Transformer and Channel ad hoc

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Joseph Maggiollino	Broadcom		

Transformer data provided by: Bel, Pulse, Tyco, other

1 ad hocs with an average attendance of 37 people since the last report.

Agenda

- **Approach taken**
- **Creating the IEEE 802.3 channel model**
- **Review task force recommendations**
- **Current unbalance**
- **Next step.**

This is a work in progress: Trends are useful, model specifics are in development.

Approach Taken

- **Agree on a system model for current unbalance calculations.**
- **Use IEEE 802.3 requirements and legacy system data to refine the model used.**
- **Use the refined approach to model IEEE 802.3at current unbalance.**

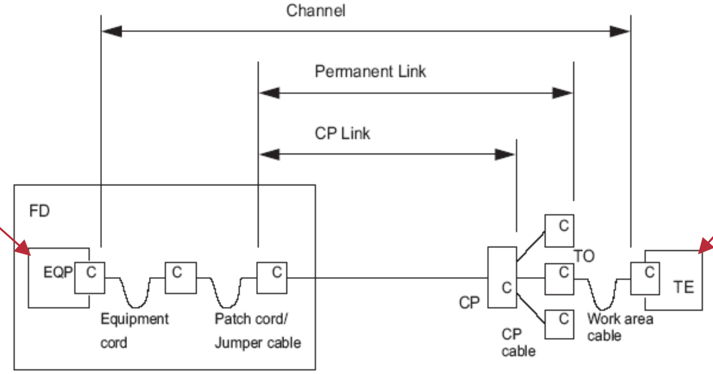
Reference to IEEE channel

33.4.8 Midspan PSE device additional requirements

The cabling specifications for 100Ω balanced cabling are described in ISO/IEC 11801-2002. Some cable category specifications that only appear in earlier editions are also supported. The configuration of “channel” and “permanent link” is defined in Figure 33–18.

end point PSE

PD



FD = floor distributor; EQP = equipment; C = connection (mated pair);
CP = consolidation point; TO = telecommunications outlet;
TE = terminal equipment

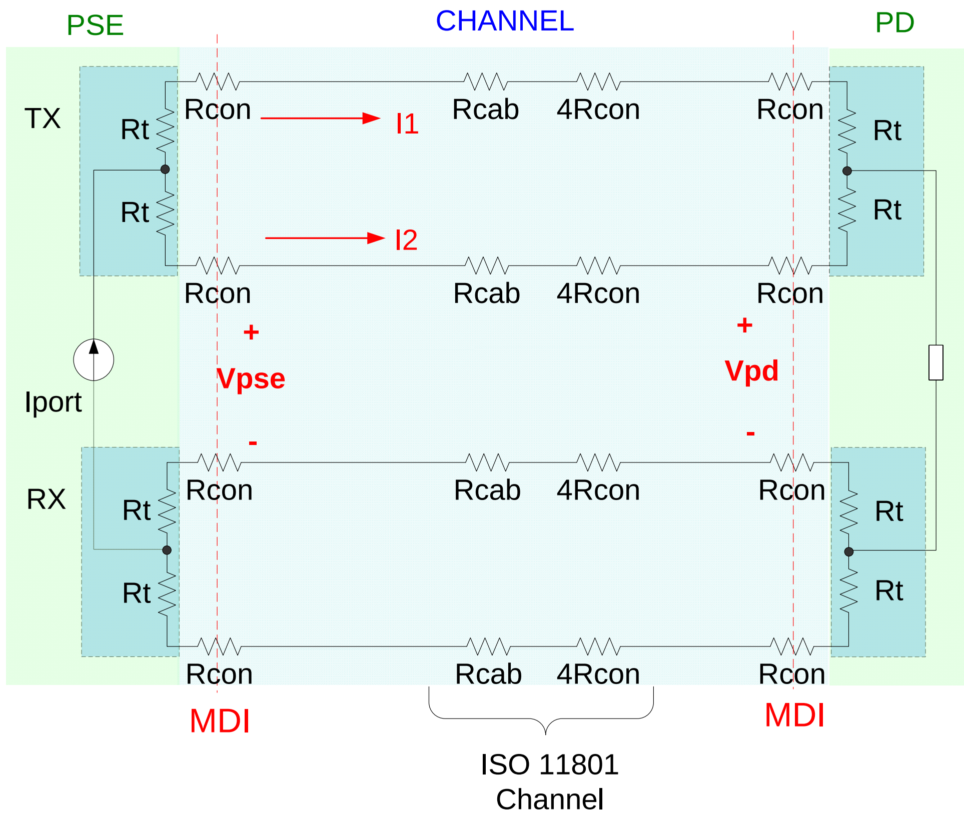
Figure 33–18—Floor distributor channel configuration

Clause 33 only discusses midspan PSEs with reference to a channel.

It can be inferred that an end point PSE needs to connect to a channel.

This system has 6 connections when a PSE is connected to a PD.

The Channel Models: Detailed IEEE 802.3



$$I_1 = I_{cable} \frac{\sum R_{\max} // \sum R_{\min}}{\sum R_{\max}}$$

$$I_2 = I_{cable} \frac{\sum R_{\max} // \sum R_{\min}}{\sum R_{\min}}$$

$$I_{UNBAL} = I_{cable} \times \sum R_{\max} // \sum R_{\min} \left(\frac{1}{\sum R_{\min}} - \frac{1}{\sum R_{\max}} \right)$$

The worst-case current unbalance is modeled by combining the ISO channel resistance unbalance with an MDI connections and transformer resistance.

a // b => Replace with the resistance of “a” in parallel with “b”.

IEEE 802.3

33.2.8.12 Current unbalance

The specification for I_{unb} in Table 33–5 shall apply to the current unbalance between the two conductors of a power pair over the current load range. The 10.5mA value is based on a simulated output current unbalance of 3%.

Valid for ISO channel with 4 connectors.

$$I_{UNBAL} = I_{cable} \times \sum R_{\max} // \sum R_{\min} \left(\frac{1}{\sum R_{\min}} - \frac{1}{\sum R_{\max}}\right)$$

$$I_{UNBAL} = 350mA \times 3\% = 10.5mA$$

This is not Ipeak.

