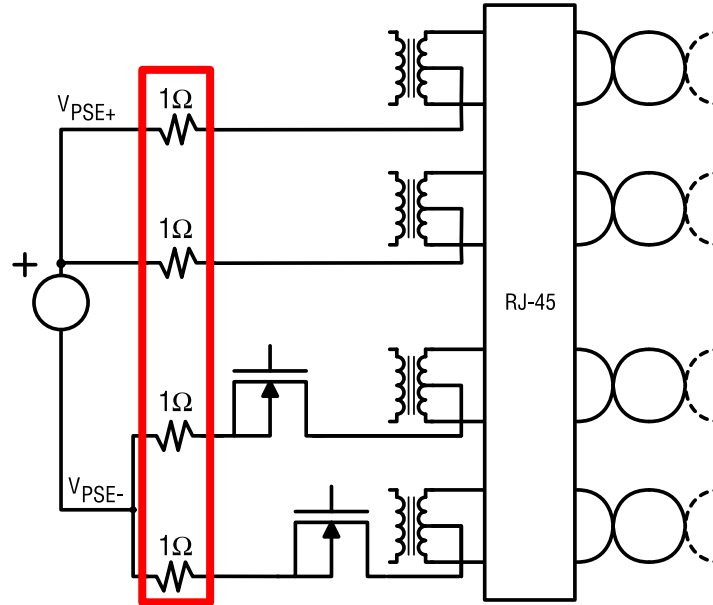# System Unbalance Requirements

David Stover, Michael Paul

Problem Statement: PSE Unbalance Requirements

- PSE unbalance is governed by multiple requirements
  - $I_{Con-2P-unb}$ (Section 33.2.8) defines an unbalance requirement
    - $I_{Con-2P-unb}$ min, I_{Con} define the maximum unbalance allowed at PSE PI
  - R_{PSE} calculations (Annex 33B) define an unbalance requirement
    - R_{load_min}, R_{load_max} define the maximum unbalance allowed at PSE PI
  - These requirements **disagree**
- For well-balanced PSEs to implement $I_{Con-2P-unb}$ min and comply with normative statements in Annex 33B, $R_{PSE} > 1\Omega$ **is required**

PSE Unbalance Requirements: Section 33.2.8

- A compliant PSE shall…
  - provide at least $I_{Con-2P-unb}$ min on a particular pairset
  - provide at least I_{Con} total on both pairsets
- $\dfrac{I_{Con-2P-unb}}{I_{Port-2P-other}}$ (K_{class}) defines an unbalance requirement at the PSE PI

PSE Class	P_{Class}	I_{Con} (Eq. 33–8)	$I_{Con-2P-unb}$ (Table 33–17)	$I_{Port-2P-other}$ (Eq. 33–7)	K_{class}
5	45	0.90 (45W/50V)	550mA	350mA	**1.57**
6	60	1.20 (60W/50V)	682mA	518mA	**1.31**
7	75	1.44 (75W/50V)	777mA	663mA	**1.17**
8	90	1.73 (90W/52V)	925mA	805mA	**1.15**

PSE Unbalance Requirements: Annex 33B (R_{PSE}, R_{load})

- A compliant PSE shall…
  - meet current unbalance requirements (R_{PSE_min}, R_{PSE_max}, and $I_{Con-2P-unb}$) with R_{load_max}, R_{load_min}
- $\frac{R_{load\_max}}{R_{load\_min}}$ (K_{load_ratio}) defines an unbalance requirement at the PSE PI

| PSE Class	R_{load_min}	R_{load_max}	K_{load_ratio}	Channel Resistance
5	0.723	1.628	**2.25**	"low"
6	0.623	1.289	**2.07**	
7	0.590	1.090	**1.85**	
8	0.544	0.975	**1.79**	
5	5.920	7.190	**1.22**	"high"
6	5.780	7.000	**1.21**	
7	5.710	6.870	**1.20**	
8	5.650	6.790	**1.20**	

Conflict: PSE Unbalance Requirements Disagree

- A compliant PSE is…
  - allowed to implement $I_{Con-2P-unb}$ min
  - required to satisfy K_{load_ratio} for R_{load_min}, R_{load_max}
- Below some arbitrary R_{PSE}…
  - well-balanced PSEs implementing valid $I_{Con-2P-unb}$ min will fail when plugged into Annex 33B test circuit (K_{load_ratio})
  - there exists no R_{PSE_min}, R_{PSE_max} to overcome R_{load_min}, R_{load_max} unbalance

