10 Mb/s Single Twisted Pair Ethernet

Technical Feasibility for Intrinsically Safe Link Segment

Steffen Graber

Pepperl+Fuchs

Supporters

David Brandt, Rockwell

Jens Gottron, Siemens

Harald Müller, E+H

Matthias Wendt, Philips

Ludwig Winkel, Siemens

Markus Wucher, E+H

Dayin Xu, Rockwell

Lennart Yseboodt, Philips

Overview

Supporting Presentation for Objective:

Do not preclude working within an Intrinsically Safe device and system as defined in IEC 60079.

Content:

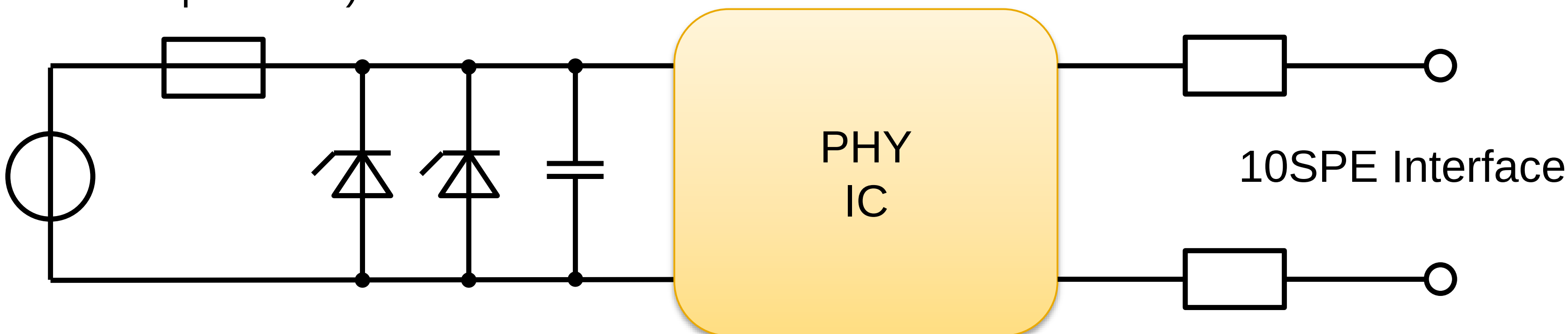
- Basic Principle of Intrinsic Safety
- Example: Maximum Temperature Limitation
- Example: Possible PHY Circuit Integration
- Example: Modulation Amplitude and Power
- Summary

Basic Principle of Intrinsic Safety

- In an intrinsically safe system the voltage, current, power and stored energy of a circuit are limited to values, which are such low so that no ignition of a potentially explosive atmosphere can occur while opening or closing the circuit during normal operation and even if there is a short within the circuit in case of a failure.
- Depending on the zone, in which an intrinsically safe device is intended to be used, up to two countable faults must be assumed within a device without causing an ignition hazard by providing too high output values or leading to an un-allowed internal heating.
  - A countable fault is a fault of a component, which is designed according to the requirements of IEC/EN 60079-11.
  - All other faults are seen as a non-countable fault.
  - There have to be assumed an arbitrary amount of non-countable faults within an intrinsically safe device.
- **Due to the small distances between the pins of todays complex ICs, such as PHY ICs, all faults happening within such ICs are typically non-countable faults, so that these ICs cannot be used for protection measures by the meaning of the IEC/EN 60079-11 standard.**
- Assessing faults of complex ICs just all possible shorts and/or interruptions between arbitrary pins are assumed, nevertheless all these faults are still only uncountable faults.
- **Additionally it is assumed, that such an IC in case of a failure can dissipate as much power as it can get (matched impedance), therefore the power to this IC needs to be limited.**

Example: Maximum Temperature Limitation

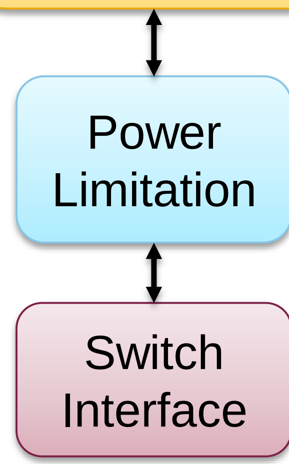
- A typical ambient temperature range for a field device is -40 °C to 70 °C.
- A temperature class of T4 (acc. to . IEC/EN 60079-0) for which most devices are designed for allows a maximum surface temperature of 130 °C for the PHY IC **in case of a fault** (no functional requirement).



