



AHEAD OF WHAT'S POSSIBLE™

10BASE-T1L Power Delivery

HEATH STEWART

ANALOG DEVICES



PD Available Power

► Draft 1.2 Annex A Optional Power Distribution

The minimum continuous power that the PSE shall be capable of supplying (P_{pd}) for the 1000 m link segment is given in Table 200A–1 for each class.

Table 200A–1—Point-to-point class power requirements

Class	V_{pse} , min (V)	I_{pi} , max (A)	R_{loop} (60C) (ohm)	$P_{pd}(\text{min})$ (1000 m) (W)
1	20	.102	59	1.4
2	20	.155	39	2.2
3	50	.255	59	8.9
4	50	.388	39	13.6

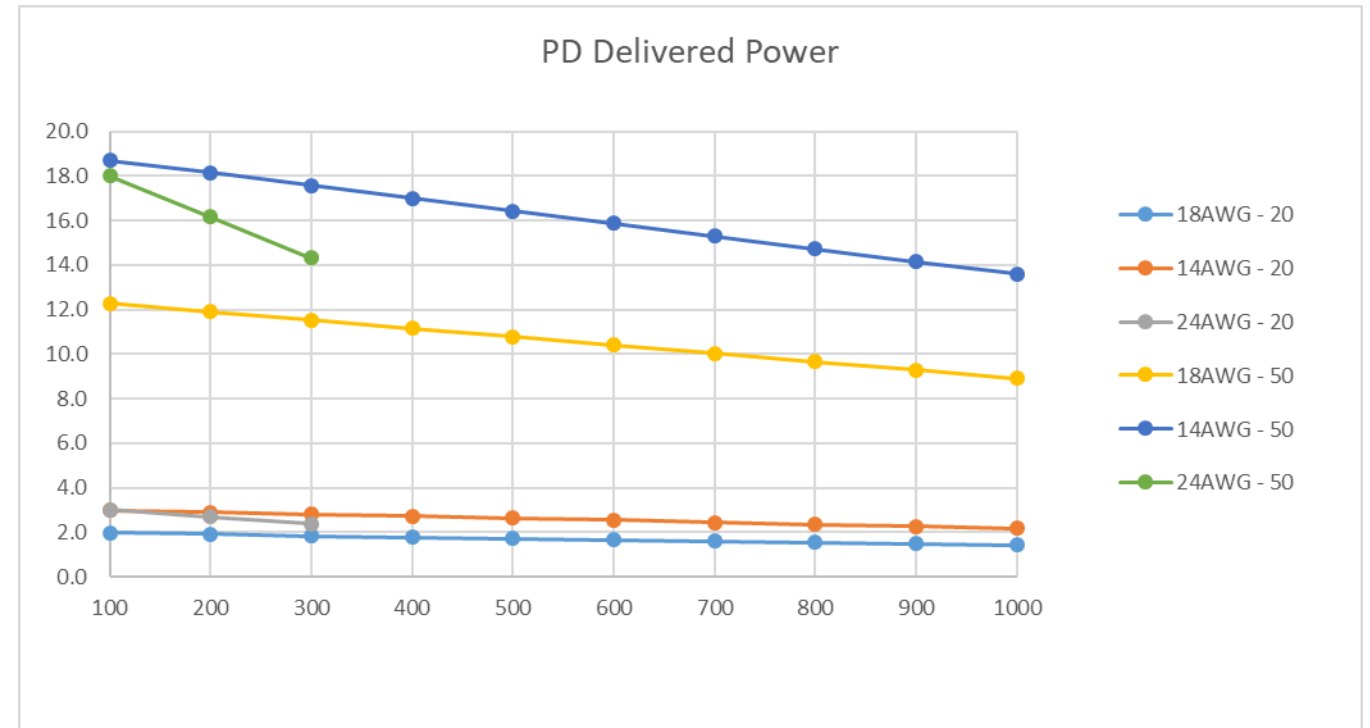
Alternate Approaches

- ▶ Annex A, today, philosophically approaches power deliver in terms of
 - 1000m cable resistance
 - “Guaranteed” PD delivered power
 - e.g. $V_{PSE} = 50V$, 18AWG @ 1000m, allows $P_{PD, max} = 8.9W$
- ▶ Alternate approaches may
 - Allow higher delivered power at shorter reaches
 - Allow more economical, thinner AWG cabling at shorter reaches
- ▶ Difficulties
 - Cable properties not pre-defined
 - Installers need to meet R_{cable} requirements as function of L_{cable}

