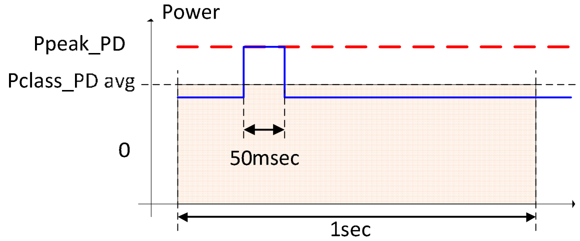
Commnent (#167):
(TDL #385 D2.2)

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

YES. See next slides why. Staring 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. 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.
~~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-2P} min, as defined in Table 145-16 and 5% duty cycle. Peak operating power shall not exceed P_{Peak_PD}.

Do we need the spec for Irms in 145.3.8.4?

(Just to remind you, the answer is YES unless some definitions will be changed changed)

- The RMS value is the average value HOWEVER
  the average value is not always equal to the RMS value!
  - ***If the spec specifies the requirement as RMS power (i.e. Pclass_rms) then it is the AVG power too and no need for further requirements.***
  - ***If the spec specifies the requirement as an average power (i.e. Pclass_avg) than the AVG value of it is not guaranteed to be the RMS value.***

  See annex A for mathematical justification and Annex B for numerical examples.

What tests are needed for 100% reliable compliance test?

What is sufficient to measure in order to verify compliance over a sliding window of 1sec				
Pclass_avg	Pclass_rms	Ppeak	Duty	100% reliable compliance test
Y	N	N	N	N
Y	Y	N	N	N
Y	Y	Y	N	Y
N	Y	Y	N	Y
Y	N	Y	Y(*)	Y(*)
(*) only if Duty is not random and waveform is not chaotic and complex and it is measurable.				

- The problem starts when Ppeak and the duty cycle combinations are not easy to measure in complex waveforms.
  - *Eg. many very short pulses (e.g 0.1msec) that need may be integrated to total of 50msec for a 1sec value and they also need to meet the spec. If it changed randomly, he we can draw*
  - *The solution is using tests that include RMS values.*
- **And we can also simplify the spec.**
  - We don't need to define what is RMS as function of the ac component and the DC component. ➔ Delete Equations 145-26, 145-27, 145-28, 145-29.
  - We just need to define the limit of the RMS value as function of existing requirements per the following text.

Option 1:

1. Delete all the RMS equations and related text
2. To add text that clarifies that in a presence of AC current content, the limits for Pclas_PD and PClass-2P_PD are RMS values (it forces that it is equal to its average value. The other way around is not correct).

Option 2 (preferred):

1. Delete all the RMS equations and related text and add the following text:
2. "The RMS value of Icon (see Equation 145-9) and Icon-2P (see Equation 145-8) shall not exceed the average value of Icon and Icon-2P, for all PDs when connected to the evaluation model in Figure 145-34 under the conditions of 145.3.8."

See proposed baseline for details:

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. $P_{Class\_PD\text{-}2P}$ is the maximum average PI power 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, ~~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.~~

[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

$V_{Overload\text{-}2P}$ 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}. See 145.3.8.2 for

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.

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

~~For single-signature PDs and dual-signature PDs, ripple current content resulting from the peak operating power conditions, (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.~~

[This is the addition for option 2. To delete it if option 1 is accepted]

The RMS value of Icon (see Equation 145-9) and Icon-2P (see Equation 145-8) shall not exceed the average value of Icon and Icon-2P, for all PDs when connected to the evaluation model in Figure 145-34 under the conditions of 145.3.8.

~~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):~~

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

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 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):~~

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

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 including when operating under the conditions of 145.3.8.4.

The RMS value of Icon (see Equation 145-9) and Icon-2P (see Equation 145-8) shall not exceed the average value of Icon and Icon-2P, for all PDs when connected to the evaluation model in Figure 145-34 under the conditions of 145.3.8 and the total input power is less than or equal to PClass and PClass-2P respectively.

~~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):~~

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

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).~~

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

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 RMS power is:

What is are the values of the AC signals V(t) and I(t) the will generate power equal to Vdc*Idc=Paverage.

$$V(t)\cdot I(t)=Vdc\cdot Idc=\sqrt{\frac{1}{T}\int_0^T V(t)\cdot I(t)\cdot dt}=\sqrt{\frac{1}{T}\int_0^T f^2(t)\cdot dt}$$

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 $X^2{}_{rms}=\overline{X}^2+\sigma^2=\overline{X^2}$

- The RMS value is the average value HOWEVER the average value is not always equal to the RMS value!
  - It will be so only if the ac content MATHEMATICALLY is =0 and negligible practically. See Annex B for examples.

So, the RMS value, I_{RMS}, of the function *I(t)* is the constant current that yields the same power dissipation as the time-averaged power dissipation of the current *I(t)*.

<u>However our problem is different.</u>

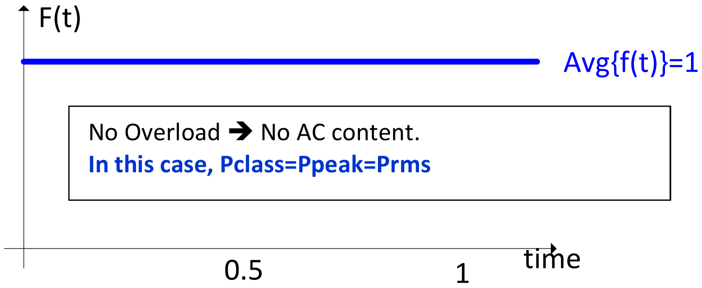
- The DC voltage is pretty much constant with negligible ripple voltage.
- The current has AC component on it which is often hard to measure its peak and duty cycle due to randome nature of the load within a 1sec time window.
- So how we will ensure that the PD meets its Ppeak specifications. The average power/current is easy to measure. The peak power and duty cycle is not.
- The problem is that if we keep the average value of the current, we need to verify that its RMS value is not greater than its average value. See examples in Annex B.

