Modify the text per the proposed baseline:

33.2.8.4.1 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 contribution of PSE PI pair-to-pair effective resistance unbalance to the effective system end to end resistance unbalance, is specified by PSE maximum (RPSE_max) and minimum (RPSE_min) common mode effective resistance in the powered pairs of same polarity.

The PSE PI pair-to-pair effective resistance unbalance determined by RPSE_max and RPSE_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 ICon-2P-unb as defined in Table 33–17 during normal operating conditions. ICon-2P-unb is the current in the pairset with the highest current in case of maximum unbalance and will be higher than ICon/2. ICon-2P-unb applies for total channel common mode pair resistance from 0.2 Ω to RCh. For channels with common mode pair resistance lower than 0.2 Ω , see Annex 33B.

RPSE_max and RPSE_min are specified and measured under maximum PClass sourcing conditions. Conformance with Equation (33–14) shall be met for RPSE_max and RPSE_min.

Change from 2.015 to 2.010 for class 6 to match with Equation 33A.4

$$R_{PSE\_max} = \left\{ \begin{array}{ll} 2.200 \times R_{PSE\_min} - 0.040 & \text{for Class 5} \\ 2.010 \times R_{PSE\_min} - 0.040 & \text{for Class 6} \\ 1.800 \times R_{PSE\_min} - 0.030 & \text{for Class 7} \\ 1.750 \times R_{PSE\_min} - 0.030 & \text{for Class 8} \end{array} \right\}_{\Omega} \qquad (33\text{–}14)$$

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 RPSE_max and RPSE_min are implementation specific and need to satisfy Equation (33–14). RPSE_max, RPSE_min and ICon-2P-unb shall be measured according to the tests described in the normative Annex 33B.

33.3.8.10 PD pair-to-pair current unbalance

Single-signature PDs assigned to Class 5 or higher shall not exceed ICon-2P-unb for longer than TCUT-2P min as defined in Table 33–17 on any pair when PD PI pairs of the same polarity are connected to any common source voltage in the range of VPort_PSE-2P through two common mode resistances, Rsource_min and Rsource_max, where Rsource_max = 1.186 * Rsource_min, and Rsource_min is in the range of 0.168 Ω to 5.28 Ω as shown in Figure ~~33–39~~33-40.

Dual-signature PDs shall not exceed ICon-2P as defined in Equation (33–7) for longer than TCUT-2P min as defined in Table 33–17 on any pair when PD PI pairs of the same polarity are connected to any common source voltage in the range of VPort_PSE-2P through two common mode resistances, Rsource_min and Rsource_max, where Rsource_max = 1.186 * Rsource_min, and Rsource_min is in the range of 0.168 Ω to 5.28 Ω as shown in Figure ~~33–39~~33-40.

Rsource_min and Rsource_max represent the Vin source common mode effective resistance that consists of the PSE PI components (RPSE_min and RPSE_max as specified in 33.2.8.4.1, VPort_PSE_diff as specified in Table 33–17, ~~and the~~ channel resistance and $R_{PAIR\_PD\_min}$, $R_{PAIR\_PD\_max}$ specified in 33A.5. See Annex D for derivation of Rsource_min and Rsource_max. Common mode effective resistance is the resistance of two conductors of the same pair and their other components (that are forming Rsource) connected in parallel including the effect of the system total pair to pair voltage difference~~VPort_PSE_diff~~. IA and IB are the pair currents of pairs with the same polarity. ~~See Annex 33A.5 for design guide lines for meeting the above requirements.~~

