General Purpose Single Pair Ethernet for Process Instruments

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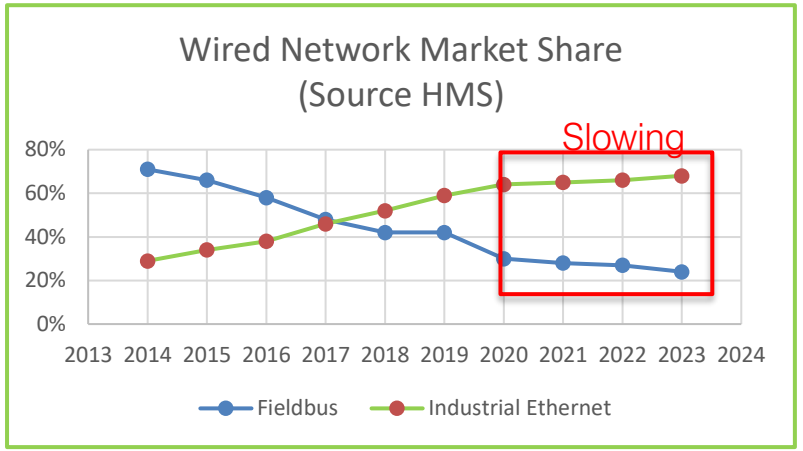
Abstract

ODVA has demonstrated industry leadership in Single Pair Ethernet (SPE) solutions. External promotion included liaison with IEEE P802.3cg project, and active stakeholder position in the APL Project. Domain-specific specification EtherNet/IP enhancements include an “In-cabinet” SPE solution (motor control components), and “Ethernet-APL” (process instruments for hazardous locations). Further specification enhancements are underway in the EtherNet/IP Physical Layer Special Interest Group for “GPSPE” (general purpose SPE). One intent of GPSPE is to utilize 10BASE-T1L to extend SPE use cases - by reaching out from inside the cabinet and into non-hazardous field locations. Another intent of GPSPE is to reference existing/emerging SPE standards rather than invent new technology. GPSPE will be useful to expand the application space of EtherNet/IP for constrained devices across industrial domains (discrete, hybrid, and process automation) – reducing the end-device electronics and field cabling. This paper discusses use cases and benefits when utilizing GPSPE with new Process Instruments. This paper also discusses minor changes that allow – EtherNet/IP end-devices using Ethernet-APL to interoperate with other GPSPE devices.

Evolution of Industrial Ethernet

- Industrial Ethernet is *displacing* fieldbus
  - Including device networks and sensor networks
- Some displacement is <u>difficult</u> for multipair Ethernet
  - Limited distance (100 m) and not intrinsically safe
  - Escalating cost, size, and power (i.e., migration to 1 Gb/s over four-pairs)
- Industrial SPE (IEEE Std 802.3cg-2019) emerged as a response!
  - 10BASE-T1L for Ethernet-APL long distance (1000 m) and intrinsic safety
  - 10BASE-T1S to achieve a lowest cost solution



Why continue the trend?

<u>Fieldbuses</u>
- Multiple network types
- Technologies not familiar to graduates
- Limited data flow (gateways)
- Lack of security

<u>Industrial Ethernet with SPE</u>
- Single network type
- Ethernet is familiar
- Free flow of information
- Security

Published ODVA Specifications Leveraging SPE

- ODVA leadership in SPE
  - IEEE 802.3 liaison
  - Stakeholder in the APL Project

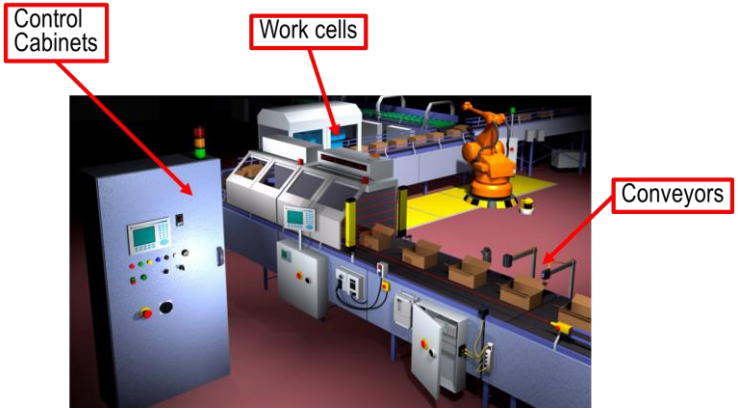
- Domain-specific EtherNet/IP specification using SPE:
  - Chapter 8-10 Industrial EtherNet/IP **In-cabinet Bus** Media and Physical Layer
  - Chapter 8-11 EtherNet/IP Media and Physical Layer for **Ethernet-APL** (Ethernet Advanced Physical Layer)

- Dramatic wire reduction
- Low component cost
- Add intelligence

- Long distance > 1000 m
- Intrinsic Safety requirement
- Legacy single pair cables
- Communication + power

