33.2.8.5.1 PSE ~~PI~~ pair-to-pair ~~resistance and~~ current unbalance

This section describes unbalance requirements for Type 3 and Type 4 PSEs that operate over 4-pair. The PSE PI pair-to-pair effective resistance unbalance contributes to the effective system end-to-end resistance unbalance as specified in Annex 33B.

A compliant unbalanced load, R_{load_min} and R_{load_max}, consists of the channel (cables and connectors) and PD effective resistances, including the effects (or influence) of system end-to-end unbalance.

Figure 33–X shows a test circuit for the current unbalance requirements measurement, illustrating the relationship between current unbalance at the PSE PI (I_a+, I_b+, I_a-, I_b-), and R_{load_min} and R_{load_max} as specified in Table 33–X.

Current unbalance requirements ($I_{Con-2P-unb}$) of a PSE shall be met with R_{load_max} and R_{load_min} as specified by Table 33–X.

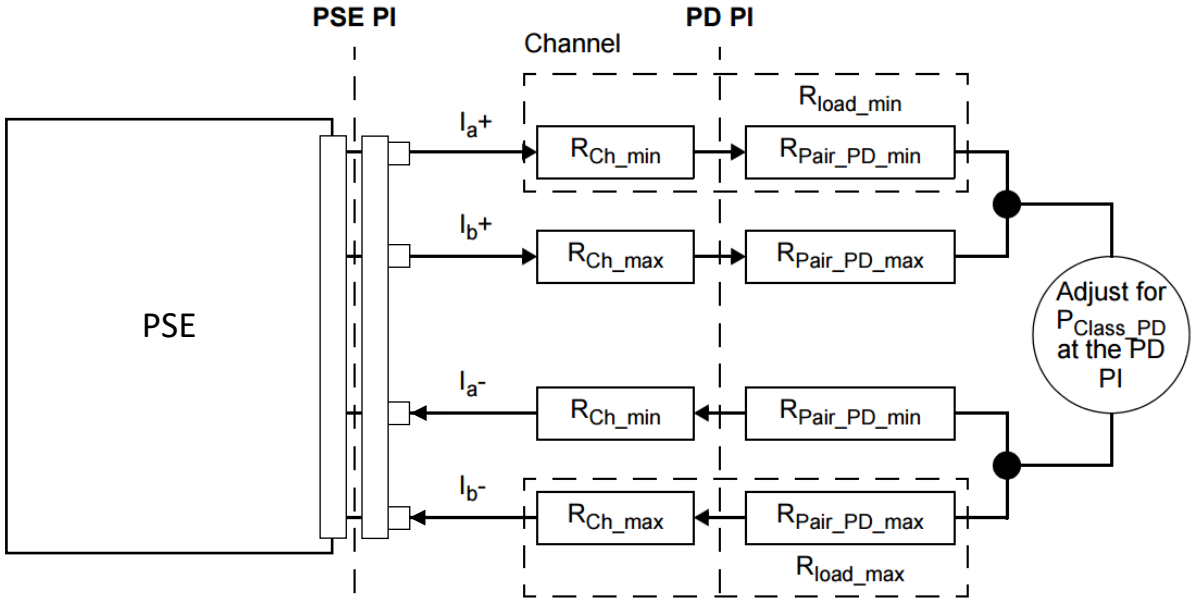

Figure 33– X—PSE unbalance evaluation model

Table 33– X—R_{load_max} and R_{load_min} requirements

PSE Class	R_{Ch_min} (Ω)	R_{Ch_max} (Ω)	$R_{Pair\_PD\_min}$ (Ω)	$R_{Pair\_PD\_max}$ (Ω)	R_{load_min} (Ω)	R_{load_max} (Ω)	Additional information
5	0.087	0.1	0.636	1.528	0.723	1.628	R_{load} is at low channel resistance conditions
6	0.087	0.1	0.536	1.189	0.623	1.289	
7	0.087	0.1	0.503	0.990	0.590	1.090	
8	0.087	0.1	0.457	0.875	0.544	0.975	
5	TBD	TBD	TBD	TBD	5.920	7.190	R_{load} is at high channel resistance conditions
6	TBD	TBD	TBD	TBD	5.780	7.000	
7	TBD	TBD	TBD	TBD	5.710	6.870	
8	TBD	TBD	TBD	TBD	5.650	6.790	

