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10BASE-T1L Power Delivery

HEATH STEWART

ANALOG DEVICES

REV 002

PD Available Power

- Draft 1.2 Annex A Optional Power Distribution

The minimum continuous power that the PSE shall be capable of supplying (Ppd) for the 1000 m link segment is given inTable 200A–1 for each class.

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

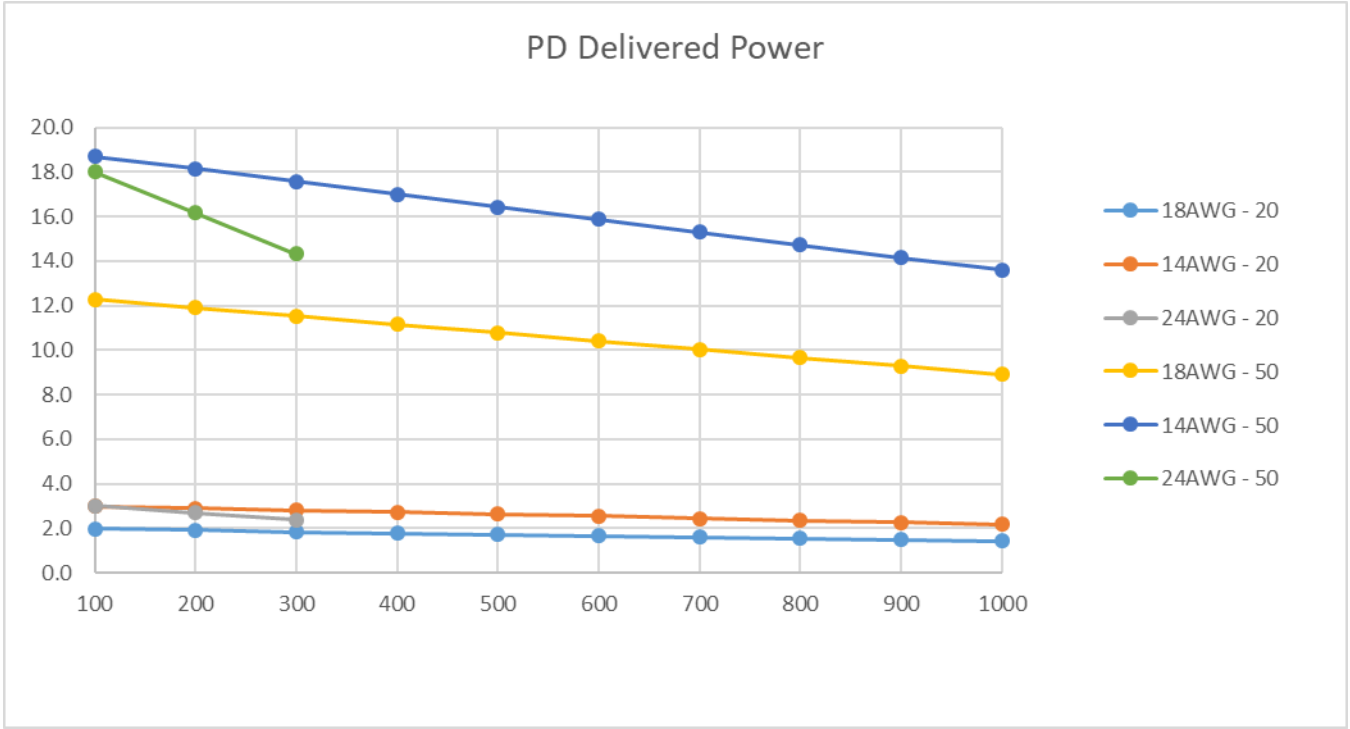
Class	Vpse, min (V)	Ipi, max (A)	Rloop (60C) (ohm)	Ppd(min) (1000 m) (W)
1	20	.102	59	1.4
2	20	.155	39	2.2
3	50	.255	59	8.9
4	50	.388	39	13.6

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: $I_{mags,\ max}$ = 400mA
      - 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

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
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

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

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
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24AWG	6	50	129	116	4.5	400	36	14.0

Link Segment Baseline

- Modify link segment description in Clause 104.2

104.2 Link segment

The dc loop resistance of the link segment shall be less than 6 Ω for ~~12 V unregulated classes~~ (Classes 0 and 1). The dc loop resistance shall be less than 6.5 Ω for ~~12 V regulated, 24 V regulated and unregulated, and 48 V regulated Classes~~ (Classes 2 through 9). The link segment dc loop resistance shall be less than 59 Ω for Classes 10 and 13. The link segment dc loop resistance shall be less than 39 Ω for classes 11 and 14. The link segment dc loop resistance shall be less than 36 Ω for classes 12 and 15.

