Considering all Noise Sources over a single data and power pair

IEEE802.3bu Task Force

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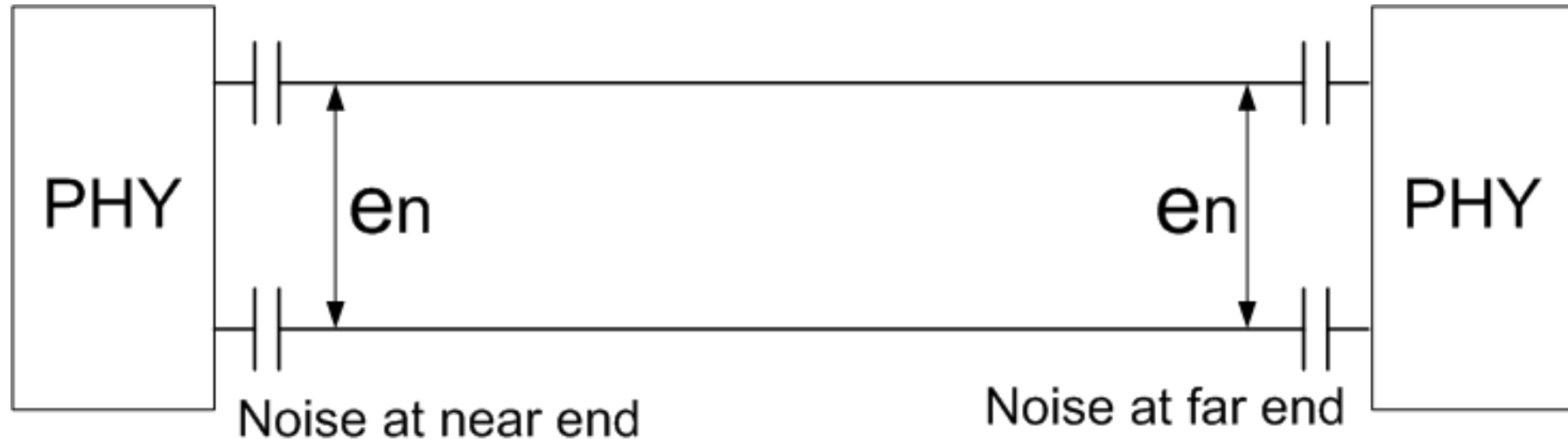### Indian Wells, CA

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Objectives

- To introduce potential noise sources over a single data pair delivering power and data simultaneously.

- Using the above data to specify later the PSE Differential and common mode noise.

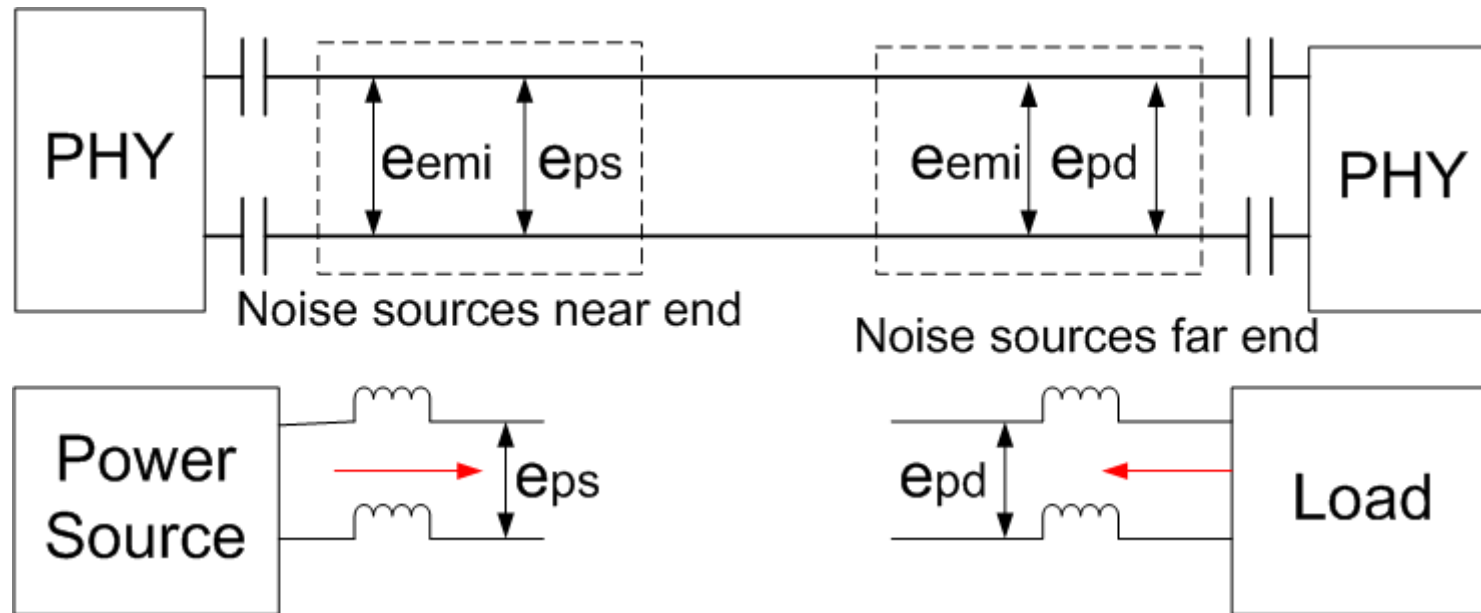# Єn(f) = Maximum Noise vs. Frequency Requirement

