# Comparison between Channel P2PRUNB specification options

## Addressing Opinions/Questions/Inputs from Meeting #11

Author: Yair Darshan
Date:  August 15, 2014
Contribution for 802.3bt End to End Channel Pair to Pair Resistance Unbalance Adhoc.
Rev 003

## Table of Contents

# *Background*

The objective is to close the TBDs in the base line text from May 2014. (Some text changes were added to use accurate terms).

In addition, we also checked alternatives specification forms such using equation **(option 2)** instead of single value for each unbalance parameter as traditionally was used in other resistance unbalance specifications (**Option 1** which is the current proposal on the table).

## The base line text with the proposed updates:

33.1.4.3 Pair Operation Channel Requirement for Pair to Pair Resistance Unbalance

4P pair operation requires the specification of resistance ~~unbalance~~ difference between each two pairs of the channel, is not greater than ~~200~~ 100 milliohms or a resistance unbalance of 7.5% whichever is greater. Resistance unbalance between the channel pairs is a measure of the difference of resistance of the common mode pairs of conductors used for power delivery.

Channel pair to pair resistance unbalance is defined by equation 33-1.1:

$$\left(\frac{R_{ch\_\max} - R_{ch\_\min}}{R_{ch\_\max} + R_{ch\_\min}}\right) \times 100\% \qquad \text{33-1.1}$$

Channel pair to pair resistance difference is defined by equation 33-1.2:

$$R_{ch\_\max} - R_{ch\_\min} \qquad \text{33.1.2}$$

Where:

Rch_max is the sum of channel pair elements with highest common mode resistance.

Rch_min is the sum of channel pair elements with lowest common mode resistance

Common mode resistance is the resistance of the two wires in a pair (including connectors), connected in parallel.

- NOTE: The pair-to-pair resistance unbalance values are preliminary working numbers used for characterizing cabling while awaiting input from ISO/IEC SC25 (developing the second edition of ISO/IEC TR 29125) and TIA TR42 (developing a revision of TIA TSB-184). These groups have works in progress that are expected to include pair-to-pair resistance unbalance specifications suitable for reference.

----------------------------------

**Optional notes (to discuss if add value) :**

Notes:

a) The above requirements are based on cable with pair to pair resistance unbalance of 5% maximum.

b) **7.5%** is the worst case pair to pair resistance unbalance at **100** milliohms of channel pair to pair resistance difference. At 100m channel length, the cable and connectors ensures 5.5% maximum channel pair to pair resistance unbalance.

3) The resistance unbalance for resistance difference < 100 milliohm should not exceed 25%. See details in informative section TBD.

Short summary. For details see next analysis and discussion.

## *Comparison between Channel P2PRUNB specification options*

For more details see detailed analysis of the comparison.

| # | Parameter | Concepts | |
|---|---|---|---|
| | | **Option 1** | **Option 2** |
| | | Single worst case value for any unbalance parameter | A Function that depends on cable length, number of connectors, Cables and connectors Rmax, Rmin. |
| 1 | Concept parameters | **"….100 milliohms** or **7.5%** whichever is greater…"<br>The above is the **TBDs** part in the baseline text motion that passed on May 2014.<br><br>The 7.5% starts at Channel Resistance difference of 100milliohm. It is a single point in **EQ-1**.<br>It represents Channel max. P2PRUNB based on use case analysis for minimizing unused margins and addresses unrealistic channel installations e.g. 4 connectors at channel length of 3m etc. | Channel General Equation<br>$C\_P2PRUNB = \frac{R_{max} - R_{min} + N \times (Rc\_max - Rc\_min)}{R_{max} + R_{min} + N \times (Rc\_max - Rc\_min)}$ EQ-1<br><br>For N=4 (4 connectors) we will get (worst case curve)<br>$C\_P2PRUNB = \frac{R_{max} - R_{min} + 0.08\Omega}{R_{max} + R_{min} + 0.032\Omega}$ EQ-2 |
| 2 | Complexity | Simple | Complex |
| 3 | Implementation Independent | YES | NO. It is Implementation Dependent.<br>-During compliance test of PSE or PD the user need to know Rmax, Rmin which are not define.<br>-The equipment vendor don't know where its equipment is going to be installed. So he will have to design to worst case any way! The worst case UNBALANCE of the equation form in option 2 is >than the UNBALANCE value in option 1 at Rdiff=100miliohm. See figure 5. |
| 4 | Risk for interoperability | NO. | YES. Undefined values for the equation parameters. |

| | | | |
|---|---|---|---|
| | with different channels? | | |

| # | Parameter | Concepts | |
|---|---|---|---|
| | | **Option 1** | **Option 2** |
| | | Single worst case value for any unbalance parameter | A Function that depends |
| 5 | Supports TIA/EIA connector specifications for Rdiff=50miliom per connector | YES. | NO. |
| 6 | Optimization method | - **Use Case AND worst case driven per EQ-1.**<br>- 1m channel cannot use 4 connectors AND if it used, It covered by the specification where Rdiff<100miliohm<br>- No unused margins at short channels.<br>- Optimized margins for short channels.<br>- No margins left on the table at 100m! **See Figure 6 demonstrating it** | -Worst case driven.<br>-4 connectors are used everywhere (e.g. 4 connectors for 1m Channel!!)<br>-High margins left on the table at short channel.<br>-Depend on channel length or channel resistance.<br>-Implementation dependent. |
| 7 | Pass Fail criteria | Simple | Complex. Implementation dependent |
| 8 | How PSE and PD designer will use channel specifications? | -They don't care what is the PD specification and what is the Channel specification. All they care is PSE PI specifications.<br>-For compliance tests, they will connect their PSE to a PD through channel that is defined by **option 1**.<br>-Option 1 guarantees that any PSE and any PD from any vendor connected to this channel will meet maximum pair current requirements. | -Need to design for worst case any way.<br>The worst case of the equation form (Option 2) is higher than **option 1**. Equation became not relevant since we need to design to the worst case any way so move to **option 1.**<br>**-moreover, since Rmin, Rmax is not defined.**<br>**It is not guaranteed that different PDs or PSEs from different vendors will give the same results (always pass) with any Channel Rmin and Rmax since they are not defined in the spec.** |

