Power Matters

IEEE802.3bu 1PODL Task Force

Table 200-1: Flexible Design guide lines for PD available power

Rev 001a

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Objectives

- To complete the proposed remedy for Comment #51 in D0.2 which is: to supply design guide lines by form of equation for addressing use case that are not specified in Table 200-1.

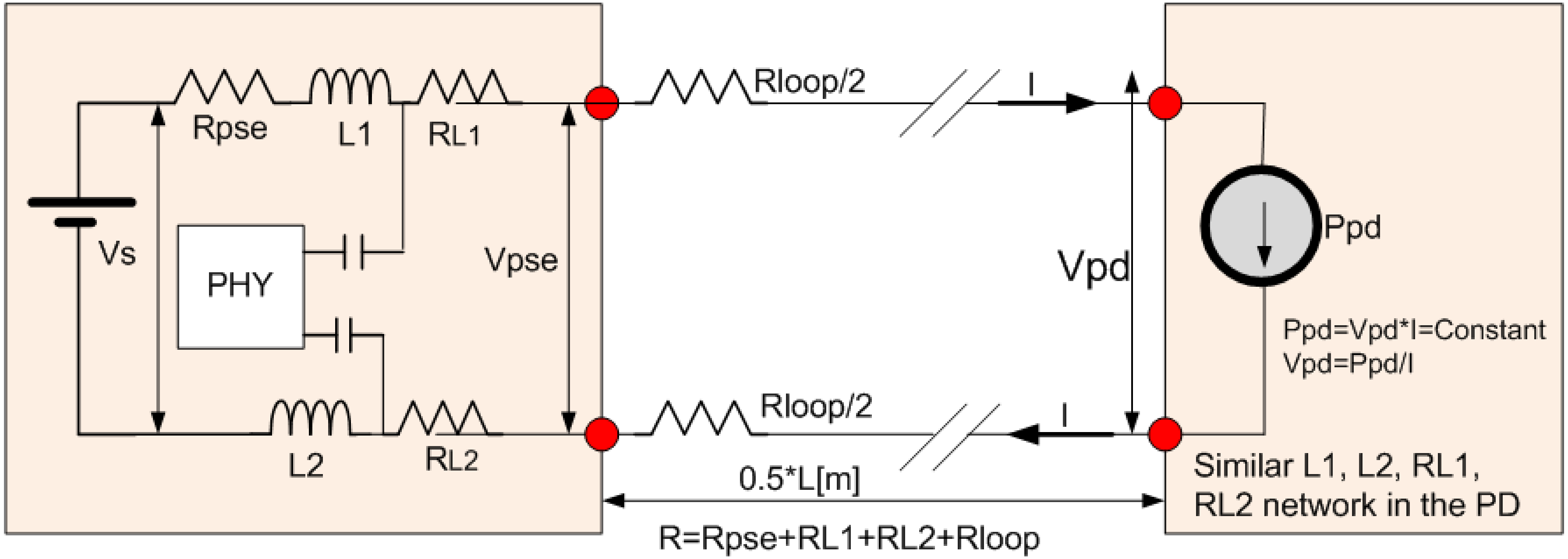
- Background material:
- http://www.ieee802.org/3/bu/public/sep14/darshan_3bu_1_0914.pdf
- http://www.ieee802.org/3/bu/public/jan14/darshan_3bu_01_0114.pdf

- See revision history details AT Annex E.

Background

- The automotive OEMs use all different gauge cables among themselves and for different use cases.
- As a result, this presentation will address the general case for setting the requirements for wire resistance per meter as function of system parameters.

Simplified system model



Rs=Rpse+RL1+RL2
R=Rs+Rloop

Wire resistance per meter as function of system parameters

$$\rho(\Omega / m) = \frac{1}{L} \cdot \left(\frac{K \cdot Vs^2}{Ppd_{\max}} - Rs \right)$$

$$K = \frac{Ppd_{\max}}{Ppd_{P\max}} = \alpha \cdot (1 - \alpha)$$

$$\alpha = \frac{Ppd_{\max}}{Ps}, \quad 0.5 < \alpha < 1$$

- Model and calculation example: See annex A.
- Equation derivation: See Annex B.