Channel Resistance	Class	K_{class}	K_{load_ratio}
Min	5	1.57	2.25
	6	1.31	2.07
	7	1.17	1.85
	8	1.15	1.79
Max	5	1.57	1.22
	6	1.31	1.21
	7	1.17	1.20
	8	1.15	1.20

LINEAR TECHNOLOGY

Conclusions

- Loosening unbalance requirements for PD (for example) reduces unbalance tolerances on PSE and link segment
  - As R_{PSE}, R_{CH} decrease in magnitude, correcting any R_{PD} unbalance in excess of total system unbalance requirements is impossible
- Increasing unbalance margin of any particular object precludes efficient system design
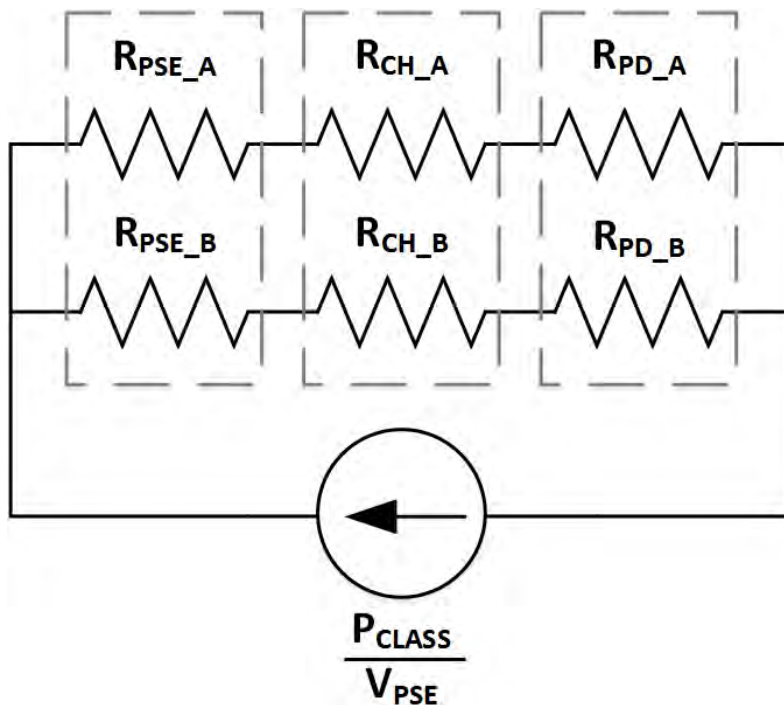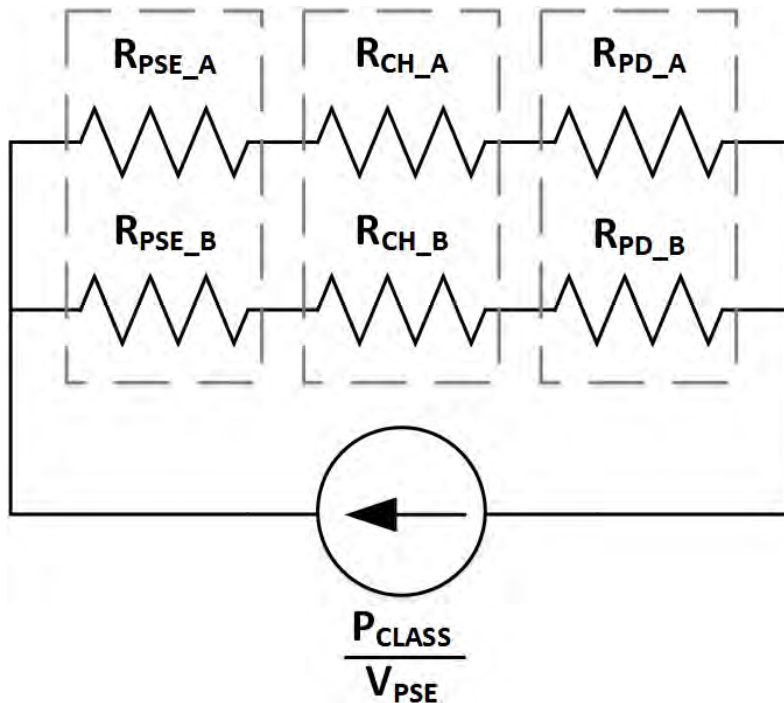

$$\frac{R_{PD\_A}}{R_{PD\_B}} > \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

$$\frac{R_{PSE\_A} + R_{CH\_A} + R_{PD\_A}}{R_{PSE\_B} + R_{CH\_B} + R_{PD\_B}} > \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

Conclusions, cont'd.