- *We need to know the maximum rms noise. Єn as function of frequency in which data specification is met.*

EMI noise source
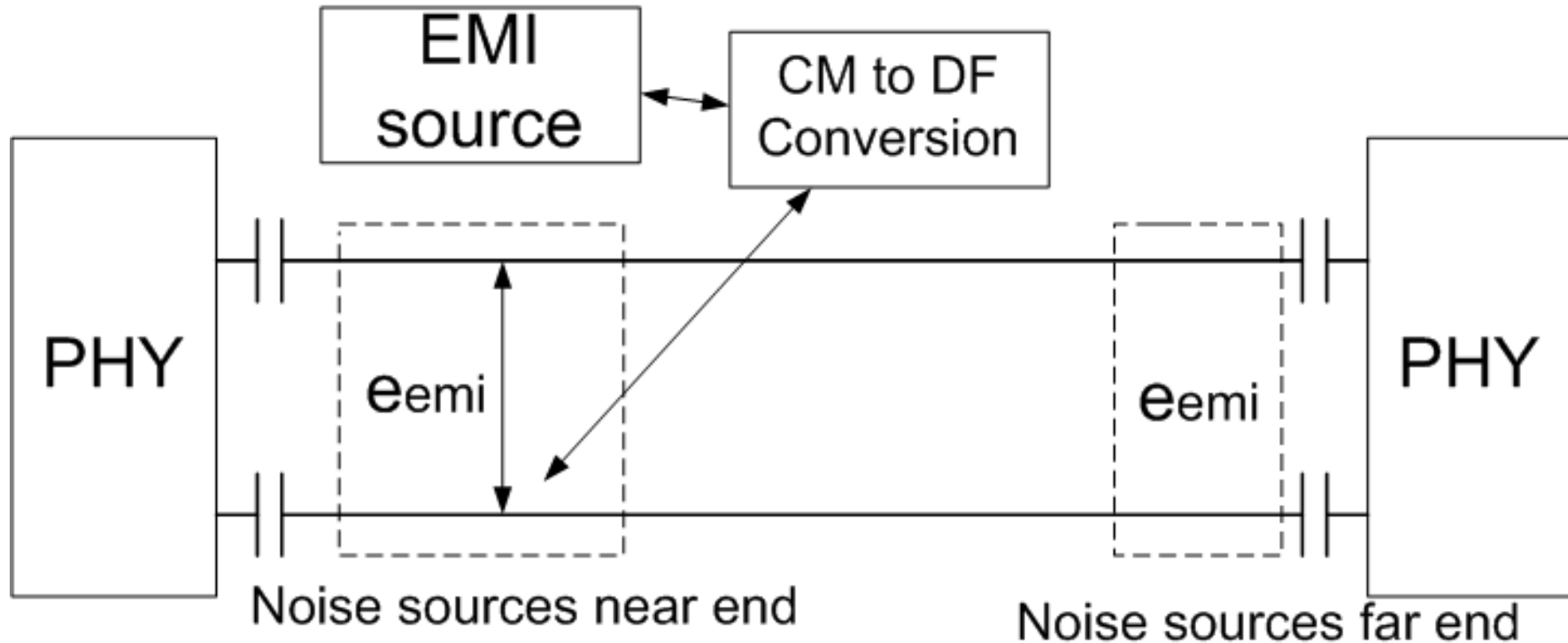
- EMI is one of the noise sources that generate DM noise

Power source and load noise sources

- If power is delivered over the same data pair, we have additional noise sources at near end (power supply noise) and far end (load noise e.g. PD DC/DC converter noise)

More about Power Source Noise

- Ripple
- Noise
- Transients

per automotive standards (ISO7637 etc.)

