Type 4- Power

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Motivation

- To explore the possible power output of a Type 4 system with the safety considerations in mind
- To estimate what parameters this would affect

Safety Consideration

- PoE is classified as LPS → Limited Power Source
- LPS is defined in IEC60950

Table 2B – Limits for inherently limited power sources

Output voltage[1] (U_{oc})		Output current[2] (I_{sc})	Apparent power[3] (S)
V a.c.	V d.c.	A	VA
≤20	≤20	≤8,0	≤5 × U_{oc}
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30	≤8,0	≤100
–	30 < U_{oc} ≤ 60	≤150/U_{oc}	≤100

1) U_{oc}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

2) I_{sc}: Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load.

3) S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load.

Table 2C – Limits for power sources not inherently limited (overcurrent protective device required)

Output voltage[1] (U_{oc})		Output current[2] (I_{sc})	Apparent power[3] (S)	Current rating of overcurrent protective device[4]
V a.c.	V d.c.	A	VA	A
≤20	≤20	≤1 000/U_{oc}	≤250	≤5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤100/U_{oc}
–	30 < U_{oc} ≤ 60			≤100/U_{oc}

1) U_{oc}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and for d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

2) I_{sc}: Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load. Current limiting impedances in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

3) S (VA): Maximum output VA with any non-capacitive load measured 60 s after application of the load. Current limiting impedances in equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

NOTE The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

4) The current ratings of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210 % of the current rating specified in the table.

LPS and Type 4

- LPS is a key safety advantage that makes PoE attractive
- Type 4 should meet LPS too → what does this mean?