Clause 104.3 Table 104-1 Baseline

- Add following columns to Table Clause 104.3 Table 104-1

Class	10	11	12	13	14	15
$V_{PSE(max)}$ (V)	36	36	36	60	60	60
$V_{PSE\_OC(min)}$ (V)	20	20	20	50	50	50
$V_{PSE(min)}$ (V)	20	20	20	50	50	50
$I_{PI(max)}$ (mA)	102	155	169	254	388	400
$P_{class(min)}$ (W)	2.04	3.1	3.38	12.7	19.4	20
$V_{PD(min)}$ (V)	13.98	13.96	13.92	35.01	34.87	35.6
$P_{PD(max)}$ (W)	1.43	2.16	2.35	8.89	13.53	14.24

- Note: Need to work with editor to achieve rational page width

SCCP Class Table 104–9 Baseline

- Add new Classes to Table 104–9—CLASS_TYPE_INFO Register Table

b[10:0]	Class	10 9 8 7 6 5 4 3 2 1 0	RO
		1 1 1 1 1 1 1 1 1 1 0 = Class 0	
		1 1 1 1 1 1 1 1 1 0 1 = Class 1	
		1 1 1 1 1 1 1 1 0 1 1 = Class 2	
		1 1 1 1 1 1 1 0 1 1 1 = Class 3	
		1 1 1 1 1 1 0 1 1 1 1 = Class 4	
		1 1 1 1 1 0 1 1 1 1 1 = Class 5	
		1 1 1 1 0 1 1 1 1 1 1 = Class 6	
		1 1 1 0 1 1 1 1 1 1 1 = Class 7	
		1 1 0 1 1 1 1 1 1 1 1 = Class 8	
		1 0 1 1 1 1 1 1 1 1 1 = Class 9	
		0 1 1 1 1 1 1 1 1 1 0 = Class 10	
		0 1 1 1 1 1 1 1 1 0 1 = Class 11	
		0 1 1 1 1 1 1 1 0 1 1 = Class 12	
		0 1 1 1 1 1 1 0 1 1 1 = Class 13	
		0 1 1 1 1 1 0 1 1 1 1 = Class 14	
		0 1 1 1 1 0 1 1 1 1 1 = Class 15	

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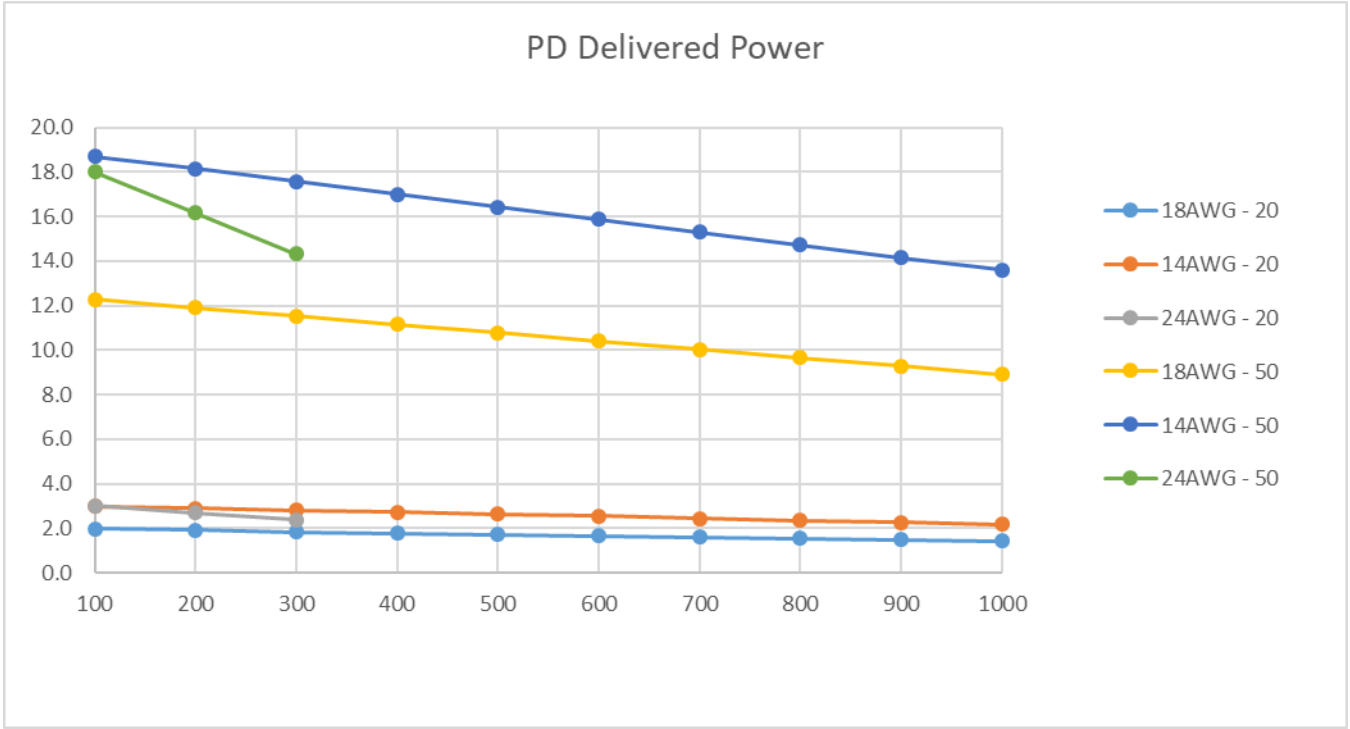
Cable Loop Resistance Measurement