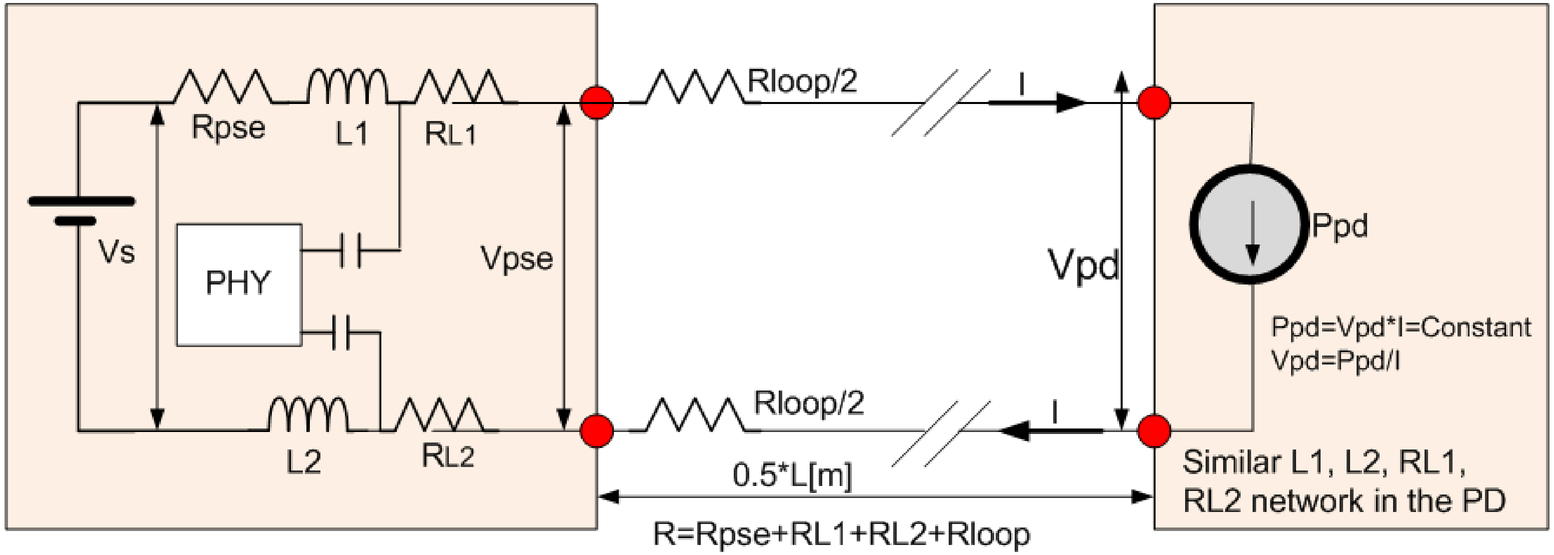
- α typical cost effective range is 0.7 to 0.85.
- Rs=PSE internal output resistance
- Ppd_{max}=Actual PD input power measured at the PI at stable operating region.
- Ppd_{Pmax}
- Vs=PSE open load voltage at the PI. Vs=Vpse at no load.
- Ps is PSE power supply output power.
- L[m]=Round loop of Wire length. E.g if channel length is 15m than L=30m.

Thank You

See detailed analysis in next slides

Backup slides

Annex A1: Detailed analysis.