PD Power, AWG, Length and IL Limit

► Three limitations exist on delivered power

- Power system stability
 - Selected: IR Drop 30% / PD Power 70%
- Economic feasibility of magnetics
 - Current carrying capability
 - Mags cost is a function of Amperage and number of stages
 - Selected: $I_{\text{mags, max}} = 400\text{mA}$
 - Best guess...
- Length at IL Limit
 - Limits max length of 24AWG to ~500m



Enable 300m Class Using 24AWG Cabling

► Moves the burden of AWG vs Length selection onto the installer

- PD label specifies
 - PD Watts
 - PSE Voltage
 - Min AWG

- 1000m 24AWG exceeds IL Limit
- At 300m, some classes exceed 400mA

Specified by AWG and Length								
AWG	Class	Vpse, min	1000m			300m		
			Ipi, max	Rloop, max (60C)	Ppd 1000m	Ipi, max	Rloop, max (60C)	Ppd 300m
18AWG	1	20	102	59	1.4	326	18	4.6
14AWG	2	20	155	39	2.2	488	12	6.8
24AWG	3	20	52	116	0.7	169	36	2.4
18AWG	4	50	254	59	8.9	815	18	28.5
14AWG	5	50	388	39	13.6	1221	12	42.7
24AWG	6	50	129	116	4.5	423	36	14.8

