



AHEAD OF WHAT'S POSSIBLE™

Optional Cable Resistance Measurement (CRM) - Part 2

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Presentation Outline

- ▶ Reference for previous work: [stewart_0918_01b](#)
- ▶ Margining Measured Cable Resistance
- ▶ Example: Margining Cable Resistance
- ▶ Example: PSE Compliance Test
- ▶ Baseline: Proposed Modifications to Clause 104.7
- ▶ Optional SCCP command for PSE read back

Margining Measured Cable Resistance

- ▶ Initial cable resistance measurement ($R_{\text{Cable_initial}}$) is subject to change due to cable temperature
- ▶ Resistance Margin Factor (K_{RMF}) is introduced to account for changes in $R_{\text{Cable_initial}}$
 - [darshan_01_0118_Rev002](#) bounds cable resistance variability across temperature
 - Max temperature rise (T_{rise}) = 15°C
 - Copper temperature coefficient (α) = 0.00393 $\Omega/^{\circ}\text{C}$
 - $K_{\text{RMF}} = 1 + (\alpha \times T_{\text{rise}}) \approx 1.06$
- ▶ $R_{\text{Cable_initial}}$ margined for changes in temperature is then expressed as
 - $R_{\text{Autoclass}} = \text{Minimum} (R_{\text{Loop(max)}}, R_{\text{Cable_initial}} \times K_{\text{RMF}})$
- ▶ K_{RMF} may further be increased by the user for exceptional applications

Example: Calculating Margined Cable Resistance

- ▶ Initial cable resistance measurement, $R_{\text{Cable_initial}}$

- $$R_{\text{Cable_initial}} = \frac{V_{\text{Meas_PSE,min}} - V_{\text{Report_PD,max}}}{I_{\text{Meas_PSE,min}}}$$

- ▶ Margined cable resistance, $R_{\text{Autoclass}}$

- $$R_{\text{Autoclass}} = \text{Minimum} (R_{\text{Loop(max)}} , R_{\text{Cable_initial}} \times K_{\text{RMF}})$$

- ▶ Fold together PD Requested Power, Class Max PD Power, and Class Loop Max Resistance to form rational PD Assigned Power

- If $P_{\text{PD_req}} > P_{\text{PD(max)}}$
 - $$P_{\text{PD_Assign}} = \text{Minimum} \{ P_{\text{PD_req}} , (P_{\text{Class(min)}} - (I_{\text{PI(max)}})^2 \times R_{\text{Autoclass}}) \}$$
 - Rule assigns $P_{\text{PD_req}}$ if possible, else it limits $P_{\text{PD_req}}$ based on $R_{\text{Autoclass}}$
 - Else ($P_{\text{PD_req}} \leq P_{\text{PD(max)}}$)
 - $$P_{\text{PD_Assign}} = P_{\text{PD_req}}$$

Example: PSE Compliance Test

1. PD is connected using cable with less than the maximum DC loop resistance
 - Example: $R_{\text{Cable_actual}} = (R_{\text{Loop(max)}} / 2)$
2. PSE performs Cable Resistance Measurement (CRM)
 - PD requests maximum PSE output power ($P_{\text{PD_req}}$) based on PD requested Class
 - $P_{\text{PD_req}} = P_{\text{Class(min)}}$
 - PSE determines PD assigned power ($P_{\text{PD_Assign}}$) based on CRM
3. PSE applies power to PD
 - PD draws $P_{\text{PD_Assign}}$
 - Cable resistance is increased to $R_{\text{Cable_actual}} \times K_{\text{RMF}}$
 - Power output at PSE shall not exceed $P_{\text{Class(min)}}$

Baseline: Add K_{RMF}

- Modify Table 104.8 to include Resistance Margin Factor

Table 104-8 SCCP electrical requirements							
Item	Parameter	Symbol	Unit	Min	Max	PSE/PD type	Additional Information
1	PSE Pull-up Voltage	V_{PUP}	V	$V_{good_PSE_max}$	5	All	See Table 104-1
2	PSE Pull-up Current	I_{PUP}	mA	9	16	All	
3	Input Logic High Voltage	V_{TH}	V	3	-	All	
4	Input Logic Low Voltage	V_{TL}	V	-	1	All A, B,C,D, Type E PD	
					2	Type E PSE	
5	Sink Current	I_L	mA	30	-	All	$V_{port} > 0.8V$
...
...
22	Resistance Margin Factor	K_{RMF}	-	1.06	-	Type E PSE	PSEs that support Cable resistance measurement

Baseline: Modify Clause 104.7 – PSE Requirement

► Modify Clause 104.7

Implementation of SCCP by PSEs and PDs that present a valid detection signature is optional. PDs that present an invalid detection signature as specified in Table 104–6 shall implement SCCP. The PSE acts as a master during the SCCP exchange, controlling the PD that acts as the slave device. SCCP is a current-sinking, wired-OR (e.g., open-drain or open-collector), half-duplex bidirectional serial data bus. The PSE sources the required pull-up current. PDs can derive power from the PSE's pull-up current during classification via the PD PI.