- The goal of all unbalance requirements is to guarantee interoperability up to some maximum system unbalance
  - Ideally, the ratios of each component (R_{PSE}, R_{CH}, and R_{PD}) should not introduce unbalance in excess of the maximum system unbalance ratio (K_{class})

$$\frac{R_{PSE\_A}}{R_{PSE\_B}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

$$\frac{R_{CH\_A}}{R_{CH\_B}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

$$\frac{R_{PD\_A}}{R_{PD\_B}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

$$\frac{R_{PSE\_A} + R_{CH\_A} + R_{PD\_A}}{R_{PSE\_B} + R_{CH\_B} + R_{PD\_B}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2P-other}}$$

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Proposed Remedy

- Revise Section 33.3.8.10 (PD Unbalance Requirements)
    - Modify unbalance requirement to match implicit ratio of $I_{Con-2P-unb}$
- Revise Section 33.2.8.4.1 (PSE Unbalance Requirements)
    - Adopt 33.3.8.10 with modifications, replacing R_{source} references with R_{load}
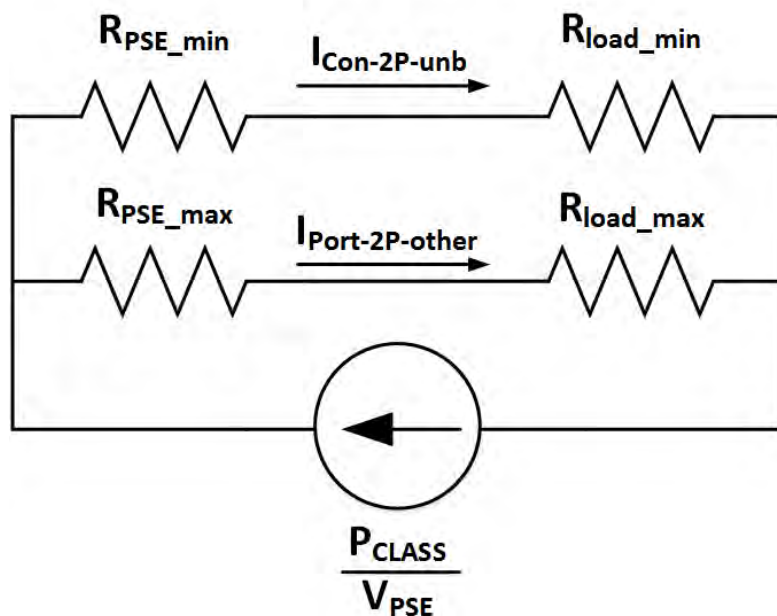- Remove Annex 33B

Proposed Remedy: 33.2.8.4.1 R_{PSE} Test Method, Revised

- R_{PSE} unbalance is limited (Section 33.2.8.4.1)
  - Section 33.3.8.10: *"…R_{load_min} and R_{load_max}, where*
    R_{load_max} = **K_{class}** * R_{load_min}, *and*
    R_{load_min} *is in the range of 0.168Ω to 5.28Ω…"*

PSE Maximum Supported Class	K_{class}
5	1.57
6	1.31
7	1.17
8	1.15

$$\frac{K_{class} * (R_{pse\_min} + R_{load\_min})}{R_{pse\_min} + R_{load\_min}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2p-other}}$$
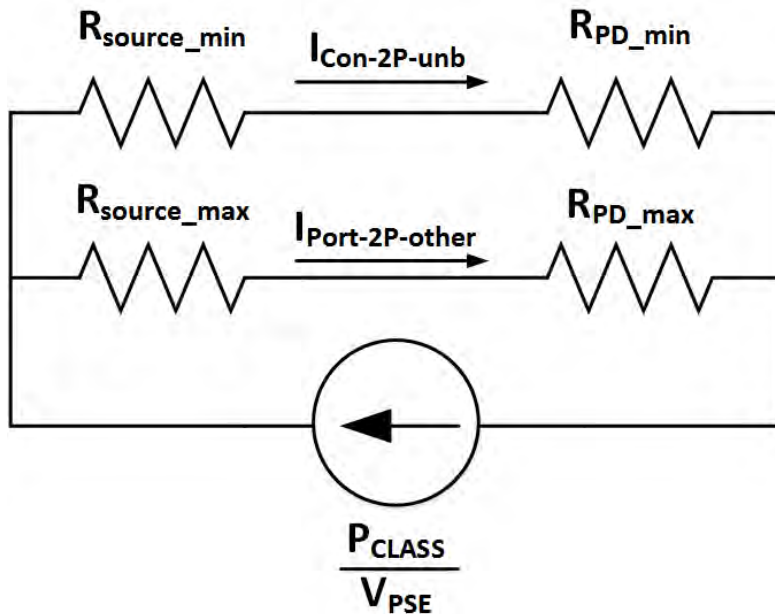
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Proposed Remedy: 33.3.8.10 R_{PD} Test Method, Revised