The current unbalance test method is described below:

1) Use R_{load_min} and R_{load_max} from Table 33–X for R_{load} at low channel resistance conditions.
2) With the PSE powered on, adjust the load to P_{Class_PD} at the PD PI.
3) Measure I_a+, I_b+.
4) Swap R_{load_max}, R_{load_min}, repeat steps 2 and 3.
5) Repeat steps 2 to 4 for I_a-, I_b-.
6) Verify that the current in each case does not exceed $I_{Con-2P-unb}$ minimum in Table 33–18.
7) Repeat steps 2 to 6 for R_{load_min} and R_{load_max} from Table 33–X for R_{load} at high channel resistance conditions.

~~This section describes unbalance requirements for Type 3 and Type 4 PSEs that operate over 4-pair. The contribution of PSE PI pair-to-pair effective resistance unbalance to the effective system end-to-end resistance unbalance, is specified by PSE maximum (R_{PSE_max}) and minimum (R_{PSE_min}) common mode effective resistance in the powered pairs of same polarity.~~

~~The PSE PI pair-to-pair effective resistance unbalance determined by R_{PSE_max} and R_{PSE_min} ensures that along with any other parts of the system, i.e. channel (cables and connectors) and the PD, the maximum pair current including unbalance does not exceed $I_{Con-2P-unb}$ as defined in Table 33–18 during normal operating conditions. $I_{Con-2P-unb}$ is the current in the pairset with the highest current in case of maximum unbalance and will be higher than $I_{Con}/2$. $I_{Con-2P-unb}$ applies for total channel common mode pair resistance from 0.2 Ω to R_{Ch}. For channels with common mode pair resistance lower than 0.2 Ω, see Annex 33B.1.~~

~~R_{PSE_max} and R_{PSE_min} are specified and measured under maximum P_{Class} sourcing conditions. Conformance with Equation (33–15) shall be met for R_{PSE_max} and R_{PSE_min}.~~

$$R_{PSE\_max} = \begin{cases} 2.200 \times R_{PSE\_min} - 0.040 & \text{for Class 5} \\ 2.010 \times R_{PSE\_min} - 0.040 & \text{for Class 6} \\ 1.800 \times R_{PSE\_min} - 0.030 & \text{for Class 7} \\ 1.750 \times R_{PSE\_min} - 0.030 & \text{for Class 8} \end{cases} \quad \Omega \qquad (33\text{–}15)$$

~~where~~

~~R_{PSE_max} is, given R_{PSE_min}, the highest allowable common mode effective resistance in the powered pairs of the same polarity~~

~~R_{PSE_min} is the lower PSE common mode effective resistance in the powered pairs of the same polarity~~

~~The values of R_{PSE_max} and R_{PSE_min} are implementation specific and need to satisfy Equation (33–15). R_{PSE_max}, R_{PSE_min} and $I_{Con-2P-unb}$ shall be measured according to the tests described in the normative Annex 33B.~~

Annex 33B

(informative)

PSE PI pair-to-pair resistance/current unbalance

33B.1 Introduction

End to end pair-to-pair resistance/current unbalance (E2EP2PRunb) refers to current differences in powered pairs of the same polarity. Current unbalance can occur in positive and negative powered pairs when a PSE uses all four pairs to deliver power to a PD.

