PI Balance Specifications

End-to-End Pair-to-Pair Ad Hoc

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Overview

- **A final worst case (WC) E2E P2PRunb model is being created for the purpose of generating specifications necessary to limit P2P Balance to that of the model**
- **Two methods have been proposed for PI's in order to meet that Balance limit:**
  - Method 1: P2PRunb: a familiar specification that has been used in the past
    - Vdiff may accompany a P2PRunb spec at the PSE and/or PD PI
  - Method 2: PI Specifications derived from effective resistances in the final WC model:

$$Rpse\_max < Rpse\_min * X + Y_{pse} \qquad Rpd\_max < Rpd\_min * X + Y_{pd}$$

    - Where $X = \frac{1+E2ER_{unb}}{1-E2ER_{unb}}$, and Y_{pse} and Y_{pd} are constants derived from E2E P2PRunb
    - Effective resistances (R=V/I) under load conditions are used, so Vdiff is inherently included in these specifications
    - Defines ratios at the PSE and PD PI's which exactly limit to the worst case target from the model
    - PI Independence: if either equation is satisfied at a corresponding PI, the equation for the other PI remains valid
- **A spreadsheet (provided separately) is presented which was created to generate, validate, and compare these potential PI Specifications**
- **A baseline balance specification is then presented, which incorporates the derived equations**

Green Background

User entered Eff. Resistances from WC Model

Blue/Orange

Calculated Specifications

Yellow Background

User entered DUT Resistance Ranges (Rmin)

Red Coloring

PI P2PRunb ok
E2E P2PRunb Fail

Neutral Coloring

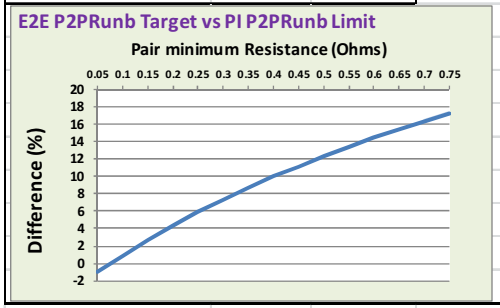
PI P2PRunb Fail
E2E P2PRunb ok

PSE PI

Rmax < (Rmin * 1.633) + -0.028 → **P2PRunb = 0.116**

Worst Case Model Values

	Rmax	Rmin	PI P2PRunb
PSE	0.096	0.076	0.1163
Channel	0.174	0.158	
PD	1.632	0.9307	
E2E-P2PRunb	0.2404		
X	1.633		
Y	-0.0281		



PSE Rmax < PSE Rmin * X + Y

Variable	Limit	Check	Compare
PSE Rmin	PSE Rmax	E2E P2PRunb	*PSE PI P2PRunb*
0.05	0.0535	0.2404	*0.0342*
0.1	0.1352	0.2404	*0.1496*
0.15	0.2168	0.2404	*0.1822*
0.2	0.2985	0.2404	*0.1976*
0.25	0.3801	0.2404	*0.2065*
0.3	0.4618	0.2404	*0.2124*
0.35	0.5435	0.2404	*0.2165*
0.4	0.6251	0.2404	*0.2196*
0.45	0.7068	0.2404	*0.2220*
0.5	0.7884	0.2404	*0.2238*
0.55	0.8701	0.2404	*0.2254*
0.6	0.9517	0.2404	*0.2267*
0.65	1.0334	0.2404	*0.2277*
0.7	1.1150	0.2404	*0.2287*
0.75	1.1967	0.2404	*0.2295*

PSE PI P2PRunb

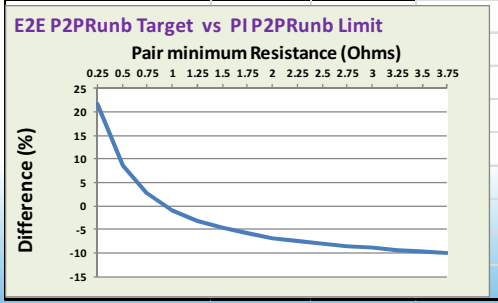
Variable	Limit	Compare	Check
PSE Rmin	PSE Rmax	E2E P2PRunb	*PSE PI P2PRunb*
0.05	0.0632	0.2428	*0.1163*
0.1	0.1263	0.2383	*0.1163*
0.15	0.1895	0.2340	*0.1163*
0.2	0.2526	0.2300	*0.1163*
0.25	0.3158	0.2263	*0.1163*
0.3	0.3789	0.2228	*0.1163*
0.35	0.4421	0.2195	*0.1163*
0.4	0.5053	0.2165	*0.1163*
0.45	0.5684	0.2136	*0.1163*
0.5	0.6316	0.2108	*0.1163*
0.55	0.6947	0.2082	*0.1163*
0.6	0.7579	0.2058	*0.1163*
0.65	0.8211	0.2035	*0.1163*
0.7	0.8842	0.2013	*0.1163*
0.75	0.9474	0.1992	*0.1163*