| # | Parameter | Concepts | |
|---|---|---|---|
| | | **Option 1** | **Option 2** |
| | | Single worst case value for any unbalance parameter | A Function that depends |
| 9 | Do we have unused margins left on the table?<br><br>If we do have margins, doe's it affects End to End Channel P2PRUNB? Or maximum current, or other components? | <u>**Case 1:**</u><br>**-No effect on E2E_CP2PRUNB**. In the End to End Channel P2PRUNB, the channel equation (option 2) is used and not "100 milliohms or 7.5% whichever is greater" which is not determine the current (option 1) so there is no wasted margin at 100m **(there is no 7.5% -5% = 2% added to the End to End Channel P2PRUNB).**<br>-The channel specification doesn't affect PSE and PD PI.<br>-The end to end equation affect the current and it includes the channel equation **(option 2).** | -There are unused margins at channel <10m.<br>-At Rdiff=0.1 ohm, the channel P2PRUNB=17% |
| | | <u>**Case 2:**</u><br>**Q:** What if somebody will build channel per option 1 with 7.5% at 100m?<br>**A:** It is impossible since cables are 5% maximum and connectors are specified so it will result with 5.5% max.<br>**Q:** What if I deliberately generate such channel, just to see how 2% at 100m at the channel will affect the system pair current?<br>**A:** The effect will not be significant due to the fact that **End to End C_P2PRUNB may reach ~15%-20% at 100m and can reach to ~50% at short channel pending components. (We can use tighter PSE and PD PI unbalance parameters and the results may be half of the above) so the effect of 2% difference became much lower at the system level.** | Same |
| 10 | How PD minimum guaranteed power will be affected? | <u>**No effect since we show in Annex C2 in http://www.ieee802.org/3/bt/public/unbaladhoc/Meeting_12_IEEE802_3bt_Channel_Pair_To_Pair_Resistance_Imbalance_ad_hoc_rev_016.pdf that:**</u><br>1. P2PRUNB>0 Reduces power loss on the cable and increase available power at PD input.<br>2. As a result, we don't need to limit pair current to 600mA as we did in our objective for 49W for getting consensus in our study group. As a result, we can easily support 51W for Type 3 systems<br>**3.** Confirmed in simulation (and lab results over 1,000,000 systems) | |

<table>
<tr><td rowspan="3">#</td><td rowspan="3">Parameter</td><td colspan="2">Concepts</td></tr>
<tr><td>Option 1</td><td>Option 2</td></tr>
<tr><td>Single worst case value for any unbalance parameter</td><td>A Function that depends</td></tr>
<tr><td>11</td><td>What is the sensitivity of the pair maximum current to a change of 2% at the channel P2PRUNB at 100m?</td><td>In a system with E2E_C_P2PRUNB per Figure 1 we will get:<br>- At 5.5% the pair current will 659mA<br>-At 7.5% it will be 668mA.<br>-This is only 9mA difference (at 51W PD load. 14mA at 80W).<br>- Only 1.4% increase in the current.<br><u>As a result,</u><br>-Transformer bias current will increase by 1.4%*3%/2=0.21%.<br>-Power loss increase on transformer located on max current pair: (1+0.014)^2-1=2.8%<br>-Total power loss change on transformer package: -0.02% !!!!<br>-No less power at PD input. See item 10.</td><td></td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Were we have more unbalance and as a result higher pair current</td><td>At 100m: 659mA per the above example</td><td>The same</td></tr>
<tr><td>At ~1m: X.</td><td>At ~1m: 2.26X</td></tr>
<tr><td>13</td><td>Does channel specification may imply that cabling manufactures will have license to build cables with 5.5% unbalance or 7.5%?</td><td>-No. Cable P2PRUNB is 5% max (nobody builds cables with 3% pair unbalance because channel is specified for 3% pair unbalance while cable alone is specified for 2% max pair resistance unbalance).<br>-This is a channel specification only.<br>-We can add a note/informative/normative text that the above requirements based on a cable with 5% maximum of pair to pair resistance unbalance.</td><td>Same.</td></tr>
</table>

<u>Other options discussed:</u>
Option 3: "5%+0.1Ω"=Equation. There is a consensus that it can't work. %+ Ω cannot be added together. Equation is undefined.
Option 4: 5% or 0.1Ω whichever is greater. This is similar to Option 1 but with wrong numbers. There is a consensus that option 4 is under estimation of option 1 when doing a worst case analysis.
Option 5: Text version of option 2 i.e. describing the equation by describing two of its part. It has the same issues of option 2 and with more sources of confusions.

- The incentive of the following work is to emphasis work that we already done during the last year.
- It includes results of email exchange and phone conference between adhoc meeting #11 and #12 as agreed according the meeting minutes.
- All results were confirmed in at least two independent tools (PSPICE and MATLAB and lately with Excel).

## Comparison between Channel P2PRUNB and End to End Channel P2PRUNB

See details in:
http://www.ieee802.org/3/bt/public/unbaladhoc/Meeting_11_IEEE802_3bt_Channel_Pair_To_Pair_Resistance_Imbalance_ad_hoc_rev_015a.pdf
http://www.ieee802.org/3/bt/public/unbaladhoc/Analzing_Channel_Pair_To_Pair_Resistance_Unbalance_use_cases_rev_5a.pdf

## Channel Definition and its equation

$$C\_P2PRUNB = \left( \frac{\sum_{R_{\max}}^{CH} - \sum_{R_{\min}}^{CH}}{\sum_{R_{\max}}^{CH} + \sum_{R_{\min}}^{CH}} \right) = \frac{\left(R_{\max} + N \cdot Rc_{\max}\right) - \left(R_{\min} + N \cdot Rc_{\min}\right)}{R_{\max} + N \cdot Rc_{\max} + R_{\min} + N \cdot Rc_{\min}} \qquad \text{EQ-0}$$

$$C\_P2PRUNB = \frac{\left(R_{\max} + N \cdot Rc_{\max}\right) - \left(R_{\min} + N \cdot Rc_{\min}\right)}{R_{\max} + N \cdot Rc_{\max} + R_{\min} + N \cdot Rc_{\min}} = \frac{\left(R_{\max} - R_{\min}\right) + 0.08}{\left(R_{\max} + R_{\min}\right) + 0.32} \qquad \text{EQ-1}$$

EQ-1 is private case for N=4 and connector Rmax=0.05Ω ,and Rmin=0.03Ω representing worst case numbers that generates highest unbalance.