Iunb

A 12.95 W PD may demand 14.8 W for 50 ms.
Isurge = 350 x 400/350 = 400 mA

Task Force recommendations 1 of 2

- **Assume a constant Power PD.**
- **Consider the PD surge power.**
- **Calculate cable current based on system parameters.**
- **Use ISO/IEC 11801, 3% resistive unbalance and Rch recommendations Class-C 40 ohms, Class-D 25 ohms) ***
- When cable reach is < 14 m assume 5 connectors
  When cable reach is >= 14 m assume 6 connectors *
- **Assume CAT-5e connectors or better are used on PSEs and PDs.**
- **When a CAT-3 connector is mated with a higher grade plug use CAT-3 resistance values. Rmate 0.3 ohms, Runbal = 0.05 ohm ***
- Assume the cable reach is 1 m to 100 m.

*** Use for worst-case Class C calculations (maximum channel resistance with the lowest PSE supply voltage. Rmate = 0.3 ohms was used. With a short channel length a lower value of Rmate is worse.**

Task Force recommendations 2 of 2

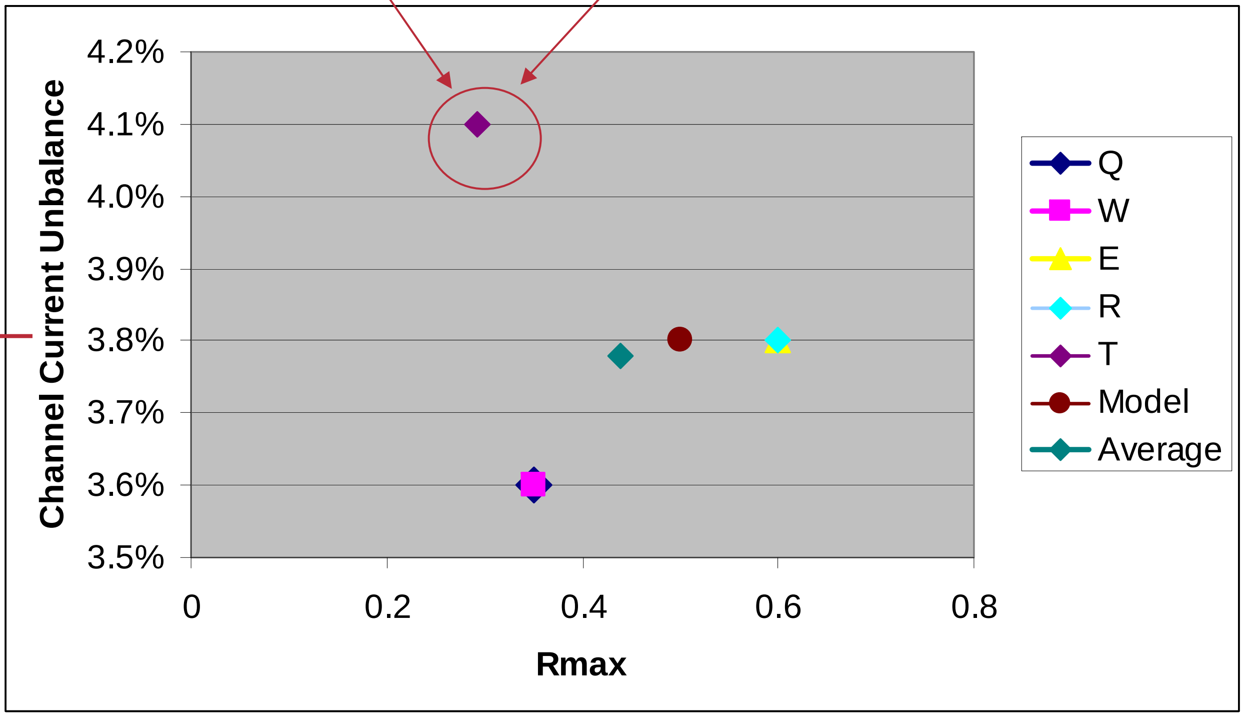
- **Assume transformers in the PSE and PD. ***
- **Use 0.5 ohms maximum for transformer resistance (CT-to-signal) with a 5% resistive unbalance (legacy). ***
- **Assume that PSE and PD transformer resistance is uncorrelated.**
- **Determine how to deal with 100 MBPS 8 mA unbalance requirements and PoE unbalance currents.**

*** Use for worst-case Class C calculations (maximum channel resistance with the lowest PSE supply voltage.**

Transformer Data

Outlier

Updated data moves this closer to the average.

