Power Matters

IEE802.3 4P Task Force

Updating E2EP2P_Iunb numbers per latest changes in Draft D1.2 and September discussions

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Contents

Table 33-11 item 4a, Icon-2P_unb

Update Table 33-11 item 4a, Icon-2P_unb as follows:

Item	Parameter	Symbol	Unit	Min	Max	PSE Type	Additional Information
4a	Pairset current including unbalance for class 5	$I_{Con-2P-unb}$	A	550 ~~536~~		3	See 33.2.7.4 and 33.2.7.4a
	Pairset current including unbalance for class 6			682 ~~668~~		3	
	Pairset current including unbalance for class 7			777 ~~778~~		4	
	Pairset current including unbalance for class 8			925 ~~926~~		4	

---------- End Of Base Line Text ----------

Notes:

1. The values of Icont-2P_unb shall be kept within the above limits in case a PD is used extended power. No additional text is required to support this. As we agreed, the burden will fall on the PD side in a way that tighter unbalance requirements will be developed to keep the same current.
   A comment was issued to build the infrastructure to do it by modifying informative Annex 33A.5.
2. See Annex C for comparison between the resultant current for different PSE and PD Vdiff
3. The values for this table were simulated for PSE Vdiff=10mV and PD Vdiff=60mV for Type 3 and PSE Vdiff=10mV and PD Vdiff=50mV for Type 3.

Table 33-11 item 7, Additional Information, K_Icut values

Update table 33-11 item 7, Additional Information, K_Icut values as follows:

Item	Parameter	Symbol	Unit	Min	Max	PSE Type	Additional Information
7	Overload current per pair set, detection range	I_{CUT-2P}	A	Pclass/Vport_PSE-2P	I_{LIM}	1, 2	Optional LIMIT; See 33.2.7.6, Table 33-7. Kicut=: ~~0.596~~ 0.611 for class 5. ~~0.557~~0.568 for class 6. 0.539 for class 7. 0.535 for class 8.
				Kicut X Pclass/Vport_PSE-2P		3,4	

---------- End of Baseline Text ----------

Notes:

1. The values for this table were simulated for PSE Vdiff=10mV and PD Vdiff=60mV for Type 3 and PSE Vdiff=10mV and PD Vdiff=50mV for Type 3.
2. See Annex B for details.

Table 33-11 Item 9, I LIM-2P

Update Table 33-11 Item 9, I LIM-2P as follows:

Item	Parameter	Symbol	Unit	Min	Max	PSE Type	Additional Information
9	Output current per pair set – at short circuit condition	I_{LIM-2P}	A	0.400	See info	1	For Class 0-3. See 33.2.7.7. Maximum value defined by Figure 33-14.
				1.14xIcable		2	For class 4. Maximum value defined by Figure 33-14.
				~~0.551~~ 0.562		3	For Class 5. Maximum value defined by Figure 33-14.
				~~0.691~~ 0.702		3	For Class 6. Maximum value defined by Figure 33-14.
				0.829		4	For Class 7. Maximum value defined by Figure 33-14.
				0.990		4	For Class 8. Maximum value defined by Figure 33-14.

----------End of Baseline Text ----------

Notes:

1. See annex A for ILIM-2P values derivation.
2. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
3. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Equation 33-4b (PSE PI):

Update equation 33-4b (PSE PI) as follows:

$$R_{Pair\_max} = \begin{cases} 2.200 \text{ x } R_{Pair\_min} - 0.040 & \text{for class 5} \\ 2.015 \text{ x } R_{Pair\_min} - 0.040 & \text{for class 6} \\ 1.800 \text{ x } R_{Pair\_min} - 0.030 & \text{for class 7} \\ 1.750 \text{ x } R_{Pair\_min} - 0.030 & \text{for class 8} \end{cases}$$

---------- End Of Base Line Text ----------

Notes:

1. This is PSE PI P2P spec.
2. Reviewing this numbers to cover extended power requires no changes due to the fact that we need that the burden will be on the PD for extended power. As a result PD PI requirements will be updated to cover extended power.
3. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
4. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.
5. $$R_{Pair\_max} = \begin{cases} 2.201 \text{ x } R_{Pair\_min} - 0.036 & \text{for class 5} \\ 2.016 \text{ x } R_{Pair\_min} - 0.033 & \text{for class 6} \\ 1.808 \text{ x } R_{Pair\_min} - 0.023 & \text{for class 7} \\ 1.751 \text{ x } R_{Pair\_min} - 0.022 & \text{for class 8} \end{cases}$$

   Rounding the numbers for worst case will give the above results as shown for the baseline text

KIpeak in equation 33-4a

To update KIpeak in equation 33-4a per latest D1.2 changes.