The Channel Equation is already in the End to End Channel P2PRUNB equation.
As a result, there is zero margins left on the table when the maximum pair current will be determined which is our goal. As a result of maximum current that we want to allow, the PSE PI and PD PI unbalance parameters will be determined.

## System Equation and Channel Equation Ingredients

See below in EQ-2 how the channel equation fits into the system equation.

$$E2E\_C\_P2PRUNB=\frac{\left(\sum R_{\max}^{PSE}-\sum R_{\min}^{PSE}\right)+\left(\sum R_{\max}^{PD}-\sum R_{\min}^{PD}\right)+\left(\sum R_{\max}^{CH}-\sum R_{\min}^{CH}\right)}{\sum R_{\max}^{PSE}+\sum R_{\min}^{PSE}+\sum R_{\max}^{PD}+\sum R_{\min}^{PD}+\sum R_{\min}^{CH}+\sum R_{\max}^{CH}} \qquad \text{EQ-2}$$

- Using adhoc database values for components. Annex G1.
- The high C_P2PRUNB at short cable is dominating by PSE PI and PD PI components.
- PSE and PD PI affect also the system unbalance at 100m.
- We can see that while channel at 100m is only 5.5%, the end to end P2PRUNB (system) is 15%.
- The End to End Channel P2PRUNB was simulated at 51W load. Confirmed with MATLAB and Excel tools.
- If mistakenly someone runs system simulations with only the channel, the current over the pair with the lower resistance will be more sensitive to channel margins at 100m and will be resulted with wrong conclusions.

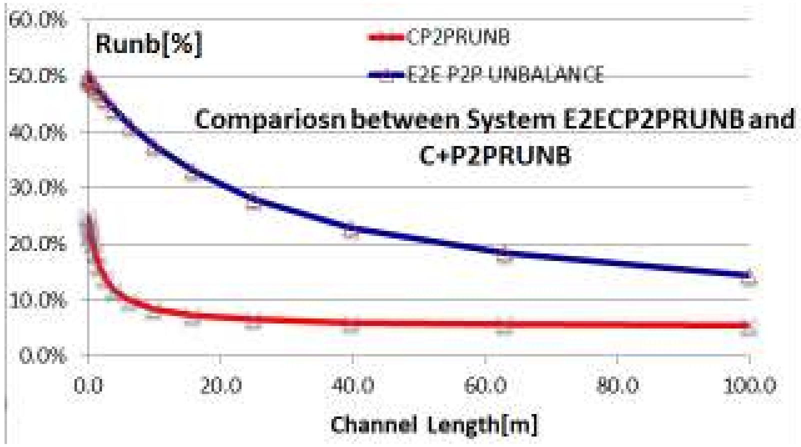



Figure 1: End to End Channel P2PRUNB vs Chanel P2PRUNB

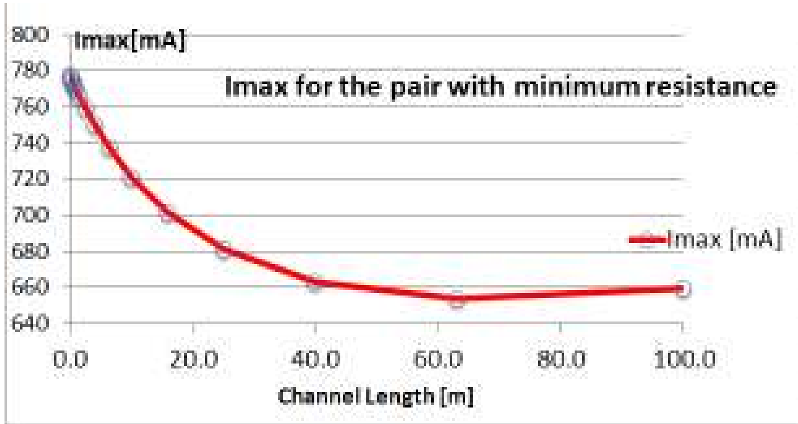



Figure 2: The pair with maximum current for Figure 3 system.

- Figure 1 and 2 based on the following system data taken from Annex G1 at the adhoc database material. PSE PI Rmax=0.4405Ω, PSE PI Rmin=0.09Ω, PD PI Rmax=1.061Ω, Pd PI Rmin=0.385. This values are for pair i.e. the common mode resistance.
  - This is an example of a system with high PSE and PD unbalance. The 1.061 Ω represents the equivalent PD PI Rmax including the diodes Vdiff and Rdiff unbalance.
- See Figures 3 and 4 for a PSE and PD with lower unbalance parameters.

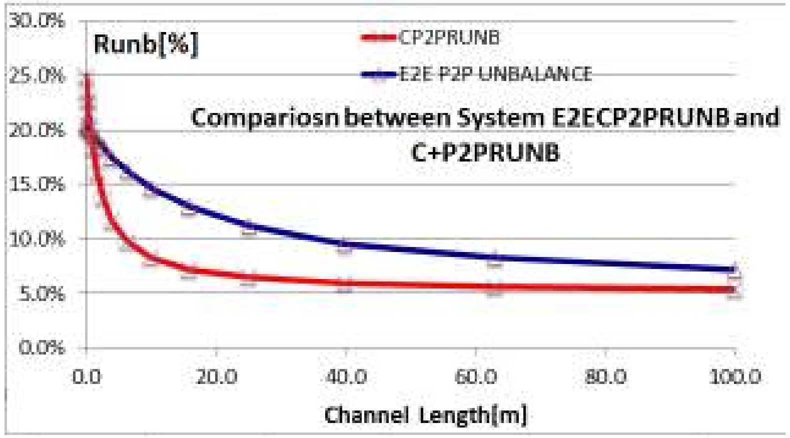



Figure 3: End to End Channel P2PRUNB vs Chanel P2PRUNB

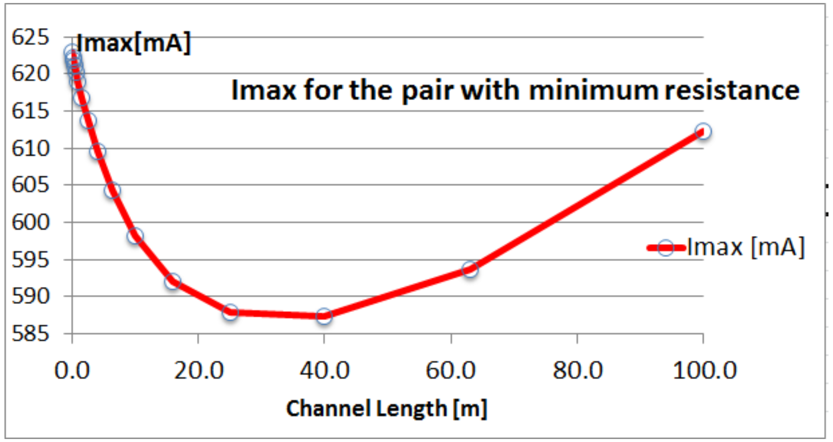



Figure 4: The pair with maximum current for Figure 3 system.

