10 Mb/s Single Twisted Pair Ethernet
Power Distribution

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Overview

Supporting Presentation for Objective:

Specify an optional power distribution technique for use over the 10 Mb/s single twisted pair link segments in conjunction with 10Mbps single-pair PHYs.

Content:

- Bus Topology vs. Daisy-Chain Topology
- Powering of a Daisy-Chain Topology
- Power Decoupling Circuit
- Simple Power Implementation
- Possible Work Flow for Task Force
- Powering Examples
- Conclusion

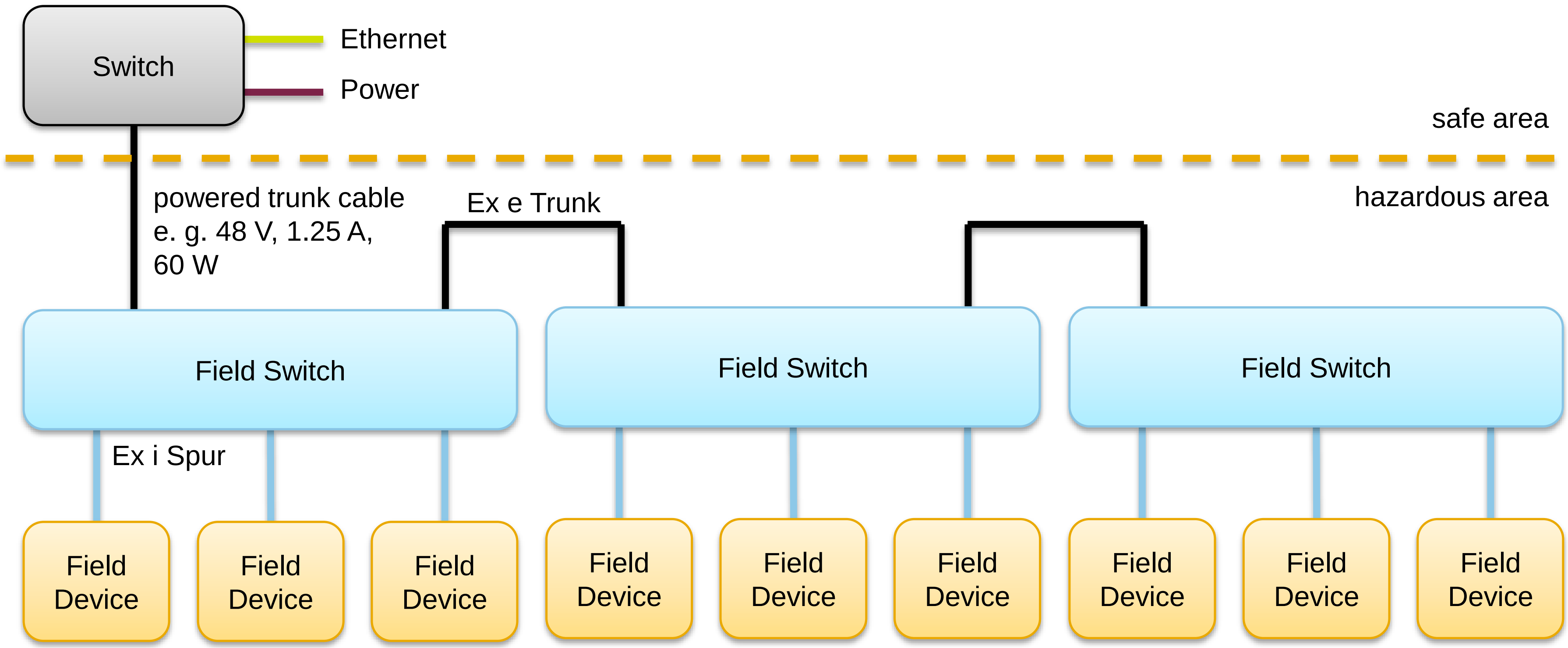
Bus Topology vs. Daisy-Chain Topology

Bus Topology	Daisy-Chain Topology
Simple, efficient power distribution.	Higher complexity, additional power losses.
Low cost power distribution, no series inductors.	Higher cost due to additional high power series inductors.
Scaling to longer distances is currently not clear.	PHY design is feasible.
Feasibility for industrial protocols is currently not clear.	Existing industrial protocols can be used.
Variable latency, depending on telegram size.	Fixed low latency.