~~Current unbalance requirements (R_{PSE_min}, R_{PSE_max} and $I_{Con-2P-unb}$) of a PSE shall be met with R_{load_max} and R_{load_min} as specified by Table 33B–1.~~

~~A compliant unbalanced load, R_{load_min} and R_{load_max}, consists of the channel (cables and connectors) and PD effective resistances, including the effects (or influence) of system end-to-end unbalance.~~

~~$I_{Con-2P-unb}$ and Equation (33–15) are specified for total channel common mode pair resistance from 0.2 Ω to 12.5 Ω and worst case unbalance contribution by a PD as specified by 33A.5. When the PSE is tested for channel common mode resistance less than 0.2 Ω, i.e. 0 Ω < $R_{chan-2P}$ < 0.2 Ω, the PSE shall be tested with (R_{load_min} – $R_{chan-2P}$) and (R_{load_max} – $R_{chan-2P}$) to meet $I_{Con-2P-unb}$ requirements and using lower R_{PSE_max} than required by Equation (33–15).~~ Lower R_{PSE_max} than required by Equation (33B–1~~5~~) is obtained by using smaller constant α and larger constant β in the equation $R_{PSE\_max} = \alpha \times R_{PSE\_min} + \beta$.

Equation (33B–1~~5~~) ~~is described in 33.2.8.5.1~~, specified for the PSE, assures that E2EP2PRunb will be met in the presence of all compliant unbalanced loads (R_{load_min} and R_{load_max}) attached to the PSE PI.

The PSE PI pair-to-pair effective resistance unbalance determined by R_{PSE_max} and R_{PSE_min} ensures that along with any other parts of the system, i.e. channel (cables and connectors) and the PD, the maximum pair current including unbalance does not exceed $I_{Con-2P-unb}$ as defined in Table 33–18 during normal operating conditions. $I_{Con-2P-unb}$ is the current in the pairset with the highest current in case of maximum unbalance and will be higher than $I_{Con}/2$.

R_{PSE_max} and R_{PSE_min} are specified and measured under maximum P_{Class} sourcing conditions. The following design guidelines may be implemented to ensure PSE PI pair-to-pair current unbalance requirements are met:

$$R_{PSE\_max} = \begin{Bmatrix} 2.200 \times R_{PSE\_min} - 0.040 & \text{for Class 5} \\ 2.010 \times R_{PSE\_min} - 0.040 & \text{for Class 6} \\ 1.800 \times R_{PSE\_min} - 0.030 & \text{for Class 7} \\ 1.750 \times R_{PSE\_min} - 0.030 & \text{for Class 8} \end{Bmatrix}_{\Omega} \quad \text{(33B–1)}$$

where

R_{PSE_max} is, given R_{PSE_min}, the highest allowable common mode effective resistance in the powered pairs of the same polarity

R_{PSE_min} is the lower PSE common mode effective resistance in the powered pairs of the same polarity

The values of R_{PSE_max} and R_{PSE_min} are implementation specific and need to satisfy Equation (33B–1). A PSE which uses current balancing methods which effectively using lower R_{PSE_max} than required by Equation (33B–1) and meets $I_{Con-2P-unb}$ requirements by definition also meets Equation (33B–1). See 33.2.8.5.1 for PSE unbalance requirements and PSE unbalance measurement method.

Figure 33B–1 illustrates the relationship between effective resistances at the PSE PI as specified by Equation (33B–15) and ~~R_{load_min} and R_{load_max} as specified in Table 33B–1~~end-to-end pair-to-pair resistance.