Change the following K equation from:

$$KIPeak = \min\begin{Bmatrix} 0.2007 \cdot Rchan^{-0.345},\ 0.306 & for\ Class\ 5. \\ 0.1882 \cdot Rchan^{-0.333},\ 0.283 & for\ Class\ 6. \\ 0.1816 \cdot Rchan^{-0.327},\ 0.270 & for\ Class\ 7 \\ 0.1775 \cdot Rchan^{-0.326},\ 0.260 & for\ Class\ 8 \end{Bmatrix}$$

To:

$$KIPeak = \min\begin{Bmatrix} 0.214 \cdot Rchan^{-0.363},\ 0.330 & for\ Class\ 5. \\ 0.199 \cdot Rchan^{-0.350},\ 0.300 & for\ Class\ 6. \\ 0.180 \cdot Rchan^{-0.326},\ 0.270 & for\ Class\ 7 \\ 0.176 \cdot Rchan^{-0.325},\ 0.260 & for\ Class\ 8 \end{Bmatrix}$$

---------- End Of Base Line Text ----------

Notes:

1. The results will not be affected for extended power due to the fact that the PD will have tighter P2PUNB to keep the same E2EP2PRunb so Icont-2P_unb and as a result Ipeak-2P will be the same as when PD power is per Table 33-18 for 100m channel.
2. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
3. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Table 33-18a – Test conditions and Test requirements for PD PI P2PCUR_unb

To check the effect when PSE Vdiff was increased to 10mV and PD Vdiff was increased to 50mV for class 7 and 8 and to 60mV for class 5 and 6.

	PSE Vdiff	PD Vdiff	Rpair_min [Ω]	Rpair_max [Ω]
Class 5	10mV	50mV	0.143	0.1915
Class 6	10mV	50mV	0.147	0.1915
Class 7	10mV	50mV	0.148	0.1915
Class 8	10mV	50mV	0.15	0.1915
Class 5	10mV	60mV	0.143	0.1915
Class 6	10mV	60mV	0.147	0.1915

The spec stays unchanged: 0.16Ω min, 0.19Ω max.

We may consider later to update Rpair_min to 0.15 Ω. It depends by the test setup accuracy.

No action required yet.

Annex 33A.5 PD PI pair-to-pair current unbalance requirements

1. Update the following requirements as follows:

For PD Type 3 class 5: $Rpair\_max_{pd} = 2.200 * Rpair\_min_{pd} + 0.125$
For PD Type 3 class 6: $Rpair\_max_{pd} = 2.010 * Rpair\_min_{pd} + 0.105$.
For PD Type 4 class 7: $Rpair\_max_{pd} = 1.800 * Rpair\_min_{pd} + 0.080$
For PD Type 4 class 8: $Rpair\_max_{pd} = 1.750 * Rpair\_min_{pd} + 0.080$

2. Add the following text:

For PD power above the values shown in Table 33-18 and up to Pclass, stringent requirement will be needed to not exceed Icont-2P_unb by means of smaller constant α and β in the equation $Rpair\_max_{pd} = \alpha * Rpair\_min_{pd} + \beta$.

Editor Note: We may add a set of equations for the case that PD power is up to Pclass for each class or use only the guideline in the added text above. Group to discuss.

---------- **End of Baseline text** ----------

Notes:

1. The following is the original simulation results compared to D1.2 numbers and were rounded up/down as presented above in the baseline proposal.

For PD Type 3 class 5: $Rpair\_max_{pd} = 2.201 * Rpair\_min_{pd} + 0.124$
For PD Type 3 class 6: $Rpair\_max_{pd} = 2.016 * Rpair\_min_{pd} + 0.105$.
For PD Type 4 class 7: $Rpair\_max_{pd} = 1.808 * Rpair\_min_{pd} + 0.077$
For PD Type 4 class 8: $Rpair\_max_{pd} = 1.751 * Rpair\_min_{pd} + 0.0716$

2. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
3. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Table 33-B1 PSE PI

Update Table 33-B1 PSE PI

Change the table as follows:

PSE Class	Rload_min, [Ω]	Rload_max, [Ω]
5	0.723~~0.739~~	~~1.562~~1.628
6	0.623~~0.635~~	~~1.250~~1.289
7	~~0.577~~0.590	1.090~~1.094~~
8	~~0.533~~0.544	~~0.979~~0.975

Table 33B-1: Rload_max and Rload_min requirements.