- A bus topology would be the preferred solution from energy distribution point of view.
- From communication point of view only the daisy-chain topology will currently fulfill the process industry requirements.
- **Therefore, even if the energy distribution is more complex for a daisy-chain topology, this is currently the only possible solution for process industry applications.**

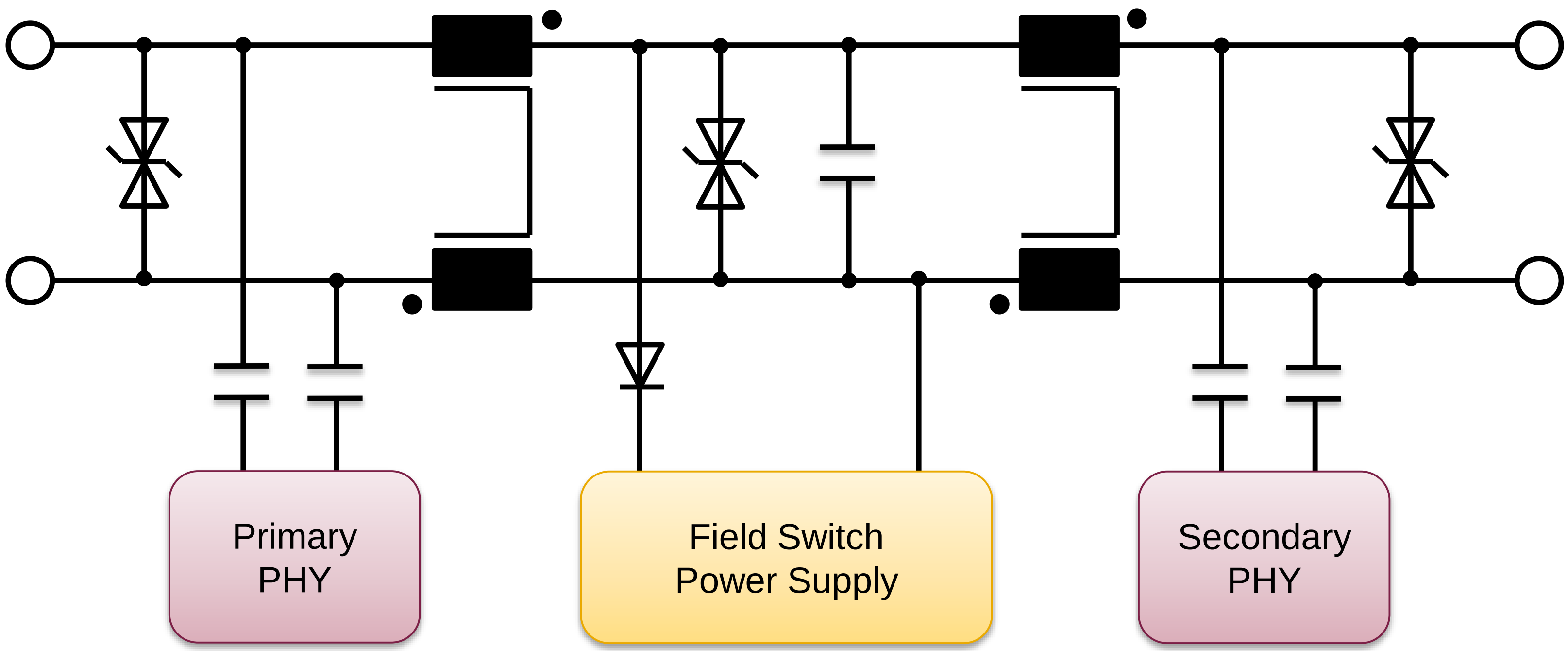
Powering of a Daisy-Chain Topology

- Depending on the overall available power and the power consumption for process automation applications several field switches need to be connected in a daisy chain topology.
- The maximum length of one trunk segment can be up to 1000 m long (the daisy-chain topology is not reducing the requirement for up to 1000 m trunk segment length).



