# PI Balance Specifications
## Rev. 02

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# Introduction

- Two options for PI Pair-to-pair balance specifications have been proposed:
  - P2PRunb = n, $R_{min}$, and possibly $V_{diff}$
  - $Reff_{max} = Reff_{min} * x + y$
- This presentation provides some additional information on the derivation, properties and benefits of the $Reff_{max} = Reff_{min} * x + y$ option
- Changes to the standard incorporating this option are proposed

# P2P Unbalance Specifications

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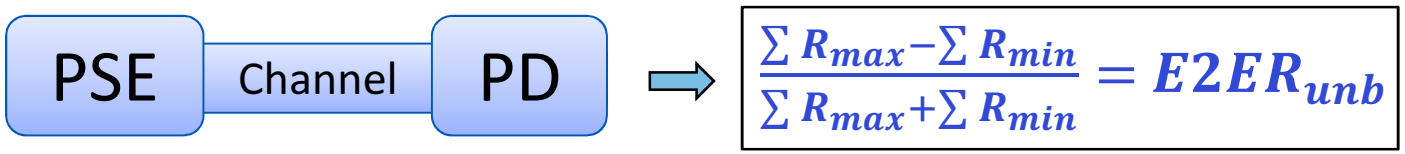
## Step 1: Set a target E2E P2P unbalance

Use Models, simulations to determine an acceptable worst case




## Step 2: Define PI Requirements such that:

Target E2E P2P Unbalance is ***never*** exceeded

Implementation independence is met:

→ No unnecessary restrictions or limits imposed

**PI Specifications which meet the above requirements:**

$$R_{PSEmax} \leq f(R_{PSEmin}) \qquad R_{PDmax} \leq f(R_{PDmin})$$

**Need to Solve for each *f( )***

# Derivation of PI Equations

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*The E2ERunb equation can be rearranged to the following form:*

$$x \cdot \sum R_{min} - \sum R_{max} = 0, \quad \text{Where } x = \frac{1 + E2ER_{unb}}{1 - E2ER_{unb}}$$

*Separating the contributors results in:*

$$(x \cdot R_{PSEmin} - R_{PSEmax}) + (x \cdot R_{CHmin} - R_{CHmax}) + (x \cdot R_{PDmin} - R_{PDmax}) = 0$$

*Each contributor is a constant in the worst case model:*

$$C_{PSE} + C_{CH} + C_{PD} = 0$$

*And any contributor can be solved for other implementations (PSE example shown below):*

$$R_{PSEmax} - x \cdot R_{PSEmin} = C_{CH} + C_{PD}$$

*Solving for Rmax results in:*

$$R_{PSEmax} = x \cdot R_{PSEmin} + y_{pse}$$

*Where:*

*X is a constant determined by the target balance, and*

*$y_{pse}$ is a constant determined by the other two contributors ($C_{CH} + C_{PD}$)*

# PI Specification Independence and Final expressions

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***From the previous slide:***

$$\left(x \cdot R_{PSEmin} - R_{PSEmax}\right) + \left(x \cdot R_{CHmin} - R_{CHmax}\right) + \left(x \cdot R_{PDmin} - R_{PDmax}\right) = 0$$

- Each contributor is a constant in the worst case model
- There are pairs of Rmax & Rmin that also equal that constant in each case
  - The Expressions for the other contributors are unaffected
  - The sets of Rmax & Rmin that satisfy this ***<u>are</u>*** the limits for PI implementations necessary to meet the target balance limit
- Contributors may have better balance without violating the target balance, so the equations may be expressed in the following form:

$$PSE_{max} \leq x \cdot (PSE_{min}) + y_{pse}$$

$$PD_{max} \leq x \cdot (PD_{min}) + y_{pd}$$

$$CH_{max} \leq x \cdot (CH_{min}) + y_{ch}$$

Where the final worst case model would provide the values for *x* and each *y*

# Properties of the equations

- **Simple expressions, described with 2 constants**
  - Exactly fit the limits necessary to meet E2E P2P target balance
  - No unnecessary restrictions, No additional specs required
- **PI specification independence**
  - If any two contributors satisfy the equations, the third equation remains valid
- **Can be used to scale WC Resistances up or down without affecting the equations for the other contributors**
  - May be useful for test set-ups
- **If a solution is not possible, the equation will indicate it**
  - Ballast resistance (or Rmin limit) might be added to the WC model to improve target balance:
    - If low resistances in a given implementation can't provide the necessary ballast, the equation will not be solvable ($Reff_{max}$ will be ***less than*** $Reff_{min}$ )