---------- End Of Base Line Text ----------

1. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
2. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Modified Remedy for comment #184

33.3.7.10 PD PI pair-to-pair resistance and current unbalance

All Class 5 and higher PDs shall not exceed Icon-2P-unb (Table 33–11, item 4a) on any pair.~~either pairset~~ PDs shall meet this requirement when connected to a common source voltage through a resistance of Rsource_min=0.16Ω±1% and Rsource_max=0.19Ω±1% (Editor Note: add longer channel resistance) to PD PI pairs of the same polarity (See Figure 33-18a), for all PD operating conditions.~~tested according to section 33.3.7.10.1.~~

See Annex 33A.5 for design guide lines for meeting the above requirements.

~~**33.3.7.10.1 Test setup and test conditions for PD PI pair-to-pair resistance and current unbalance**~~

~~Th e test setup described in Figure 33–18a and its test conditions (shown in Table 33–18a) shall be used to verify that the requirements in section 33.3.7.10 are met.~~

~~Table 33–18a—Test conditions and test requirements for PD PI pair-to-pair current unbalance and resistance unbalance test setup~~

Item	Parameter	Unit	Value	Additional Information
1	Vin	V	$V_{Port\_PSE\_min}$	
2	R_{pair_max}	Ω	0.16±1%	See Annex 33A.5
3	R_{pair_min}	Ω	0.19±1%	See Annex 33A.5
4	PD power	W	Set to maximum per its Class	

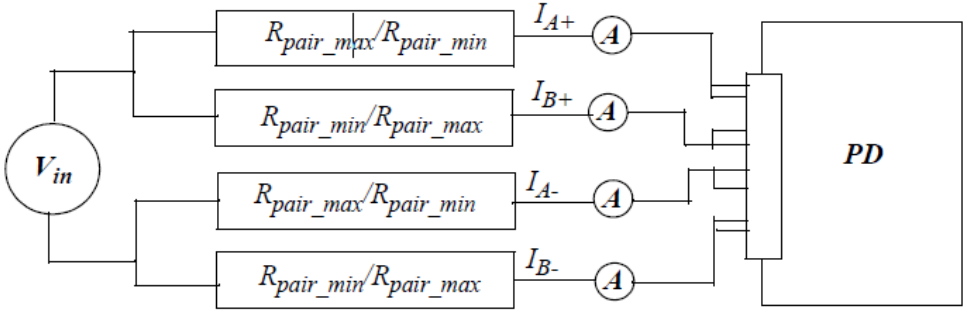

Figure 33–18a—PD PI Icon-2P_unb test~~fault tolerance test circuit~~

Rsource_max and Rsource_min ~~Rpair_min~~ ~~represents~~represent the Vin source impedance that is consist of PSE PI components (Rpair_max and Rpair_min as specified in 33.2.7.4.1) and channel resistance.~~effective source impedance that includes the effect of VPort_PSE_diff as specified by Table 33–11 item 1a~~. IA and IB are the pair current of pairs with the same polarity.

Annex A1: Derivation of ILIM_2P_MIN, Table 33-11 Item 9, I LIM-2P

The following calculations are based on:

1. Using Peak_PD=1.05*Pclass_PD for Type 3 and Type 4 for power levels above class 4 per equation 33-12a in IEEE802.3bt D1.1.
2. Not keeping the same ratios between Icut_max/Icon-2P_unb of 802.3AT as we had in 802.3bt D1.1. This allows reduction of ILIM(min) and if user wants to keep Icut_max/Icon-2P_unb of 802.3AT, it can be used as implementation specifics i.e. user can use any Ilim above Ilim_min per figure 33-14.

3. Continue to use the concept that Ilim_min=Icut_max+small margin. Icut_max=Ipeak-2P including E2EP2P_Iunb effect.

4. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
5. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Background

ILIM-2P_MIN≥ Ipeak-2P_max per figure 33-14. ILIM-2P_MIN for Type 2 is: 1.14*Icable=Ipeak-2P_max[1]

ILIM-2P_MIN for type 2 is 0.684A and Ipeak is 0.682A which is 2mA difference hence ILIM_2P>Ipeak-2P as required.

We will use same concept for Type 3 and 4 with the additional effect of P2P_Iunb.

Ipeak_2P max for Vpse_min for Type 3 and 4 can be found by equation 33-4 for maximum and minimum channel resistance (Rch=12.5Ω and Rch =0.1 Ω) and maximum Ppeak_PD-2P per Table 33-18 item 7.