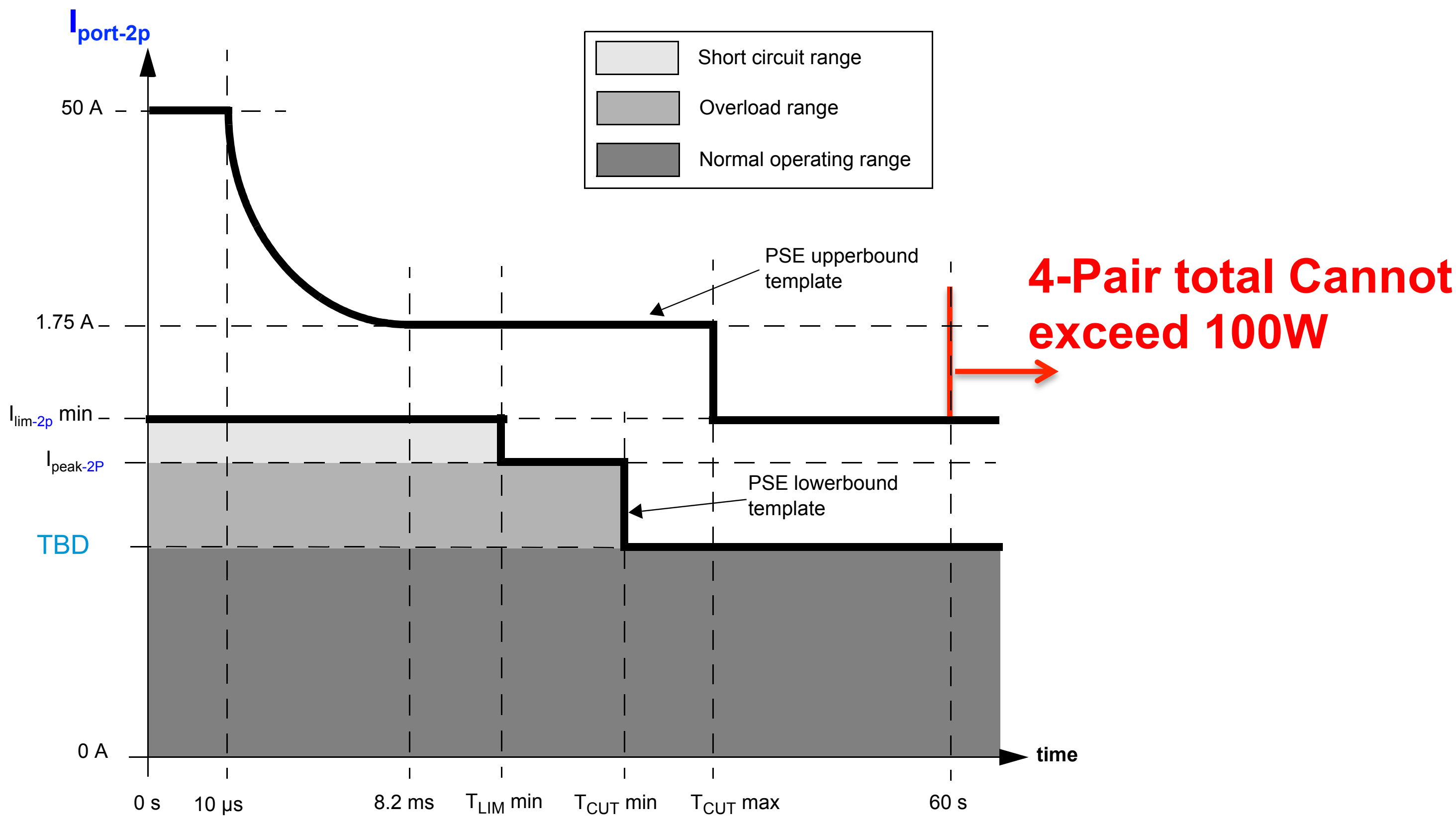


Figure 33-14-POWER_ON state, per two-pair operating current templates

Backward Calculation

- A backward calculation from Ilim-min can be used to see what power is available for Type 4 within LPS premises.
- Following table shows the base parameters used for the backward calculation → to derive at the max power for Type 4

Parameter	Value	Notes
$V_{PSE\text{-}min}$	50V	
$V_{PSE\text{-}max}$	57V	
I_{lim_min} per alternative	**877mA**	• **Equation:: ½ * LPS Power limit/Max Voltage** • **Max Voltage is used to derive this, because, even at max voltage LPS needs to be met**
$R_{channel}$	12.5 Ohms	• This is the max possible $R_{channel}$ specified for Cat5e, Cat6 and Cat6A in Cable specifications
Cable Length	100 meter	

Calculation Results

Parameter	Value	Notes
I_{peak} per Alternative	875.65 mA	• From IEEE 802.3at, $P_{peak\text{-}pd} = P_{pd} * 1.11$ • This translates to $I_{peak} = 1.138 * I_{cable}$ • $I_{lim\text{-}min} = 1.14 * I_{cable}$ • Same margin is used to derive at I_{peak} for Type 4 • **Equation used :: Ipeak = $1.138*I_{lim\text{-}min}/1.14$**
$P_{peak\text{-}PD}$ per alternative	34.21 W	• **Equation used ::** **$(I_{peak} * V_{pse\text{-}min}) – (I_{peak}^2 * R_{channel})$**
P_{pd} per alternative	30.82 W	• **Equation used :: $P_{peak\text{-}pd} = P_{pd} * 1.11$**
Total Power at PD	61.64 W	• **Equation used :: P_{pd} per alternative * 2** • With imbalance this might be even lesser
Total Type 4 power at PSE	**76.09 Watts**	

What parameter can we play with?

