DC Resistance and Powering Scenarios

IEEE P802.3cg 10 Mbps Single Pair Ethernet Task Force

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Overview

- Use cases for 802.3cg
- Review of what we've seen on powering
  - Process control topologies
  - Use cases in Industrial
  - PoDL and extensions
  - Multiple profiles
  - Relation of power, Vpse and efficiency
  - Best effort+plug & play
- Where does this leave us? (thoughts on strawman)
- Recommendation

Use cases for 802.3cg

- Process Control Trunks
  - Long links, heavy gauge (14-18AWG)
  - Engineered systems, (can be I.S. which implies engineered links)
- Process Control Spurs
  - Up to 200m links, gauge driven by power needs?
  - Engineered systems (can be I.S. which implies engineered links)
- Industrial pods
  - Up to 15m links, small gauge (24-28AWG)
  - Plug-and-Play or I.S.
- Building Automation
  - Wide range of link lengths, generally not IS
  - More value in plug-and play
  - Long links similar to process control
  - Shorter links (100-200m and less) similar to Industrial Pod?
- Premises and data center applications
  - 100m or less, value in plug and play

Gardner: PoDL & extensions

- Plug and Play at 6.5 ohms
  - Extendable to higher loop resistance, more classes
- >70% efficient

Table 104–1—Class power requirements matrix for PSE, PI, and PD

	12 V unregulated PSE		12 V regulated PSE		24 V unregulated PSE		24 V regulated PSE		48 V regulated PSE	
Class	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
$V_{PSE(max)}$ (V)[a]	18	18	18	18	36	36	36	36	60	60
$V_{PSE\_OC(min)}$ (V)[b]	6	6	14.4	14.4	12	12	26	26	48	48
$V_{PSE(min)}$ (V)	5.6	5.77	14.4	14.4	11.7	11.7	26	26	48	48
$I_{PI(max)}$ (mA)[c]	101	227	249	471	97	339	215	461	735	1 360
P_{Class} (W)	0.566	1.31	3.59	6.79	11.4	3.97	5.59	12	35.3	65.3
$V_{PD(min)}$ (V)	4.94	4.41	12	10.6	10.3	8.86	23.3	21.7	40.8	36.7
P_{PD} (W)[d]	0.5	1	3	5	1	3	5	10	30	50

[a] V_{PSE} is the voltage measured at the PSE PI over the full range of operating conditions.
[b] $V_{PSE\_OC(min)}$ is the minimum allowed open circuit voltage measured at the PSE PI.
[c] $I_{PI(max)}$ is the maximum current flowing at the PSE and PD PIs except during inrush or an overload condition. $I_{PI(max)}$ may be exceeded during inrush or an overload (see 104.4.6.2). Users are cautioned to be aware of the ampacity of cabling, as installed, and local codes and regulations (see 104.8.1).
[d] P_{PD} is the maximum average available power at the PD PI.

Franchuck_3cG_10_0117.pdf: Process control

- Non-IS trunk, IS or non-IS spurs
  - IS is for engineered networks, outside our scope

High Power Trunk (HPT), 2002

- Trunk + Spur topology
- Limits power at the spur, rather than the trunk
- Trunk is not IS, but is protected via other means (e.g. explosion proof)

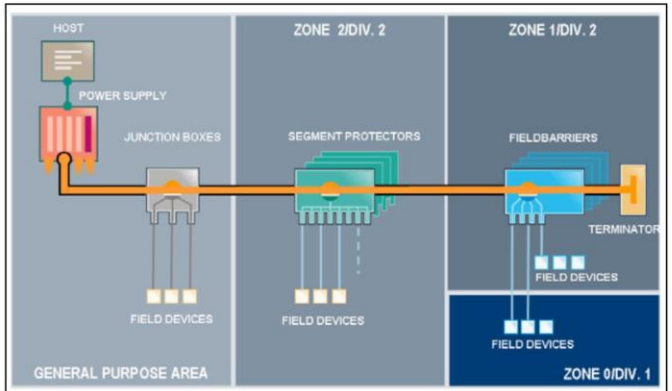

Figure 3: High-Power Trunk for any hazardous area Segment Protectors provide short-circuit protection and non-incendive energy limitation (Ex nL).. FieldBarriers provide intrinsic safety (Ex i).