# Proposed Text

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## PSE PI Table 33-11 New Content for Types 3, 4

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | Current Unbalance | Iunb | A | | 3% x Icable | 1 | See 33.2.7.11, 33.4.8. NOTE--For practical implementations, it is recommended that Type 1 PSEs support Type 2,3,4 Iunb requirements. |
| | | | | | 3% x Ipeak | 2,3,4 | |
| | | Iunb_ptp | A | | TBD% x Ipeak | 3, 4 | See 33.2.7.x. |

## PD Table 33-18 New Content for Types 3, 4

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ## | Current Unbalance | Iunb_ptp | A | | TBD% x Iport | 3, 4 | See 33.3.7.x. |

# PSE Subsection Content

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## 33.2.7.x Pair-to-Pair Current Unbalance

**Iunb_ptp** shall be met at >85% of maximum PSE port capacity with the 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-#$_3$

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

$$Reff_{max} < Reff_{min} * TBD_x + TBD_{Ypse} \quad 33\text{-}\#_4$$

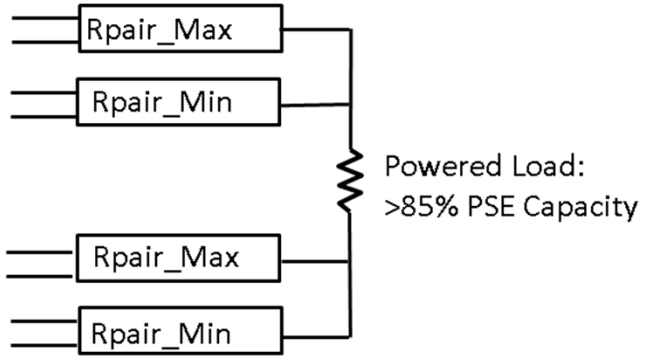


FIG. 33-#$_3$

where $Reff_{max}$ and $Reff_{min}$ are maximum and minimum effective resistances determined at >85% of maximum port capacity.
Each of the *Reff* 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***

# PD Subsection Content

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### 33.3.7.x Pair-to-Pair Current Unbalance

**Iunb_ptp** shall be met at >85% of maximum PD port operating Current Sourced through the unbalanced resistances defined in 33-#$_5$

Rpair_max = TBD, Rpair_min=TBD 33-#$_5$

Where the pair resistances are common mode resistances in the wire pairs of the same polarity, as shown in figure 33-#$_6$

Iunb_ptp may be met with PD PI effective resistances between pairs of the same polarity by conforming to equation 33-#$_7$:

$$Reff_{max} < Reff_{min} * TBD_x + TBD_{Ypd} \quad 33\text{-}\#_7$$

where $Reff_{max}$ and $Reff_{min}$ are maximum and minimum effective resistances determined at >85% of maximum port capacity.
Each of the *Reff* 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-#7 are derived from worst case system models***

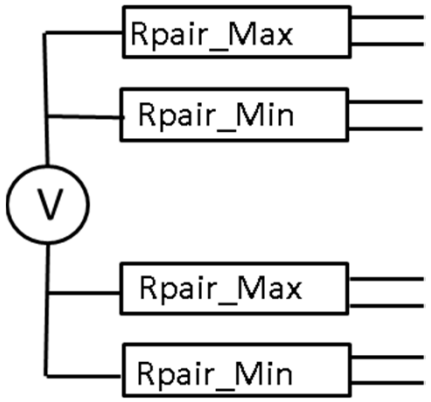


FIG. 33-#$_6$

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# Questions and Comments

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# Thank You