Measurement of **initial** cable resistance, $R_{\text{Cable_initial}}$, by PSEs and PDs that implement SCCP is optional. PSEs and PDs that implement cable resistance measurement shall support the VOLT_POWER_INFO and POWER_ASSIGN registers (Table 104.10, 104.11). PSEs that implement cable resistance measurement shall report assigned power through PSE Status Register 2 (See 45.2.7b.3).

A PSE that implements cable resistance measurement shall assign a PD Assigned Power which results in a PSE output power, in the POWER_ON state, of less than $P_{\text{Class(min)}}$ when:

- **PD input power consumption is equal to PD Assigned Power, and**
- **the cable resistance is increased to $R_{\text{Autoclass}}$ as defined in Equation 104-4**

$$R_{\text{Autoclass}} = \text{Minimum} (R_{\text{Loop(max)}}, R_{\text{Cable_initial}} \times K_{\text{RMF}}) \quad (\text{Equation 104-4})$$

Baseline: Modify Clause 104.7 – CRM Calculation

- Modify Clause 104.7 (continued from previous slide)

Calculations for Cable Resistance

A PSE that implements Cable Resistance Measurement may calculate cable resistance (dc loop resistance of the link segment) using the voltage and current at the PSE PI during the presence pulse and the voltage at the PD PI as shown in Equation 104-A below. The measurement tolerances in the voltage and current values should be included in the Cable Resistance Measurement calculation :

$$R_{\text{Cable_initial}} = \frac{V_{\text{Meas_PSE,min}} - V_{\text{Report_PD,max}}}{I_{\text{Meas_PSE,min}}} \quad \text{-Equation 104-5}$$

where

$V_{\text{Report_PD}}$	is the voltage at PD's PI during presence pulse as reported in b[7:0] of VOLT_POWER_INFO in Table 104-10
$V_{\text{Meas_PSE}}$	is the voltage at PSE's PI during the presence pulse
$I_{\text{Meas_PSE}}$	is the current at PSE's PI during the presence pulse
$R_{\text{Cable_initial}}$	is the initial calculated link segment cable resistance

Baseline: Modify Clause 104.7 – CRM Calculation, cont'd.

► Modify Clause 104.7 (continued from previous slide)

The initial cable resistance value calculated in Equation 104-5, is then margined by the Resistance Margin Factor (K_{RMF}) factor as shown in Equation 104-6. The cable resistance value should not exceed the maximum allowable link segment dc loop resistance for the class as shown in Equation 104-7.

$$R_{\text{Cable_margined}} = R_{\text{Cable_initial}} \times K_{\text{RMF}} \quad \text{-Equation 104-6}$$

$$R_{\text{Autoclass}} = \text{Minimum} ((R_{\text{Cable_margined}}), R_{\text{Loop(max)}}) \quad \text{-Equation 104-7}$$

where

$R_{\text{Cable_initial}}$ is the initial calculated link segment cable resistance

$R_{\text{Cable_margined}}$ is the margined link segment cable resistance

K_{RMF} is the Resistance Margin Factor per Table 104-8

$R_{\text{Loop(max)}}$ is the maximum allowable link segment dc loop resistance for the class per 104.2

$R_{\text{Autoclass}}$ is the margined link segment cable resistance, limited to $R_{\text{Loop(max)}}$

Baseline: Modify Clause 104.7 – Power Allocation

- Modify Clause 104.7 (continued from previous slide)

Calculations for Power Allocation

A PD that supports Cable Resistance Measurement may request a power allocation between 0.1W and $P_{\text{Class(max)}}$ via the PD Requested Power ($P_{\text{PD_req}}$) field of the VOLT_POWER_INFO Register b[13:8]. The PD Requested Power may exceed $P_{\text{PD(max)}}$.

