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

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

- **YES.**
  - If PClass is met, it doesn't mean automatically that Ppeak and duty are met too.
  - If PClass meets the spec and Ppeak is measurable then it is sufficient for verify compliance.
  - The problem starts when Ppeak is not measurable in complex waveforms.
  - When the current/power waveforms are complex Pclass alone Is not sufficient to gurantee that the RMS value is not greater than the average value Ppeak and duty is hard to determine. In this case RMS power (or current) needs to be measured in addition to average Pclass or average current.
  - See why in the Annexes.
- **However we can simplify the spec.**
  - We don't need to define what is RMS as function of the ac component and the DC component. ➔ Delete equation 145-26.
  - We can combine Equations 145-28 and 145-29 and delete redundant text.
  - We just need to define the limit of the RMS value as Irms<=Pclass_PD/Vpd as already done and delete the rest of the RMS definitions and their related text.

Suggested Remedy:

Make the following changes:

145.3.8.4 Peak operating power

$V_{Overload\text{-}2P}$ is the PD PI voltage when the PD is drawing the permissible P_{Peak_PD} for single-signature PDs, or $P_{Peak\_PD\text{-}2P}$ 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 $T_{CUT\text{-}2P}$ 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 $P_{Class\_PD\text{-}2P}$ for more than $T_{CUT\text{-}2P}$ min, as defined in Table 145–16 and 5% duty cycle. Peak operating power shall not exceed $P_{Peak\_PD\text{-}2P}$.

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

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

~~For dual-signature PDs, ripple current content ($I_{Port\_ac\text{-}2P}$) superimposed on the DC current level ($I_{Port\_dc\text{-}2P}$) is allowed if $P_{Peak\_PD\text{-}2P}$ requirements are met and the total input power is less than or equal to $P_{Class\_PD\text{-}2P}$.~~

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

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

~~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~~

~~$I_{Port\_dc\text{-}2P}$ is the DC component of the input current for a dual-signature PD~~

~~$I_{Port\_ac\text{-}2P}$ is the RMS value of the AC component of the input current for a dual-signature PD~~

The maximum RMS value of I_{Port} and $I_{Port\text{-}2P}$, ~~$I_{Port\_RMS\_max}$~~ ~~value~~ for all PDs except those described in 145.3.8.2.1 and 145.3.8.4.1, over the operating $V_{Port\_PD\text{-}2P}$ range shall be defined by Equation (145–27):

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

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 informa-tion 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.

For single-signature PDs and dual-signature PDs, ripple current content superimposed on the DC current level is allowed if PPeak_PD and PPeak_PD-2P requirements are met and the total input power is less than or equal to PClass_PD and PClass_PD-2P respectively.

~~For single-signature PDs ripple current content (*I*Port_ac) superimposed on the DC current level (*I*Port_dc) is allowed if PPeak_PD requirements are met and the total input power is less than or equal to PClass at the PSE PI.~~

The ~~For single-signature PDs, the~~ maximum RMS value of I_{Port} and $I_{Port-2P}$, ~~*I*Port_RMS_max value~~ over the operating *V*Port_PD-2P range shall be defined by Equation (145–28):

$$I_{RMS\_max} = \left\{ \begin{array}{ll} \dfrac{P_{Class}}{V_{PSE}} & for\ \ \text{sin}\, gle\ -signature\ PD \\ \dfrac{P_{Class-2P}}{V_{PSE}} & for\ dual\ -signature\ PD \end{array} \right\}_A$$

where

*P*Class is the allocated Class power as defined in 145.2.7 and Equation (145–2)
*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.