$P_{max} = 1.7 * I_{fuse} * U_{z,max} + P_{switch} + P_{10SPE}$

$T_{max} = P_{max} * R_{th,PHY} + T_{service} \leq 130\ °C$

$T_{service}$ is the internal temperature nearby the PHY IC during normal operation, e. g. 85 °C (70 °C ambient, 15 °C heating due to power dissipation within the housing).



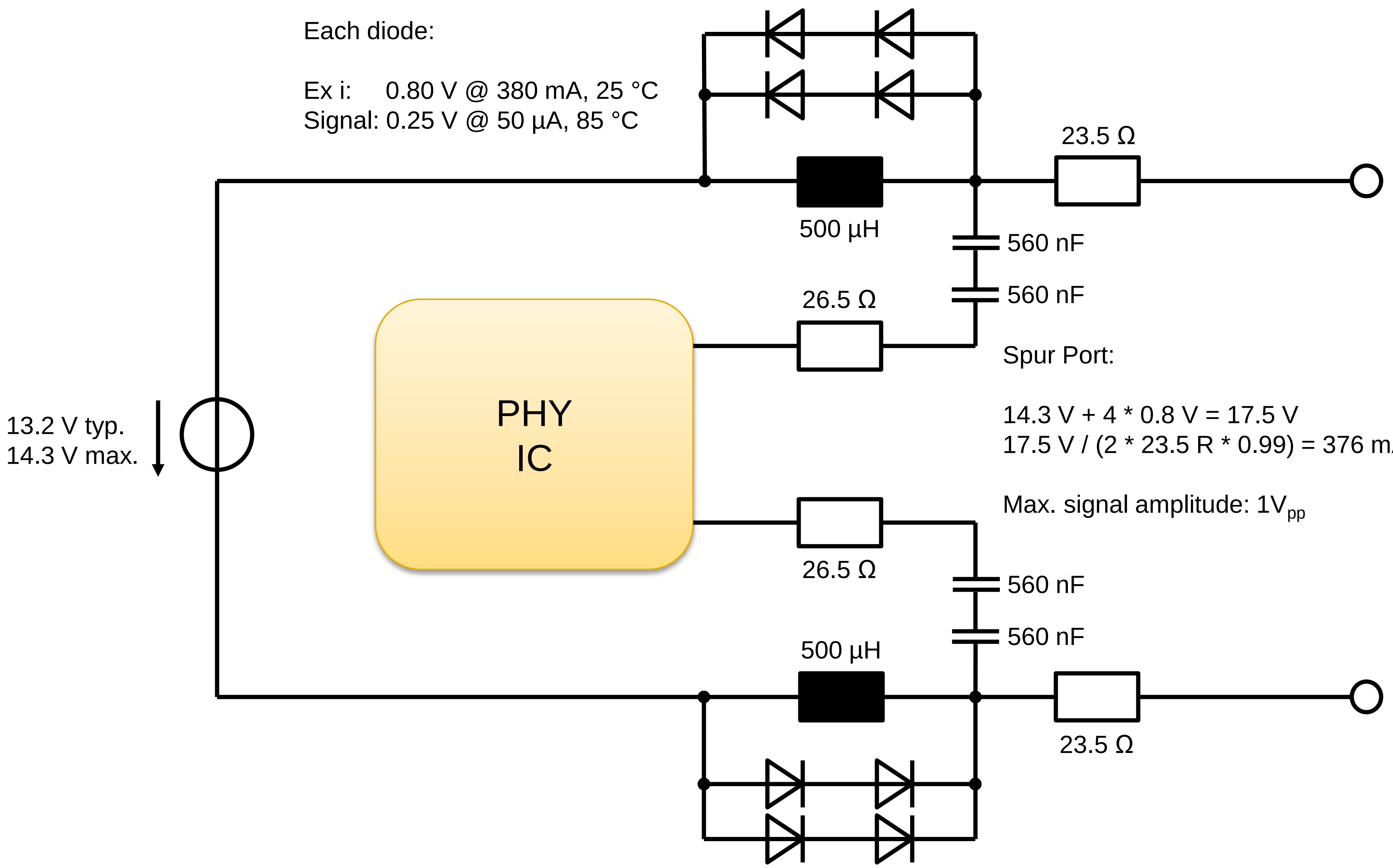
Industrial PHY operating temperature range e.g. -40 … 85 °C, for some applications up to 105 °C.

