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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:**

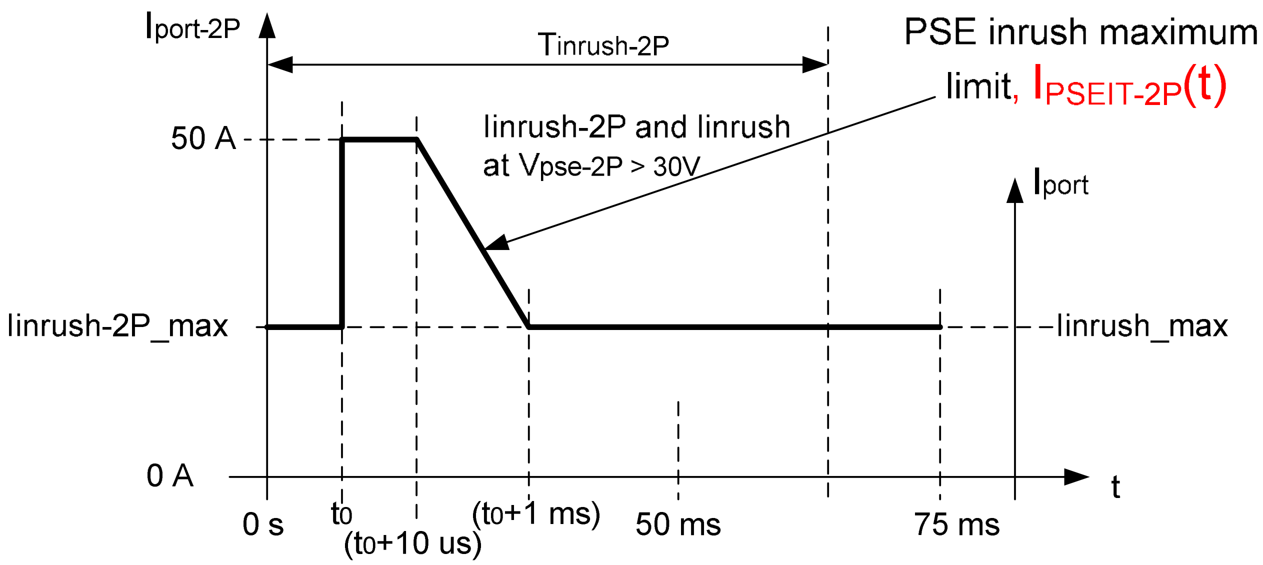

Figure 33-26 – Iinrush-2P and Iinrush current and timing limits, per pairset in POWER_UP state

2. Update Equation 33-15 as follows:

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

with: $\mathrm{Im}\,ax + \frac{(50 - \mathrm{Im}\,ax) \cdot (0.001 + t_0 - t)}{99 \times 10^{-5}}$

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

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

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

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

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

Will be converged to the same equation in D1.7 i.e. Imax + (50-Imax)*(0.001-t)/99*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:

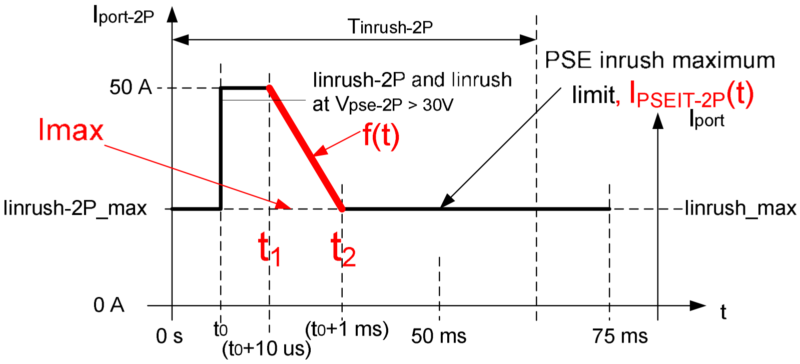

Figure 33-26 – Iinrush-2P and Iinrush current and timing limits, per pairset in POWER_UP state

$$
I_{PSEIT-2P}(t)=\left\{\begin{array}{lll} \mathrm{Im}ax & for & 0<t<t_0 \\ 50 & for & t_0<t<\left(t_0+10\times10^{-6}\right) \\ f(t) & for & \left(t_0+10\times10^{-6}\right)<t<\left(t_0+0.001\right) \\ \mathrm{Im}ax & for & \left(t_0+0.001\right)<t<0.075 \end{array}\right\}
$$