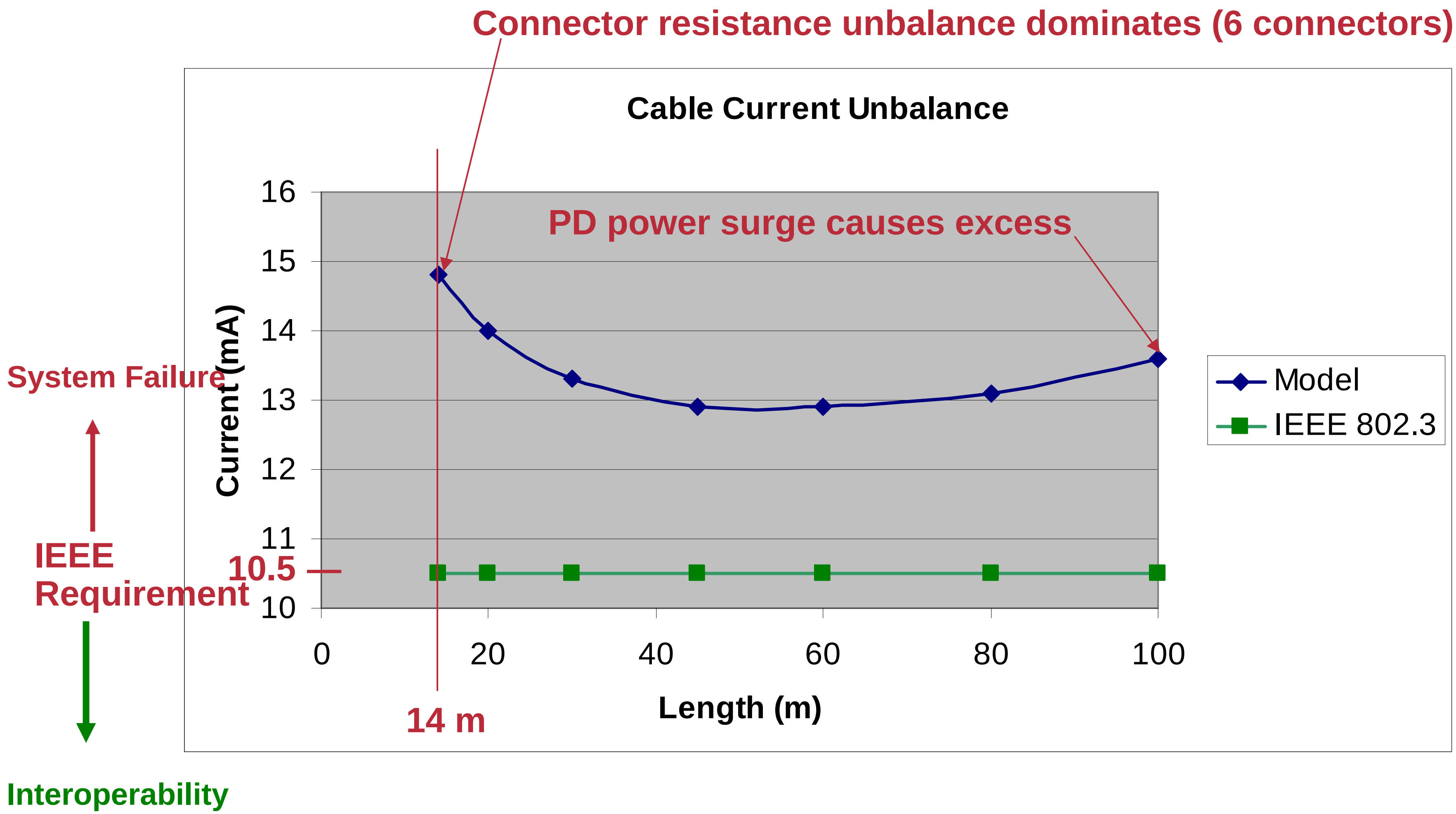


Better

There is no specification for Rmax or transformer unbalance.
The model creates a channel unbalance comparable to most of these data.

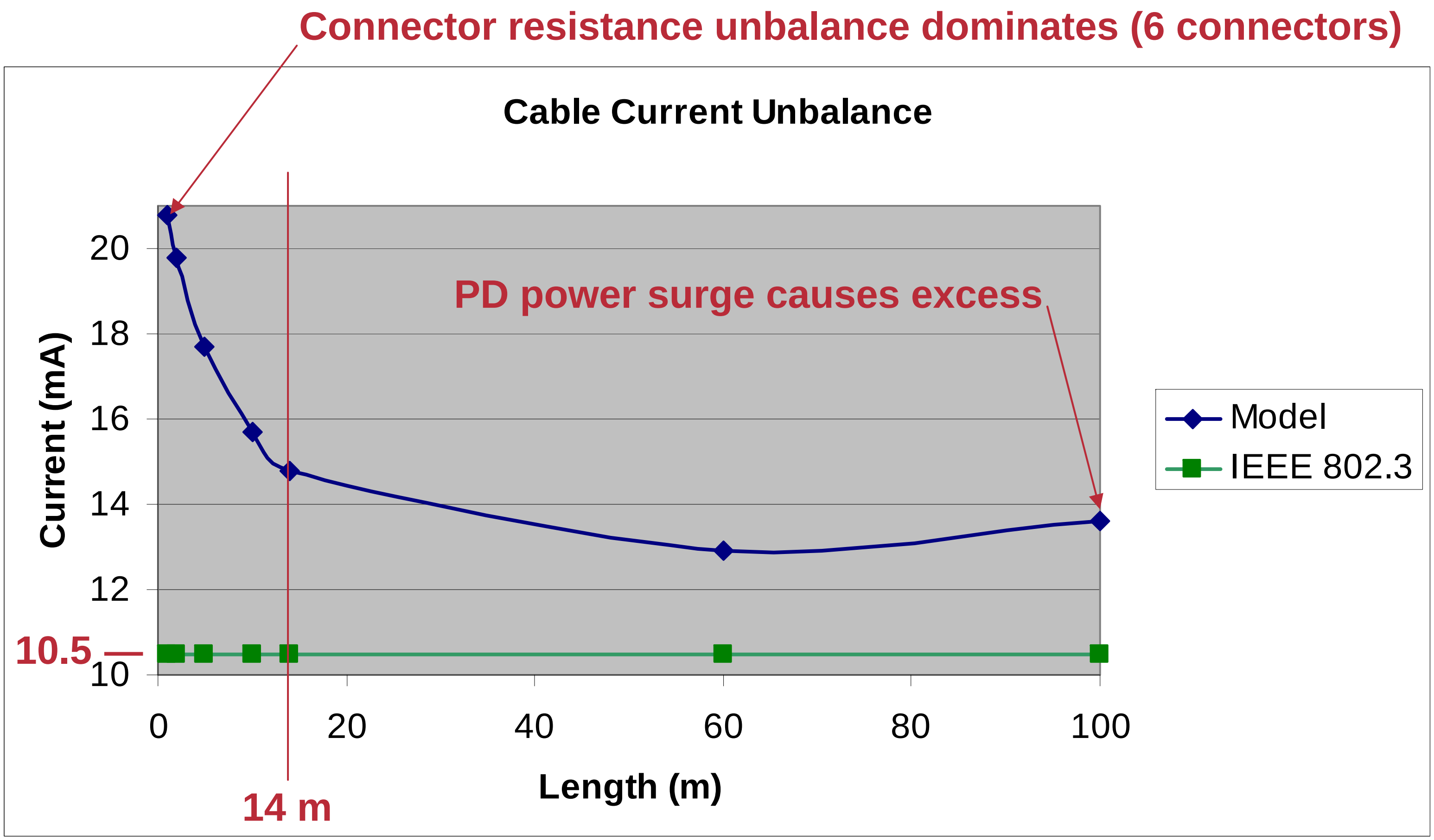
The y-axis shows current unbalance for a 12.95 W PD demanding a power surge of 14.8 W in a worst-case Class C with a 14 m channel. Average does not include the model.

