PSE PI Imbalance

Ken Bennett – Sifos Technologies, Inc.

Resistive Imbalance Ad Hoc

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- Review of inequality between PSE PI Contribution to P2PRunb and PSE PI Runbalance
- A mathematically derived PSE PI Spec using worst case P2PRunb
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A fixed PSE PI Runbalance spec *can't* be derived from worst case P2PRunb

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- **The following is a Resistive imbalance equation for determining current imbalance between pairs (Single source, single PD)**

$$\frac{\sum R_{max} - \sum R_{min}}{\sum(R_{max}+R_{min})}$$

- **This can be separated into contributions of the PSE, PD and Channel:**

$$\frac{R_{pseRmax}-R_{pseRmin}}{\sum(R_{max}+R_{min})} + \frac{R_{CableRmax}-R_{CableRmin}}{\sum(R_{max}+R_{min})} + \frac{R_{pdRmax}-R_{pdRmin}}{\sum(R_{max}+R_{min})}$$

- **PSE PI Runbalance contribution is not the same as PSE PI Runbalance**

$$\frac{R_{pseRmax}-R_{pseRmin}}{\sum(R_{max}+R_{min})} \neq \frac{R_{pseRmax}-R_{pseRmin}}{R_{pseRmax}+R_{pseRmin}}$$

  - Changes in total resistance can change Runbalance requirements.
  - *An Runbalance specification at the PSE PI does not take this into account*

A PSE Resistance Limit *can* be derived from P2PRunb

- Annex A shows the derivation of the following from the P2PRunb Equation

$$R_{psemax} = X * R_{psemin} + Y$$

$$X = \frac{1 + R_{unb}}{1 - R_{unb}}$$

$$Y = \frac{1 + R_{unb}}{1 - R_{unb}} [R_{chmin} + R_{pdmin}] - [R_{chmax} + R_{pdmax}]$$

Runb = Worst case P2PRunb

Rchmax, Rchmin = Channel Resistance values for Worst case P2PRunb

Rpdmax, Rpdmin = PD Effective Resistance values for Worst case P2PR**unb**

- X, Y can be reduced to constants, based upon the worst case modeling
- Result can be used to determine Resistance limits between PI pairs of the same polarity

A Possible Test Method

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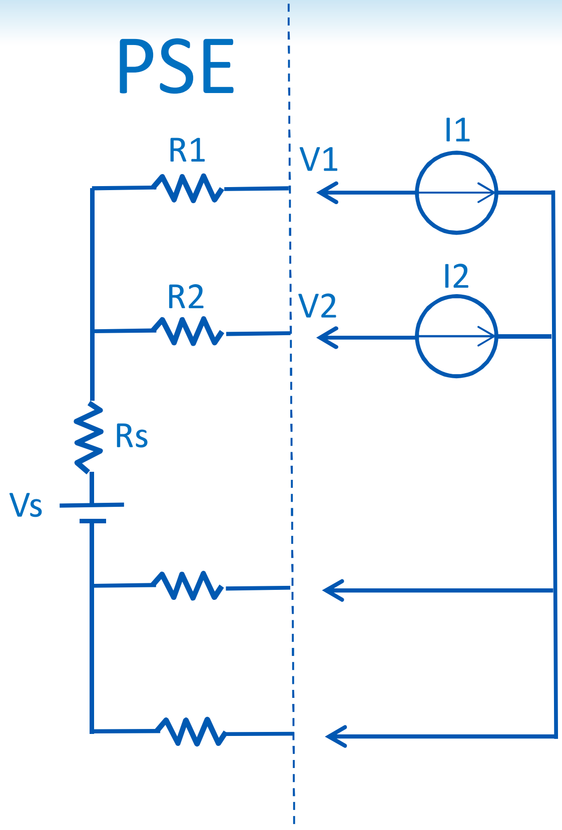

Test shown is for positive pairs. Negative pair tests would repeat on negative pairs with circuit to right

Steps:

1. I1 = Imax, I2 = Imin, Measure V1, V2
2. Calculate R1: = (V2-V1)/I1
3. I1 = Imin, I2 = Imax, Measure V1, V2
4. Calculate R2: = (V1-V2)/I2
5. Calculate Runb: (Rmax-Rmin)/(Rmax+Rmin)
6. I1, I2 = Imax, Measure V1, V2
7. Calculate Vunb: (Vmax-Vmin)/(Vmax+Vmin)

