PI Balance Specifications

Ken Bennett
Sifos Technologies, Inc.
802.3bt September 2014

Introduction

Sifos Technologies

- The Pair-to-pair Runbalance Ad Hoc has two options for specifying PI Balance parameters
  - PI P2PRunb
  - PI Specifications derived from the final E2E Worst case model
- Shortcomings of the PI P2PRunb option have been presented previously and can be found in
  - http://www.ieee802.org/3/bt/public/jul14/bennett_01_0714.pdf
  - http://www.ieee802.org/3/bt/public/unbaladhoc/PI Balance Specifications rev 2.pdf
- This presentation provides additional information on the second option
- Possible changes to the standard which include the second option are then presented

Equation Derivation

Sifos® Technologies

Rewrite the E2ERunb in the following form

$$\frac{\sum R_{max} - \sum R_{min}}{\sum R_{max} + \sum R_{min}} = E2ER_{unb} \quad \Rightarrow \quad \frac{1 + E2ER_{unb}}{1 - E2ER_{unb}} \sum R_{min} - \sum R_{max} = 0$$

Substitute constant x:

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

Separate the contributors:

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

Solve for a contributor:

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

Solve non-contributor factors:

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

Final contributor expression:

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

Where: *x is a constant determined by the target balance*

y is a constant determined by the worst case models of the other contributors

PI Specification Independence and Final expressions

The initial separation of contributors in the previous slide was:

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

- Each contributor is a constant for the worst case model
- There are pairs of Rmax & Rmin that also equal that constant in each case
  - 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 final equations may be expressed in the following form:

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

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

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

Properties of the equations

- **Simple expressions, described with 2 constants**
  - **Exactly fit the limits necessary to meet E2E balance**
  - **No unnecessary restrictions nor implementation dependencies**
- **PI specification independence**
  - **If any two contributors satisfy the equations, the third equation remains Valid**
- **The equations may be useful for test parameters**
  - **Worst case Resistances of other contributors, if used in a test, may be scaled higher without affecting the requirement for the DUT**
    - (measurement accuracy needs to be considered in any case)
- **If a solution is not possible, the equation will indicate it**
  - **Consider the case where the worst case E2E model includes a contributor that improves the final target balance:**
    - If the pair of effective resistances satisfying the equation for that contributor are too small to provide the improvement necessary to meet the target balance, then the resulting $Reff_{max}$ will be less than $Reff_{min}$

Proposed Balance Specifications

Changes to 802.3at requirements by section

Sifos® Technologies

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:	I_{unb_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:

Sifos® Technologies

33.2.7.x Pair-to-Pair Current Unbalance

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

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

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-#$_2$

$$R_{pair\_max} = TBD, \quad R_{pair\_min} = TBD \qquad 33\text{-}\#_2$$

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):

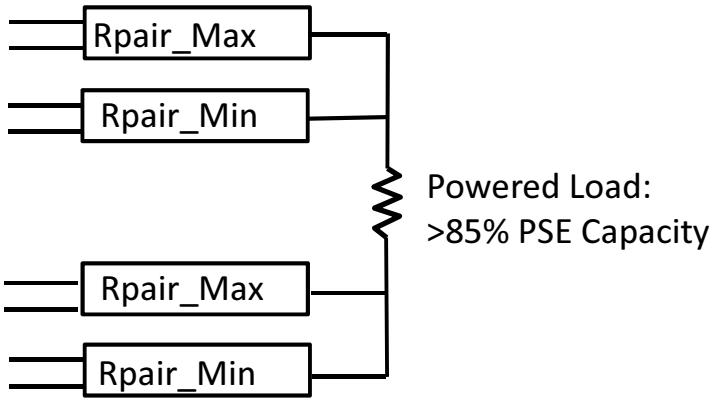

FIG. 33-#$_3$ Unbalanced load configuration

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:

Sifos® Technologies

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-#$_7$.

(Continued)

Table 33-11 Reference (Continued):

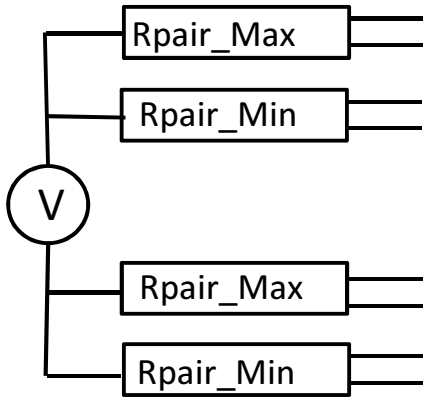

FIG. 33-#$_7$ Unbalanced source configuration

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

Sifos® Technologies

Questions and Comments

Sifos® Technologies

Thank You