IEEE 802.3 Current Unbalance



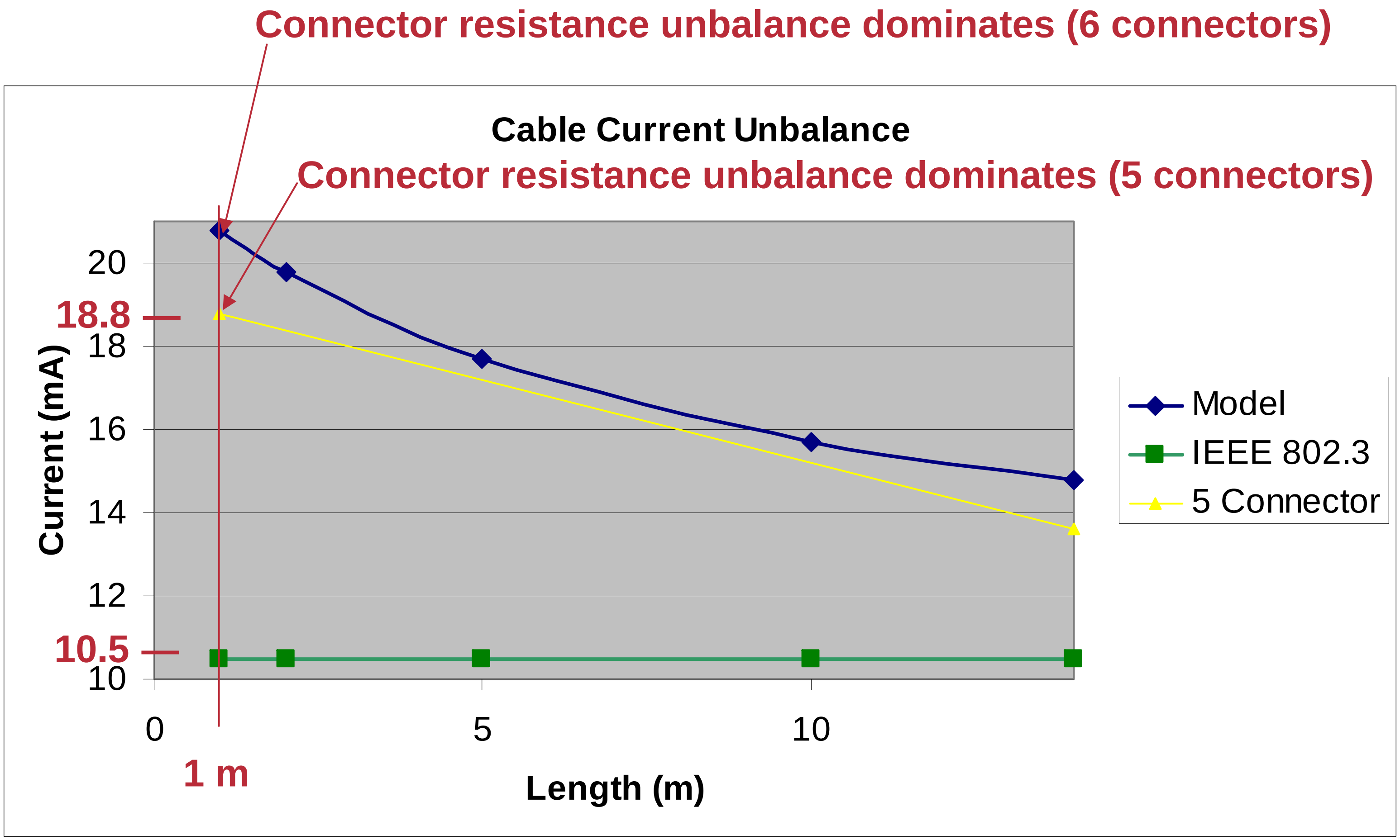
Power surge to 14.8 W, worst-case Class C.

IEEE 802.3 Current Unbalance



Power surge to 14.8 W, worst-case Class C.

IEEE 802.3 Current Unbalance

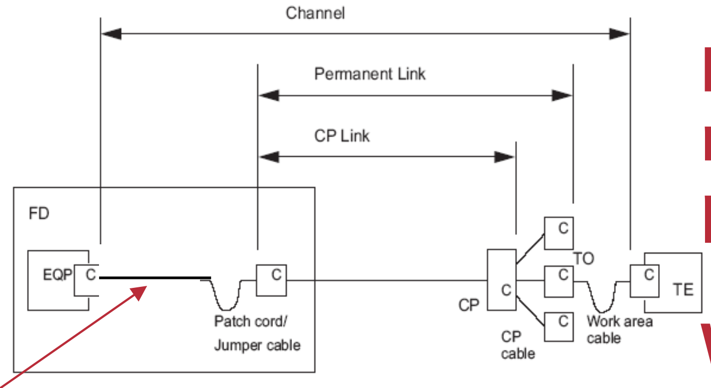


Power surge to 14.8 W, worst-case Class C.

Short Channel Topology

33.4.8 Midspan PSE device additional requirements

The cabling specifications for 100Ω balanced cabling are described in ISO/IEC 11801-2002. Some cable category specifications that only appear in earlier editions are also supported. The configuration of "channel" and "permanent link" is defined in Figure 33–18.



FD = floor distributor; EQP = equipment; C = connection (mated pair);
CP = consolidation point; TO = telecommunications outlet;
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Figure 33–18—Floor distributor channel configuration

Do we want more reach cable or more patch cord?

Would using the 4 connector channel model be sufficient for lengths < 14 m?

One connection has been removed.