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

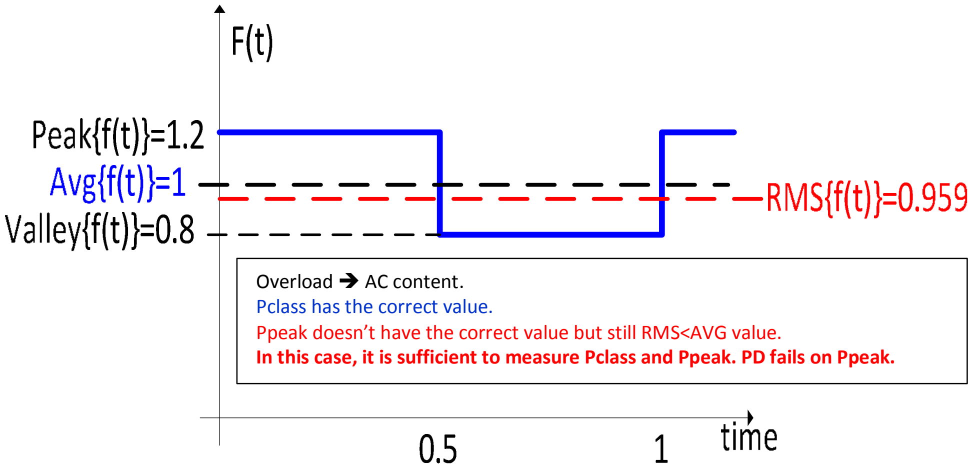
- F(t) avg is the average value of F(t). It can be Pclass[W] or Idc[A].
- F(t) average was set to 1 for simplicity.
- F(t) peak correct value was set to 1.2 for simplicity. F(t) avg still =1.
- F(t) peak un-correct value was set to 1.4. F(t) avg still =1.
- F(t) RMS is the RMS value of F(t). It can be 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 cycle are measurable and not random.

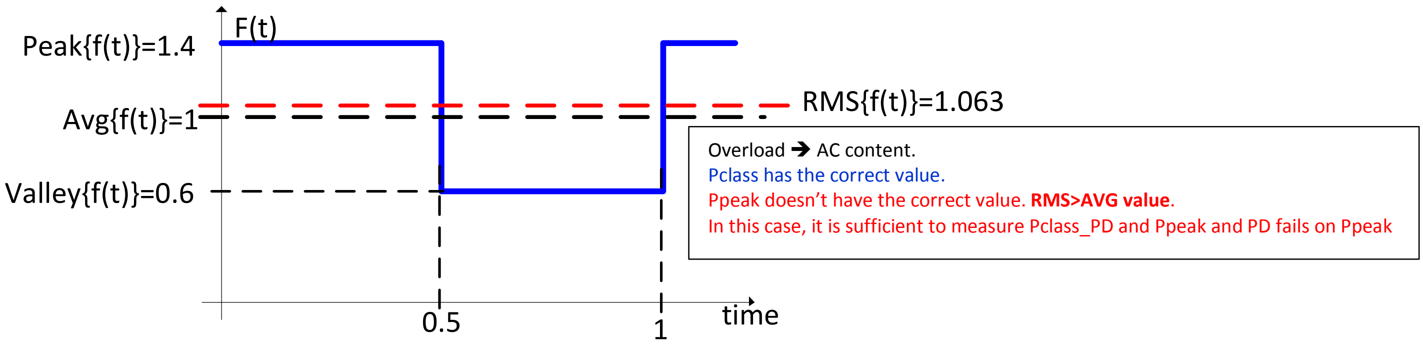
List of facts for the measurable simple case of rectangular pulse:

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

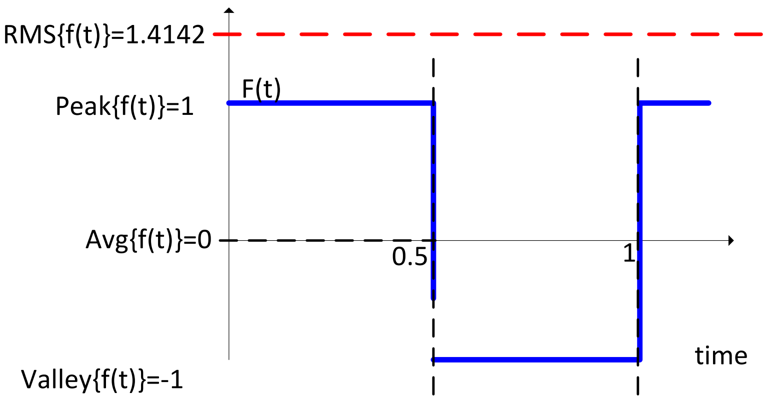


- When the Load has AC content, RMS power and the Average power are not equal.





- And the famous example of all that is clearly not allowed by our spec …
  In this example the average value is 0 and the RMS value is $\sqrt{2}$.



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 the current generated by PClass will be the same as the RMS value of the current generated by PClass.

The 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.

By a simple rule:
Irms<=Idc=Pclass_PD/Vpd-2P

In IEEE802.3bt we can further simplify it by asking the following:
RMS value of Icon and Icon-2P will be lower or equal than the DC value of Icon and Icon-2P.

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 current value may be > Average current 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.