IR Drop Recovery

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



Cable Resistance Measurement

- Two optional 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 RCABLE measurements
  - Eg
    - V_{MEAS_PD} is measured (as a nominal)
    - V_{MEAS_PD} measurement tolerance is provided as characterized value
    - V_{MEAS_PD} used in calculation is $V_{MEAS\_PD,min} = V_{MEAS\_PD,actual} - V_{MEAS\_PD,tolerance}$

Option 2a: Physical Classification
Cable Resistance Measurement Built into Physical Classification

- Add V_{MEAS_PSE} as measurement source
  - 4.7V to 5V with I_{MEAS_PD} load
- Add I_{MEAS_PD}
  - 10mA +/- 20%
  - From 3.9V to 5V
- Add V_{MEAS_PD} readback accuracy
  - Range 0 to 5V
  - Max offset error 10mV
  - Max gain error+/-5%
  - Lsb 2.34mV
- Add I_{MEAS_PSE} readback accuracy
  - Range 0 to 20mA
  - Max offset error 200uA
  - Max gain error +/-5%
  - Lsb TBD (eg 20mA / 256)
- Add optional V_{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_{MEAS_PD}
  - PD measures V_{MEAS_PD}
  - PSE measures I_{MEAS_PSE}
  - PSE optionally measures V_{MEAS_PSE}
  - After 20ms, PSE reads back
    - V_{MEAS_PD}
    - V_{MEAS_PD} accuracy
    - P_{PD_REQ}
  - PSE computes R_{CABLE}, P_{PD_ASSIGN}, P_{PSE_ALLOC}
    - See following slide
  - PSE writes P_{PD_ASSIGN} to PD
    - Default is per R_{CABLE_CLASS}

Option 2b: Data Link Layer Classification
Cable Resistance Measurement Built into LLDP

- Add V_{MEAS_PSE} as readback accuracy
  - Range $V_{CLASS,MIN}$ to $V_{CLASS,MAX}$
  - Max offset error 1% * $V_{CLASS,MAX}$
  - Max gain error +/-5%
  - Lsb 50mV
- Add I_{MEAS_PSE} as readback accuracy
  - Range 0 to $I_{CLASS,MAX}$
  - Max offset error 1% * $I_{CLASS,MAX}$
  - Max gain error +/-5%
  - Lsb TBD (eg $I_{CLASS,MAX}$ / 256)
- Add V_{MEAS_PD} readback accuracy
  - Range 0 to 600mV
  - Max offset error 1% * $V_{CLASS,MAX}$
  - Max gain error +/-5%
  - Lsb TBD (eg $V_{CLASS,MAX}$ / 256)
- Add reported P_{MEAS_PD}
  - Allows PD to enable tighter computed R_{CABLE} accuracy
  - Report $P_{MEAS\_PD,MAX}$ 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
    - Max($P_{PD,MAX}$, P_{Class}/4) to Max($P_{PD,MAX}$, P_{Class})
  - PD measures V_{MEAS_PD}
  - PSE measures V_{MEAS_PSE}
  - PSE measures I_{MEAS_PSE}
  - After 40ms, PSE reads back
    - V_{MEAS_PD}
    - V_{MEAS_PD} accuracy
    - I_{MEAS_PSE}
    - I_{MEAS_PSE} accuracy
  - PSE computes R_{CABLE}
    - (add) Equation
  - PSE writes P_{PD_ASSIGN} to PD
    - Default is per Physical class SCCP P_{PD_ASSIGN}

Calculations
Cable Resistance Measurement Built into Physical/Data Link Classification

- $R_{CABLE\_MEAS} = \frac{V_{MEAS\_PSE,min} - V_{MEAS\_PD,max}}{I_{MEAS\_PSE,min}}$
- $R_{CABLE} = Min\ ((R_{CABLE\_MEAS} \times 1.16), R_{LOOP(CLASS)})$
- If $P_{PD\_REQ} > P_{PD(CLASS),min}$
  - $P_{PD\_ASSIGN} = Min\ \{P_{PD\_REQ}\ ,\ (P_{PSE(CLASS),min} - \frac{V_{PSE\ CLASS\ min}{}^{2}}{R_{CABLE}})\}$
    - Note: When $R_{CABLE} = R_{LOOP(CLASS)}$; $(P_{PSE(CLASS),min} - \frac{V_{PSE\ CLASS\ min}{}^{2}}{R_{CABLE}}) = P_{PD(CLASS),min}$
- Else $(P_{PD\_REQ} \leq P_{PD(CLASS),min})$
  - $P_{PD\_ASSIGN} = P_{PD\_REQ}$
- $P_{PSE\_ALLOC} = V_{PSE(CLASS),min} \times \frac{V_{PSE(CLASS),min} - \sqrt{(V_{PSE(CLASS),min}{}^{2} - 4 \times R_{CABLE} \times P_{PD\_ASSIGN})}}{2 \times R_{CABLE}}$