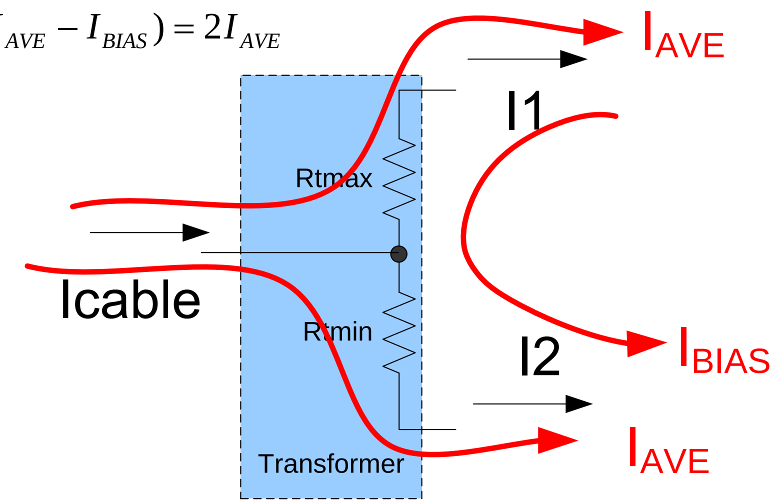
Is a 5 connector system realistic for 1 m < Length < 14 m ?

Review

- **IEEE 802.3 used average PD power (12.95 W) and ISO channel characteristics (4 connectors) to determine I_{unb} (10.5 mA).**
- **The model for this presentation results in an unbalance current (18.8 mA) that exceeds IEEE 802.3 requirements for all channel lengths.**
  - **PD surge power 14.8 W**
  - **Transformers and 1 to 2 additional connectors**

Unbalance Current Affect on the Transformer

$$I_{cable} = I_1 + I_2 = (I_{AVE} - I_{BIAS}) + (I_{AVE} - I_{BIAS}) = 2I_{AVE}$$



$$I_1 = I_{AVE} - I_{BIAS}$$

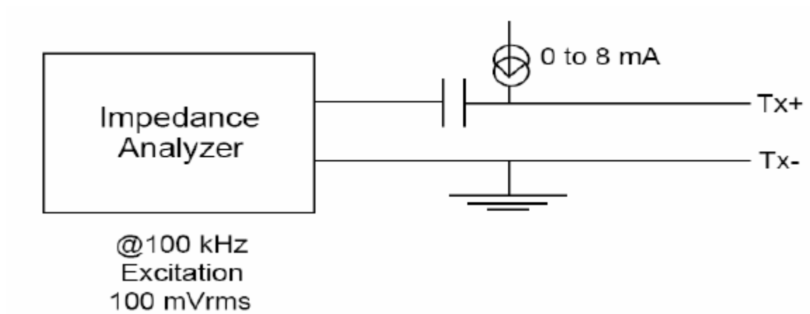
$$I_2 = I_{AVE} + I_{BIAS}$$

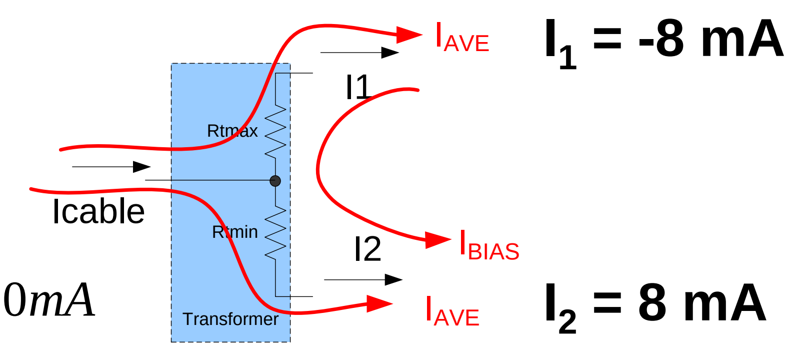
$$I_2 - I_1 = (I_{AVE} + I_{BIAS}) - (I_{AVE} - I_{BIAS}) = 2I_{BIAS}$$

$$\frac{I_2 - I_1}{2} = I_{BIAS}$$

ANSI X3.263-1995 (TP-PMD)

- **Transformers used for 100 MBPS Ethernet are required to provide 350 uH inductance with a bias current of 0 to 8 mA.**
- **See David Law's Ad Hoc report for more details.**