Source: Technical White Paper, "INTRINSICALLY SAFE FIELDBUS IN HAZARDOUS AREAS", Pepperl & Fuchs

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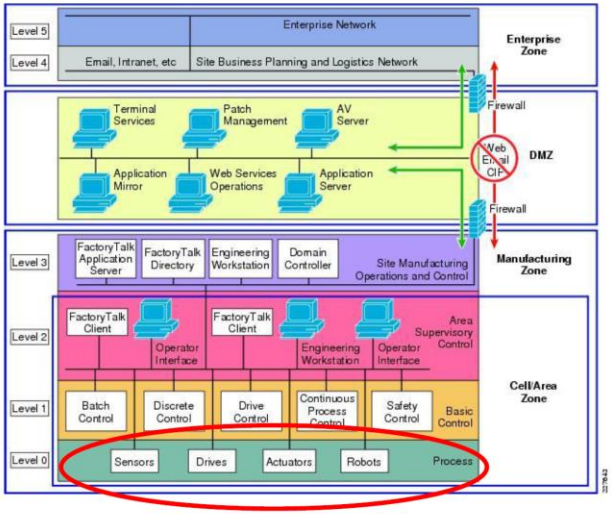
Voss: 10SPE_Powering_Use_Cases.pdf (Jan '17)

- 24 V at edge in industrial, both IS and non-IS on network
- Mixed connection types:
  - Long distance connections (1000m) and Machine/skid connections (<100m)
  - PoE still has a role

Industrial Network Power Usage

- Network-supplied power greatly simplifies installations at the edge
  - Achieve a "one wire ideal" where power and control are one connection
- The network edge relies on 24 volt DC power today
  - The nominal 48 VDC of PoE would encounter resistance at the edge
- Some edge devices like actuators require significant power
  - Local source of 24 volt power is still needed



Graber_10SPE_09_1216

- Multiple power profiles
- Flexibility for applications
  - The following table shows one possible set of power profiles for a field switch (trunk port):

Profile	Description
Non-powered	For separately powered field switches
17.5 V, 0.38 A	Not relevant for a field switch, but could make sense as a power supply output, if only one field device should be supplied.
48 V, 1.25 A, tbd.	For hazardous area field switches, Ex e port
57 V, 1.8 A, tbd.	For non-hazardous area field switches, non-Ex

  - The following table shows one possible set of power profiles for a field device (spur port):

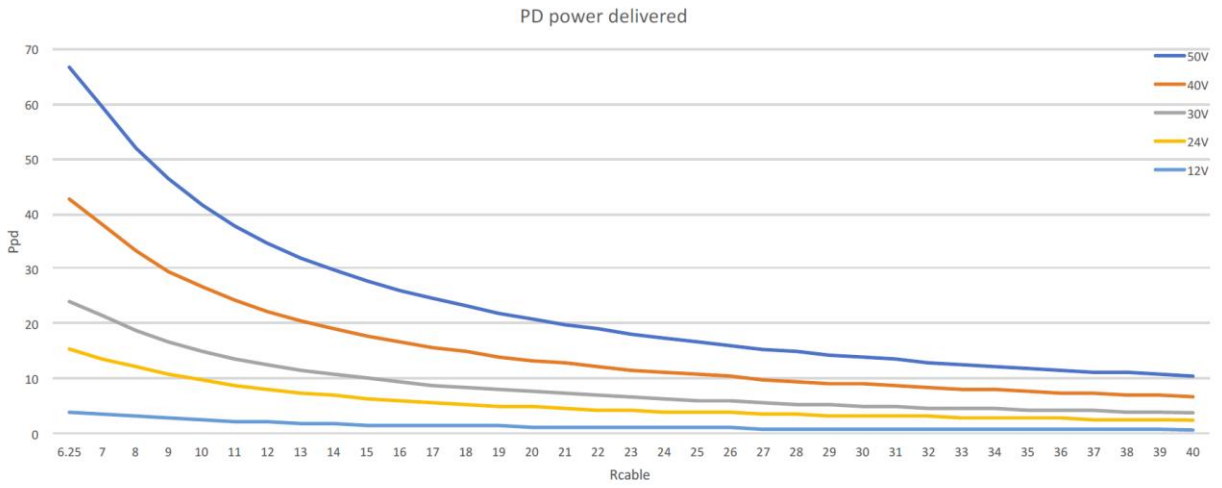
Profile	Description
Non-powered	For separately powered field devices
17.5 V, 0.38 A	For low power field devices, Ex ia/ib port or non-Ex
48 V, 1.25 A, tbd.	For high power field devices, Ex e port
57 V, 1.8 A, tbd.	For high power field devices, non-Ex

  - A field switch or field device should always support the maximum supply voltage of the respective profile, the supply voltage range should be clearly marked on the device.
  - It could make sense to add more profiles, depending on the application.