Figure 3 and 4 based on the following system data taken from Annex G1 at the adhoc database material some of the components with better unbalance parameters. PSE PI Rmax=0.2Ω, PSE PI Rmin=0.09Ω, PD PI Rmax=0.511Ω, Pd PI Rmin=0.385.

## The maximum pair current with the lowest resistance equation

The maximum pair current as function of system equation that includes channel behavior in its equation form will be:

$$\mathrm{Im}ax = \frac{It\cdot(1+E2E\_P2PRUNB)}{2} = \frac{It\cdot\left[1+\left(\frac{\left(\sum R_{\max}^{PSE}-\sum R_{\min}^{PSE}\right)+\left(\sum R_{\max}^{PD}-\sum R_{\min}^{PD}\right)+\left(\sum R_{\max}^{CH}-\sum R_{\min}^{CH}\right)}{\sum R_{\max}^{PSE}+\sum R_{\max}^{PD}+\sum R_{\max}^{CH}+\sum R_{\min}^{PSE}+\sum R_{\min}^{PD}+\sum R_{\min}^{CH}}\right)\right]}{2} \qquad \text{EQ-3}$$

- Using adhoc database values for components. Annex G1.
- The high C_P2PRUNB at short cable is dominating by PSE PI and PD PI components.
- PSE and PD PI affect also the system unbalance at 100m.
- We can see that if Channel P2PRUNB=5.5% or 7.5% at 100m YOU will not notice the differences with high PSE and PD unbalance!
- In addition, most of the problems are at lower channel length and NOT at 100m! See again below Figures 2 and 4.
- The End to End Channel P2PRUNB was simulated at 51W load. Confirmed with PSPICE, MATLAB and Excel tools.
  (Results Differences between tools are negligible for the purpose of drawing conclusions and mainly are results of diode model approximation used with MATLAB and Excel).

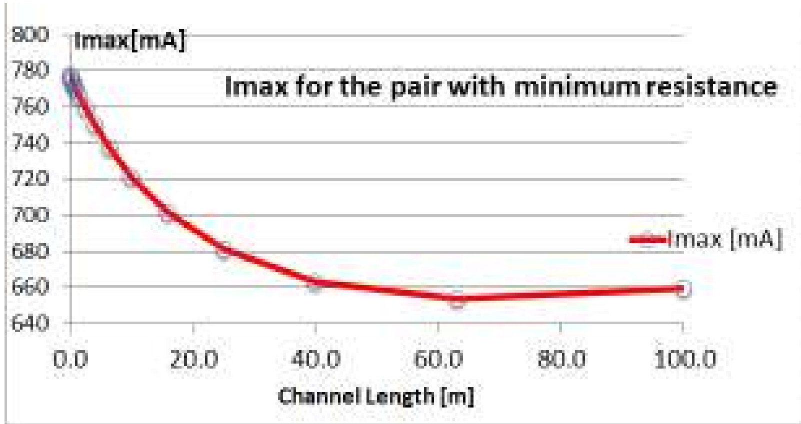



Figure 2:Pair current as a result of the system in Figure 1.

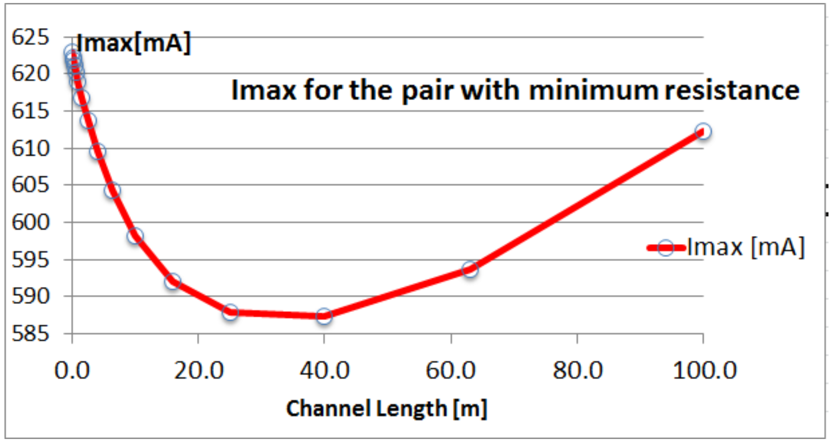



Figure 4:Pair current as a result of the system in Figure 3

# *More examples for Spice simulations for model shown in Annex F per data shown in Annex G1* ***with slight diode unbalance***

| Parameter | L=1m | | L=100m | |
|---|---|---|---|---|
| | I (mA) | P2PRUNB | I (mA) | P2PRUNB |
| Ia+ (I(R41)) | 743.32 | 40.03% | 649.94 | 11.12% |
| Ib+ (I(R42)) | 318.33 | REF | 519.88 | REF |
| Ia- (I(R20)) | 671.34 | 35.67% | 633.87 | 9.88% |
| Ib- (I(R19)) | 390.3 | 10.16% | 535.95 | 1.52% |
| Ia total | 1061.65 | | 1169.82 | |
| Ib total | 1061.65 | | 1169.82 | |
| Idiff_pos_max | 425 | | 130 | |
| Idiff_neg_max | 281 | | 65 | |

PARAMETERS:
P2PRunb = 0.05 — 0.05 for Pait to Pair Run
Pair_Runb = 0.02 — 0.02 for Pair Runb
Ppd = 51
ILIM = 2
Lcable = 100
Resistivity = {0.1*Cordage_Resistivity+0.9*Cable_Resistivity}
Cordage_Resistivity = 0.0926
Cable_Resistivity = 0.0792
Rcable_max = {Lcable*Resistivity}

alfa = {(1-Pair_Runb)/(1+Pair_Runb)}
beta = {(1-P2PRunb)/(1+P2PRunb)}
beta_special = 0.925

Rt_max = 0.13 Rt_min = 0.12
Rsense_max = 0.25 Rsense_min = {Rsense_max*0.98}
Rdson_max = 0.1 Rdson_min = 0.05
Rconn_max = 0.05 Rconn_min = 0.03
Vd_max = 0.1 Vd_min = 0
Rd_max = 0.1 Rd_min = 0.0001

Spice model Revision 005. Note: Ppd is constant power sink parameter model. The actual PD input power (including Diode bridges is 53.339W at 100m per cable data below.