Enable 300m Class Using 24AWG Cabling

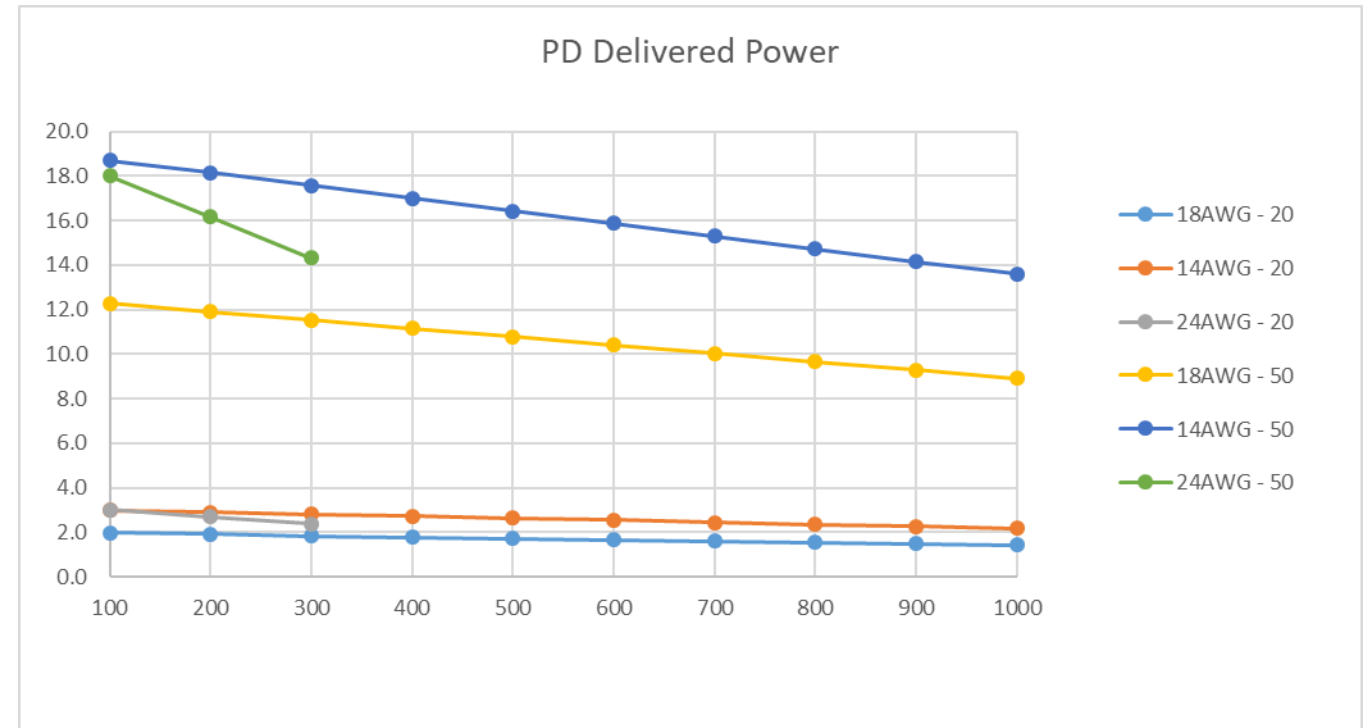
► Recommendation

- Add two 24AWG Classes at 300m
 - 20V, 2.4W
 - 50V, 14.0W

Specified by AWG and Length								
			1000m			300m		
AWG	Class	Vpse, min	Ipi, max	Rloop, max (60C)	Ppd 1000m	Ipi, max	Rloop, max (60C)	Ppd 300m
18AWG	1	20	102	59	1.4	326	18	4.6
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24AWG	6	50	129	116	4.5	400	36	14.0

IR Drop Recovery

- ▶ 1000m classes are penalized for worst case IR drop
- ▶ Allow systems to recover IR drop and allocate to the PD as usable power



Cable Resistance Measurement

- ▶ Two techniques for measuring cable resistance are presented
 - Physical Classification Technique
 - LLDP Classification Technique
- ▶ R_{CABLE} measurements are netted up by x1.16 to accommodate 40°C rise
- ▶ Various voltage and current measurements are made by the PSE and PD
 - Tolerance values are provided to allow more precise system to arrive at less margined R_{CABLE} measurements
 - Eg
 - $V_{\text{MEAS_PD}}$ is measured (as a nominal)
 - $V_{\text{MEAS_PD}}$ measurement tolerance is provided as characterized value
 - $V_{\text{MEAS_PD}}$ used in calculation is $V_{\text{MEAS_PD,min}} = V_{\text{MEAS_PD,actual}} - V_{\text{MEAS_PD,tolerance}}$

Option 2a: Physical Classification

Cable Resistance Measurement Built into Physical Classification

- ▶ Add $V_{\text{MEAS_PSE}}$ as measurement source
 - 4.7V to 5V with $I_{\text{MEAS_PD}}$ load
- ▶ Add $I_{\text{MEAS_PD}}$
 - 10mA +/- 2%
 - From 4.1V to 5V
- ▶ Add $V_{\text{MEAS_PD}}$ readback accuracy
 - Range 0 to 600mV
 - Max offset error 1mV
 - Max gain error +/-5%
 - Lsb 2.34mV
- ▶ Add $I_{\text{MEAS_PSE}}$ readback accuracy
 - Range 0 to 20mA
 - Max offset error 200uA
 - Max gain error +/-5%
 - Lsb TBD (eg 20mA / 256)
- ▶ Add optional $V_{\text{MEAS_PSE}}$ readback accuracy
 - Allows PSE to tighten computed R_{CABLE} accuracy
- ▶ Use Serial communication classification protocol (SCCP) to initiate negotiation
 - PSE requests R_{CABLE} measurement
 - PD acks support
 - PD presents/settles $I_{\text{MEAS_PD}}$
 - PD measures $V_{\text{MEAS_PD}}$
 - PSE measures $I_{\text{MEAS_PSE}}$
 - PSE optionally measures $V_{\text{MEAS_PSE}}$
 - After 20ms, PSE reads back
 - $V_{\text{MEAS_PD}}$
 - $V_{\text{MEAS_PD}}$ accuracy
 - $P_{\text{PD_REQ}}$
 - PSE computes R_{CABLE} , $P_{\text{PD_ASSIGN}}$, $P_{\text{PSE_ALLOC}}$
 - See following slide
 - PSE writes $P_{\text{PD_ASSIGN}}$ to PD
 - Default is per $R_{\text{CABLE_CLASS}}$