The calculation procedure will be based on the fact that we need minimum ILIM-2P(min) requirement per PD class that is fixed number so we will not have to adjust ILIM-2P per PSE voltage and Channel Resistance. The way to do it is to calculate Ipeak-2P for the channel resistance that will generate maximum current by using equation 33-4 and 33-4a that specifies the K factor that give us the ratio between Ipeak-2P of unbalanced system and Ipeak-2P of perfect balance system as function of channel resistance. This gives the worst case possible ILIM-2P.

Ppeak_PD can be calculated per equation 33-12a

Class 5: Ppeak_pd=1.05*Pclass_PD=1.05*40W=42W

Class 6: Ppeak_pd=1.05*Pclass_PD=1.05*51W=53.55W

Class 7: Ppeak_pd=1.05*Pclass_PD=1.05*62W=65.1W

Class 8: Ppeak_pd=1.05*Pclass_PD =1.05*71W=74.55W

Running simulations for the above Ppeak_PD for all classes as function of channel resistance and Vpse_min resulted with the numbers in the proposed Table 33-11 item 9 with additional 2mA for margin to ensure ILIM-2P>Ipeak-2P:

The results were confirmed by calculating per equation 33-4 and using the K that corresponds to the channel resistance where the maximum current is obtained (in Type 4 it is with long cable and for Type 3 it is in short cable).

See calculated and simulated results in next table.

Annex A2: Simulation vs Calculation comparison

Notes:

1. (Ipeak/Icon_max)=1.14 is the ratio used in 802.3af and 802.3at.
2. The values of ILIM-2P min will be the same for extended power mode.

#	Reference	Parameter	Class 5	Class 6	Class 7	Class 8
		Calculated Results per the curve fit equations				
1		Rch [Ω]	0.1	0.1	12.5	12.5
2	Eq 33-4a	K	0.330	0.300	0.079	0.078
3	Table 33-11	Vpse [V]	50	50	52	52
4	Table 33-18	Pclass_PD [W]	40	51	62	71
5	Eq 33-12a	Ppeak_PD [W]	42	53.55	65.1	74.55
6	Ppeak-PD/2	Ppeak_PD-2P [W]	21	26.775	32.55	37.275
7	Eq 33-4	Ipeak-2P for K=0 [A].	0.421	0.537	0.768	0.921
8	Eq 33-4	Ipeak-2P_unb (K>0) [A]	0.560	0.698	0.828	0.992
9	ILIM-2P table 33-11	ILIM-2P_min[1]=Ipeak-2P+2mA [A]	0.562	0.702	0.830	0.994
	Simulation Results[1,3,4]					
10	NEW Proposed Spec.[2]	ILIM-2P_min[1]=Ipeak+2mA	0.562	0.702	0.830	0.990
11	Table 33-11 item 4a	Icon-2P_unb[4]	0.550	0.682	0.777	0.925
12	The difference between ILIM-2P and Icon-2P_unb		0.012	0.02	0.053	0.065

Notes:

1. Item 2: The results are per the calculations of Eq 33-4a for the new curve fit per class which was done for October 2015 meeting.
2. Items 9 and 10: The error between calculated values and simulated values are due to the usage of curve fit for K. The simulation results are the accurate results and based on worst case system model.
3. TIA spec for channel pair to pair resistance unbalance of 7% flat or 0.1 ohm whichever is greater adds 10mA to Class 8 limits. The simulation was using the system model that generates channel pair to pair resistance unbalance =7.5% at the 0.1 ohm point and the 7.5% is decreasing as channel resistance is decreasing which gives more accurate results. Therefore the simulation results were chosen to be for the specification of ILIM-2P minimum value.
4. Item 11 and 12: Icont-2P_unb is shown for reference in order to show the difference between DC maximum current Ico-2P_unb and peak current under E2EP2P_Iunb condition over the pair with the maximum current.

Annex A3: Why we need ILIM(min) per class 5 to 8?

In IEEE802.3bt D1.1 we have defined ILIM-2P (MIN) value for class 5 and 7 (class 6 and 8 were already defined).

ILIM(min) per class adds design flexibility to the PSE due to the fact that PSEs allowed to support power levels lower than their maximum Ptype so PSE is not required to be designed for higher current when there is no need for it.

PSE limits the current when pair-set current hits ILIM-2P threshold. Port current hits Due to the fact that PSE is designed to support ILIM-2P were normally ILIM-2P threshold point is higher than ILIM-2P (MIN) .Until current reaches this point, PSE may supply the full current so pairs and their components need to be designed to support that current.