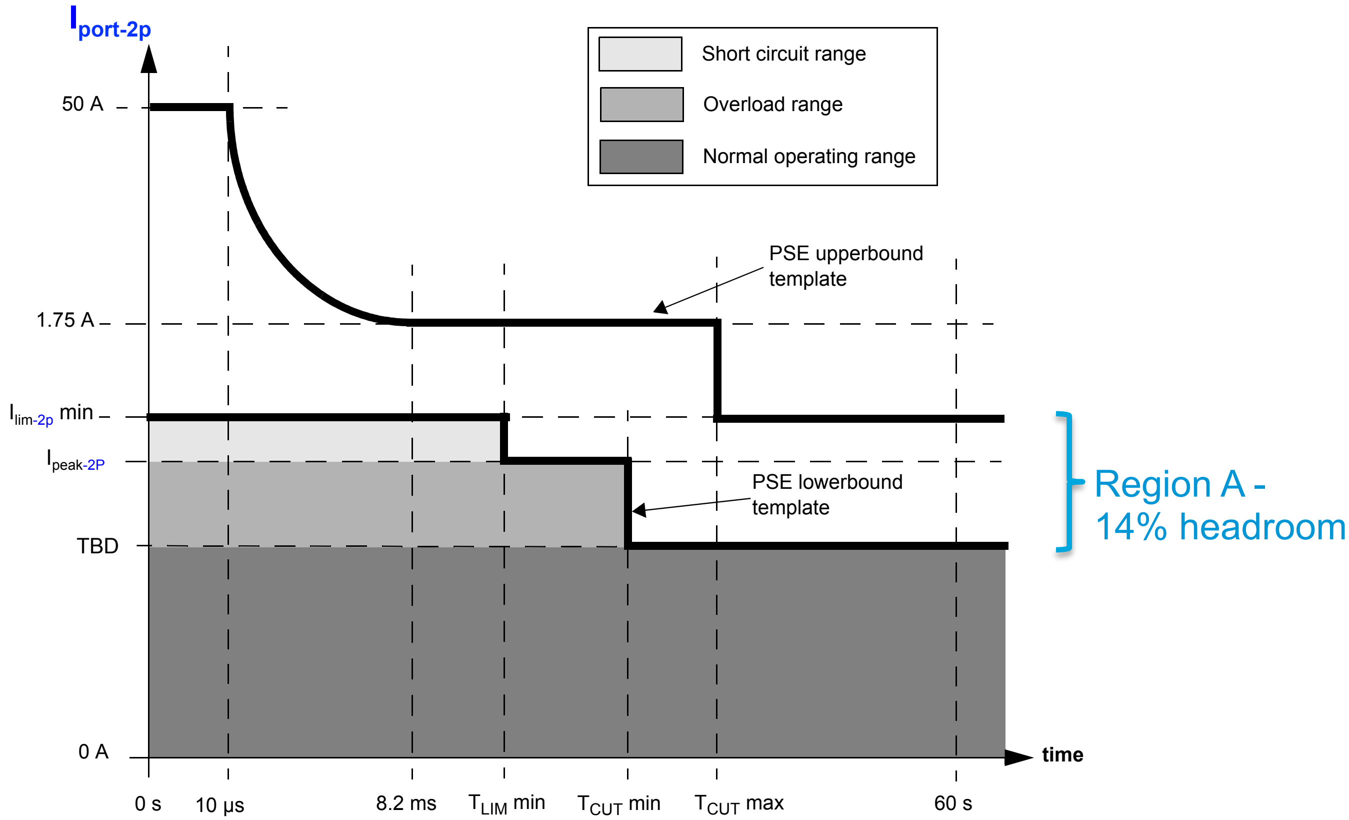


Figure 33-14-POWER_ON state, per two-pair operating current templates

1. Vpse can be increased
2. Ilim min and Ipeak can be allowed to go higher as these are anyways <60seconds
   - The upper template portion C will no longer be same as Ilim min
3. Cable resistance can be improved
4. The region between TBD and Ilim min (region A) can be compressed