$$I_{cable} = I_2 + I_1 = 8 + (-8) = 0mA$$

$$\frac{I_2 - I_1}{2} = I_{BIAS} = \frac{8-(-8)}{2} = 8mA$$

IEEE 802.3 Unbalance Currents @ 100 MBPS

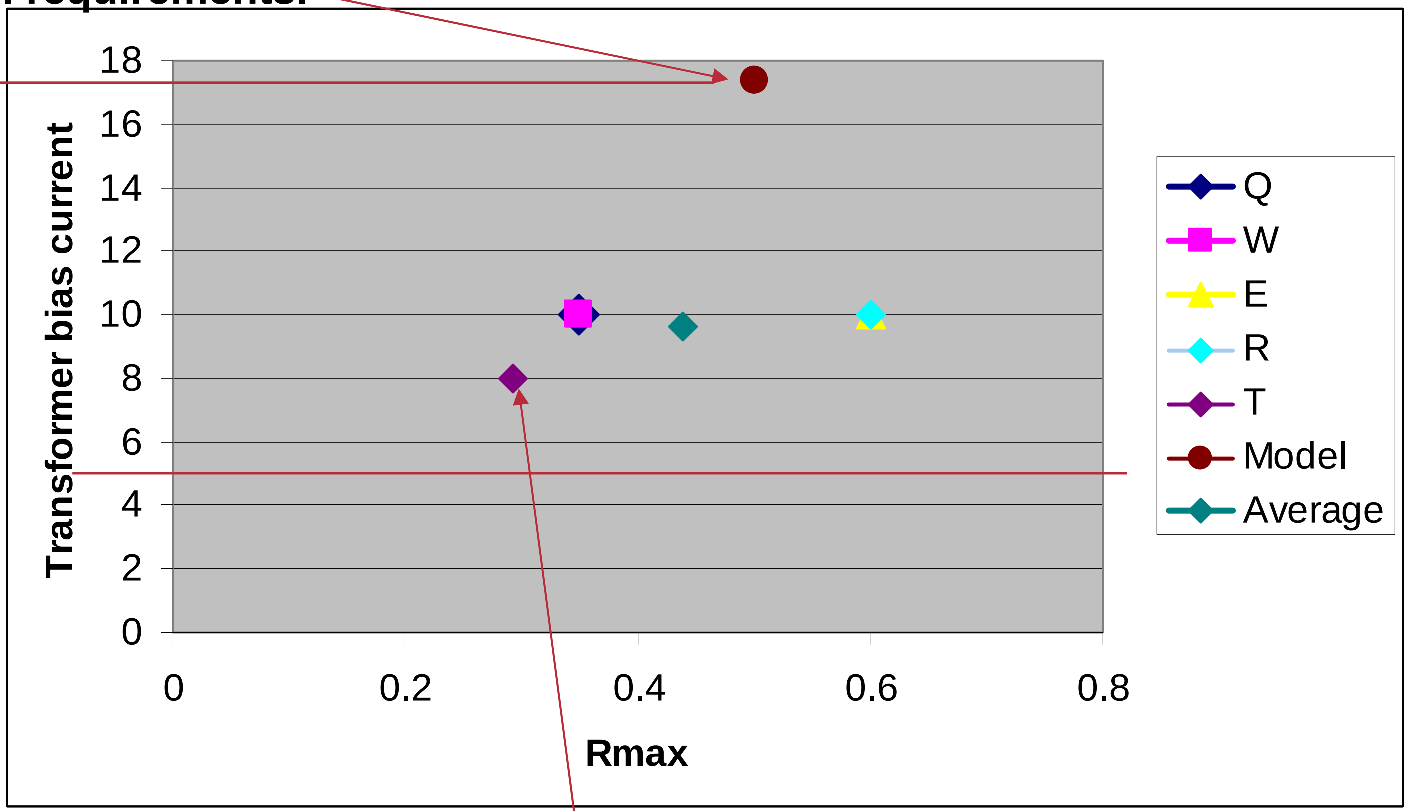
- **With 5 connectors and a cable length of 1 m with a PD power surge to 14.8 W, Iunbal = 18.8 mA.**
- **In order to support 100 MBPS operation and additional 8 mA of bias current is required.**
- **PoE transform bias current = 18.8/2 + 8 = 17.4 mA This is equivalent to an unbalance current of 17.4 x 2 = 35 mA**

PoE Transformer bias current limits

The average transformer exceed the IEEE 802.3 requirements and does not meet the worst-case model requirements.

Worse

IEEE 10.5/2 = 5.3 mA

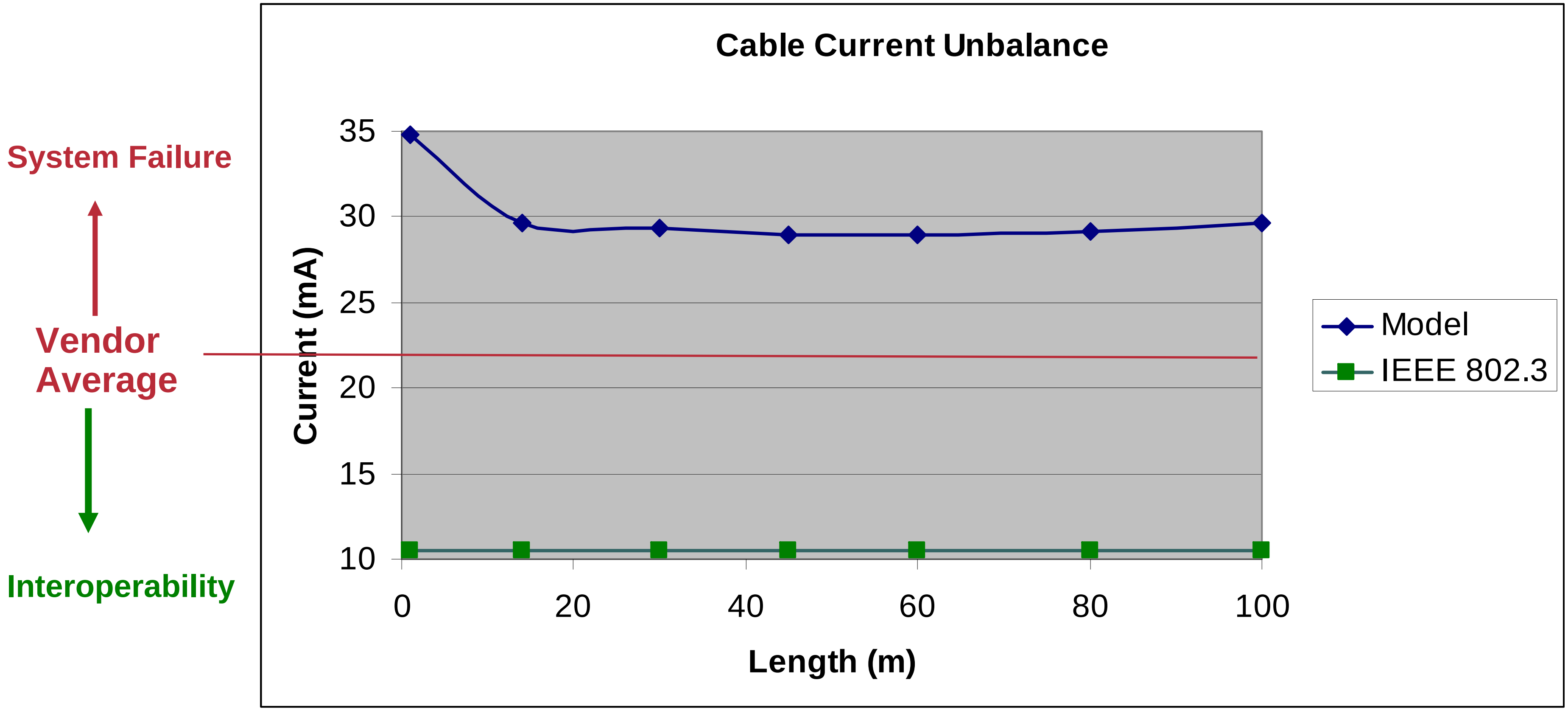


Updated data moves this closer to the average.

Average does not include the model.

