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Simplifying Equation 33-15.

Comment:

In July meeting we have updated Figure 33-26 and Equation 33-15 for D1.8.

1. In Figure 33-26 there is text missing marked in **RED**.
2. Equation 33-15 can be simplified per the work done in:
http://www.ieee802.org/3/bt/public/may16/darshan_18_0516.pdf (See Annex A for reference in this document.

Proposed Remedy

1. Update Figure 33-26 with the additions marked RED:

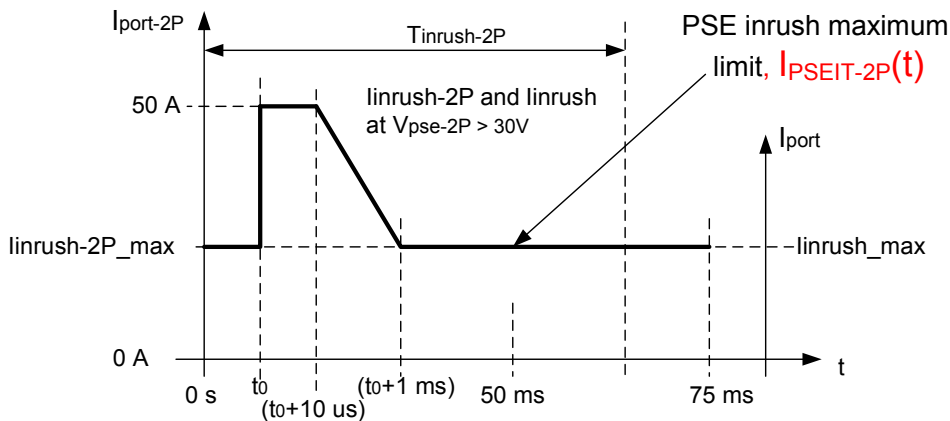


Figure 33-26 – I_rush-2P and I_rush current and timing limits, per pairset in POWER_UP state

2. Update Equation 33-15 as follows:

2.1: Replace $a \times (t + t_0) + b$ from the 3rd line

with:
$$\text{Im}ax + \frac{(50 - \text{Im}ax) \cdot (0.001 + t_0 - t)}{(t_2 - t_1)}$$

2.2 Delete from the “where” list the “a” and “b” constants (they are already embedded in the new equation):

$$a = -\frac{(50 - \text{Im}ax)}{99 \times 10^{-5}}$$

and

$$b = 50 - a \times (t_0 + 10^{-5})$$

2.3 Update the definition of t_0 in the “where” list to:

“ t_0 is the time when IPort-2P exceeds IInrush-2P max for the first time during POWER_UP.

The range of t_0 is: $0 \leq t_0 \leq 49$ msec.”

End of baseline text

Annex A – The objective from May 2016 contribution.

See: http://www.ieee802.org/3/bt/public/may16/darshan_18_0516.pdf

“Note: I am expecting that the new equation above $a \times (t + t_0) + b$ and

$$a = -\frac{(50 - I_{max})}{99 \times 10^{-5}}$$

$$b = 50 - a \times (t_0 + 10^{-5})$$

Will be converged to the same equation in D1.7 i.e. $I_{max} + (50 - I_{max}) \times (0.001 - t) / 99 \times 10^{-5}$.

Will be verified for D1.8. “

Annex B – Derivation of Equation 33-15.

The following derivation will address $f(t)$ part which is marked in red:

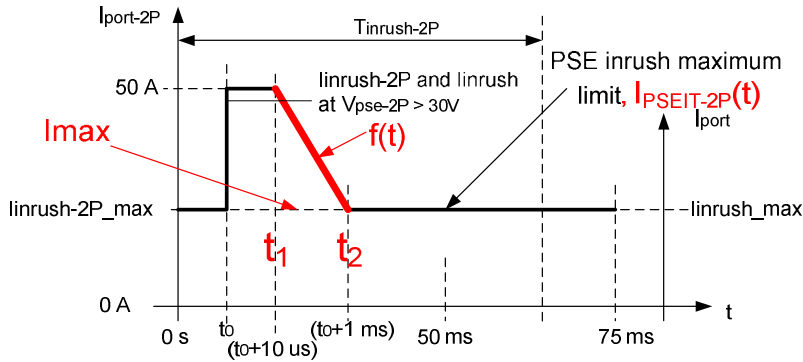


Figure 33-26 – linrush-2P and linrush current and timing limits, per pairset in POWER_UP state

$$I_{PSEIT-2P}(t) = \left\{ \begin{array}{ll} I_{max} & \text{for } 0 < t < t_0 \\ 50 & \text{for } t_0 < t < (t_0 + 10 \times 10^{-6}) \\ f(t) & \text{for } (t_0 + 10 \times 10^{-6}) < t < (t_0 + 0.001) \\ I_{max} & \text{for } (t_0 + 0.001) < t < 0.075 \end{array} \right\}$$

From observation, the value of equation 33-15 in the range 10usec to 1msec in D1.7 should be the same as in D1.8 in the range $(t_0 + 10 \times 10^{-6}) < t < (t_0 + 0.001)$ without being dependent in t_0 since its slope described by $f(t)$, the maximum value (50A) and the minimum value (Inrush-2P_max or linrush which is described by I_{max}) will remain the same.

t_0 is limited to 49msec (50msec maximum PD inrush time duration minus 1msec PD max transient time during PD inrush period).

Derivation for $f(t)=a \cdot t + b$ as was in D1.7 (prior adding the feature that Inrush transient part above I_m can be shift by t_0):

$$f(t) = a \cdot t + b$$

$$50 = a \cdot t_1 + b$$

$$I_{max} = a \cdot t_2 + b$$

$$a = \frac{(50 - I_{max})}{(t_1 - t_2)}$$

$$b = I_{max} - a \cdot t_2 = I_{max} - \frac{(50 - I_{max})}{(t_1 - t_2)} \cdot t_2$$

$$f(t) = a \cdot t + b = \frac{(50 - I_{max})}{(t_1 - t_2)} \cdot t + I_{max} - \frac{(50 - I_{max})}{(t_1 - t_2)} \cdot t_2 \Rightarrow$$

$$f(t) = I_{max} + \frac{(50 - I_{max}) \cdot (t - t_2)}{(t_1 - t_2)} =$$

$$= I_{max} + \frac{(50 - I_{max}) \cdot (t - 0.001)}{-99 \cdot 10^{-5}}$$

$$f(t) = I_{max} + \frac{(50 - I_{max}) \cdot (0.001 - t)}{99 \cdot 10^{-5}}$$

Simplifying $f(t)$ as in D1.8 by embedding the variables “a” and “b” in the main equation:

$f(t)$ is allowed to shift by t_0 from $t=0$ to $t=49\text{msec}$.

From observation the function developed for D1.7: $f(t) = \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (0.001 - t)}{99 \cdot 10^{-5}}$

can be modified to address the shift in time (the quick way):

$$f(t) = f(t - t_0) = \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (0.001 - (t - t_0))}{99 \cdot 10^{-5}} \Rightarrow$$

$$f(t) = \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (0.001 + t_0 - t)}{99 \cdot 10^{-5}}$$

Testing: $\text{Im } ax = 0.45$, $t = t_1 = (t_0 + 10\text{usec})$.

$$f(t) = 0.45 + \frac{(50 - 0.45) \cdot (0.001 + t_0 - (t_0 + 10 \cdot 10^{-6}))}{99 \cdot 10^{-5}} = 50A$$

Testing: $\text{Im } ax = 0.45$, $t = t_2 = (t_0 + 1\text{msec})$.

$$f(t) = 0.45 + \frac{(50 - 0.45) \cdot (0.001 + t_0 - (t_0 + 0.001))}{99 \cdot 10^{-5}} = 0.45A$$