Examples:

1. There is no point that PSE Type 3 that supports up to class 2 power (25.5W) that needs ILIM(min)=~0.35A to support ILIM(min)=0.700A
2. There is no point that PSE Type 4 that supports up to class 5 power (40W) that needs ILIM(min)=0.562A to support ILIM(min)=0.990A

Annex B1: Derivation of Icut-2P

1. Icut_min-2P = Icont-2P_unb by definition.
2. Worst case P2P_Iunb conditions in Type 3 is at short cable (0.1Ω) and in Type 4 is at long cable (12.5Ω) therefore the ratio

   $$Optimized\_E2EP2P\_Iunb\_effect = \frac{\text{Icont - 2P\_unb\_max}}{\text{Icont - 2P\_max}}$$ Can be used to set Pclass/Vport_PSE-2P at E2EP2P_Iunb conditions, therefore:

Icont-2P_max=0.5*(Pclass/Vport_PSE_min)
Icont-2P_unb_max=Simulation results, the pair with maximum current from Rch=0.1 Ω to 12.5Ω

For Type 3 class 5:
Icut_min-2P = Icont-2P_unb= (Icont-2P_unb_max/Icont-2P_max)*0.5*Pclass/Vport_PSE-2P=
= (0.550/0.45))*0.5*Pclass/Vport_PSE-2P=0.611*Pclass/Vport_PSE-2P.
For Type 3 class 6:
Icut_min-2P = Icont-2P_unb= (Icont-2P_unb_max/Icont-2P_max)*0.5*Pclass/Vport_PSE-2P=
= (0.682/0.6)*0.5*Pclass/Vport_PSE-2P=**0.568*Pclass/Vport_PSE-2P.**

For Type 4 class 7:
Icut_min-2P = Icont-2P_unb= (Icont-2P_unb_max/Icont-2P_max)*0.5*Pclass/Vport_PSE-2P=
= (0.777/0.721)*0.5*Pclass/Vport_PSE-2P=**0.539*Pclass/Vport_PSE-2P.**
For Type 4 class 8:
Icont-2P_unb= (0.925/0.865)*0.5*Pclass/Vport_PSE-2P=**0.535*Pclass/Vport_PSE-2P**
Notes:

1. All Kicut values are worst case ratio and not depend on Vport_PSE-2P. Generating Kicut as function of Vport_PSE-2P to reduce unnecessary margins in Icut_min is possible but not necessary and adds complexity.
2. As long as total system Vdiff stays 60mV and we require the same Icon-2P_unb per class to be met with extended power mode, the Kicut ratio per class will remain the same for extended power.
3. Class 5 and 6 were updated per PSE Vdiff=10mV, PD Vdiff=60mV.
4. Class 7 and 8 were updated per PSE Vdiff=10mV. PD Vdiff=50mV.

Annex C: Update Table 33-11 item 4a, Icon-2P_unb. Comparison for different PSE and PD Vdiff

				1	2	3			
Item	Parameter	Symbol	Unit	Min	Min	Min	Max	PSE Type	Additional Information
4a	Pairset current including unbalance for class 5	$I_{Con-2P-unb}$	A	0.536 2mV/58mV	535 10mV/50mV	**550** **10mV/60mV**		3	See 33.2.7.4 and 33.2.7.4a
	Pairset current including unbalance for class 6			0.668 2mV/58mV	667 10mV/50mV	**682** **10mV/60mV**		3	
	Pairset current including unbalance for class 7			0.778 2mV/58mV	777 10mV/50mV	**777** **10mV/50mV**		4	
	Pairset current including unbalance for class 8			0.926 2mV/58mV	925 10mV/50mV	**925** **10mV/50mV**		4	

Annex D: Alternative way for presenting Icon-2P_unb as Icut-2P minimum

Due to the fact that Icon-2P_unb=Icut-2P min per Figure 33-14/a/b we can alternatively present Icon-2P_unb as KIcut*Pclass/VPORT_PSE-2P.

Option 1:

Item	Parameter	Symbol	Unit	Min	Max	PSE Type	Additional Information
4a	Pairset current including unbalance for class 5	$I_{Con-2P-unb}$	A	550		3	See 33.2.7.4 and 33.2.7.4a KIcut*Pclass/Vport_PSE-2P can be used as Icon-2P_unb minimum value as well. See details in Table 33-11 item 7.
	Pairset current including unbalance for class 6			682		3	
	Pairset current including unbalance for class 7			777		4	
	Pairset current including unbalance for class 8			925		4	

Option 2

Item	Parameter	Symbol	Unit	Min	Max	PSE Type	Additional Information
4a	Pairset current including unbalance for class 5-8	$I_{Con-2P-unb}$	A	Kicut x Pclass/Vport_PSE-2P		3,4	See 33.2.7.4 and 33.2.7.4a. See item 7 for Kicut values.