System Equation

$$\frac{Vs - Vpd}{R} = I = \frac{Ppd}{Vpd} = constant$$

Solving for Vpd:

$$Vpd = 0.5 \cdot \left(Vs \pm \sqrt{Vs^2 - 4 \cdot R \cdot Ppd}\right)$$

Working only with the positive solution of the quadratic equation for stable operation and higher power efficiency:

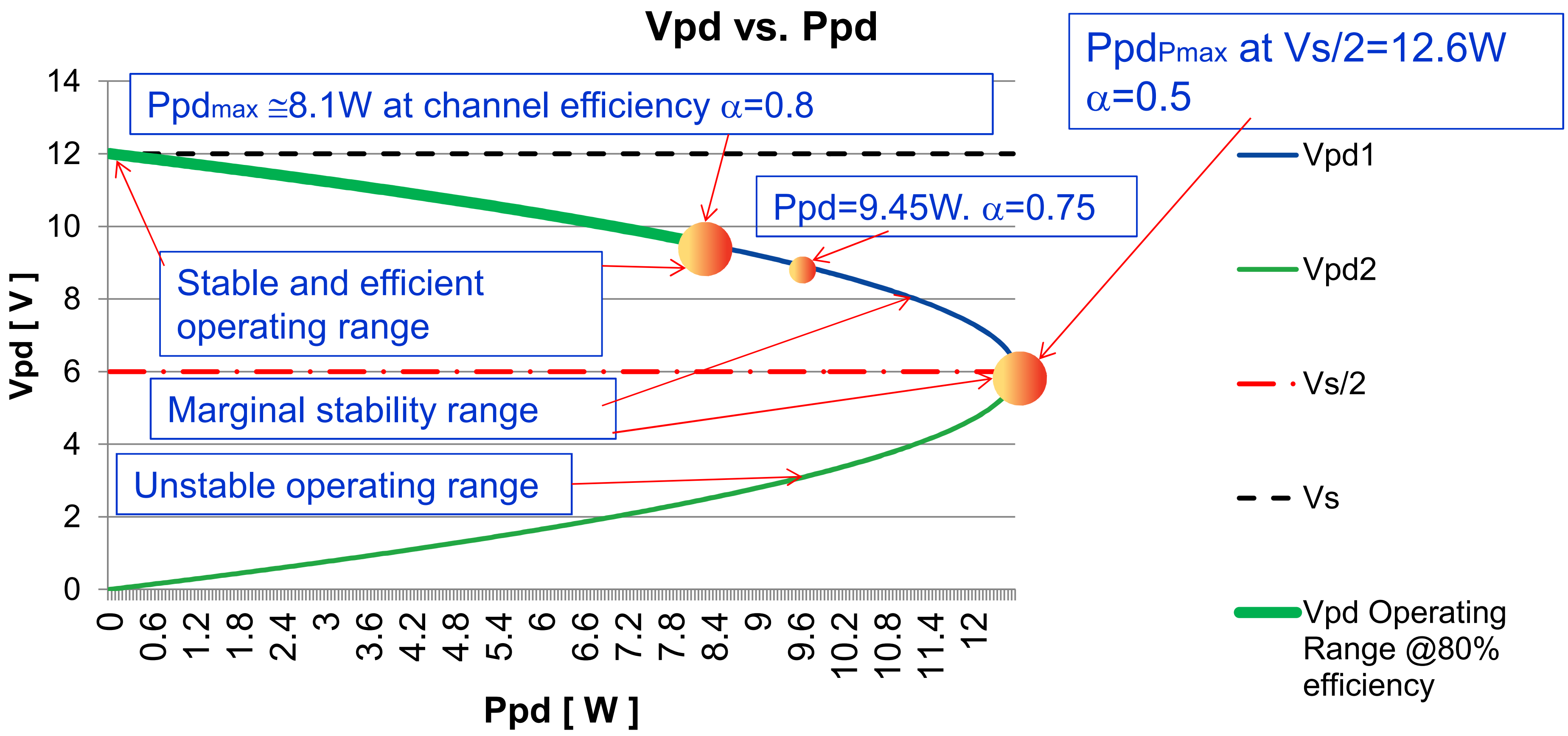
$$Vpd = 0.5 \cdot \left(Vs + \sqrt{Vs^2 - 4 \cdot R \cdot Ppd}\right)$$

$$I = 0.5 \cdot \left(Vs - \sqrt{Vs^2 - 4 \cdot R \cdot Ppd}\right) / R$$

For stable operation: $Ppd < Ppd_{P\max} = \frac{Vs^2}{4 \cdot R}$, $Ppd = \alpha \cdot Ps$ α=0.8 is cost effective choice.