PD PI

Rmax < (Rmin * 1.633) + 0.112 → **P2PRunb = 0.274**

Worst Case Model Values

	Rmax	Rmin	PI P2PRunb
PD	1.632	0.9307	0.2737
Channel	0.174	0.158	
PSE	0.096	0.076	
E2E-P2PRunb	0.2404		
X	1.633		
Y	0.1121		



PD Rmax < PD Rmin * X + Y

Variable	Limit	Check	Compare
PD Rmin	PD Rmax	E2E P2PRunb	*PD PI P2PRunb*
0.25	0.5204	0.2404	*0.3510*
0.5	0.9287	0.2404	*0.3000*
0.75	1.3369	0.2404	*0.2812*
1	1.7452	0.2404	*0.2714*
1.25	2.1534	0.2404	*0.2654*
1.5	2.5617	0.2404	*0.2614*
1.75	2.9699	0.2404	*0.2585*
2	3.3782	0.2404	*0.2563*
2.25	3.7865	0.2404	*0.2545*
2.5	4.1947	0.2404	*0.2531*
2.75	4.6030	0.2404	*0.2520*
3	5.0112	0.2404	*0.2511*
3.25	5.4195	0.2404	*0.2502*
3.5	5.8278	0.2404	*0.2496*
3.75	6.2360	0.2404	*0.2490*

PD PI P2PRunb

Variable	Limit	Compare	Check
PD Rmin	PD Rmax	E2E P2PRunb	*PD PI P2PRunb*
0.25	0.4384	0.1882	*0.2737*
0.5	0.8768	0.2195	*0.2737*
0.75	1.3151	0.2340	*0.2737*
1	1.7535	0.2424	*0.2737*
1.25	2.1919	0.2478	*0.2737*
1.5	2.6303	0.2517	*0.2737*
1.75	3.0687	0.2545	*0.2737*
2	3.5070	0.2567	*0.2737*
2.25	3.9454	0.2584	*0.2737*
2.5	4.3838	0.2599	*0.2737*
2.75	4.8222	0.2610	*0.2737*
3	5.2606	0.2620	*0.2737*
3.25	5.6989	0.2629	*0.2737*
3.5	6.1373	0.2636	*0.2737*
3.75	6.5757	0.2642	*0.2737*

Specification Comparison

- **If the PI P2PRunb limit is *lower* than worst case (WC) E2E P2PRunb, which is likely to occur in the PSE PI:**
  - Low PI resistances may pass PI P2PRunb and exceed WC E2E P2PRunb
  - High PI resistances may fail PI P2PRunb and meet WC E2E P2PRunb
- **If the PI P2PRunb limit is *higher* than worst case E2E P2PRunb, which is likely to occur in the PD PI:**
  - Low PI resistances may fail PI P2PRunb and meet WC E2E P2PRunb
  - High PI resistances may pass PI P2PRunb and exceed WC E2E P2PRunb
- **If the specification is derived from worst case E2E P2PRunb:**
  (Rmax < Rmin * TBDx + TBDy)
  - Worst case E2E P2PRunb is not exceeded for any PI resistance range
  - The specification is implementation independent and least restrictive
- **Effective resistances (*Reff = V/I*) taken near maximum capacity are composed of active, passive resistances and voltage offsets**
  - No additional resistance or voltage balance specifications are necessary
  - A simple comprehensive specification – No confusion about “Resistance Unbalance” conveying passive resistance (as precedence in standards suggest)

Proposed Balance Specifications

Changes to 802.3at requirements by section

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33.1 Overview

Currently has channel, cabling parameters, and includes resistance unbalance in the channel

Historically Does not contain PI specifications

Changes are only for the channel resistances.

Specifics are not proposed herein, but they could take the following form

33.1.4 Type 1, Type 2, Type 3 and Type 4 system parameters

Loop resistance, highest current, cable type

33.1.4.1 Type 2, Type 3 and Type 4 cabling requirement

Cable Categories, etc.

33.1.4.2 Type 1 and Type 2 channel requirement

3% Resistance Unbalance (Based on ISO/IEC Specifications)

33.1.4.3 Type 3 and Type 4 channel requirement

3% Resistance Unbalance Based on ISO/IEC Specifications

AND TBD Pair-to-Pair spec

33.2 PSE

Currently has pair Current Unbalance content in Table 33.11 (PSE PI).

Changes add pair-to-pair current unbalance, and additional information section covering P2P current unbalance and PSE PI effective resistance

33.3 PD

Currently No Unbalance requirements other than Ibias tolerance.