Model Adjustment

PoE interoperates => Evaluate broader market

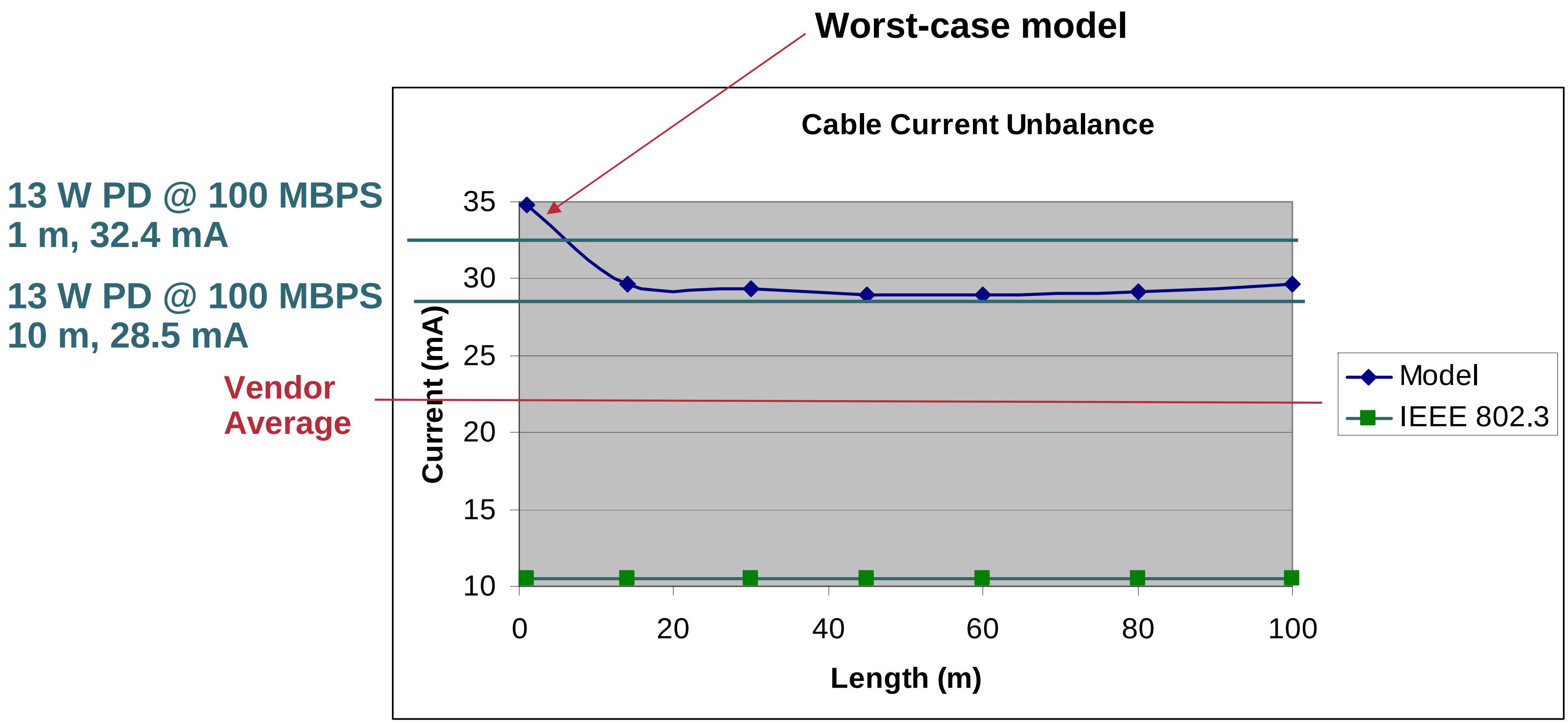


IEEE 802.3 clause 33 devices interoperate.
Therefore, adjustments to the worst-case model are appropriate.

Model Adjustment

- IEEE 802.3 clause 33 was published in June 2003
  Therefore, significant system volume is interoperating now.
- The most prevalent PDs are IP-phones.
  Most phones draw 6 to 11 W.
- AP are the second most prevalent PD.
  Most APs draw between 10 and 13 W.
- Data obtained in the Vport ad hoc shows that most PDs do not demand power above the classification power.
- A PD that demands 13 W on a 1 m cable with 5 connectors has an unbalance current of 16.4 mA. At 100 MBPS this results in an unbalance current of 32.4 mA.

Model Adjustment



Because PDs reliably interoperate, the channel model need to be adjusted further.

Model Adjustment

- **It is improbable that 5 to 6 connectors:**
  - all have minimum resistance on the same contact point AND
  - all have the maximum resistance on the same contact point

- **Many of these connectors are uncorrelated. They are made at different times possibly by different vendors.**

RJ-45 Contact Resistance	
	Rmate
Conductor	**ALT-B**
1	
2	
3	
4	**Max**
5	Min
6	
7	**Rmate**
8	Rmate

RJ-45 Contact Resistance	
	Rmate
Conductor	**ALT-B**
1	
2	
3	
4	**Max**
5	Min
6	
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8	Rmate

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2	
3	
4	**Max**
5	Min
6	
7	**Rmate**
8	Rmate

I_1

I_2

Each of these represents one connector in the channel.