Detailed derivation (OPTION 1):

$$f(t) = a \cdot t + b$$

$$50 = a \cdot t_1 + b$$

$$\text{Im } ax = a \cdot t_2 + b$$

$$a = \frac{(50 - \text{Im } ax)}{((t_1 + t_0) - (t_2 + t_0))} = \frac{(50 - \text{Im } ax)}{(t_1 - t_2)}$$

$$b = \text{Im } ax - a \cdot t_2 = \text{Im } ax - \frac{(50 - \text{Im } ax)}{(t_1 - t_2)} \cdot t_2$$

$$f(t) = a \cdot t + b = \frac{(50 - \text{Im } ax) \cdot t}{(t_1 - t_2)} + \text{Im } ax - \frac{(50 - \text{Im } ax) \cdot t_2}{(t_1 - t_2)} =$$

$$= \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (t - t_2)}{(t_1 - t_2)}$$

$$t_2 = t_0 + 0.001$$

$$f(t) = \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (t - (t_0 + 0.001))}{(t_1 - t_2)} = \text{Im } ax + \frac{(50 - \text{Im } ax) \cdot (0.001 + t_0 - t)}{(t_2 - t_1)}$$

Detailed derivation (OPTION 2 – The form used in D1.8):

In option 2 the only difference is that “b” was derived using equation (1) while in option 1 it was derived by using equation (2).

$$f(t) = a \cdot t + b$$

$$1. \quad 50 = a \cdot t_1 + b$$

$$2. \quad \text{Imax} = a \cdot t_2 + b$$

$$a = \frac{(50 - \text{Imax})}{((t_1 + t_0) - (t_2 + t_0))} = \frac{(50 - \text{Imax})}{(t_1 - t_2)}$$

$$b = 50 - a \cdot t_1 = 50 - \frac{(50 - \text{Imax})}{(t_1 - t_2)} \cdot t_1$$

$$\begin{aligned} f(t) = a \cdot t + b &= \frac{(50 - \text{Imax}) \cdot t}{(t_1 - t_2)} + 50 - \frac{(50 - \text{Imax}) \cdot t_1}{(t_1 - t_2)} = \\ &= \text{Imax} + \frac{(50 - \text{Imax}) \cdot (t - t_1)}{(t_1 - t_2)} \end{aligned}$$

$$t_1 = t_0 + 10 \cdot 10^{-6}$$

$$f(t) = 50 + \frac{(50 - \text{Imax}) \cdot (t - (t_0 + 10 \cdot 10^{-6}))}{(t_1 - t_2)} = 50 + \frac{(50 - \text{Imax}) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)}$$

Testing: $\text{Imax} = 0.45$, $t = t_1 = (t_0 + 10 \text{usec})$.

$$f(t) = 50 + \frac{(50 - \text{Imax}) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)} = 50 + \frac{(50 - 0.45) \cdot (10 \cdot 10^{-6} + t_0 - (t_0 + 10 \cdot 10^{-6}))}{99 \cdot 10^{-5}} = 50A$$

Testing: $\text{Imax} = 0.45$, $t = t_2 = (t_0 + 1 \text{msec})$.

$$\begin{aligned} f(t) &= 50 + \frac{(50 - \text{Imax}) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)} = 50 + \frac{(50 - 0.45) \cdot (10 \cdot 10^{-6} + t_0 - (t_0 + 0.001))}{99 \cdot 10^{-5}} = \\ &= 50 + \frac{(49.55) \cdot (10 \cdot 10^{-6} - (0.001))}{99 \cdot 10^{-5}} = 0.45A \end{aligned}$$

Annex C – Does $t_0 < 49\text{msec}$ is OK?

A PD may finish inrush period within 1msec and the inrush period may be delayed up to 49msec.

Example:

| linrush [A] | Tinrush [msec] | C[uF] | Vpd [V] |
|----------------|-------------------|-------|---------|
| 0.3 | 0.95 | 5 | 57 |

Tinrush < 1msec.

As a result $t_0 \text{ max} = 50\text{msec} - 1\text{msec} = 49\text{msec}$