techniques i.e. the average power is the average sum of signal squared samples over time.

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-2P} is the maximum average PI power 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, ~~is~~ shall be calculated over a 1 second interval including when operating under the conditions of 145.3.8.4.
~~NOTE - Average power is calculated using any sliding window with a width of 1 s.~~



Problem #1:
Pclass_PD-2P as the maximum average power is missing from 145.3.8.2

Problem #2:
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 #3:
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-2P} min, as defined in Table 145-16 and 5% duty cycle. Peak operating power shall not exceed P_{Peak_PD}.

Problem #4:
Missing instructions that "The maximum average power, P_{Class_PD} or P_{Class_PD-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 text that defines that the input current to the PD under over load conditions in RMS value.

[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 PI power 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, ~~is~~ shall be calculated over a 1 second interval including when operating under the conditions of 145.3.8.4.

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

NOTE – Average power relates to the true RMS power consumed by the PD.

[Ensuring that Pclass_pd and Pclass-PD-2P is the maximum average power over a 1sec sliding window in the presence of Peak operating power conditions. This is achieved by the changes made to 145.3.8.2]

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.

[Now due the changes made to 145.3.8.2 we can delete the text marked with YELLOW marker.]

~~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):~~

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

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):~~

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

where

V_{Port_PD-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-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 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-2P} range shall be defined by Equation (145–28):~~

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

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 (I_{Port_ac-2P}) superimposed on the DC current level (I_{Port_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).~~

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

where

$P_{Class-2P}$ 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 :

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

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

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

This match to other areas where RMS is used 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 not Pavg. $Pavg = \overline{X^2} = \Pr ms$ only for constant loads.

- ***The RMS value of voltage or currents is not equal to the average value unless it is DC signal. See Annex B for examples.***

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:

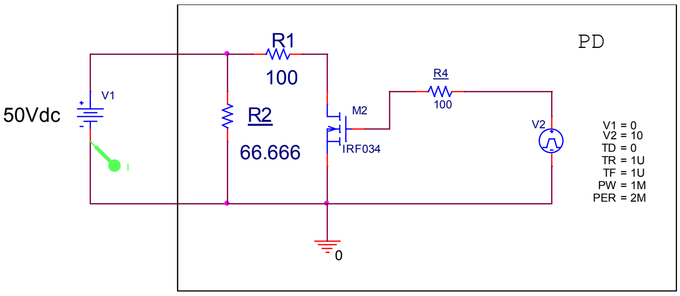
1. RMS Power (or average power in power meter) and Peak power
2. RMS Power (or average power in power meter) and RMS current

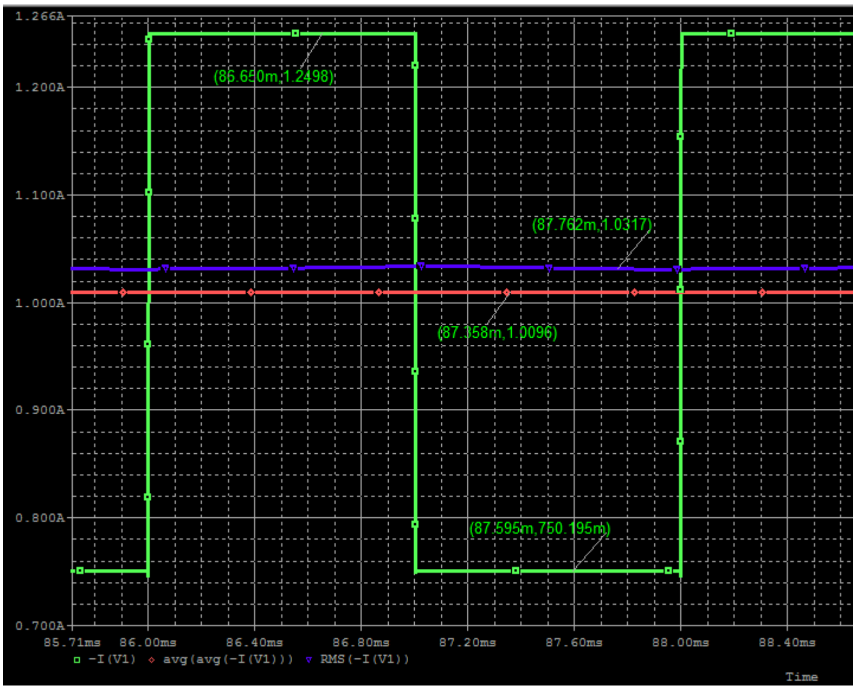
In order to prevent excessive heat to PSE and PD components due to the fact that RMS value > AVG values, when we define limits for parameters that are current, we need to measure its RMS content and not their DC content.
The issue is lake of awareness that a DC current measurement is misleading.

The rule is: in a definition such Icon=Pclass_PD/Vpd-2P, Icon is the RMS value and not the average value for correct measurements and calculations.

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: Iavg= (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=Vpse*Iavg=50V*1A=50W
4. The RMS power dissipated at the PD is Duty*R1*Irms1^2+R2*Irms2^2= 0.5*100Ω*(0.5^2)+66.666Ω*(0.75^2)=50W

In this case Prms=Pavg only because we did it correctly when mixing DC voltage with average current through the load.

It the following case, more complex example, the current through the load and the voltage across the load are time varying. It shows that there is a problem with the definition Pavg=Irms*Vrms; it gives the wrong answer for power consumption. R is stepped for the pulse, and since R is not constant, Irms*Vrms=Pavg is invalid.

	Vpse [V]	50	
	Rcable [Ω]	12	
(Pulse)	Rload_PD1 [Ω]	60	
	Rload_PD2 [Ω]	400	
	Irms [A]	0.207	SQRT(SUM(Ipd^2)/100)
	Vrms [V]	47.913	SQRT(SUM(Vpd^2)/100)
	Pavg(rms) [W]	9.910	=Vrms*Irms
	Ppeak(Actual)	28.935	

	Instantaneous at PD			Square for RMS calc.	
Time	Ipd	Vpd	Power	I^2	V^2
0	0.121	48.544	5.891	0.015	2356.490
0.01	0.121	48.544	5.891	0.015	2356.490
0.02	0.121	48.544	5.891	0.015	2356.490
0.03	0.121	48.544	5.891	0.015	2356.490
0.04	0.121	48.544	5.891	0.015	2356.490
0.05	0.694	41.667	28.935	0.482	1736.111
0.06	0.694	41.667	28.935	0.482	1736.111
0.07	0.694	41.667	28.935	0.482	1736.111
0.08	0.694	41.667	28.935	0.482	1736.111
0.09	0.694	41.667	28.935	0.482	1736.111
0.1	0.694	41.667	28.935	0.482	1736.111
0.11	0.121	48.544	5.891	0.015	2356.490
0.12	0.121	48.544	5.891	0.015	2356.490
0.13	0.121	48.544	5.891	0.015	2356.490
•					
•					
•					
0.97	0.121	48.544	5.891	0.015	2356.490
0.98	0.121	48.544	5.891	0.015	2356.490
0.99	0.121	48.544	5.891	0.015	2356.490

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

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

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

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.