ODVA General Purpose SPE (GPSPE) Initiative

- EtherNet/IP Physical Layer Special Interest Group is developing an EtherNet/IP Specification Enhancements (ESEs) for General Purpose SPE (GPSPE)
- Expand the application space of EtherNet/IP
  - Discrete, hybrid, and process automation
  - **Reduced edge-device electronics and field cabling**
- "General purpose" **references** SPE standards **rather than invent** new technology
  - IEEE (10BASE-T1L), ISO/IEC, ANSI/TIA
- On-going effort - subject to change

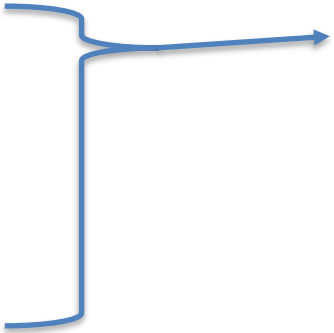


- GPSPE reaches from the cabinet and into non-hazardous field locations
- Ethernet-APL reaches from the cabinet and into hazardous locations

Relation of GPSPE to EtherNet/IP for Constrained Devices

EtherNet/IP for Constrained Devices

- Reduced Physical Layer
  - Cabling
  - Connectors
  - Coupling circuit
  - EMC protection
  - SPI MAC/PHY interface
- Reduced protocol stack
  - Less FLASH and RAM for smaller MCUs
  - Transport (UDP-only)
  - Security (DTLS-only)



GPSPE

- A reduced Physical Layer
- Can be used with a reduced protocol stack

GPSPE Power Classes

- References IEEE Std 802.3-2022 Clause 104 (PoDL)
- PSE and PD are Type E
- Classes are 10-15
  - Added for long reach (1000 m) and industrial usage
  - Classes 0-9 exist primarily for short reach (15 m) and automotive usage
- Both Plug and Play and Engineered power are under consideration

Source: IEEE Std 802.3-2022

Table 104–2—Class power requirements matrix for PSE, PI, and PD for classes 10 through 15

Class	10	11	12	13	14	15
$V_{PSE(max)}$ (V)	30	30	30	58	58	58
$V_{PSE\_OC(min)}$ (V)	20	20	20	50	50	50
$V_{PSE(min)}$ (V)	20	20	20	50	50	50
$I_{PI(max)}$ (mA)	92	240	632	231	600	1579
$P_{class(min)}$ (W)	1.85	4.8	12.63	11.54	30	79
$V_{PD(min)}$ (V)	14	14	14	35	35	35
$P_{PD(max)}$ (W)	1.23	3.2	8.4	7.7	20	52

Wet environments and typical industrial voltages

More power over longer distance with smaller wires

GPSPE Use Cases for Process Instruments

- Non-hazardous process applications are prevalent
- Process Skids
  - Specialty OEM modules
  - Shipped to a site
  - Interconnected via piping and supervisory communication to perform a series of production functions
  - Distances are short
  - OEM applications are often cost-sensitive
- Life Sciences, Food and Beverage, and Water and Wastewater
  - Plantwide automation (areas and lines), may include skids
  - Distances fall between skids and large plants

GPSPE Use Cases for Process Instruments

- The introduction of SPE (Ethernet-APL) is driving all instruments toward Ethernet connection in hazardous location

- Harmonization on a full suite of EtherNet/IP instruments has these advantages:
  - Fast update
  - Reduction of gateways
  - Reduction of cabling – single pair with power
  - Increased information capability from instruments
  - Multiple measurements from the same instrument

- Instruments in non-hazardous areas:
  - Limited set of EtherNet/IP instruments + HART instruments
  - Traditional 2-wire instruments not available as EtherNet/IP

➢ GPSPE could drive all instrument types toward Ethernet connection in non-hazardous areas

Example Instrument Types

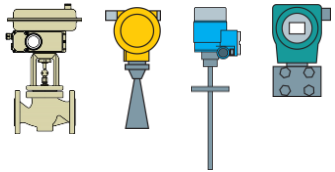
Flow

Level

Pressure

Temperature

Liquid Analysis



Comparison of GPSPE with Ethernet-APL for Process Instruments

GPSPE (subject to change)	Ethernet-APL (published specification)
Physical Layer for EtherNet/IP	Physical Layer for EtherNet/IP
10BASE-T1L (initial PHY)	10BASE-T1L
Non-hazardous locations	Hazardous locations
No extra IS hardware	Extra hardware for IS protection
Plug-and-play power (device detection, voltage/power negotiation) Engineered power option	Engineered power (directly applied)
60 Vdc tolerance (from 10BASE-T1L)	60 Vdc requirement precluded, must operate up to 15 Vdc
Classes 10-12, 30 Vdc, up to 8.4 W Classes 13-15, 58 Vdc, up to 52 W	9-15 Vdc, 0.5 W or 1 W
Connectors and bulkheads	Terminal blocks and cable glands
No IS certification or marking	IS certification and marking

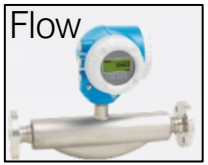
Intrinsic Safety Comparison of GPSPE and Ethernet-APL

- *Intrinsic safety fault protection adds cost*
- Cost factors:
  - Redundant protection hardware
  - Agency certification