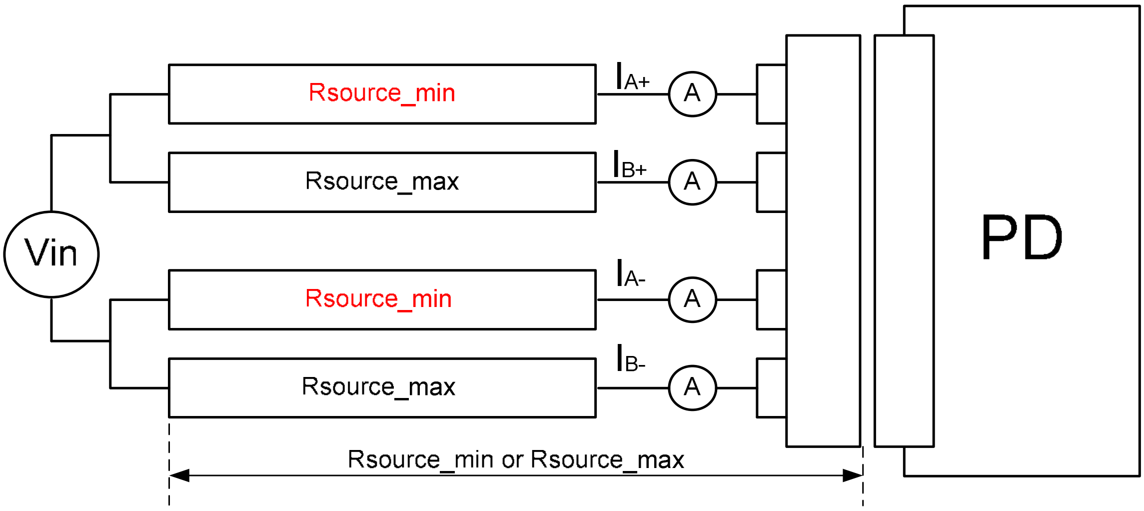

Figure 33–40—PD PI pair-to-pair current unbalance test model~~setup~~

NOTE 1—Rsource includes test model~~setup~~ plug resistance Rcon. The maximum recommended Rcon value is 0.02 Ω however it is test setup implementation specific choice how to meet Rsource_min and Rsource_max.

NOTE 2—The pairset current limits should also be met when Rsource_max and Rsource_min are swapped between pairs of the same polarity.

33A.4 Pair-to-pair channel resistance unbalance requirement for 4-pair operation

Operation using 4-pair requires the specification of resistance unbalance between each two pairs of the channel, not greater than 100 milliohm or resistance unbalance of 7% whichever is a greater unbalance. Resistance unbalance between the channel pairs is a measure of the difference of resistance of the common mode pairs of conductors used for power delivery. Channel pair-to-pair resistance unbalance is defined by Equation (33A–2):

$$\left\{\frac{(R_{ch\_max} - R_{ch\_min})}{(R_{ch\_max} + R_{ch\_min})} \times 100\right\}_{\%} \qquad (33A–2)$$

Channel pair-to-pair resistance difference is defined by Equation (33A–3):

$$\{R_{ch\_max} - R_{ch\_min}\} \qquad (33A–3)$$

where

R_{ch_max} is the sum of channel pair elements with highest common mode resistance

R_{ch_min} is the sum of channel pair elements with lowest common mode resistance Common mode resistance is the resistance of the two wires in a pair (including connectors), connected in parallel.

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

The following design guide lines may be implemented to ensure PD PI pair-to-pair current unbalance requirements are met:

In the current and previous drafts the order of the equations per class in Equation 33A-4 was reversed. The following order is the correct order according to the original contribution:

$$R_{Pair\_PD\_max} = \begin{cases} 2.200 \times R_{Pair\_PD\_min} + 0.125 & \text{for PD Type 3, Class 5} \\ 2.010 \times R_{Pair\_PD\_min} + 0.105 & \text{for PD Type 3, Class 6} \\ 1.800 \times R_{Pair\_PD\_min} + 0.080 & \text{for PD Type 4, Class 7} \\ 1.750 \times R_{Pair\_PD\_min} + 0.080 & \text{for PD Type 4, Class 8} \end{cases} \Omega \quad (33A\text{-}4)$$

For PD power above the values shown in Table 33–28 and up to P_{Class}, stringent requirement will be needed to not exceed $I_{Con\text{-}2P\_unb}$ by means of smaller constants α and β in the equation $R_{Pair\_PD\_max} = \alpha \times R_{Pair\_PD\_min} + \beta$.

Adding missing information regarding the definition of common mode effective resistance as we did in PSE part.

$R_{Pair\_PD\_max}$ and $R_{Pair\_PD\_min}$ represent PD common mode input effective ~~impedance~~ resistance of pairs of the same polarity. Common mode effective resistance is the resistance of two conductors of the same pair and their other components connected in parallel including the effect of PD pair-to-pair voltage difference of pairs with the same polarity (e.g. Vf1-Vf3). The common mode effective resistance R_n is the measured voltage $V_{eff\_pd\_n}$, divided by the current through the path as described below and as shown in the example in Figure 33A–4, where *n* is the pair number.