-Simulation results were validated with other simulation tools and were sync with lab results. (May 2013, July 2013, August 2014).
-Components value taken from Data base Annex G1 with some changes on diode data (tighter unbalance)
See earlier work at:
http://www.ieee802.org/3/4PPOE/public/jul13/beia_1_0713.pdf
http://www.ieee802.org/3/4PPOE/public/jul13/darshan_2_0713.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/beia_01_1113.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/darshan_02_1113.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/darshan_03_1113.pdf

# Examples for Spice simulations for model shown in Annex F per data shown in Annex G1 ***with PD identical diodes/ Ideal Diode Bridge(*)***

| Parameter | L=1m | | L=100m | |
|---|---|---|---|---|
| | I (mA) | P2PRUNB | I (mA) | P2PRUNB |
| Ia+ (I(R41)) | 562.2 / 564.6 | 6.4% / 10.6% | 630 / 602 | 7.73% / 8.12% |
| Ib+ (I(R42)) | 499.6 / 456.2 | 0.5% / REF | 540 / 512 | REF |
| Ia- (I(R20)) | 567.2 / 557.7 | 6.8%/10% | 617 / 588 | 6.61% / 6.94% |
| Ib- (I(R19)) | 494.7 / 463 | REF / 0.75% | 554 / 526 | 1.28% / 1.37% |
| Ia total | 1061.82 / 1020.8 | | 1170 /1114 | |
| Ib total | 1061.82 / 1020.8 | | 1170/1114 | |
| Idiff_pos_max | 62.6 | | 90.4 / 90 | |
| Idiff_neg_max | 72.45 | | 62.3 / 62 | |

- Simulation results were validated with other simulation tools and were sync with lab results. (August 2014).
- Components value taken from Data base Annex G1 with some changes on diode data (tighter unbalance)
- Spice model Revision 005. Note: Ppd is constant power sink parameter model. The actual PD input power (including Diode Bridges is 51W + diode

PARAMETERS:

P2PRunb = 0.05 — 0.05 for Pait to Pair Run

Pair_Runb = 0.02 — 0.02 for Pair Runb

Ppd = 51

ILIM = 2

Lcable = 100

Resistivity = {0.1*Cordage_Resistivity+0.9*Cable_Resistivity}

Cordage_Resistivity = 0.0926

Cable_Resistivity = 0.0792

Rcable_max = {Lcable*Resistivity}

alfa = {(1-Pair_Runb)/(1+Pair_Runb)}

beta = {(1-P2PRunb)/(1+P2PRunb)}

beta_special = 0.925

Rt_max = 0.13 Rt_min = 0.12

Rsense_max = 0.25 Rsense_min = {Rsense_max*0.98}

Rdson_max = 0.1 Rdson_min = 0.05

Rconn_max = 0.05 Rconn_min = 0.03

Vd_max = 0.1 Vd_min = 0

Rd_max = 0.1 Rd_min = 0.0001

## Do we have margins left on the table between option 1 and option 2?

**The answer is no!.** When system equation contains channel equation ad is the default case of how we calculate the pair current, there is no unusable margin. The channel specification "100 milliohms or 7.5% whichever is greater" is not used to calculate pair current by the system equation that do use channel equation.

The proposed channel spec per option 1, is a worst case number that is used to test channel for compliance at unique worst case point which corresponds to Rdiff=0.1Ω. As a result, it will use to test the whole system for compliance.

The cables has 5% pair to pair resistance unbalance, the connectors unbalance is 25% max so channel actual performance is specified when channel Rmax and Rmin are specified.

- As a result the "100 milliohms or 7.5% whichever is greater" has a zero margins left on the table! (And it was confirmed by simulation as well)
- The "100 milliohms or 7.5% whichever is greater" is a Channel Only specification and not system specification!

### What if the 7.5% will be used in the system equation (EQ-2) instead of channel equation (EQ-1)?

In this case the effect will be not significant as well.

- AT 100m, The 2% margin will be overtaken by the PSE PI and PD PI which are>>5.5% (10-20% at system level pending PSE/PD PI components).
- It is easy to quick calculate it:
- The system has 15% unbalance at 100m. The current is per simulation 659mA.
- The Channel unbalance at 100m increases from 5.5% to 7.5%=2%.
- The current in system level was increased to just 668mA. **This is only 9mA** at 51W.
  - 14mA at 80W.
- Only 1.4% increase in pair current due to 2% margin in the channel level.
  (Higher effects as claimed at adhoc meeting #11 was due to error in the commenter's model and calculations as expected. The source of the error is that the commenter use only channel in the system level for calculating the pair current without accounting for PSE and PD PI. <u>It will be also incorrect if it will be argued in the future that there is a PSE or PD that has unbalance qualities similar to the channel i.e. 5.5%. This is not practical. PSE PI and PD PIs have connector and transformers and other components that has>>5% unbalance.</u> See adhoc database for details.

- The effect on magnetic is also insignificant. 1.4%*3%/2=0.21%. =>0.21%*9mA=0.0189mA ➔ <<<1mA.
- The effect on magnetic power loss: 2.8% ➔ Don't care.
- The effect on magnetic package power loss all 4 pairs magnetics inside): -0.2% (Improvement..!!!)

## Why Equation form for the specification is a problem?

- As we can see below, equation form is Implementation Dependent
  - We need to know the channel length, The number of connectors?, Cordage length?, Cable length? Cable and Cordage Resistance?
- This is a problem for compliance tests. We cannot be dependent on user interpretation how what is correct installation to use!
- We can improve it by setting it to maximum connectors=4 (see equation below), but then all the worries of margin on the tables will go to short channel length were we have more problems!!!!!!
  - We will have 4 connectors to channel with 1m or 10m ➔ unrealistic – wasted margins.
  - Still it is implementation dependent!
- How PSE or PD designers design their systems? They design for the worst case in the curve correct?
  So why not to use "100 milliohms or 7.5% whichever is greater" which is use case based optimized specification that is the worst case and shows lower unbalance at <100m were it is more important to limit pair current?