Option 2b: Data Link Layer Classification

Cable Resistance Measurement Built into LLDP

- ▶ Add $V_{\text{MEAS_PSE}}$ as readback accuracy
 - Range $V_{\text{CLASS,MIN}}$ to $V_{\text{CLASS,MAX}}$
 - Max offset error $1\% * V_{\text{CLASS,MAX}}$
 - Max gain error $\pm 5\%$
 - Lsb 50mV
- ▶ Add $I_{\text{MEAS_PSE}}$ as readback accuracy
 - Range 0 to $I_{\text{CLASS,MAX}}$
 - Max offset error $1\% * I_{\text{CLASS,MAX}}$
 - Max gain error $\pm 5\%$
 - Lsb TBD (eg $I_{\text{CLASS,MAX}} / 256$)
- ▶ Add $V_{\text{MEAS_PD}}$ readback accuracy
 - Range 0 to 600mV
 - Max offset error $1\% * V_{\text{CLASS,MAX}}$
 - Max gain error $\pm 5\%$
 - Lsb TBD (eg $V_{\text{CLASS,MAX}} / 256$)
- ▶ Add reported $P_{\text{MEAS_PD}}$
 - Allows PD to enable tighter computed R_{CABLE} accuracy
 - Report $P_{\text{MEAS_PD,MAX}}$ to PSE as either
 - system characterized or
 - dynamically measured value
- ▶ Use LLDP to initiate negotiation
 - PSE requests Autoclass reference measurement
 - PD acks support
 - PD presents P_{PDAUTO} in range of
 - $\text{Max}(P_{\text{PD,MAX}}, P_{\text{Class}}/4)$ to $\text{Max}(P_{\text{PD,MAX}}, P_{\text{Class}})$
 - PD measures $V_{\text{MEAS_PD}}$
 - PSE measures $V_{\text{MEAS_PSE}}$
 - PSE measures $I_{\text{MEAS_PSE}}$
 - After 40ms, PSE reads back
 - $V_{\text{MEAS_PD}}$
 - $V_{\text{MEAS_PD}}$ accuracy
 - $I_{\text{MEAS_PSE}}$
 - $I_{\text{MEAS_PSE}}$ accuracy
 - PSE computes R_{CABLE}
 - (add) Equation
 - PSE writes $P_{\text{PD_ASSIGN}}$ to PD
 - Default is per Physical class SCCP $P_{\text{PD_ASSIGN}}$

Calculations

Cable Resistance Measurement Built into Physical/Data Link Classification

$$\text{▶ } R_{\text{CABLE_MEAS}} = \frac{V_{\text{MEAS_PSE,min}} - V_{\text{MEAS_PD,max}}}{I_{\text{MEAS_PSE,min}}}$$

$$\text{▶ } R_{\text{CABLE}} = \text{Min} ((R_{\text{CABLE_MEAS}} \times 1.16), R_{\text{LOOP(CLASS)}})$$

$$\text{▶ If } P_{\text{PD_REQ}} > P_{\text{PD(CLASS),min}}$$

$$\text{■ } P_{\text{PD_ASSIGN}} = \text{Min} \left\{ P_{\text{PD_REQ}}, \left(P_{\text{PSE(CLASS),min}} - \frac{V_{\text{PSE_CLASS,min}}^2}{R_{\text{CABLE}}} \right) \right\}$$

■ Note: When $R_{\text{CABLE}} = R_{\text{LOOP(CLASS)}}$; $\left(P_{\text{PSE(CLASS),min}} - \frac{V_{\text{PSE_CLASS,min}}^2}{R_{\text{CABLE}}} \right) = P_{\text{PD(CLASS),min}}$

$$\text{▶ Else } (P_{\text{PD_REQ}} \leq P_{\text{PD(CLASS),min}})$$

$$\text{■ } P_{\text{PD_ASSIGN}} = P_{\text{PD_REQ}}$$

$$\text{▶ } P_{\text{PSE_ALLOC}} = V_{\text{PSE(CLASS),min}} \times \frac{V_{\text{PSE(CLASS),min}} - \sqrt{(V_{\text{PSE(CLASS),min}}^2 - 4 \times R_{\text{CABLE}} \times P_{\text{PD_ASSIGN}})}}{2 \times R_{\text{CABLE}}}$$