Update Figure 33A-4 as follows:

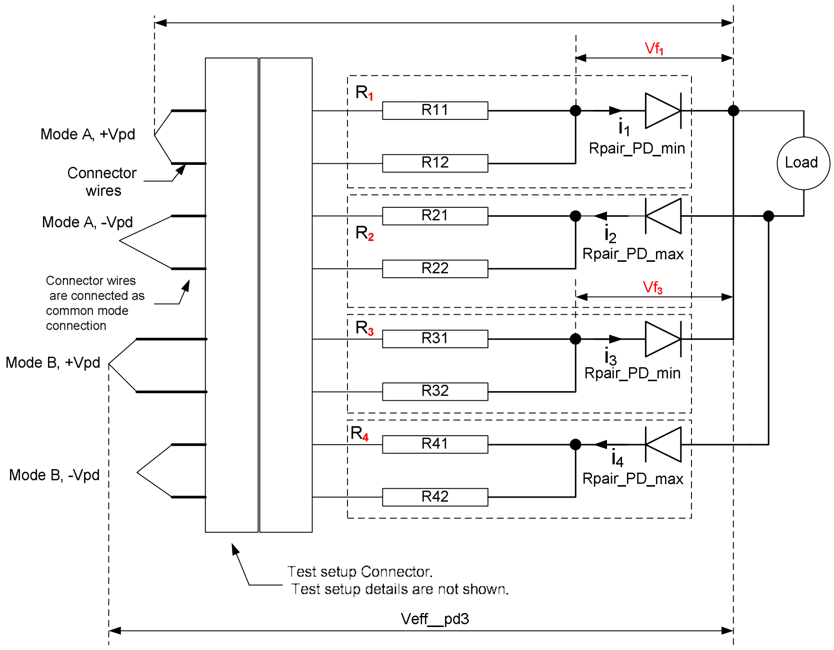

Figure 33A–4—PD resistance unbalance elements overview

Positive pairs:

R_1= RPair_ PD_min =Veff_pd1/i1

R_3= RPair_PD_max =Veff_pd3/i3

Negative pairs:

R_2= RPair_ PD_min =Veff_pd2/i2

R_4= RPair_PD_max =Veff_pd4/i4

Annex 33B

(normative) ***Insert Annex 33B after Annex 33A as follows:***

PSE PI pair-to-pair resistance/current unbalance

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 (Rpse_min, RPSE_max and Icon-2P_unb) of a PSE shall be met with R_{load_max} and R_{load_min} as specified by Table 33B-1. The details for derivation of R_{load_max} and R_{load_min}, which are composed of compliant channel and PD effective resistances, can be found in Annex 33D.

A compliant unbalanced load, R_{load_min}~~Rload~~ and R_{load_max} consists of the channel (cables and connectors) ~~and the~~ , PD effective resistances and PSE PI effective resistance. See Annex D.

Equation (33–14) is described in 33.2.8.4.1, specified for the PSE, assures that E2EP2PRunb will be met in a compliant 4-pair powered system. Figure 33B-1 illustrates the relationship between PSE PI Equation (33–14) and R_{load_min} and R_{load_max} as specified in Table 33B-1.

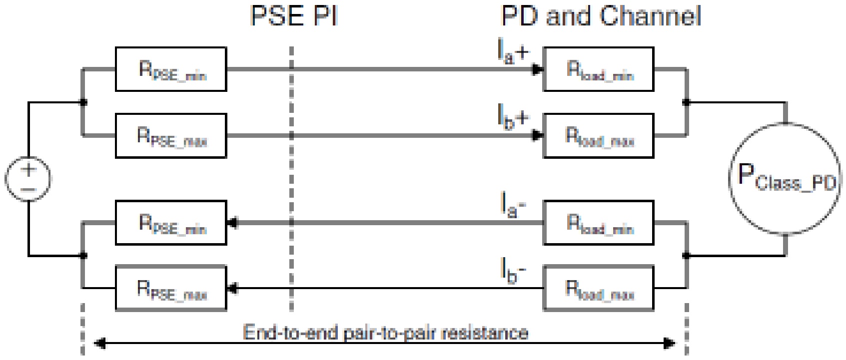

Figure 33B–1—PSE PI unbalance specification and E2EP2PRunb

Equation (33–14) specifies the PSE effective resistances required to meet E2EP2PRunb in the presence of all compliant, unbalanced loads attached to the PSE PI. There are three alternate test methods for R_{PSE_max} and R_{PSE_min} and determining conformance to Equation (33–14) and to Icon-2P_unb.

Measurement methods to determine R_{PSE_max} and R_{PSE_min} and Icon-2P_unb are defined in 33B.1, 33B.2, and 33B.3.

33B.1 Direct RPSE measurement

If there is access to internal circuits, effective resistance may be determined by sourcing current in each path corresponding to maximum PClass 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 Veff, divided by the current through the path e.g. the effective value of R_{PSE_min} for i1 is $R_{PSE\_min} = Veff1/i1$ as shown in Figure33B-2.