A PSE that supports Cable Resistance Measurement assigns PD power ($P_{\text{PD_Assign}}$) based on PD Requested Power ($P_{\text{PD_req}}$) and Measured Cable Resistance as shown in Equation 104-8:

$$P_{\text{PD_assign}} = \left\{ \begin{array}{ll} \text{Minimum}(P_{\text{PD_req}}, P_{\text{Class(min)}} - I_{\text{PI(max)}}^2 \times P_{\text{Autoclass}}) & \text{for } P_{\text{PD_req}} > P_{\text{PD(max)}} \\ P_{\text{PD_req}} & \text{for } P_{\text{PD_req}} \leq P_{\text{PD(max)}} \end{array} \right\}_W \quad (104-8)$$

where

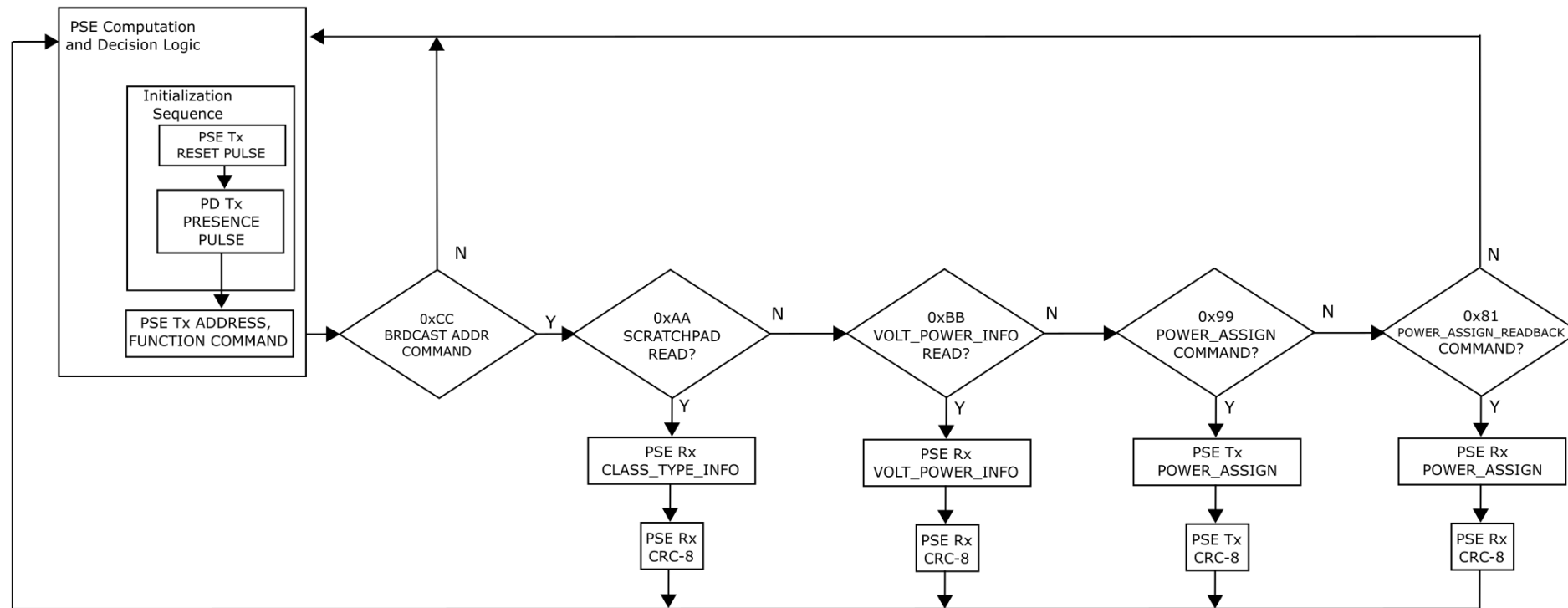
$P_{\text{PD_req}}$ is the PD Requested Power as reported in b[13:8] of VOLT_POWER_INFO in Table 104-10

$P_{\text{PD_Assign}}$ is the PD Assigned Power by PSE as reported in b[5:0] of POWER_ASSIGN in Table 104-11

For systems that implement Cable Resistance Measurement, the PSE determines $P_{\text{PD_assign}}$. Maximum average available power at the PD PI is $P_{\text{PD_Assign}}$. $P_{\text{PD_Assign}}$ may be greater or less than $P_{\text{PD(max)}}$.

Optional: Add SCCP command for PSE readback

- Add SCCP Command
 - 0x81 : POWER_ASSIGN_READBACK
- Replace Figure 104-13 with the figure shown on this slide



Thank You!

QUESTIONS? FEEDBACK?