Annex A2: Detailed analysis.

- Example with Vs=12V. Rs=0.4Ω,
- Wire size: AWG24 (d=0.511mm, 0.205mm^2, 0.082Ω/m).



Annex B1: Detailed mathematical analysis.

From Annex 1, Vpd solution at worst case operating range is at Vs_min:

$$Vpd = \frac{Vs_{\min} + \sqrt{Vs_{\min}{}^2 - 4 \cdot R \cdot Ppd}}{2}$$ Eq-1

Where: $R = Rs + R_{loop}$ Eq-2

For stable operation: $Vs^2 - 4 \cdot R \cdot Ppd \geq 0$

Resulting with Ppdmax for stable operation:

$$Ppd_{\max} < \frac{Vs_{\min}{}^2}{4 \cdot (Rs + R_{loop})} = Ppd_{P\max}$$ Eq-3

Ppd_{max} =Actual maximum PD power at stable operating range.
Ppd_{Pmax}=Maximum possible theoretical PD input power.

At Ppd_{Pmax} which happens at Vpd=Vs/2, we get channel power loss, Pc=Ppd which is equivalent to a channel power efficiency of α=Ppd/Ps=50%. To be in stable operating region, we need to work at α>50%.

$$\alpha = \frac{Ppd_{\max}}{Ps} > 0.5$$ Eq-4

See curve in Annex A2 for the reason why α need to be >0.5 for stable operation.

Ps is the PSE power supply output power. α=1 only if R=0. Since R>0, α<1

Therefore: $\alpha = \frac{Ppd_{\max}}{Ps}$ $0.5 < \alpha < 1$ Eq-5

Annex B3: Detailed mathematical analysis.

From Eq-4:

$$Ppd_{\max} = \alpha \cdot Ps$$

$$Vpd \cdot I = \alpha \cdot Vs_{\min} \cdot I$$

$$I = Ppd_{\max} / Vpd$$

$$Vpd = \alpha \cdot Vs_{\min} \quad \text{Eq-6}$$

$$I = \frac{Ppd_{\max}}{\alpha \cdot Vs_{\min}} \quad \text{Eq-7}$$

$$Ploss = R \cdot I^2 = Ps - Ppd_{\max} =$$

$$R \cdot I^2 = Vs \cdot I - Vpd \cdot I =$$

$$R \cdot I = Vs - Vpd \quad \textbf{Eq-8}$$

Combining Eq-6 and Eq-7 in Eq -8

$$R \cdot \frac{Ppd_{\max}}{\alpha \cdot Vs} = Vs - \alpha \cdot Vs$$

$$Ppd_{\max} = \frac{\alpha \cdot (1-\alpha) \cdot Vs^2}{R} = \frac{\alpha \cdot (1-\alpha) \cdot Vs^2}{Rs + Rloop} = \frac{K \cdot Vs^2}{Rs + Rloop}$$

$$\rho(\Omega / m) = \frac{Rloop}{L} = \frac{1}{L} \cdot \left(\frac{K \cdot Vs_{\min}{}^2}{Ppd_{\max}} - Rs \right)$$

$$K = \alpha \cdot (1-\alpha)$$

$$0.5 < \alpha < 1$$

Annex E: Revision History

Rev	Updates
000	-
001	-Converting Epse to Vs for using conventional voltage notation -Clarifying the definition of K.