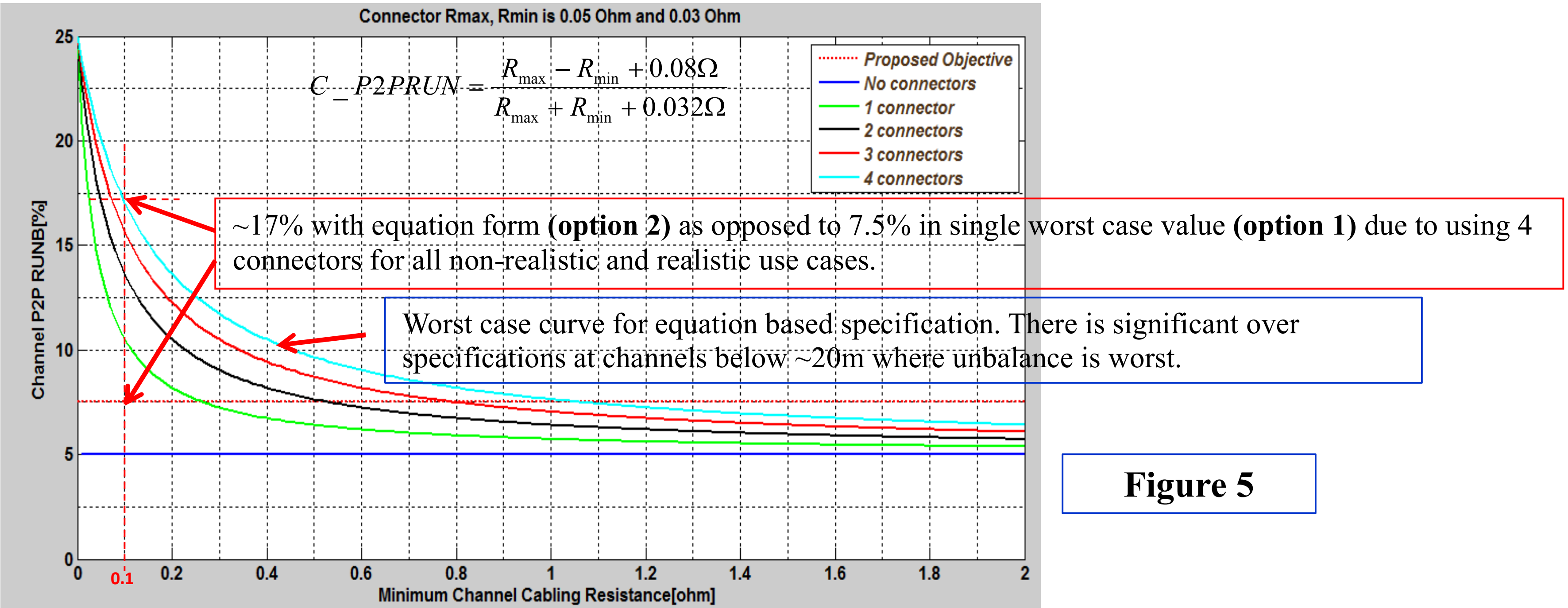



**Figure 5**

## Why proposed base line text is better specification?

- The base line proposal main part: "100 milliohms or 7.5% whichever is greater
- Use Case optimized and yet based on Channel Equation!
- No wasted margins. This is only Channel spec. System specification is not affected with any way we go.
- Optimized margins at short and long channels
- Simple specification.
- Single worst case value.
- Below 100 milliohms, C_P2PRUNB is limited by 25% (worst case connector data). (Slide 22 in the link below)
    - It can be part of the normative text or as a note.
    - Group to discuss at meeting #12.

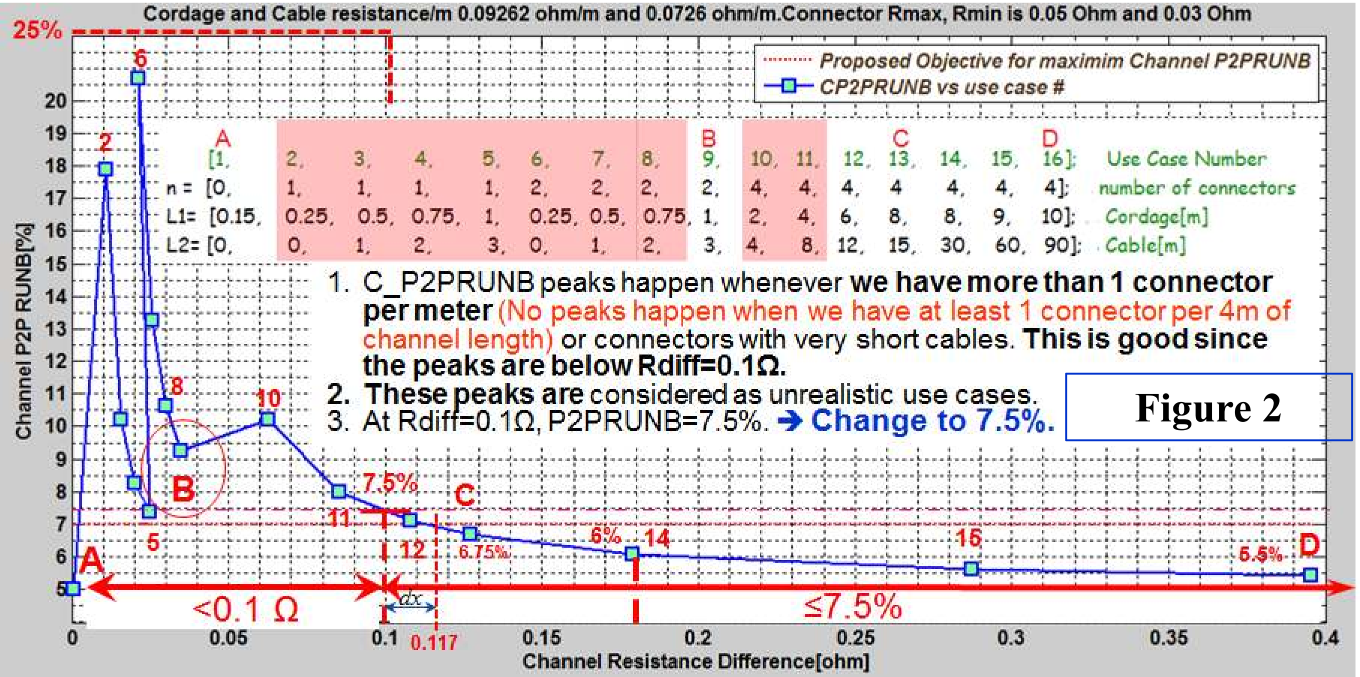



**Figure 6: Option 1 specification derivation based on the general case of channel equation (EQ-0) AND use case analysis**
http://www.ieee802.org/3/bt/public/jul14/darshan_01_0714.pdf