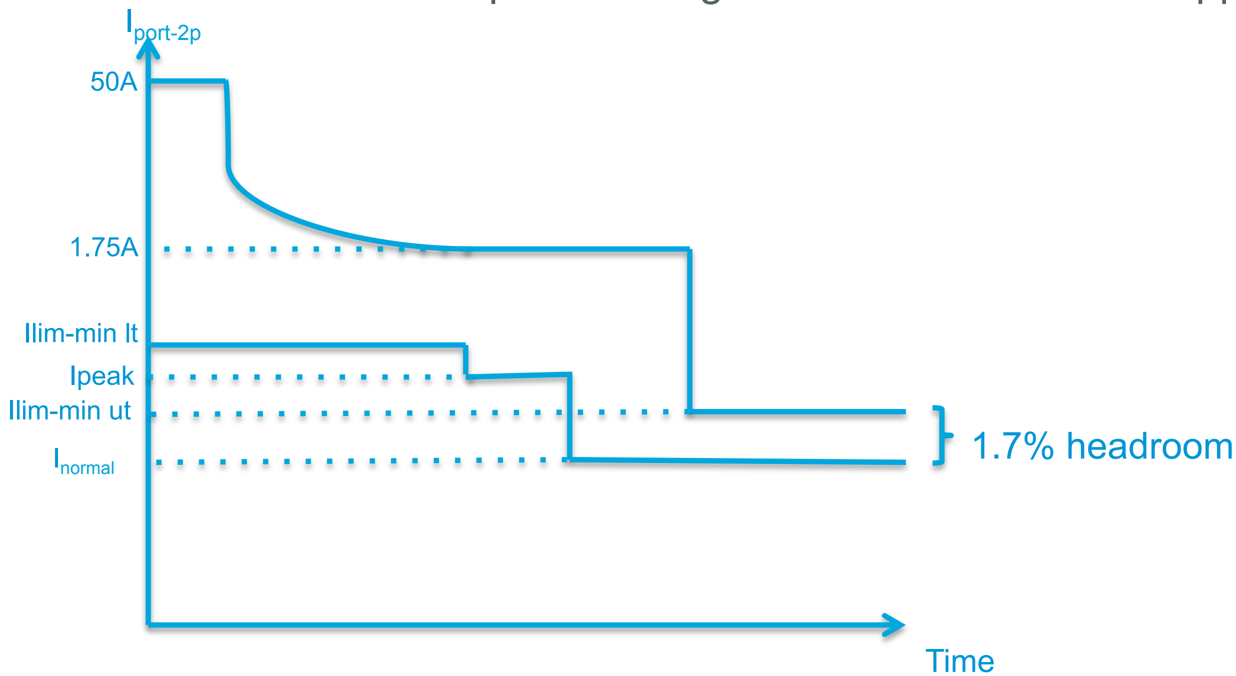
Changing Vpse and Upper Template limit

Parameter	Value	Notes
$V_{pse\text{-}min}$	52 V	• CHANGING Vpse-min to provide more power
$V_{pse\text{-}max}$	57 V	
$I_{lim\text{-}min}$ lower template	1 A	• Fixed → the upper and lower graph and not aligned here anymore. Upper graph should still meet = 0.5*100W/Vpse-max for IEC
Ilim-min upper template	877mA	
I_{peak} per Alternative	998.25 mA	• From IEEE 802.3at, $P_{peak\text{-}pd} = P_{pd} * 1.11$ • This translates to $I_{peak} = 1.138 * I_{cable}$ • $I_{lim\text{-}min} = 1.14 * I_{cable}$ • Same margin is used to derive at I_{peak} for Type 4 • **Equation used :: Ipeak = $1.138*I_{lim\text{-}min}/1.14$**
$P_{peak\text{-}PD}$ per alternative	39.45 W	• **Equation used ::** **$(I_{peak} * V_{pse\text{-}min}) - (I_{peak}^2 * R_{channel})$**
P_{pd} per alternative	35.5 W	• **Equation used :: $P_{peak\text{-}pd} = P_{pd} * 1.11$**
Total Power at PD	71 W	• **Equation used :: P_{pd} per alternative * 2** • With imbalance this might be even lesser
I_{cable} per alternative	862.22 mA	
Total Type 4 power at PSE	**89.67 Watts**	

Impacts & Notes

Impacts:

- Ilim-min-UT = 1.017* Inormal → only 1.7% headroom between lower and upper template
- Ipeak and Ilim-min of lower template are higher than the Ilim-min of upper template



NOTES

- The analysis assumes worst case in terms of Vpse for all calculations. But if Vpse of a system is greater then it can allow more current on the upper template → bigger headroom
- Analysis doesn't include unbalance.

How to specify Type 4?

- Specify upper template ($I_{lim\text{-}min\text{-}ut}$) more freely based on V_{pse}, unbalance etc., But specify that total power cannot exceed TBD W.
- Ask Cable standards for better than 12.5Ohms Rchan (worst case)
- Bundling and Temperature increase should be addressed.

Summary

- 90W of power delivery at PSE for Type 4 is possible
- Cable resistance improvements should be looked into
- Cable bundling should be studied

THANK YOU

BACK UP SLIDES

Link Segment DC Resistance Definitions

- The table below is from the following link:
  Call For Interest PoE-plus - Cabling . The assumptions were:
  - 90m horizontal cable temperature is 65°C. Size is 24AWG (ex: **Cat5e** cable).
  - 10m patch cord temperature is 20°C. Size is 26AWG.
  - Connector resistance (per mated connector) = 0.3 ohm, referring to Cat3.
- This gave a total of ~25Ω/2 = 12.5Ω per 2-pair set.

Link Segment DCR

Link Segment (4 connectors):

•DC Resistance

Table 2

	90 meters	90 meters	4 connectors	100 meter channel
degC	conductor	loop	2x(4x.3 ohm per connector)	with 10m ScTP patch (2.8 ohm)
20.00	8.44	16.88	2.40	22.08
30.00	8.78	17.56	2.40	22.76
40.00	9.12	18.23	2.40	23.43
50.00	9.46	18.91	2.40	24.11
60.00	9.79	19.59	2.40	24.79
65.00	9.96	19.92	2.40	25.12

100 ohm ScTP patch cords and cross-connect:

•TIA/EIA/IS-729- DC resistance - For 26 AWG conductors, the resistance of the conductors shall not exceed 14 ohm per 100 meters (328 ft) at or corrected to a temperature of 20 C. (DC correction-ASTM