- R_{PD} unbalance is limited (Section 33.3.8.10)
  - Section 33.3.8.10: "…R_{source_min} and R_{source_max}, where

    R_{source_max} = $\boldsymbol{K_{class}}$ * R_{source_min}, and

    R_{source_min} is in the range of 0.168Ω to 5.28Ω…"

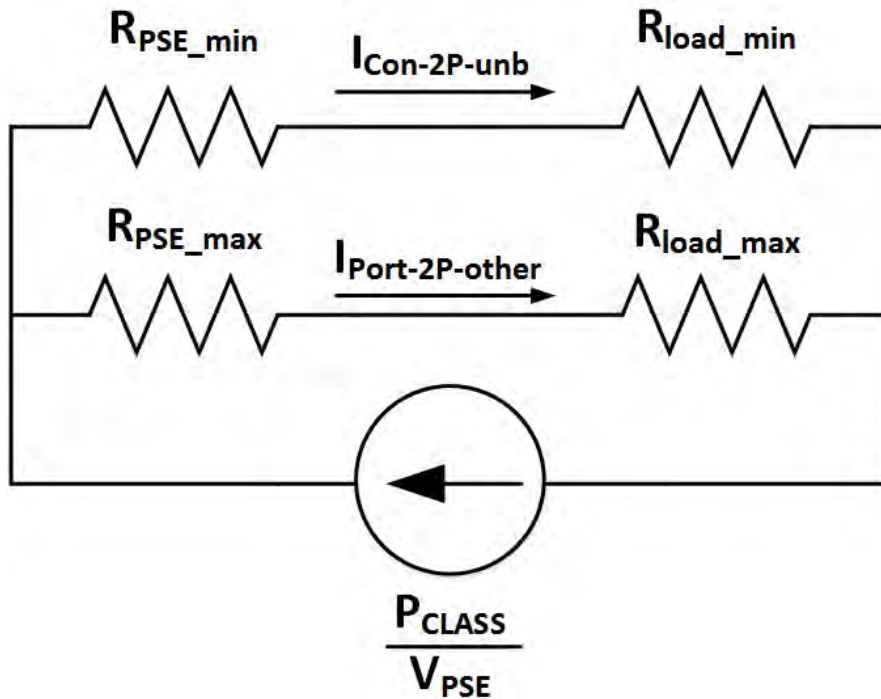| PD Class	K_{class}
5	1.57
6	1.31
7	1.17
8	1.15

$$\frac{K_{class} * (R_{pd\_min} + R_{source\_min})}{R_{pd\_min} + R_{source\_min}} \leq \frac{I_{Con-2P-unb}}{I_{Port-2p-other}}$$
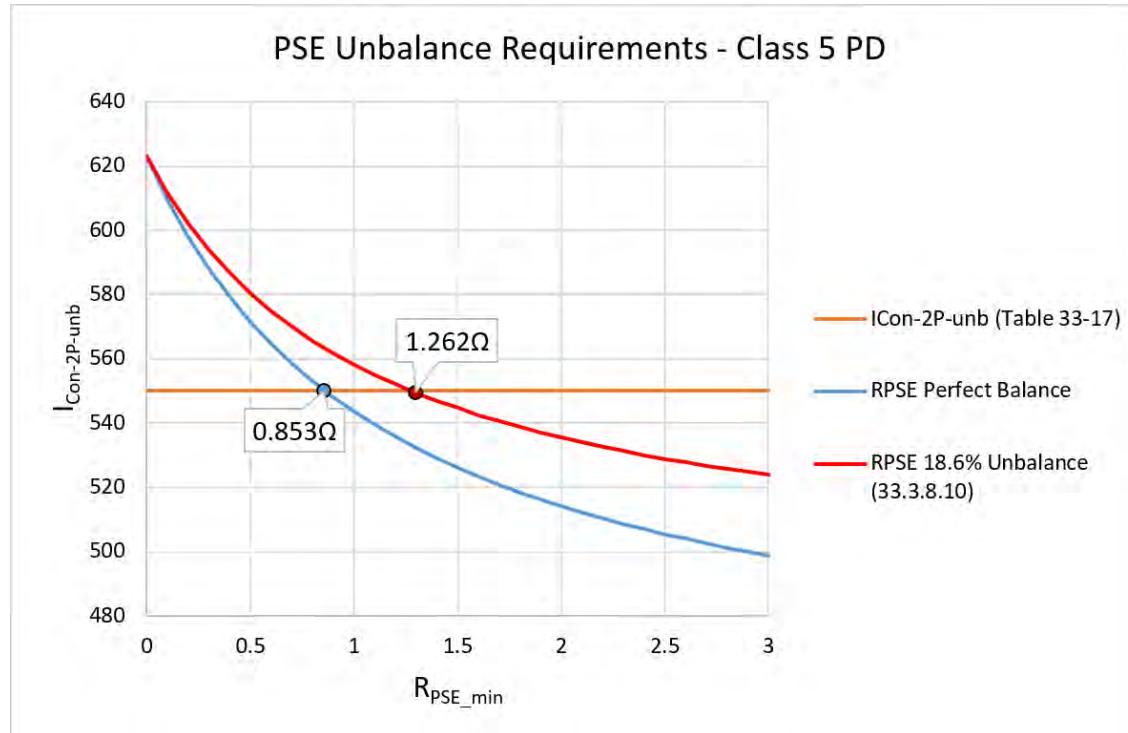
ANNEX