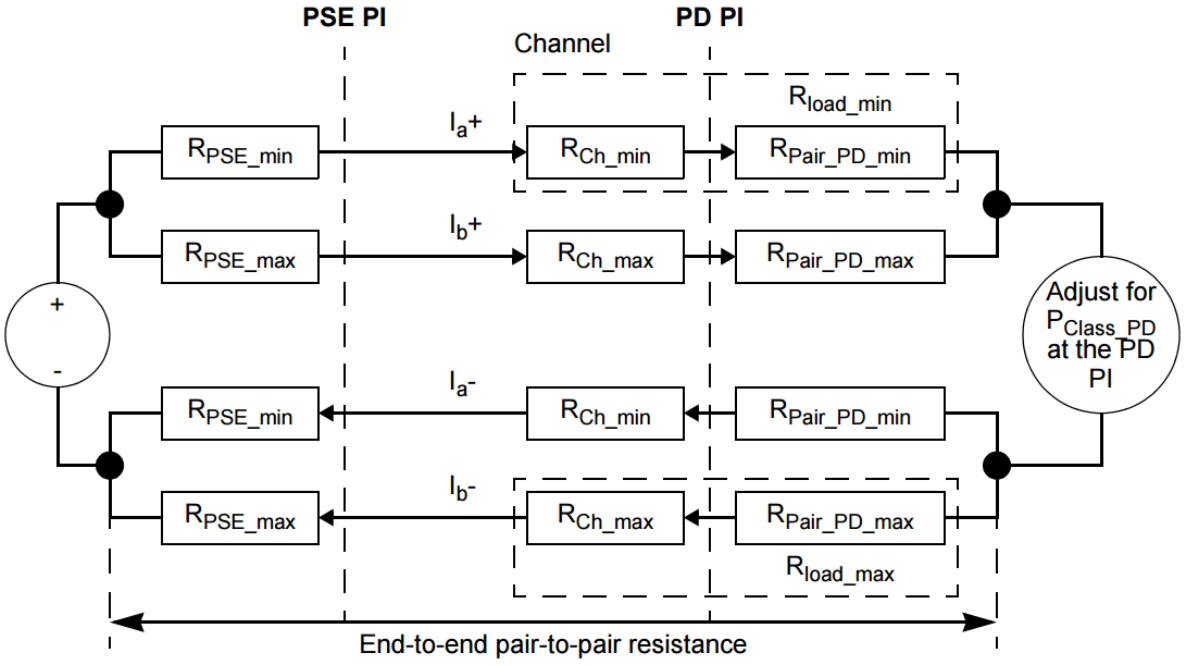

Figure 33B– 1—PSE PI unbalance specification ~~and E2EP2PRunb~~

~~Table 33B– 1—R_{load_max} and R_{load_min} requirements~~

~~PSE Class~~	~~R_{Ch_min} (Ω)~~	~~R_{Ch_max} (Ω)~~	~~$R_{Pair\_PD\_min}$ (Ω)~~	~~$R_{Pair\_PD\_max}$ (Ω)~~	~~R_{load_min} (Ω)~~	~~R_{load_max} (Ω)~~	~~Additional information~~
~~5~~	~~0.087~~	~~0.1~~	~~0.636~~	~~1.528~~	~~0.723~~	~~1.628~~	~~R_{load} is at low channel resistance conditions~~
~~6~~	~~0.087~~	~~0.1~~	~~0.536~~	~~1.189~~	~~0.623~~	~~1.289~~	
~~7~~	~~0.087~~	~~0.1~~	~~0.503~~	~~0.990~~	~~0.590~~	~~1.090~~	
~~8~~	~~0.087~~	~~0.1~~	~~0.457~~	~~0.875~~	~~0.544~~	~~0.975~~	
~~5~~					~~5.920~~	~~7.190~~	~~R_{load} is at high channel resistance conditions~~
~~6~~					~~5.780~~	~~7.000~~	
~~7~~					~~5.710~~	~~6.870~~	
~~8~~					~~5.650~~	~~6.790~~	

~~There are three alternate test methods for R_{PSE_max} and R_{PSE_min} and determining conformance to Equation (33–15) and to $I_{Con-2P-unb}$.~~

~~Measurement methods to determine R_{PSE_max} and R_{PSE_min} and $I_{Con-2P-unb}$ are defined in 33B.2, 33B.3, and 33B.4.~~

33B.2 Direct R_{PSE} measurement

If there is access to internal circuits, effective resistance may be determined by sourcing current in each path corresponding to maximum P_{Class} operation, and measuring the voltage across all components that contribute to the effective resistance, including circuit board traces and all components passing current to the PSE PI output connection. The effective resistance is the measured voltage V_{eff}, divided by the current through the path e.g. the effective value of R_{PSE_min} for i_1 is $R_{PSE\_min}=V_{eff1}/i_1$ as shown in Figure 33B–2.