Jones: PD Power, Vpse and Rcable

- Looks at constant power delivery
  - Max power is only 50% efficient: $P_{PD\_max} = \frac{{V_{PSE}}^2}{4R}$
  - More realistic is 80% efficient: $P_{PD\_max} = \frac{{V_{PSE}}^2}{6R}$

More Realistic Efficiency



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Diminico: Best effort + Plug & Play

- Specify both plug and play and “best-effort”

Optional Power Distribution Concept

•Link Segment DCR and length @ IL limit different for each AWG.
•Variety of voltages, currents and power for “use cases” presented.
•Optional power distribution concept;
- Specify power/voltage/current/DCR for a link segment topology* (plug-and-play).
- Specify “Best effort” power delivery for other topologies*.

*Topology with DCR less than or equal to DCR and length @ IL limit.

Diminico: Loop resistance vs. length

- 14-18AWG at IL limit gives 30-47ohms
  - Smaller gauges at IL limit drive loop resistance to ~100 ohms 24AWG @ 500m
    - Jones tells us that means ~ 4 W at 50V, 1W at 24V
  - Aren't these engineered anyway?

802.3cg Link Segment Proposal - DCR

AWG	Diameter(in)	Diameter(mm)	Diameter(m)	area (m^2)	Resistance per meter (ohm)	Length @ IL limit (m)	Conductor resistance @ IL limit (ohm)	Loop resistance @ IL limit (ohm)	10 connector DCR	Link segment resistance @ IL limit (ohm)
14	0.064085	1.627754	0.001627754	2.08098E-06	0.0092	1589	14.67	29.33	4.00	33.33
15	0.057069	1.449551	0.001449551	1.65028E-06	0.0116	1415	16.47	32.94	4.00	36.94
16	0.050821	1.290858	0.001290858	1.30872E-06	0.0147	1261	18.50	37.00	4.00	41.00
17	0.045257	1.149538	0.001149538	1.03785E-06	0.0185	1123	20.78	41.55	4.00	45.55
18	0.040303	1.023689	0.001023689	8.2305E-07	0.0233	1000	23.33	46.66	4.00	50.66
19	0.035890	0.911618	0.000911618	6.52703E-07	0.0294	891	26.20	52.40	4.00	56.40
20	0.031961	0.811816	0.000811816	5.17614E-07	0.0371	793	29.42	58.84	4.00	62.84
21	0.028462	0.722941	0.000722941	4.10483E-07	0.0468	706	33.04	66.07	4.00	70.07
22	0.025346	0.643795	0.000643795	3.25526E-07	0.0590	629	37.10	74.19	4.00	78.19
23	0.022571	0.573314	0.000573314	2.58152E-07	0.0744	560	41.66	83.31	4.00	87.31
24	0.020100	0.510549	0.000510549	2.04722E-07	0.0938	499	46.78	93.55	4.00	97.55
25	0.017900	0.454655	0.000454655	1.62351E-07	0.1183	444	52.53	105.05	4.00	109.05
26	0.015940	0.404881	0.000404881	1.28749E-07	0.1492	395	58.98	117.96	4.00	121.96
27	0.014195	0.360555	0.000360555	1.02102E-07	0.1881	352	66.23	132.46	4.00	136.46
28	0.012641	0.321083	0.000321083	8.09698E-08	0.2372	314	74.37	148.74	4.00	152.74
29	0.011257	0.285931	0.000285931	6.42115E-08	0.30	279	83.51	167.02	4.00	171.02
30	0.010025	0.254628	0.000254628	5.09217E-08	0.38	249	93.78	187.55	4.00	191.55
31	0.008927	0.226752	0.000226752	4.03824E-08	0.48	221	105.30	210.60	4.00	214.60
32	0.007950	0.201928	0.000201928	3.20245E-08	0.60	197	118.24	236.49	4.00	240.49

- Use Table xx as 802.3cg link segment DCR characteristics.

Where does this leave us

- Lots of engineered situations
  - These we provide tables for guidance
- Lots of plug and play situations: Choices!
  - Lots of choices for resistance, voltages, PD_power
  - Generally needed within building
    - (<100m) thinner wires
  - Start somewhere: possible cases:
    - 25Ω: 4 W at 24V, 16 at 50V; 112m (24AWG)
    - 12.5Ω: 8W at 24 V, 32 at 50V; 45m 24 AWG
    - 6.5Ω: Consistent w/PoDL
  - Do these make sense?

Recommendation:

- Always specify coupling characteristics to interoperate with PHYs
  - MDI return loss, droop and noise characteristics
- Specify DC loop resistance(s) (R) for plug and play power
  - Only specify DC loop resistance as a link segment parameter when plug-and-play power is used
  - Recommend: start w/PoDL for plug-and-play applications
    - Need something a lot better to justify new text
- Provide an informative guide to power for Engineered power delivery when loop resistance is > R, or lower efficiency can be tolerated
  - Leave intrinsic safety issues to users (can we reference)?

Thank You!