→ The energy to the PHY IC needs to be limited on each possible power or signal path.

Example: Possible PHY Circuit Integration

- **The PHY IC itself does not need to contain any protection measures for intrinsic safety.**
- All protection measures for intrinsic safety and meeting the allowed maximum temperature will be added externally, so that a safe operation within hazardous areas can be guaranteed.
- **Therefore all power and signal lines to and from the PHY need to be protected accordingly.**
- The thermal resistance of the PHY IC needs to match the maximum possible power within the circuit node to prevent an un-allowed heating in case of a fault.
- A low thermal resistance would allow having a higher number of PHYs within the same circuit node thus reducing the effort for the external protection circuits.
- Additionally to the power lines, there will also be need for limiting the power to the switch interface and to the 10SPE interface.
- The power coming from the 10SPE interface can be limited by external resistors, which will be part of the termination impedance and also will limit the current coming from the interface port.
- The power coming from the switch interface will also need resistive or combined resistive/capacitive power limitation.
- To reduce the circuit effort a low pin count interface additionally to a standard MII interface to the switch or microcontroller is preferred.

Example: Modulation Amplitude and Power



Spur Port:

14.3 V + 4 * 0.8 V = 17.5 V
17.5 V / (2 * 23.5 R * 0.99) = 376 mA

Max. signal amplitude: $1V_{pp}$

Example: Modulation Amplitude and Power

- Intrinsic safety requires to take the maximum forward voltage at the maximum current (380 mA) of each clamping diode into account (e.g. 0.8 V).
- As the diodes may not significantly disturb the low energy communication signal the allowed diode forward voltage for not relevantly influencing the communication signal is much lower (e.g. 0.25 V).
- Assuming full duplex bidirectional communication, the voltage at the inductors is double the voltage on the line.
- For each 1 V of signal voltage on the line, therefore 4 diodes (with a forward voltage drop of 0.25 V) are needed, causing a clamping voltage of 3.2 V, which the supply voltage has to be reduced to stay intrinsically safe.
- The following table provides information on the maximum power which could be provided, depending on the number of clamping diodes:

Signal amplitude	Clamping diodes in series	Available field device power (low power devices)
0.5 V_{pp} (±0.25 V)	2 Diodes	700 mW
1.0 V_{pp} (±0.50 V)	**4 Diodes**	**500 mW**
2.0 V_{pp} (±1.00 V)	8 Diodes	125 mW

Summary

- IEC/EN 60079-11 standard does not allow a PHY IC to be used for protection measures according to this standard. Therefore the PHY IC itself does not need to contain any protection measures for intrinsic safety.
- All power and signal lines to and from the PHY need to provide a current limitation to prevent un-allowed heating of the PHY IC in case of an internal fault.
- External limiting resistors respective termination resistors within the signal lines are required to support intrinsically safe applications.
- To be able to maximize the supply energy for a connected field device, the communication signal amplitude needs to be limited.

Thank You