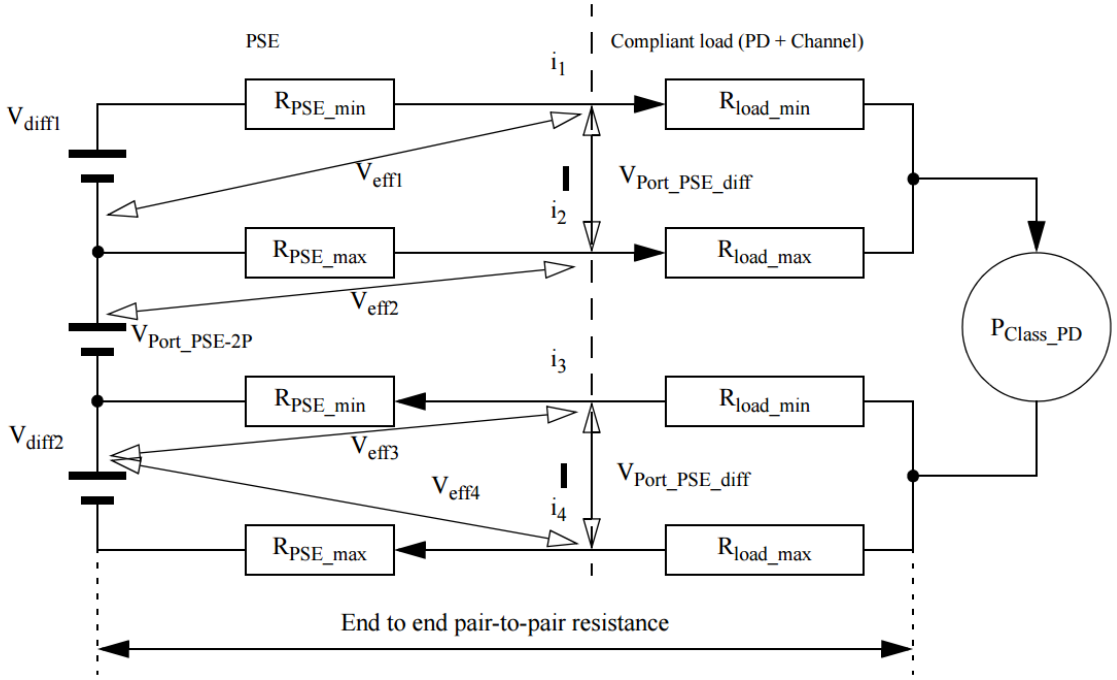

Figure 33B– 2—Direct measurements of effective R_{PSE_max} and R_{PSE_min}

33B.3 Effective resistance R_{PSE} measurement

Figure 33B–3 shows a possible test circuit for effective resistance measurements on a PSE port for evaluating conformance to Equation (33B–1~~5~~) if the internal circuits are not accessible. In Figure 33B–3, the positive pairs of the same polarity are shown as an example. The same concept applies to the negative pairs.