Requirements for Compliance:

Rmax ≤ X*Rmin + Y (See previous Slide for X, Y)

Vunb ≤ Runb + N

(Vunb due to Runb is expected…
N is an additional TBD allowance)

Parameter Descriptions:

Imin: 0mA (Up to 10mA if needed for MPS)

Imax: At least 90% of Maximum Port Capability

(Variant tests could use Resistive Loading)

Comments

- Applicable to PSE’s which
  - Are Type 3, 4
  - Don’t otherwise provide a balancing technique

- Other suggested requirements for applicable PSE’s
  - 4 pair powering shall be sourced from a single DC supply
  - If used, a forward-biased protection diode shall be installed in a path common to both pairs of the same polarity
  - Could tighten the overall P2PRunb by specifying a lower Limit on Rpsemin
    - Helps the PD imbalance, which may not have a practical test
    - Rpsemin in the AD Hoc model is an extreme case that can be addressed with a couple of inexpensive resistors

Annex

Derivation of PSE Resistance Limit

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Let $R_{\propto} = R_{chmax} + R_{pdmax}$, $R_{\beta} = R_{chmin} + R_{pdmin}$:

$$\frac{R_{psemax} - R_{psemin} + R_{\propto} - R_{\beta}}{R_{psemax} + R_{psemin} + R_{\propto} + R_{\beta}} = R_{unb}$$

← **P2PRunb Equation**

$$R_{psemax} - R_{psemin} + R_{\propto} - R_{\beta} = R_{unb}\left[R_{\propto} + R_{\beta}\right] + R_{unb}\left[R_{psemax} + R_{psemin}\right]$$

$$R_{psemax} - R_{psemin} - R_{unb}\left[R_{psemax} + R_{psemin}\right] = R_{unb}\left[R_{\propto} + R_{\beta}\right] - \left[R_{\propto} - R_{\beta}\right]$$

$$[1 - R_{unb}]R_{psemax} - [1 + R_{unb}]R_{psemin} = R_{unb}\left[R_{\propto} + R_{\beta}\right] - \left[R_{\propto} - R_{\beta}\right]$$

$$[1 - R_{unb}]R_{psemax} = [1 + R_{unb}]R_{psemin} + R_{unb}\left[R_{\propto} + R_{\beta}\right] - \left[R_{\propto} - R_{\beta}\right]$$

$$R_{psemax} = \frac{1 + R_{unb}}{1 - R_{unb}} R_{psemin} + \frac{R_{unb}\left[R_{\propto} + R_{\beta}\right] - \left[R_{\propto} - R_{\beta}\right]}{1 - R_{unb}}$$

$$R_{psemax} = \frac{1 + R_{unb}}{1 - R_{unb}} R_{psemin} + \frac{1 + R_{unb}}{1 - R_{unb}} R_{\beta} - R_{\propto}$$

Runbalance Example *(Values are not from the model)*

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- **Simulation Conditions common to each:**
  - **~1M Cable, worst case model used to arrive at ~26%**
  - **PD with Diode Bridge**
  - **PD, Channel fixed, PSE varied**

	PSE Runbal		Channel		PD Runbal	
Rpse other	0.001	0.001				
Rtrans	0.06	0.065				
Rconn	0.015	0.03	0.015	0.03		
Wire			0.0275	0.0285		
Rconn			0.015	0.03	0.015	0.03
Rtrans					0.06	0.065
Rdiode					0.8557	1.537
Unbalance	0.1163	12%	0.2123	21%	0.2737	27%
System Runbalance						
	0.26115	26.1%				
Simulation Iunbalance Result						
(mA)	658.35	385.65	0.261207	26.1%		

	PSE Runbal		Channel		PD Runbal	
Rpse other	0.23	0.392				
Rtrans	0.06	0.065				
Rconn	0.015	0.03	0.015	0.03		
Wire			0.0275	0.0285		
Rconn			0.015	0.03	0.015	0.03
Rtrans					0.06	0.065
Rdiode					0.8557	1.537
Unbalance	0.2298	23%	0.2123	21%	0.2737	27%
System Runbalance						
	0.26118	26.1%				
Simulation Iunbalance Result						
(mA)	658.35	385.65	0.261207	26.1%		

PSE Runbalance can vary significantly for a fixed total Runbalance

Reason: PI Runbalance ≠ PI Runbalance Contribution to P2PRunb