Comment:

In order to sync the new Equation 33-12 with Equation 33-10 and 33-11, the accuracy of the curve fit of Equation 33-11 need to be increase to the range of ~<0.25mA.

Suggested Remedy:

Change Equation 33-11 from:

$$K_{\text{Ipeak}} = \begin{cases} \min(0.214 \times (R_{\text{chan-2P}})^{-0.363}, \text{0.331 } \cancel{0.330}) & \text{for Class 5} \\ \min(0.199 \times (R_{\text{chan-2P}})^{-0.350}, \text{0.304 } \cancel{0.300}) & \text{for Class 6} \\ \min(0.180 \times (R_{\text{chan-2P}})^{\text{-0.335 } \cancel{-0.326}}, 0.270) & \text{for Class 7} \\ \min(0.176 \times (R_{\text{chan-2P}})^{\text{-0.347 } \cancel{-0.325}}, 0.260) & \text{for Class 8} \end{cases}$$

Change Equation 33-11 to:

$$K_{Ipeak} = \begin{cases} \min(0.214 \times (R_{chan-2P})^{-0.363}, 0.331) & for \quad Class \quad 5 \\ \min(0.199 \times (R_{chan-2P})^{-0.350}, 0.304) & for \quad Class \quad 6 \\ \min(0.180 \times (R_{chan-2P})^{-0.335}, 0.270) & for \quad Class \quad 7 \\ \min(0.176 \times (R_{chan-2P})^{-0.347}, 0.260) & for \quad Class \quad 8 \end{cases} \qquad \text{33-11}$$

End of baseline text. See detailed analysis in next pages

Analysis and detailed derivation

Background

ILIM-2P of table 33-17 was generated from simulated[1] values of Ipeak-2P_unb_max (*) per class and adding to it 2mA. See Table 1 for details.

Pclass_pd [w]	Ppeak_pd= 1.05*Pclass_PD [W]	Rchan_max[2] [Ω]	Rchan_min [Ω]	Calculated Ipeak [A]	Calculated Ipeak-2P [A]	Simulated Ipeak-2P_unb_max [A]	Table 33-17: ILIM-2P= Ipeak-2P_unb_max+0.002 [A]
40	41.934	0.1[3]	See note 2	0.952	0.476	0.560	**0.562**
51	53.55	0.1[3]		1.274	0.637	0.700	**0.702**
62	65.098	6.25		1.535	0.768	0.827	**0.829**
71	74.841	6.25		1.851	0.926	0.988	**0.990**

Table 1: ILIM-2P per Table 33-17 as function of simulated results of the simulated Ipeak-2P_unb_max.

Notes:

1. The simulated values of Ipeak-2P were obtained using the 4-pairs system model as presented in the latest ad-hoc database material.
2. Rchan_max is the total cable + connectors resistance as function of channel length per the add hock data base material. Rchan_min is the minimum value of Rchan that was determined for the channel components per their individual pair to pair unbalance value as set by per the adhoc data base. Rchan_max and Rchan_min are the resistance of two the pairs in parallel of the same polarity.
3. In Type 3 class 5 and 6, the maximum current due to pair to pair unbalance is obtained at the shortest channel length that per the model was set to:
   Equation 33-9: Rchan= ~0.1Ω for Type 3 class 5 and 6
   Equation 33-9: Rchan= ~6.25Ω for Type 4 class 7 and 8.
   Equation 33-11: Rchan-2P= ~0.2Ω for Type 3 class 5 and 6
   Equation 33-11: Rchan-2P= ~12.5Ω for Type 4 class 7 and 8.

As a result, for the fixed values of the **simulated** Ipeak_2P_unb_max and ILIM_2P, the results are accurate although the **simulated** Ipeak-2P_unb_max worst case value is not explicitly specified in the standard. However it could be evaluated by using by Equation 33-9, Equation 33-10 and Equation 33-11 when the correct Rchan and Rchan-2P values were used. See note 3 above. Using these equations gave accurate results of Ipeak-2P_unb_max within 4.5mA max error pending the class. See table 2

The issue is that lately we add Equation 33-12 to D1.8 that specifies explicitly the requirement of 2mA difference between the calculated value of Ipeak-2P_unb_max based on Equation 33-11 and the fixed value of ILIM-2P.

"The worst case value of IPeak-2P-unb is defined by Equation (33–12).

$$\text{Ipeak-2P\_unb\_max} = \{\text{ILIM-2P-0.002}\}_{\text{A}} \quad (33\text{-}12)$$

Where

ILIM-2P is the ILIM-2P min value per pairset for the PSE, as defined in Table 33–17"

Per Table 2, we can see that the differences are higher or lower than 2mA that now must be corrected since Equation 33-12 in now in the spec. See Table 2 for details.