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

~~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).~~

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

~~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.~~

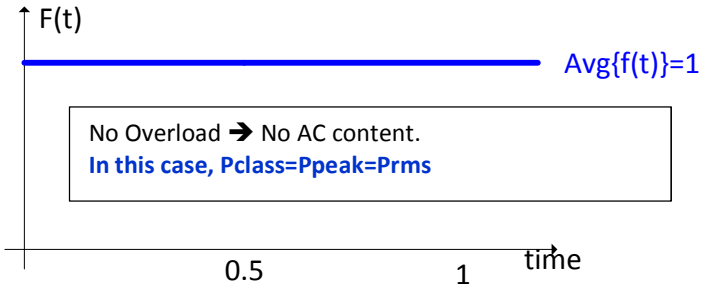
End of baseline

Annex – A

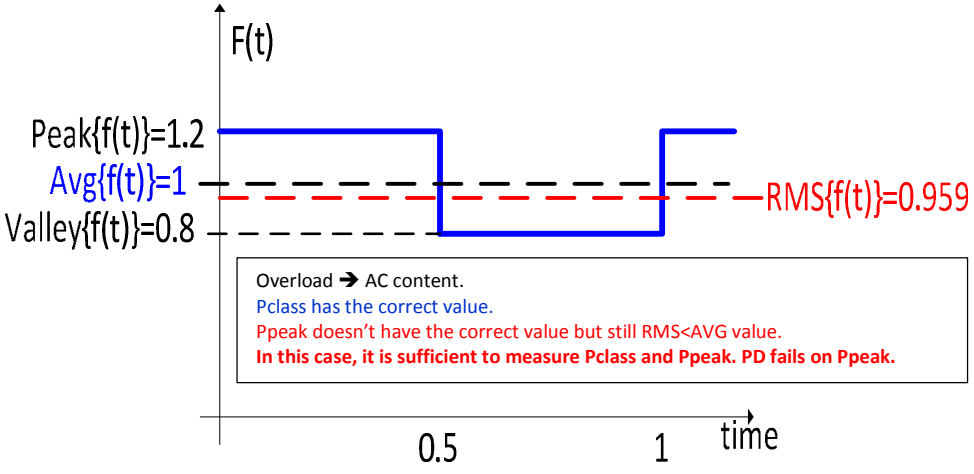
- F(t) avg is the average value of F(t). It can be Pclass[W] or Idc[A].
- F(t) average was set to 1 for simplicity.
- F(t) peak correct value was set to 1.2 for simplicity. F(t) avg still =1.
- F(t) peak un correct value was set to 1.4. F(t) avg still =1.
- F(t) RMS is the RMS value of F(t). It can be PClass RMS[W] or Irms[A]
- Duty cycle=0.5 for simplicity
- Rectangular pulse was used to show the simple case when peak value and duty are measurable and not random.

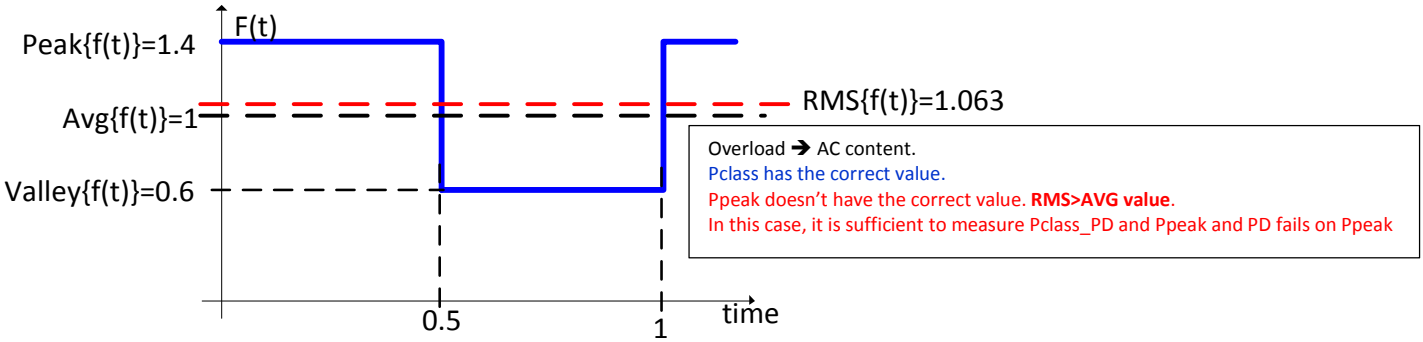
List of facts for the measurable simple case of rectangular pulse:

- By definition the RMS power and the average power of a given load with DC current and voltage has to be equal.



- When the Load has AC content, RMS power and the Average power are not equal.





In order to prevent excessive heat due to RMS values > AVG values we need to set a limit to the RMS value in order to guarantee that the RMS value of PClass will be the same as the average value of PClass.

The best way to do it is to limit the RMS value of the current as we did in

- IEEE802.3af,
- IEEE802.3-2012 and in
- IEEE802.3 d2.3.

The rule is simple:
PClass_rms <=PClass_average
➔
Irms<=Idc=Pclass_PD/Vpd-2P

Annex A – IEEE802.3-2012 - 33.3.7.4 Peak operating power

33.3.7.4 Peak operating power

VOverload is the PD PI voltage when the PD is drawing the permissible PPeak_PD.

At any static voltage at the PI, and any PD operating condition, the peak power shall not exceed PClass_PD max for more than TCUT min, as defined in Table 33–11 and 5% duty cycle. Peak operating power shall not exceed PPeak max.

Ripple current content (*I*Port_ac) superimposed on the DC current level (*I*Port_dc) is allowed if the total input power is less than or equal to PClass_PD max.