Problem #1
Example: Perfectly Balanced, Low-Resistance PSE

PD Class	Class 5 (SS)
R_{load_min}	0.723Ω
R_{load_max}	1.628Ω
R_{PSE_a}	0.3Ω
R_{PSE_b}	0.3Ω
P_{Class}/V_{PSE}	0.9A
$I_{Con-2P-unb}$ (Annex 33B)	**0.588A**
$I_{Con-2P-unb}$ (Table 33–17)	**0.550A**

LINEAR TECHNOLOGY

Problem #1
## Example, cont'd.

PSE Unbalance Requirements - Class 5 PD

- PSEs with ideal balance require $\mathbf{R_{PSE} \geq 0.853\Omega}$ to achieve $I_{Con-2P-unb}$ min
- Per 33.3.8.10, PDs are required to draw no greater than $I_{Con-2P-unb}$ when connected to "R_{source}" (unbalance ratio of 1.186:1)
  - This requirement places additional restrictions on the PSE, requiring PSEs with ideal balance to implement $\mathbf{R_{PSE} \geq 1.262\Omega}$

Problem #2
Conflict: 33.3.8.10 R_{PD} Test Method vs $I_{Con-2P-unb}$

- R_{PD} unbalance is limited (Section 33.3.8.10)
  - Section 33.3.8.10: *"…R_{source_min} and R_{source_max}, where*
    R_{source_max} = 1.186 * R_{source_min}, and
    R_{source_min} is in the range of 0.168 Ω to 5.28Ω…"
  - **R_{source} ratio is 1.186:1**

- $I_{Con-2P-unb}$ ratio is limited (slide 5)
  - **Class 8 $I_{Con-2P-unb}$ ratio is 1.15:1**

- R_{PD} unbalance contribution must be matched and large to comply
  - or actively balanced
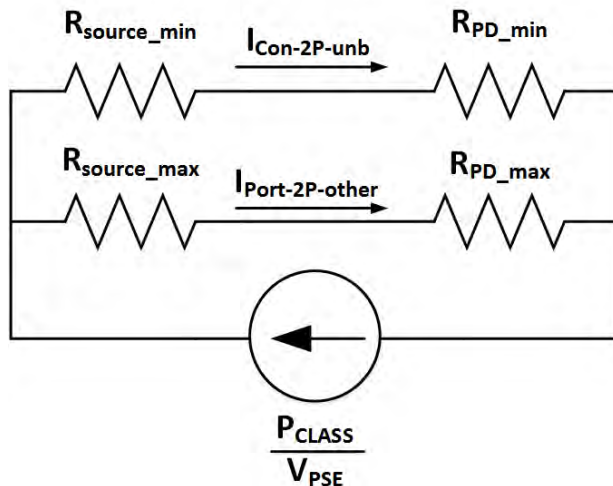
$$\frac{R_{source\_min} + R_{pd\_min}}{R_{source\_max} + R_{pd\_max}} \leq \frac{I_{con-2p-unb}}{I_{con-2p-other}}$$

1.186   1.15