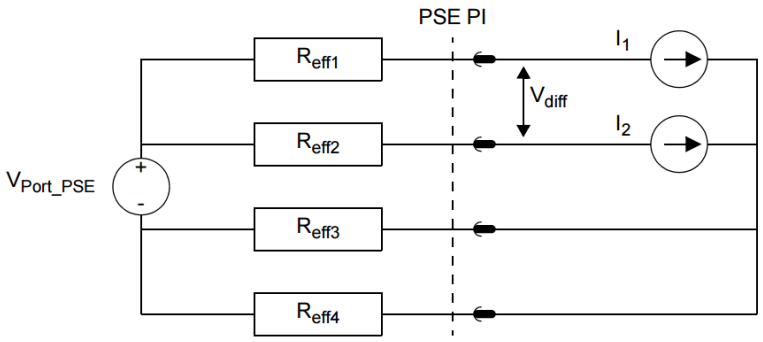

Figure 33B– 3—Effective resistance test circuit

The effective resistance test procedure is described below:

1) With the PSE powered on, set the following current values
   a. 10 mA < I_2 < 50 mA
   b. $I_1 = 0.5 \times (P_{max}/V_{port}) - I_2$
2) Measure V_{diff}.
3) Reduce I_1 by 20% (=I_1'). Ensure I_2 remains unchanged.
4) Measure V_{diff}' in the same manner as V_{diff}.
5) Calculate R_{eff1}: $R_{eff1} = [(V_{diff}) - (V_{diff}')] / (I_1 - I_1')$
7) Repeat procedure for R_{eff2}, with I_1, I_2 values swapped.
8) Repeat procedure for R_{eff3}, R_{eff4}.
9) Evaluate compliance of R_{eff1} and R_{eff2} with Equation (33B–1~~5~~). Evaluate compliance of R_{eff3}, and R_{eff4} with Equation (33B–1~~5~~).

~~The effective resistance test method applies to the general case. If pair-to-pair balance is actively controlled in a manner that changes effective resistance to achieve balance, then the current unbalance measurement method described in 33B.4 shall be used.~~

~~33B.4 Current unbalance measurement~~

~~The following method may be used if the PSE is using active or passive current balancing circuitry that results in a variable effective resistance to control current unbalance. The current unbalance requirement shall be met for any pairs of the same polarity and with the load resistances per Table 33B–1. A PSE which uses current balancing methods which effectively using lower R_{PSE_max} than required by Equation (33–15) and meets $I_{Con-2P-unb}$ requirements by definition also meets Equation (33–15). Figure 33B–4 shows a test circuit for the current unbalance requirements measurement.~~

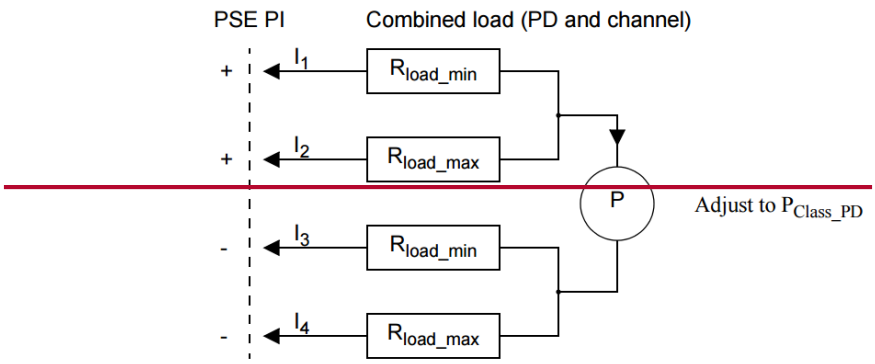

Figure 33B–4—Current unbalance test circuit

The current unbalance test method is described below:

1) Use R_{load_min} and R_{load_max} from Table 33B–1 for R_{load} at low channel resistance conditions.
2) With the PSE powered on, adjust the load to P_{Class_PD}.
3) Measure I_1, I_2.
4) Swap R_{load_max}, R_{load_min}, repeat steps 1 and 2.
5) Repeat for I_3, I_4.
6) Verify that the current in each case does not exceed $I_{Con\_2P\_unb}$ minimum in Table 33–18.
7) Repeat steps 1 to 6 for R_{load_min} and R_{load_max} from Table 33B–1 for R_{load} at high channel resistance conditions.