Connector Statistics

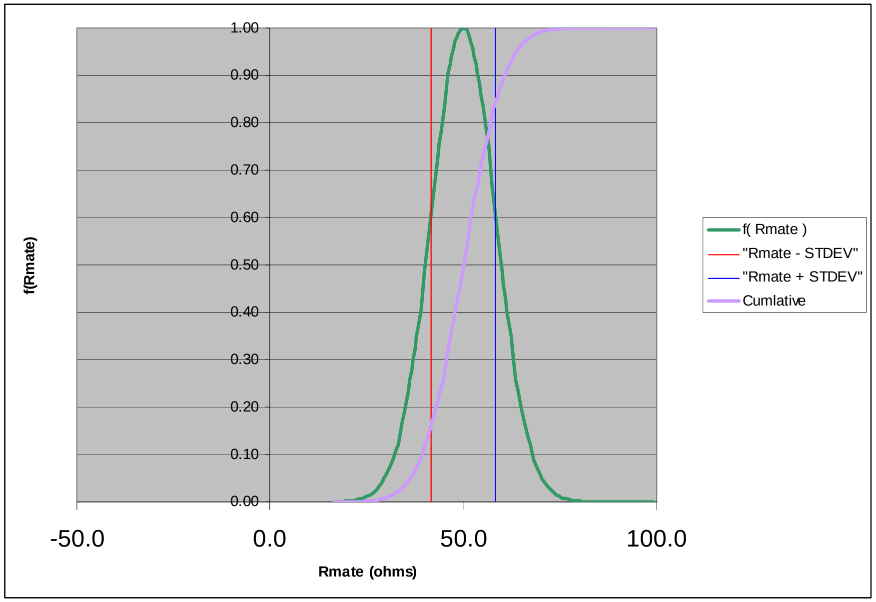
- The ISO model includes 4 connectors in the channel and has a 3% unbalance.
- Assume the ISO Rmate STDEV = σ_1
- 6 connectors in series have a mean = 6xRmate_mean

a

$$\sigma_6 = \sqrt{6\sigma_1^2}$$

Unbalance system = 2.449 x 50 = 120 m-ohm

- Add 120/6 = 20 m-ohms per connector outside the ISO channel model



- The graph shows a normal distribution with:
  Rmate_mean = 50 m-ohms, standard deviation (STDEV) = 50/6 m-ohms
- 68% of the populations is within 1 standard deviation of the mean.
  1 in 3 is outside this region.
- 99.7% of the population is within 3 standard deviations of the mean.
  1 in 370 is outside this region
- 99.9…% of the population is within 6 standard deviations of the mean.
  1 in 570 M is outside this region

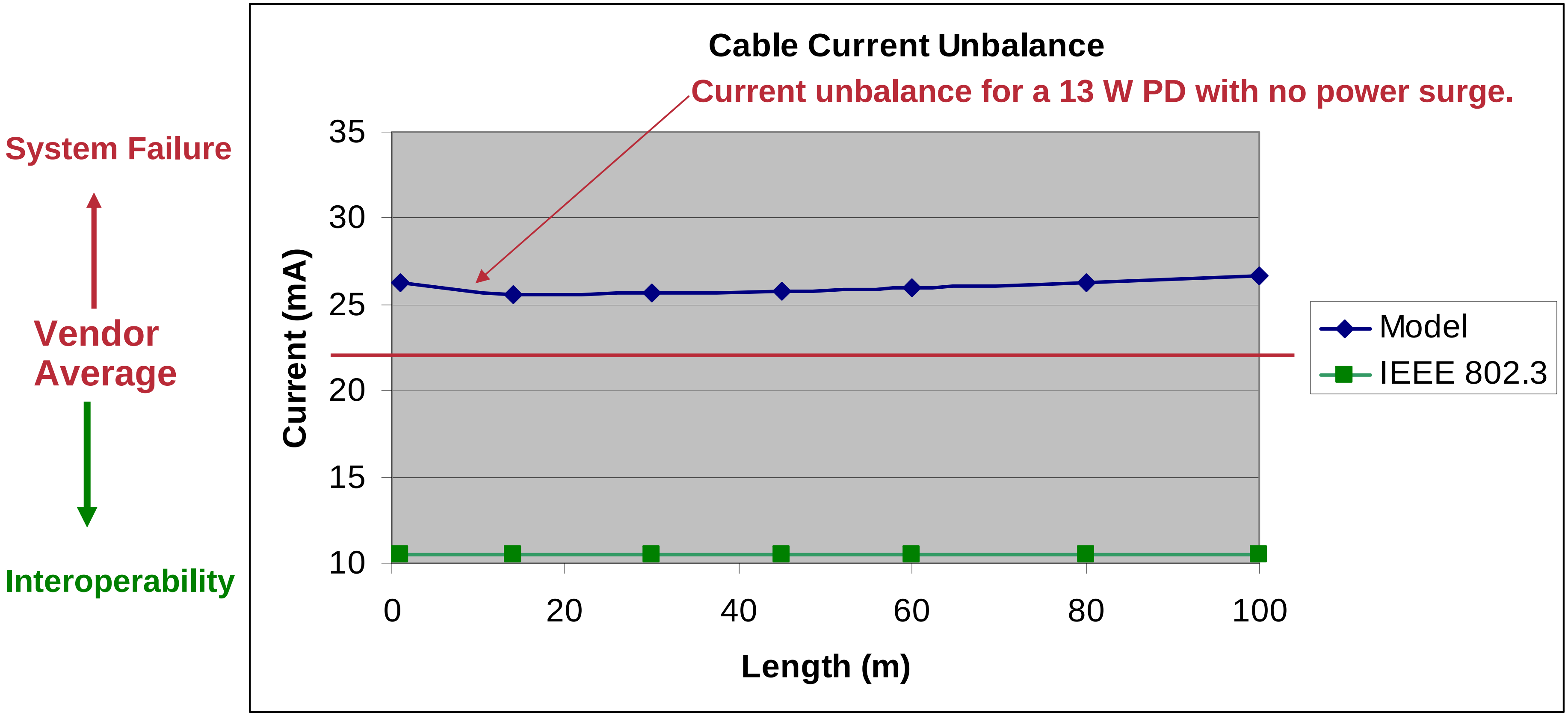
Model Adjustment

- **PSE and PD transformer resistance are uncorrelated.**
- **Two transformer unbalance is:**

$$\sigma_2 = \sqrt{2\sigma_1^2}$$

1.414x5% = 7%

Adjusted model



Adjustments:

- Use sum-of-squares for connectors and transformer.

Model Adjustment

- **Assume the IEEE channel is comparable to the structured cabling channel (4 connectors) when**
  L < 14 m: Yes

- **Assume PHYs baseline wander correction deals with the 8 mA bias requirement for 100 MBPS.**
  Contact PHY vendors for information.

- **What else?**

Next Step

- **Contact PHY vendors to better understand baseline wander correction.**
- **Refine the model used.**
- **Determine IEEE 802.3 and transformer current unbalance requirements.**
- **Select parameters for PoE plus.**
- **Determine IEEE 802.3at and transformer unbalance requirements.**