We need to define e_{ps} for any frequency at Vbat and the data range operating frequencies.

Proposed general case for noise sources - 1

$$e_n{}^2 = e_{emi}{}^2 + e_{ps}{}^2 + e_{RL}{}^2 + e_{other}{}^2 \qquad e_n{}^2 = e_{emi}{}^2 + e_{pd}{}^2 + e_{RL}{}^2 + e_{other}{}^2$$
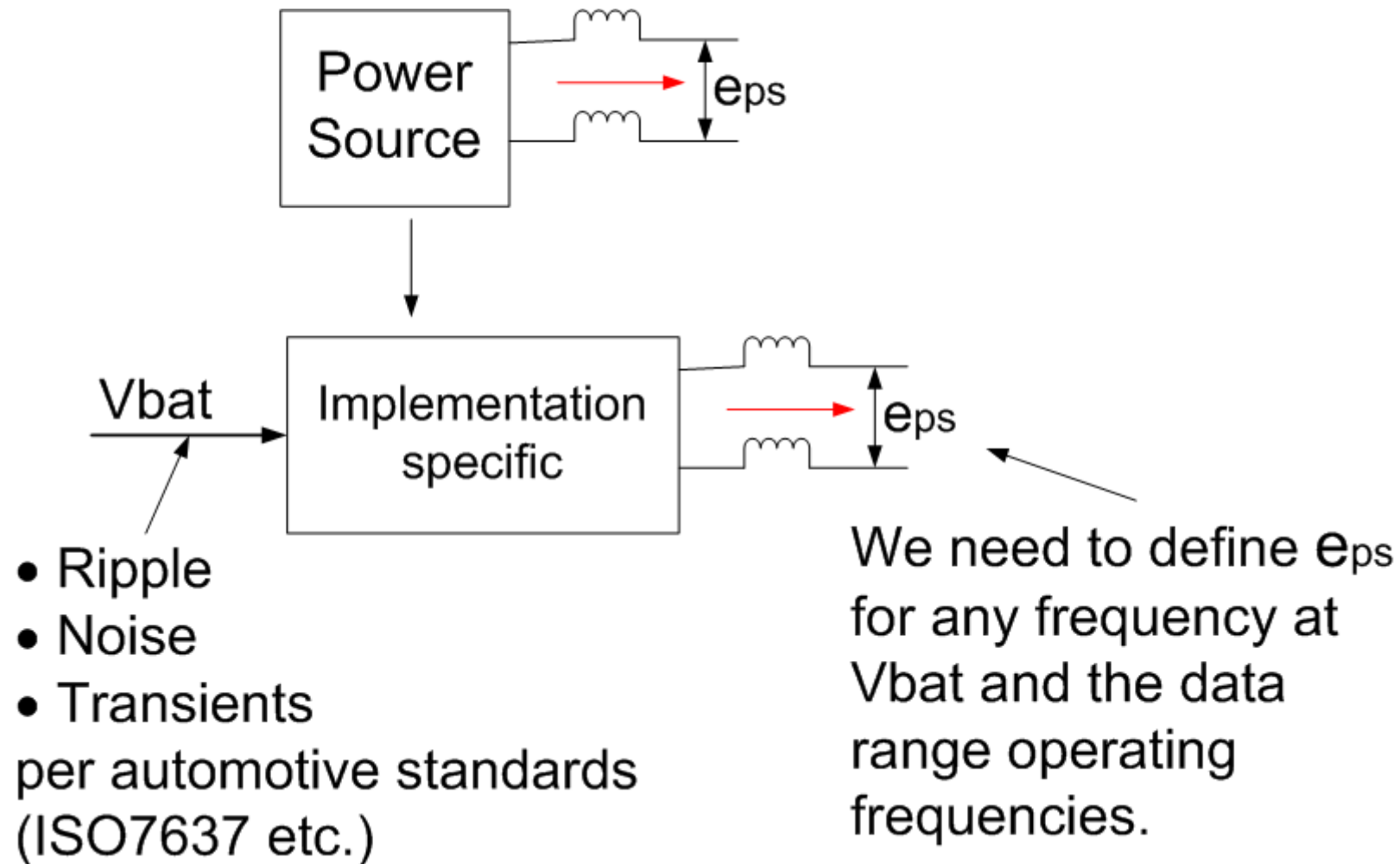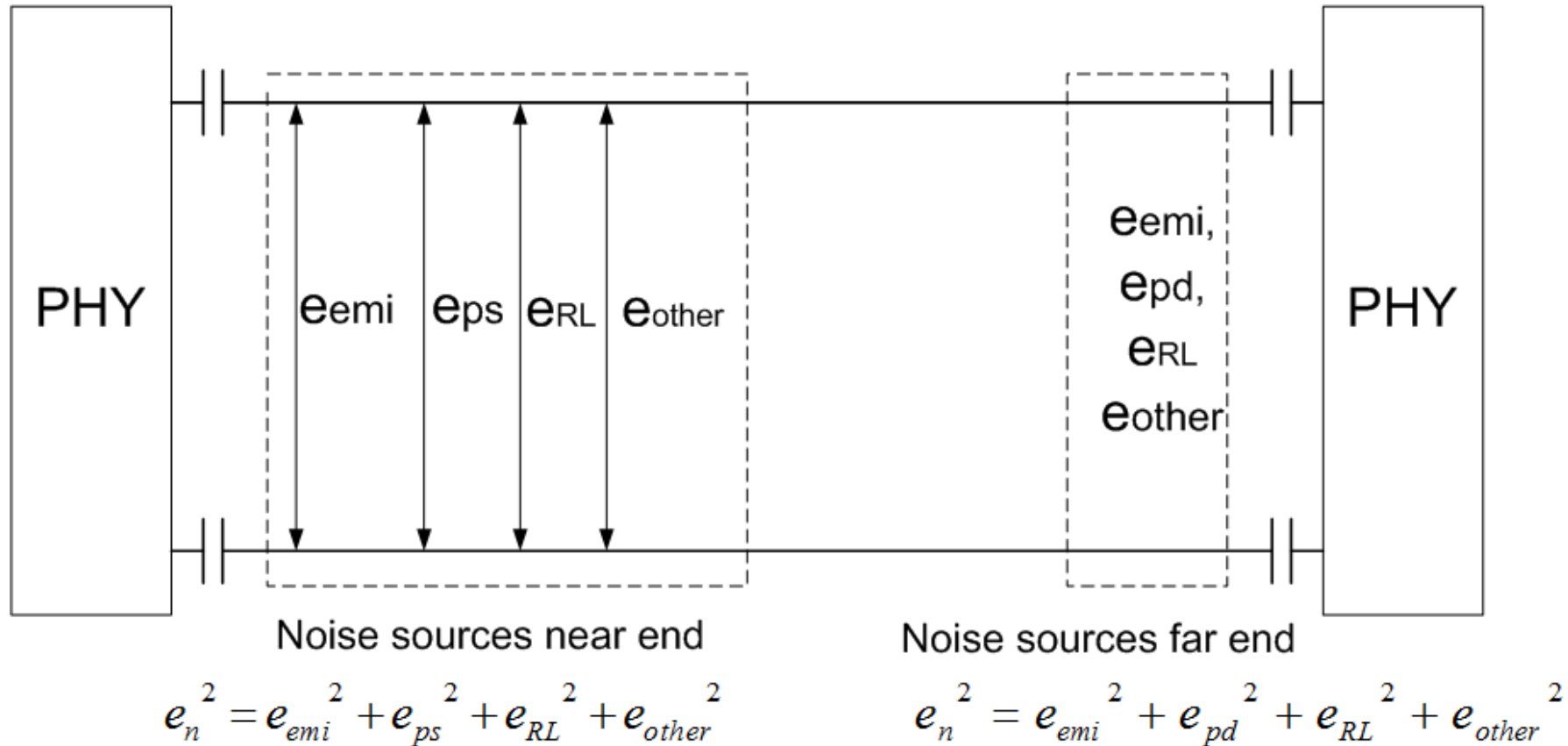
- e_{RL} is the noise generated by the return loss during transmission.