# Reference material for FAQ

## How maximum pair current and E2EP2PCRUNB affects magnetics bias current

See at:
http://www.ieee802.org/3/bt/public/unbaladhoc/Meeting_11_IEEE802_3bt_Channel_Pair_To_Pair_Resistance_Imbalance_ad_hoc_rev_015a.pdf

How Ibias is tested: See annex D
Negligible effect on Ibias: See Annex D1.
See Study Group presentation showing negligible effect on Ibias through Spice simulations for E2ECP2PRUNB=26-30% .
http://www.ieee802.org/3/4PPOE/public/jul13/beia_1_0713.pdf
http://www.ieee802.org/3/4PPOE/public/jul13/darshan_2_0713.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/beia_01_1113.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/darshan_02_1113.pdf
http://www.ieee802.org/3/4PPOE/public/nov13/darshan_03_1113.pdf

## *Other specification alternatives*

a) Regarding the proposal made in the minority report for (5% + 0.1ohms).

Dave Explains that he agreed that (5% + 0.1ohms) is not equation and cannot be a valid equation but the intention was a “MAX” or logical “OR” of the greater of 5% or 0.1ohms.

Yair review of the above proposal:

5% OR 0.1 whichever is greater is the same format of current proposal at the motion. The difference is 5% instead of 7.5%. This proposal will not work too. See slide 16 at http://www.ieee802.org/3/bt/public/unbaladhoc/Analzing_Channel_Pair_To_Pair_Resistance_Unbalance_use_cases_rev_5a.pdf that show clearly under estimation of the use cases for worst case analysis at C_P2PRUNB=5%.

Since there is single correct mathematical solution, any other solution is incorrect. In addition to the fact that equation form vs. single worst case value form doesn’t leave margins on the table and it is much better due to long list of parameters per the table above.

b) Other text proposals:

Any text proposal that describe the equation per option 2 or the specification for cable and Rdiff=0.1 ohms is even worst that option 2 since now there is more room for interpretation.

# Summary

It was shown above and demonstrates to Dave Dwelley that in our OOO conference meeting that:

1. The curve is accurate representation of the channel. This was the basis for the work.
2. Equation form is not the optimum choice.
   - 2.1 It doesn't reduce margins at 100m.
   - 2.2 Equation form leaves margins on the table at short channel were we have much higher unbalance than at 100m. It is due to the fact that it uses 4 connectors for any use case, even for short cables.
   - 2.3 End user has to design its PSE or PD for the worst case channel conditions.

     How he will use equation?

     Subject to interpretation of vendors, test houses etc.

     And he will have to use equation worst case since user doesn't have control on installation.
   - 2.4 Therefore equation form should not be use in the specification.
3. Equation form is implementation dependent specification. This alone argument is a big problem.
4. It was shown that the effect on **pair current** (with lowest resistance) at 100m is <1.4% in all methods.
5. It was shown that the effect on **transformer bias current** is 0.14%.
6. It was shown the effect on transformer **power loss** is -0.02%.
7. It was show that the higher current may happen at short cable and not at 100m
8. It was shown that a power system with 50-99W with active diode bridge in the PD which has a better balance than typical diodes, and using Purely resistive PSE at maximum channel length of 100m (where we expected that the imbalance in the cable and cordage would dominate) the PSE PI and PD PI still have tremendous effect that cause the whole channel to increase its unbalance from 5.5% actual at 100m channel to 15% at system level! In this case it was shown that the transformer bias current will be changed by 0.14% maximum which is insignificant.
   As a result, the 5.5% to 7.5% differences don't exist in system level. See case 1 and 2 in the table above.

As a result of the above, the adhoc approach of "100 milliohms or 7.5% whichever is greater " that was based on detailed analysis and reviewed many times, for long time, and supported by cabling and connector experts and system experts and based on extensive field experience is the best choice.

9. The error in the analysis that suggested that the 2% difference is important was confirmed.
   -All errors were corrected and the analysis was sync with Yair's work.
   (The PSE PI and PD PI were missing (due to Dave assumption that in Ideal diode bridge in the PD and resistive PSE PI with R<<Rcable ) will make the channel only main contributor to unbalance at the system. This is incorrect since PSE and PD PI have other components such connectors, transformers and other that will make PSE PI and PD PI with higher unbalance than the channel).
   Calculating the real maximum pair current requires adding actual PSE and PD PI components.
   -I bias need to multiplied by 3%/2 which makes all arguments about transformers a non-issue.

10. As a final result, no value in using equation. Moreover it causes issues in many aspects. See table above.

11. **So eventually the whole discussion came down to what really bothers Dave: He agrees that differences are negligible regarding the 7.5% compared to 5.5%. But the concerns are as follows:**

We may have interpretations issue of the proposed specification: "100 milliohms or 7.5% whichever is greater"

11.1 It may be interpreted as allowing cabling (not including connectors) P2P resistance unbalance of 7.5%, and the cable manufacturers may loosen their specs accordingly.

My proposal: We remove this worry by adding the following notes.
Notes:

a) The above requirements are based on cable with pair to pair resistance unbalance of 5% maximum.