Table 33B-1—Rload_max and Rload_min requirements

PSE Class	Rload_min, [Ω]	Rload_max, [Ω]	Additional Information
5	0.723	1.628	Rload is at low channel resistance conditions
6	0.623	1.289	
7	0.590	1.090	
8	0.544	0.975	
5	5.920	7.190	Rload is at high channel resistance conditions
6	5.780	7.000	
7	5.710	6.870	
8	5.650	6.790	

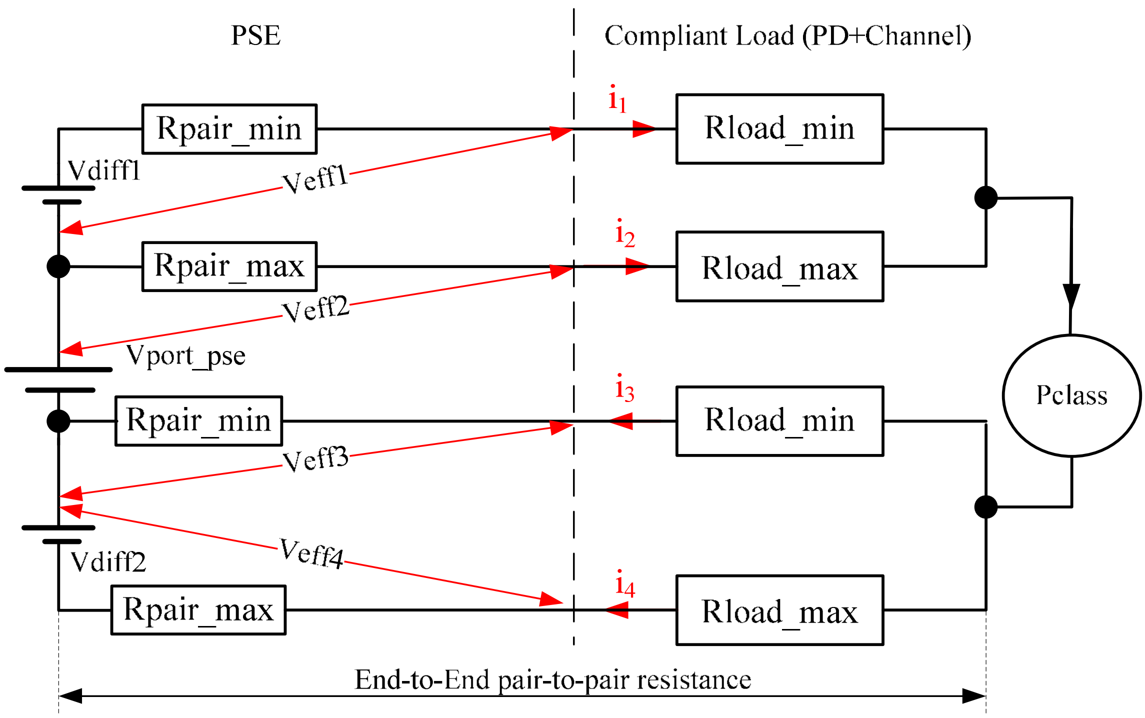

Figure 33B–2—Direct measurements of effective R_{pse_max} and R_{pse_min}

33B.2 Effective resistance Rpse measurement

Figure 33B-3 shows a possible test circuit for effective resistance measurements on a PSE port for evaluating conformance to Equation (33–14) 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.

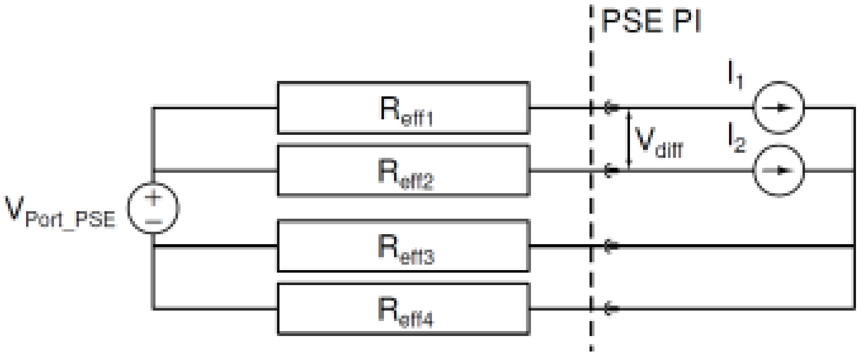

Figure 33B-3 – Effective resistance test circuit

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 mannar 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 (33–14). Evaluate compliance of R_{eff3} and R_{eff4} with Equation (33–14).