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 $\left(t_0+10\times10^{-6}\right)<t<\left(t_0+0.001\right)$ 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 Iinrush which is described by Imax) 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*t +b as was in D1.7 (prior adding the feature that Inrush transient part above Im can be shift by t_0:

$$
\begin{aligned}
&f(t)=a\cdot t+b \\
&50=a\cdot t_1+b \\
&\mathrm{Im}ax=a\cdot t_2+b \\
&a=\frac{(50-\mathrm{Im}ax)}{(t_1-t_2)} \\
&b=\mathrm{Im}ax-a\cdot t_2=\mathrm{Im}ax-\frac{(50-\mathrm{Im}ax)}{(t_1-t_2)}\cdot t_2 \\
&f(t)=a\cdot t+b=\frac{(50-\mathrm{Im}ax)}{(t_1-t_2)}\cdot t+\mathrm{Im}ax-\frac{(50-\mathrm{Im}ax)}{(t_1-t_2)}\cdot t_2 \Rightarrow
\end{aligned}
$$

$$
\begin{aligned}
f(t)&=\mathrm{Im}ax+\frac{(50-\mathrm{Im}ax)\cdot(t-t_2)}{(t_1-t_2)}= \\
&=\mathrm{Im}ax+\frac{(50-\mathrm{Im}ax)\cdot(t-0.001)}{-99\cdot10^{-5}} \\
f(t)&=\mathrm{Im}ax+\frac{(50-\mathrm{Im}ax)\cdot(0.001-t)}{99\cdot10^{-5}}
\end{aligned}
$$

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=49msec.

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

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

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

Testing: Imax=0.45, t=t1=(t_0+10usec).

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

Testing: Imax=0.45, t=t2=(t_0+1msec).

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

Detailed derivation (OPTION 1):

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

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. $50 = a \cdot t_1 + b$

2. $\mathrm{Im}\,ax = a \cdot t_2 + b$

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

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

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

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

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

$$f(t) = 50 + \frac{(50 - \mathrm{Im}\,ax) \cdot (t - (t_0 + 10 \cdot 10^{-6}))}{(t_1 - t_2)} = 50 + \frac{(50 - \mathrm{Im}\,ax) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)}$$

Testing: Imax=0.45, t=t1=(t_0+10usec).

$$f(t) = 50 + \frac{(50 - \mathrm{Im}\,ax) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)} = 50 + \frac{(50 - 0.45) \cdot \left(10 \cdot 10^{-6} + t_0 - (\mathrm{t}_0 + 10 \cdot 10^{-6})\right)}{99 \cdot 10^{-5}} = 50A$$

Testing: Imax=0.45, t=t2=(t_0+1msec).

$$f(t) = 50 + \frac{(50 - \mathrm{Im}\,ax) \cdot (10 \cdot 10^{-6} + t_0 - t)}{(t_2 - t_1)} = 50 + \frac{(50 - 0.45) \cdot \left(10 \cdot 10^{-6} + t_0 - (\mathrm{t}_0 + 0.001)\right)}{99 \cdot 10^{-5}} =$$

$$= 50 + \frac{(49.55) \cdot \left(10 \cdot 10^{-6} - (0.001)\right)}{99 \cdot 10^{-5}} = 0.45A$$

Annex C – Does t_0 <49msec is OK?

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

Example:

Iinrush [A]	Tinrush [msec]	C[uF]	Vpd [V]
0.3	**0.95**	5	57

Tinrush <1msec.

As a result t_0 max =50msec-1msec=49msec