Changes add pair-to-pair current unbalance, and additional information section covering P2P current unbalance and PD PI effective resistance

New Parameter for Table 33-11 (PSE) and Table 33-18 (PD):

Type 3 and Type 4 Pair-to-Pair Current Unbalance

Item #:	TBD
Parameter:	Pair-to-pair current unbalance
Symbol:	Iunb_ptp
Unit:	%
Min:	- -
Max:	TBD% *(From Worst Case E2E P2PRunb Model)*
Type:	3, 4
Additional Info:	See 33.2.7.x (Table 33-11) 33.3.7.x (Table 33-18)

Table 33-11 (PSE) Referenced Content:

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33.2.7.x Pair-to-Pair Current Unbalance

Pair-to-Pair current unbalance is specified for 4-pair power by equation 33-#$_1$

$I_{unb\_ptp} = (I_{max} - I_{min}) / (I_{max} + I_{min})$ 33-#$_1$

Where I_{unb_ptp} is the current unbalance between pairs of the same polarity when 4-pair power is provided at >85% of maximum PSE port capacity. Imax, Imin is the maximum and minimum total current in each pair. I_{unb_ptp} is specified for worst case unbalanced resistive loads defined in 33-#$_2$

Rpair_max = TBD, Rpair_min=TBD 33-#$_2$

Where the pair resistances are common mode resistances in the wire pairs of the same polarity, as shown in figure 33-#$_3$

(Continued)

Table 33-11 Reference (Continued):

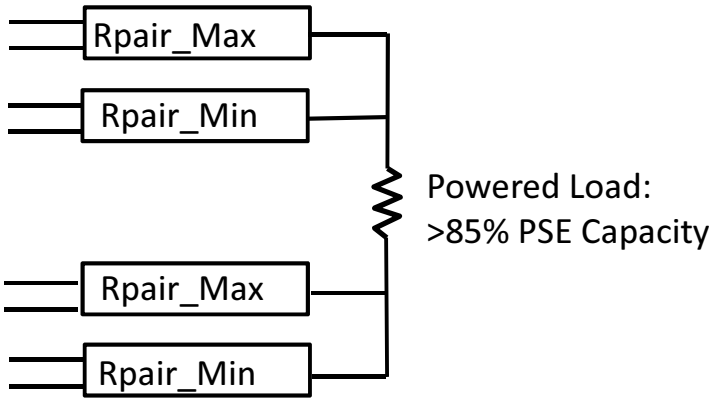

FIG. 33-#$_3$ Unbalanced load configuration

Iunb_ptp may be met with PSE PI effective resistances between pairs of the same polarity by conforming to equation 33-#$_4$:

$$Rpse\_max < Rpse\_min * X + Ypse \qquad 33\text{-}\#_4$$

where Rpse_max and Rpse_min are maximum and minimum effective resistances determined at >85% of maximum port capacity. Each of the Rpse parameters is the common mode effective resistance in the path of a twisted wire pair, including all PSE elements that are exclusively in the path of that wire pair.

* Rpair values and Equation 33-#$_4$ are derived from worst case system models

Table 33-18 (PD) Referenced Content:

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33.3.7.x Pair-to-Pair Current Unbalance

Pair-to-Pair current unbalance is specified for 4-pair power by equation 33-#$_5$

$I_{unb\_ptp} = (I_{max} - I_{min}) / (I_{max} + I_{min})$ 33-#$_5$

Where I_{unb_ptp} is the current unbalance between pairs of the same polarity when 4-pair power is provided at >85% of maximum PD power consumption. Imax, Imin is the maximum and minimum total current in each pair. I_{unb_ptp} is specified for worst case currents sourced through unbalanced resistances defined in 33-#$_6$

R_{pair_max} = TBD, R_{pair_min}=TBD 33-#$_6$

Where the pair resistances are common mode resistances in the wire pairs of the same polarity, as shown in figure 33-#$_7$.

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Table 33-11 Reference (Continued):

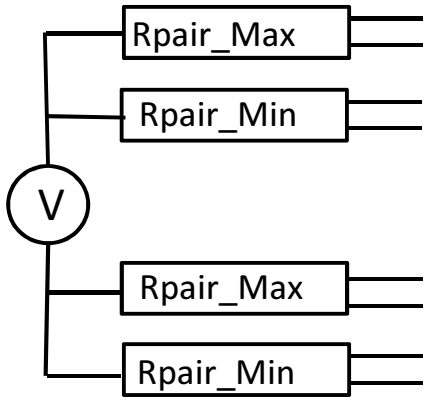

FIG. 33-#$_7$ Unbalanced source configuration

Iunb_ptp may be met with PD PI effective resistances between pairs of the same polarity by conforming to equation 33-#$_8$:

$$Rpd\_max < Rpd\_min * X + Ypd \qquad 33\text{-}\#_8$$

where Rpd_max and Rpd_min are maximum and minimum effective resistances determined at >85% of maximum port capacity. Each of the Rpd parameters is the common mode effective resistance in the path of a twisted wire pair, including all PD elements that are exclusively in the path of that wire pair.

* Rpair values and Equation 33-#$_8$ are derived from worst case system models