- e_{other} is other noise sources that we may add to the list including design margin

Proposed general case for noise sources - 2

- Working assumptions
  - *en as function of frequency i.e. en(f) in which data specification is met. The same applies for the other noise sources.*
  - eemi on both ends is the same quantity
  - eps and epd are independent noise sources
  - eRL on both sides is the same quantity
  - eother is unknown noise source or a design margin
  - ak is the <u>total</u> weight factor and is a function of frequency as well.
  - As a result, for different weight per noise source and for k noise sources:

$$e_n^{\;2} \geq \sum_{i=1}^{k} a_k e_k^{\;2} \qquad \sum_{i=1}^{5} a_k = 1$$

In our example we will have:

$$e_n^{\;2} \geq a_1 e_{emi}^{\;2} + a_2 e_{ps}^{\;2} + a_3 e_{pd}^{\;2} + a_4 \cdot e_{RL}^{\;2} + a_5 \cdot e_{other}^{\;2} + a_6 \cdot e_{other}^{\;2}$$

Proposed general case for noise sources - 3

- For the example shown with 6 noise sources, If all noise sources are with the <u>same weight</u> (noise budget is equally distributed between all noise sources for simplified what-if analysis):

$$e_n(f)^2 \geq= 6 \cdot e(f)^2 \quad \rightarrow e_{n\_rms}(f) \leq \frac{e(f)}{\sqrt{6}} = 0.4 \cdot e_n(f)$$

Each noise source at any given frequency, will need to be ~8dB lower than $e_n(f)$ which is the noise limit to meet data integrity.