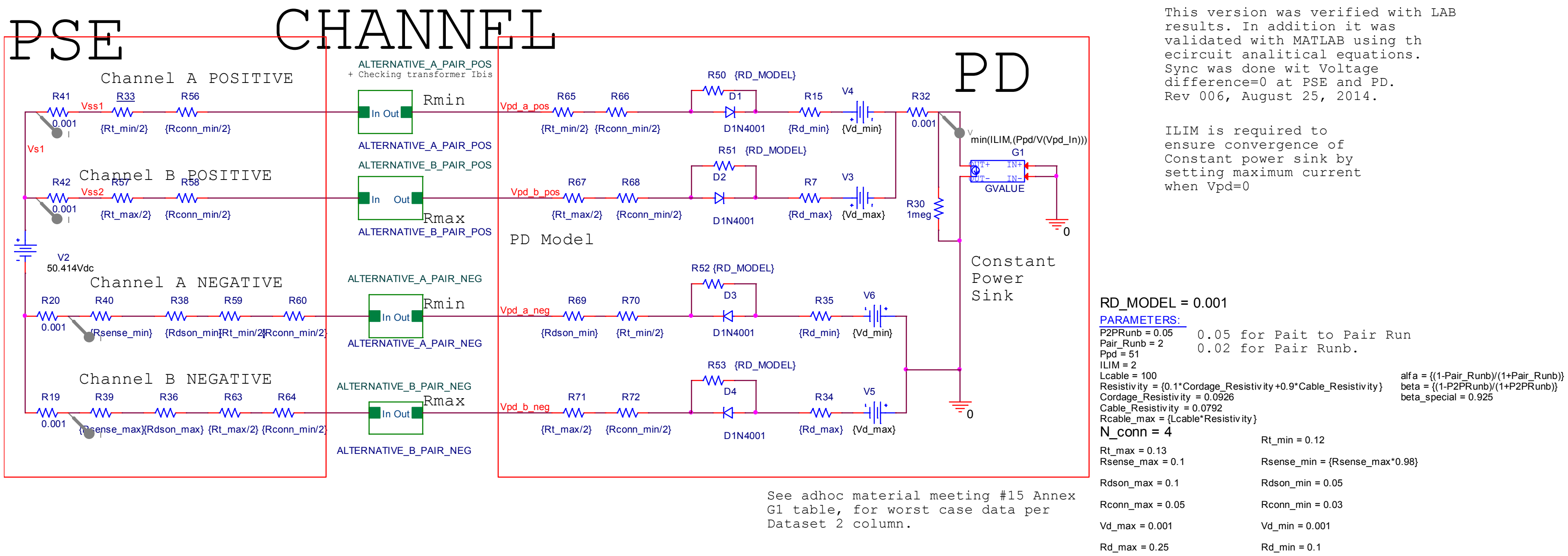
11.2 It can also be interpreted as allowing nearly infinite mismatch for a short channel since we don't define (in section 33.1.4.3) what the minimum connector resistance is. Because of the complex relationship between % mismatch and cable length, it's very easy to misinterpret this seemingly simple spec!

My response:

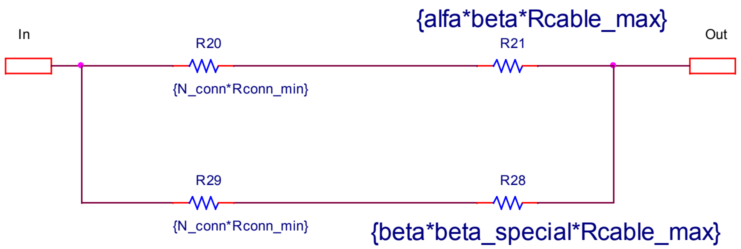
- Infinite mismatch is impossible. The maximum possible unbalance is 100%.
- So if you meant 100% maximum, I agree and I have addressed it in my work see: http://www.ieee802.org/3/bt/public/jul14/darshan_01_0714.pdf slide 22 that address it and suggest that it will be a subject for later work based on the analysis we already done and we have all the information in this link were we see red dashed border limits at 25%.

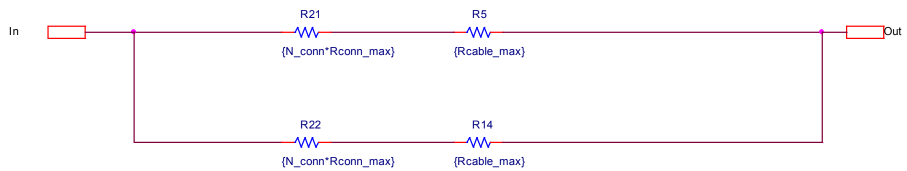
To handle this I suggest using the following text as a note or as part of the normative text.

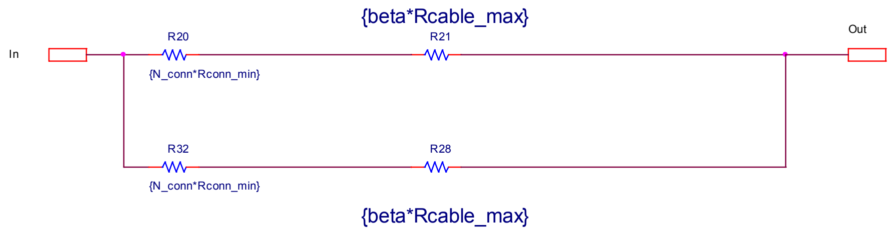
# Spice Model used during the End to End P2PRUNB adhoc.

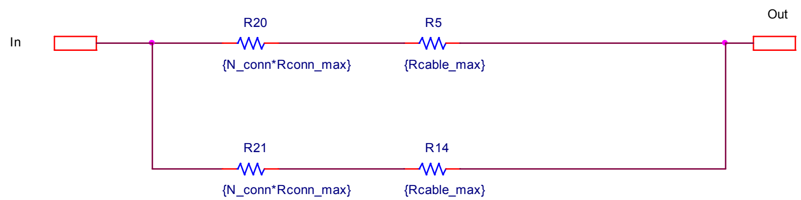



The parameters above are used in the example in Annex G6 at the adhoc material of meeting #12.
Vpd_in is generated from PD inputs.


{alfa*beta*Rcable_max}
In
R20
R21
Out
{N_conn*Rconn_min}
R29
R28
{N_conn*Rconn_min}
{beta*beta_special*Rcable_max}


In
R21
R5
Out
{N_conn*Rconn_max}
{Rcable_max}
R22
R14
{N_conn*Rconn_max}
{Rcable_max}


{beta*Rcable_max}
In
R20
R21
Out
{N_conn*Rconn_min}
R32
R28
{N_conn*Rconn_min}
{beta*Rcable_max}


In
R20
R5
Out
{N_conn*Rconn_max}
{Rcable_max}
R21
R14
{N_conn*Rconn_max}
{Rcable_max}