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.3 shall be used.

33B.3 Current unbalance measurement

The following method may be used if the internal PSE circuits are not accessible or 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 and meets the current unbalance measurement test by definition also meets Equation (33–14). Figure 33B–4 shows a test circuit for the current unbalance requirements measurement.

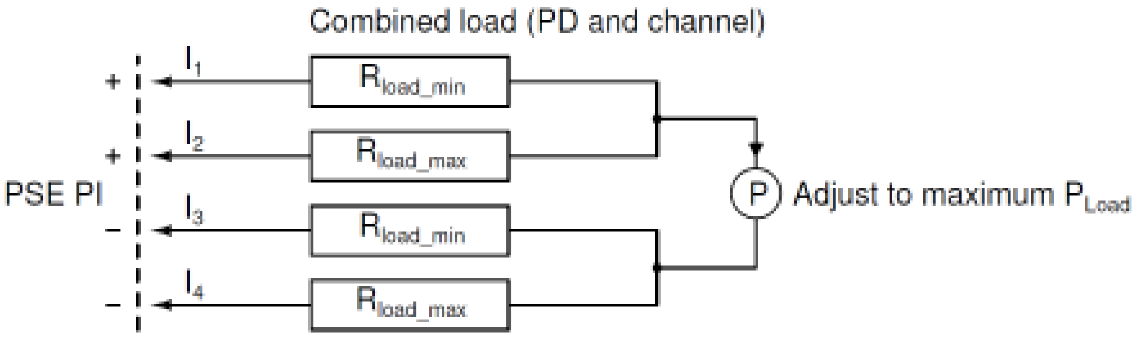

Figure 33B-4--Current unbalance test circuit

The current unbalance test method is described below:

1) Use Rload_min and Rload_max from Table 33B-1 for Rload at low channel resistance conditions.
2) With the PSE powered on, adjust the load for maximum power at the PSE.
3) Measure I1, I2.
4) Swap Rload_max, Rload_min, repeat steps 1 and 2.
5) Repeat for I3, I4.
6) Verify that the current in each case does not exceed Icon-2P_unb minimum in Table 33–17.
7) Repeat steps 1-6 for Rload_min and Rload_max from Table 33B-1 for for Rload at high channel resistance conditions.

Verification of Icon-2P_unb in step 6 and 7 confirms that PSE Rpse_max and Rpse_min are in conformance to this specifications.

33B.4 Channel resistance with less than ~~0.1~~0.2Ω

Icon_2P_unb max and Equation 33-14 are specified for total channel common mode pair resistance from ~~0.1~~0.2Ω to 12.5Ω and worst case unbalance contribution by a PD. When the PSE is tested for channel common mode resistance less than ~~0.1~~0.2 Ω, i.e. 0 Ω < Rchan-2P < ~~0.1~~0.2 Ω, the PSE shall be tested with (Rload_min – Rchan-2P) and (Rload_max – Rchan-2P) to meet Icon_2P_unb requirements and Rpse_min and Rpse_max conformance to Equation (33–14).

The following is not part of the baseline:
At short cable, what is the resistance in this case. Is it 0.1 Ω or 0.2 Ω in our simulations and calculations across the specifications?

For finding Kipeak and doing the curve fit for it, the simulation was run from 0.25 Ω to 12.5 Ω.
0.25 Ω is 2m channel (12.5 Ω /100m=0.125 Ω /m which is from 2m to 100m).

For calculating Icon-2P_unb, Ipeak-2P_unb and as a result ILIM-2P, I have used 2.65m cable as min and 100m cable as max in my simulations with the following parameters:
Rch-2P=0.1*Channel length *cordage ohm/m + 0.9* Channel length *cable ohm/m
For 2.65m, # of connectors =0. Rch-2P=0.1*2.65m*0.0926 Ω /m+0.9*2.65m*0.076 Ω /m=0.205 ohm.
I.e. 2.65m=0.205 ohm ➔ ~0.2 ohm.
The value is actually lower than 0.2 Ω due to the cable unbalance (2%).
So in all cases the minimum resistance over 2-Pairs is ~0.2 Ω and for 4-pairs is 0.1 Ω.

Note: as regard to 7% or 0.1 ohm channel spec.: the 0.1 Ω came from 4*Rdiff=4*0.05 Ω =0.2 Ω for 4 connectors per wire for Rdiff. Two wires in parallel gives minimum resistance of 0.1 Ω when pair to pair channel resistance difference is considered for the shortest channel length where cable length is zero (theoretical case). So connector Rdiff Is not related to the above subject.