Class	Vpse	Pclass_pd	Ppeak_pd	Rchan	Ipeak	Rchan-2P	Kipeak	Ipeak_2P_unb_max[6] (Curve fit)	Ilim-2P	Ilim-2P – Ipeak-2P_unb_max[6]
			=1.05 X Pclass_pd		Ipeak per Equation 33-9 (Quadratic)		EQ 33-11	Calculated per Eq-33-10	See Table 33-17.	Should be =2mA according to Eq 33-12[1]
5	50	40	42	0.1	0.841	0.2	0.330	0.5595	0.562	0.0025[2]
6	50	51	53.55	0.1	1.073	0.2	0.300	0.6976	0.702	0.0044[3]
7	52	62	65.1	6.25	1.535	12.5	0.079	0.8282	0.829	0.0008[4]
8	52	71	74.55	6.25	1.841	12.5	0.0774	0.9918	0.99	-0.0018[5]

Table 2: Calculated Ipeak-2P_unb_max and comparing it to ILIM-2P to verify if the difference is 2mA according to Equation 33-12

Notes:

1. It is equivalent to Eq. 33-12
2. *Need to decrease from 2.5mA to 2mA.*
3. Note Need to decrease from 4.4mA to 2mA.
4. Need to increase from 0.8mA to 2mA.
5. Need to increase from -1.8mA to 2mA.
6. In this case it is the result of Ipeak-2P_unb_max that was generated by Equation 33-10 and the curve fit of Equation 33-11 were the correct Rchan, Rcha-2P were plugged to generate the maximum current. It should also need to be 2mA less that ILIM-2P value.

In order to meet equation 33-12 for 2mA difference, equation 33-11 accuracy needs to be improved. With 3 digits for the constants of Equation 33-11, it is possible to achieve accuracy better than 0.25mA. For less than 0.1mA, 4 digits will be required.

The following changes were made to improve accuracy under the following conditions:
Type 3 class 5 and 6: short cable (2m, ~0.1 Ω)➔ maximum Kipeak ➔ maximum pair current.
Type 4 class 7 and 8: long cable (100m, ~6.25 Ω) ➔ minimum Kipeak) ➔ maximum pair current.

The new Equation 33-11 will be:

$$K_{\text{Ipeak}} = \begin{cases} \min(0.214 \times (R_{\text{chan-2P}})^{-0.363}, \cancel{0.330}\ 0.331) & \text{for Class 5} \\ \min(0.199 \times (R_{\text{chan-2P}})^{-0.350}, \cancel{0.300}\ 0.304) & \text{for Class 6} \\ \min(0.180 \times (R_{\text{chan-2P}})^{\cancel{-0.326}\ -0.335}, 0.270) & \text{for Class 7} \\ \min(0.176 \times (R_{\text{chan-2P}})^{\cancel{-0.325}\ -0.347}, 0.260) & \text{for Class 8} \end{cases}$$

Note:

The Kipeak equation is based on the form $\min(\alpha \cdot R_{chan-2P}^{-\beta}, \gamma)$.

The reason why in class 5 and 6 the limiters γ=0.330 was changed is that maximum current happened at maximum pair to pair unbalance i.e. maximum Kipeak so it easier to change the limiters (0.330) to get the desired accuracy rather than changing β for class 5 and 6.

In Type 4 class 7 and 8, we can't change the limiters γ since Kipeak_min which happens at long cable is generating the maximum current and if we use a limiter that is close to Kipeak_min then at short cable Kipeak_max will be truncated. As a result β was updated instead of γ.

As a result, ILIM-2P - Ipeak-2P_unb_max[2]~=2mA was obtained as required.

Class	Vpse	Pclass_pd	Ppeak_pd	Rchan	Ipeak	Rchan-2P	Kipeak	Ipeak_2P_unb_max (Curve fit)	Ilim-2P	Ilim-2P – Ipeak-2P_unb_max[2]
			=1.05 X Pclass_pd		Ipeak per Equation 33-9 (Quadratic)		EQ 33-11	Calculated per Eq-33-10	See Table 33-17.	Should be =2mA according to Eq 33-12[1]
5	50	40	42	0.1	0.841	0.2	0.331	0.5600	0.562	0.00204
6	50	51	53.55	0.1	1.073	0.2	0.304	0.6998	0.702	0.00221
7	52	62	65.1	6.25	1.535	12.5	0.077	**0.8269**	0.829	0.00212
8	52	71	74.55	6.25	1.841	12.5	0.073	**0.9880**	0.99	0.00204

Notes:

1. It is equivalent to Eq. 33-12
2. In this case it is the result of Ipeak-2P_unb_max that was generated by Equation 33-10 and the curve fit Equation 33-11 were the correct Rchan, Rcha-2P were plugged to generate the maximum current. It should also need to be 2mA less that ILIM-2P value.