Power Decoupling Circuit

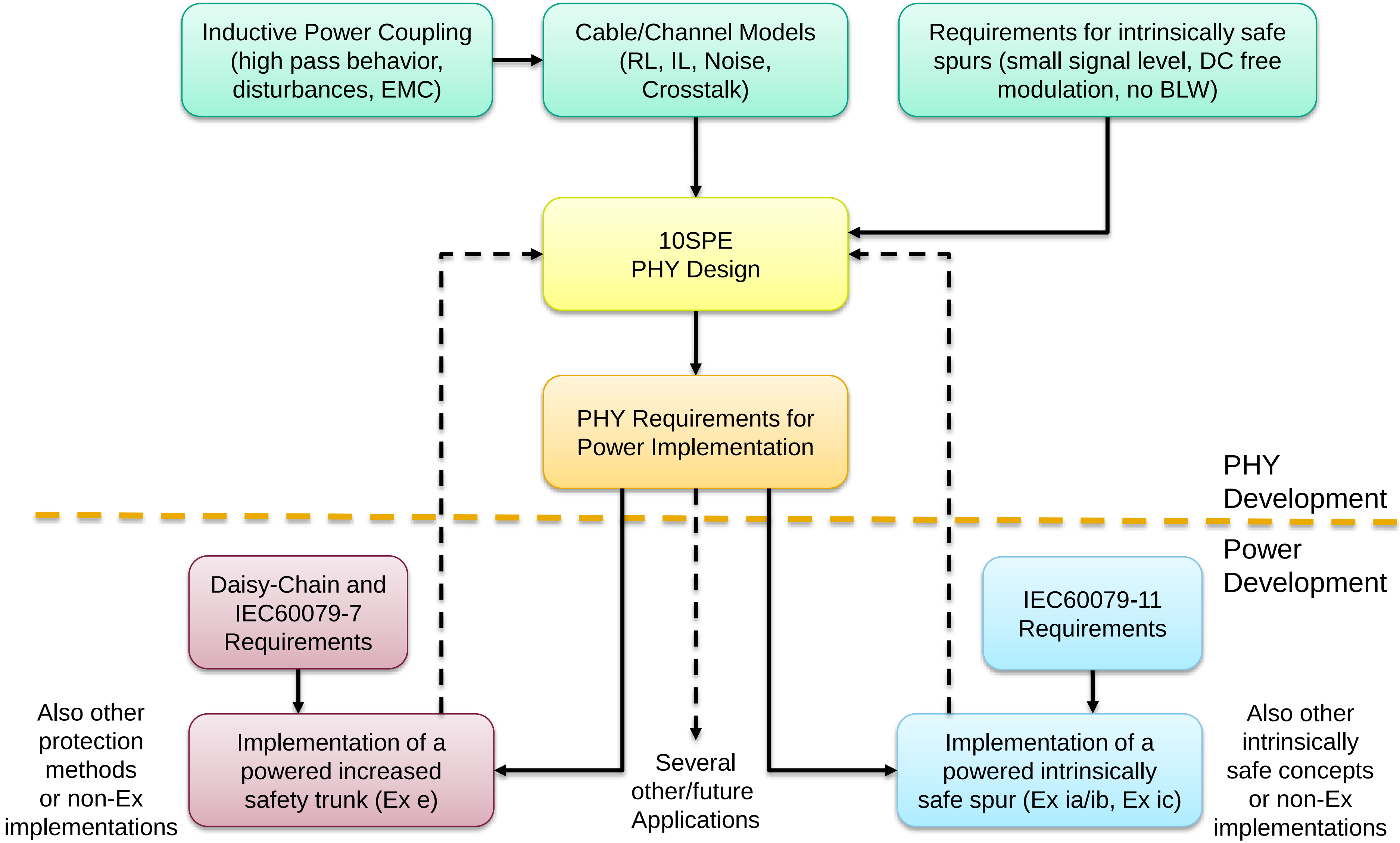
- To minimize the losses within a daisy chain trunk, the series impedance of the high power path needs to be as low as possible.
- In the suggested circuit below the losses are minimized.
- The voltage drop is mainly caused by the series resistance of the inductors.
- Depending on the inductor size these losses can be relatively low.



Simple Power Implementation

- The power implementation should not need any configuration and be simple plug & play.
- To guarantee the interoperability of the PHY and to prevent communication disturbances during powered operation, requirements for the power implementation need to be derived while defining the PHY.
  - These requirements have to guarantee, that the disturbances introduced by the power supply and other components can be tolerated by the PHY circuit without causing communication errors or link loss.
  - On the other side there will be some physical effects when implementing inductive power coupling circuits and intrinsically safe spurs, which have to be taken into account while designing the PHY.
- There will be many different application requirements.
  - Different power levels.
  - Different amount of preplanning (e. g. automotive vs. industrial vs. building automation).
  - Intrinsically safe applications vs. non-intrinsically safe applications.
  - Currently unknown, newly upcoming applications.
- Therefore power implementation could get complicated.
  - Complexity needs to be reduced.
  - It makes sense for the power implementation to be decoupled from PHY implementation.
  - Nevertheless there needs to be a closed loop between power implementation and PHY implementation.

Possible Work Flow for Task Force



Powering Examples

- Powering options for non-Ex applications, Ex e (increased safety) and Ex i (intrinsic safety).
- The following tables gives technically possible example values for Ex ia/ib spur power values and Ex e trunk power values.

Parameter (Ex ia/ib)	Value
Maximum output voltage U_o	17.5 V
Inductor clamping voltage	3.2 V
Maximum allowed supply voltage	14.3 V
Overvoltage limitation	14.0 V ± 0.3 V
Functional supply voltage	13.2 V ± 0.3 V
Short circuit current I_o	380 mA
Minimum output voltage	9.6 V
Minimum device voltage	9.0 V
Maximum device current	55.6 mA
Maximum available device power	500 mW
Maximum allowed inductance L_o	10 µH + cable *)
Maximum allowed capacitance C_o	5 nF + cable *)

Parameter (Ex e)	Value
Maximum functional supply voltage	48.0 V
Maximum supply voltage for Ex e	52.8 V
Minimum functional supply voltage	24.0 V
Minimum supply voltage for Ex e	21.6 V
Maximum supply current	1.25 A (tbd.)

*) 10 µH/5 nF per field device, up to 200 m spur cable.

Possible cable parameters:

R_C = 15 Ω/km … 150 Ω/km
L_C = 0.4 mH/km … 1 mH/km
C_C = 45 nF/km … 200 nF/km
$L_C / R_C \leq 30$ µH/Ω

- Depending on other use cases there will be several other power profiles, which need to be defined.

Conclusion

- From process industry point of view it is important for a success of 10SPE to allow powering of the trunk and spur.
- Use of PoDL could be an option for specific applications, but the 10SPE standard needs to be open enough to also allow other powering options (e. g. daisy-chain structures) to be implemented in a simple and cost effective way, being from the cost point of view in the same range as today’s solutions.

Thank You