The RMS, DC and ripple current shall be bounded by Equation (33–10):

$$I_{Port} = \{\sqrt{(I_{Port\_dc})^2 + (I_{Port\_ac})^2}\}_A \qquad (33–10)$$

Where
*I*Port is the RMS input current
*I*Port_dc is the DC component of the input current
*I*Port_ac is the RMS value of the AC component of the input current

The maximum *I*Port value for all operating *V*Port_PD range shall be defined by the following equation:

$$I\text{portmax} = \{P\text{Class\_PD} / V\text{Port\_PD}\}_A \qquad (33–11)$$

Where
*I*portmax is the maximum DC and RMS input current
*V*Port_PD is the static input voltage at the PD PI
*P*Class_PD is the maximum power, *P*Class_PD max, as defined in Table 33–18

Peak power, *P*Peak_PD, for Class 4 is based on Equation (33–12), which approximates the ratiometric peak powers of Class 0 through Class 3. This equation may be used to calculate peak operating power for *P*Peak_PD values obtained via Data Link Layer classification.

$$P\text{Peak\_PD} = \{1.11 \times P\text{Class\_PD}\}_W \qquad (33–12)$$

Where
*P*Peak_PD is the peak operating power
*P*Class_PD is the input average power

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

IEEE802.3-2012 summary

Parameter name	Symbol	Location	EXAMPLES
Average power	Pclass PD	Table 33-18 Item 4	13W
		clause 33.3.7.2	"The maximum average power, PClass_PD .....is calculated over a 1 second interval."
Peak power	Ppeak_PD	Table 33-18 item 7	14.4W
		clause 33.3.7.4	"At any static voltage at the PI, and any PD operating condition, the peak power shall not exceed PClass_PD max for more than TCUT min, as defined in Table 33–11 and 5% duty cycle. Peak operating power shall not exceed PPeak max."
RMS current and DC current	I_{port_dc}, I_{port_ac}	Equation 33-10 in clause 33.3.7.4	$\sqrt{I_{port\_dc}^{\ 2} + I_{port\_ac}^{\ 2}}$
Max Iport Range	$I_{portmax}$	Equation33-11 in clause 33.3.7.4	$\frac{P_{class\_PD}}{V_{port\_PD}}$

IEEE802.3af

33.3.5.4 Peak operating current

At any operating condition the peak current shall not exceed P_{Port} max/V_{Port} for more than 50ms max and 5% duty cycle max. Peak current shall not exceed I_{Port} max.

Ripple current content (I_{ac}) superimposed on the DC current level (I_{dc}) is allowed if the total input power is less than or equal to P_{Port} max.

The RMS, DC and ripple current shall be bounded by the following equation: $Irms = \sqrt{(Idc)^2 + (Iac)^2}$.

The maximum I_{Port_dc} and I_{Port_rms} values for all operating V_{Port} range shall be defined by the following equation: I_{Port_max} [mA] =12950/V_{Port}.

Annex B – Q&A

1. If we calculate Irms and Idc when the PD meet the spec, we see small differences so why we need Irms definition?
   Answer:
   a) It is not relevant to the discussion if the difference between Irms and IDC is small when the PClass and Ppeak are within the limits of the spec. The spec has to be accurate and not depend on interpretations. So the RMS power and the Average power must be the same by definition.
   b) In addition the problem is what if Ppeak is not meeting the spec and it is hard to measure it? In this case only RMS power measurements or RMS current measurement will solve the problem.
   c) We must stick to the rule that we can't specify parameter if we can't measure it in cost effective way.

2. Does the fact that in IEEE802.3af we specify currents in the overload conditions instead of power cause to the definitions of Irms?
   Answer: Yes in part. However even if the spec will only specify all parameters in terms of power we will still have the problem that RMS value may be > Average value when it is impossible to measure the peak and duty cycle.

3. Does the PD could draw significant Peak POWER when the PSE voltage is high without the I_rms equation?
   Answer: Yes. Irms and Pclass definitions will prevent it.

4. Does the input average power section is weakly defined in 802.3af allowing significant abuse by the PD.
   Answer: Not really. The average power is defined in Table 33-12 and in **33.3.5.2:**
   "The specification for PPort in Table 33–12 shall apply for the input power averaged over 1 second."

5. Does the fact that in our 802.3bt standard the specification is about Peak POWER, not current and the input average power is also tightly defined makes the definition of IPort_RMS as well unnecessary?
   Answer: Not realy.
   a) It doesn't matter if the spec is defined by power terms and not current because I=P/V and both P and V are well defined so current and power are equivalents multiply by a constant (1/V).
   b) We saw in the examples that if PD designer meets Pclass average, it may still can violate Pclass RMS an as a result, Irms which is the concern when Ppeak and duty are not measurable in case of complex ripple waveforms or random behavior with in 1sec window.
   c) Very important to understand that the Icut and ILIM protections are mainly based on current measurements and not peak power measurements.