The general case for the simplified equal weight case would be:

$$e_{rms}(f) \leq \frac{e_n(f)}{\sqrt{k}} \quad \text{which is} \quad 20 \cdot \log\left(\frac{1}{\sqrt{k}}\right) \quad \text{below en(f).}$$

More about the evaluation of spec limits - 4

- There are other ways to plug in the design margin.

- The straight forward way for us (per the previous slides) is:

  – RTPGE to deliver the noise mask required to meet data integrity.

  – If the noise mask is due to only EMI noise source, this would be the $en(f)$. Then we need to get from RTPG our budget (our weight) assuming RTPGE take in account all noise sources.

  – Our budget will be equally distributed for PSE and PD budget.

  – The result is PSE and PD noise mask.

Summary

- Based on en(f) (differential and common mode noise data) given from the RTPGE group, we can define the PSE and PD noise requirements.

- For the RTPGE group: There are additional noise to the EMI noise such as PSE and PD noise that need to be considered in the total maximum DM and CM noise requirements.

Proposed next steps

- To ask RTPGE group for channel noise requirements, EMI masks etc. or to define for us their noise requirements to meet their data integrity requirements. ($e_n(f)$ test data).

- It is highly practical from power source and load point of view, to define a detailed table of differential and CM noise per frequency over the frequency range of interest.

- It is important to define the noise also for low frequencies outside the data range from 1-2Hz to 1-10MHz. It will allow more flexibility and cost effective power source when power over data will be implemented.

Proposed text/table for the specification

- The following noise limits shall be met at the output of the PSE (see item 5)

Item	Parameter	Symbol	Unit	Min	Max	TBD	Additional Information
1	Output Voltage in the TBD1 state	TBD	V	TBD	TBD	TBD	TBD
2	Output Voltage in the TBD2 state	TBD	V	TBD	TBD	TBD	TBD
3	Output Voltage in the Power_ON state	Vport_PSE	V	TBD	TBD	TBD	TBD
4	Voltage transient below VPort_PSE min.	KTran_lo	%	TBD	TBD	TBD	TBD
5	**Power feeding ripple and noise Vpp**						
	f<f1		**Vpp**	**TBD**	**TBD**		**TBD**
	f1 to f2			**TBD**	**TBD**		
	f2 to f3			**TBD**	**TBD**		
	f3 to f4			**TBD**	**TBD**		
	f4 to f5			**TBD**	**TBD**		
	F(n-1) 6 to f(n)			**TBD**	**TBD**		
6	Continuous output current capability in POWER_ON state	Icon	A	TBD	TBD	TBD	TBD
7	Output current in POWER_UP state	Iinrush	A	TBD	TBD	TBD	TBD
8	Inrush time	Tinrush	s	TBD	TBD	TBD	TBD

Proposed text/table for the specification

Item	Parameter	Symbol	Unit	Min	Max	TBD	Additional Information
12	Output Current at short Circuit	ILIM	A	TBD	TBD	TBD	TBD
13	Short circuit time limit	TLIM	s	TBD	TBD	TBD	TBD
14	Continuous output current capability in POWER_ON state	Icon	A	TBD	TBD	TBD	TBD
15	Output current in POWER_UP state	Iinrush	A	TBD	TBD	TBD	TBD
16	Inrush time	Tinrush	s	TBD	TBD	TBD	TBD
17	Continuous output power capability in POWER_ON state	Pcon	W	TBD	TBD	TBD	TBD
18	Power turn on time	Tpon	s	TBD	TBD	TBD	TBD
19	Turn on rise time	Trise	us	TBD	TBD	TBD	TBD
20	Turn off time	Toff	s	TBD	TBD	TBD	TBD
21	Turn off voltage	Voff	V	TBD	TBD	TBD	TBD
22	Resistance Imbalance	TBD		TBD	TBD	TBD	TBD
23	Output Capacitance	Cout	uF	TBD	TBD	TBD	TBD
24	Error Delay Timing	Ted	S	TBD	TBD	TBD	TBD

Discussion

Thank You