➢ GPSPE will have no intrinsic safety cost

▪ Devices (especially switches) will be more cost effective

- *Intrinsic safety limits field device power*
- Ethernet-APL: 0.5 W (Ex ia) or 1 W (Ex ic) @ 15 Vdc
- More power benefits some instruments
  - Separate power cable is undesirable
  - Higher power budget is desirable

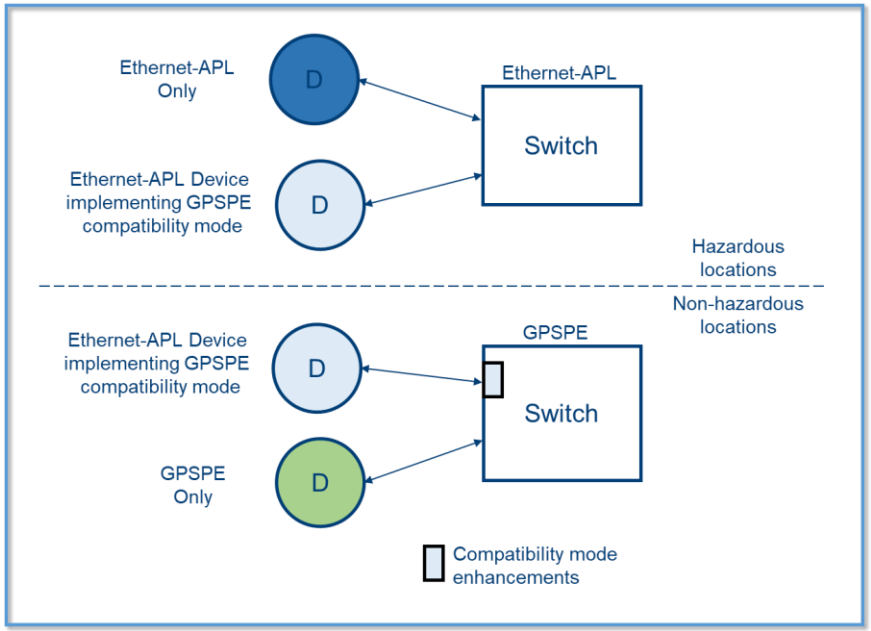


➢ GPSPE will have no intrinsic safety power restriction

- GPSPE is expected to specify PoDL (Power over Data Line) Classes 10,11 and 12
  - 30 Vdc at up to 8.4 W

Extension of GPSPE with Ethernet-APL Devices

- Vendors are preparing Ethernet-APL Field Devices for market
- There is advantage in enabling these devices to attach to GPSPE
  - Ethernet-APL hardware/firmware re-use
  - Faster GPSPE launch
- Ethernet-APL and GPSPE are both EtherNet/IP over 10BASE-T1L, but the power systems are different
- GPSPE could include a compatibility mode that allows operation within both systems



Harmonizing GPSPE and Ethernet-APL Power

- PoDL PSE (Power Source Equipment) does not supply full voltage unless a PD (Powered Device) is present on the link
  - Detection:
    - PSE sources a low voltage - PD draws a specified specific current if present
    - PSE is pre-configured to supply a specific power Class
  - Classification:
    - Serial protocol detections PD and negotiates power Class negotiation without pre-configuration

- Ethernet-APL power source directly applies power
  - PoDL circuitry is not intrinsically safety and reduces limited Ethernet-APL power

- "PoDL-bypass" is simple method to power Ethernet-APL devices in GPSPE
  - PSE is pre-configured to provide full voltage without Detection or Classification.
  - PSE utilizes PoDL coupling circuit and a subset of the state machines

SDO alignment may be possible

PoDL-bypass Considerations – Device Damage

- Ethernet-APL devices for GPSPE must operate from and tolerate at least 30 Vdc

- GPSPE PoDL-bypass pre-configured voltage could be specified as 30 Vdc and/or 58 Vdc
  - It is important to prevent damage

- GPSPE PoDL is expected to support both voltages and to retain the IEEE requirement for 10BASE-T1L is to tolerate up to 60 Vdc
  - GPSPE devices would never be damaged by direct application of 58 Vdc

- Ethernet-APL Field Switches supply Class A and C power at 15 Vdc and Field Devices are not required to tolerate 60 Vdc
  - Damage could occur even at 30 Vdc

PoDL-bypass Considerations - Voltage Selection

- It is proposed that GPSPE specify a PoDL-bypass option for Classes 10, 11 and 12 (30 Vdc)
  - An Ethernet-APL device could be powered in a GPSPE system - if it operates from and tolerates 30 Vdc

- Factors in voltage selection:
  - Limiting pre-configuration to 30 Vdc could preclude damage
  - 8 W is considered adequate
  - Class 12 voltage drop across a 200 m cable is reasonable
    - 9.5 Ω loop resistance / 400 m loop = 0.024 Ω/m (i.e.,18 AWG)
  - 58 Vdc operation/tolerance increases component ratings, size, and heat dissipation
  - Additional qualification and installation restrictions may also apply when exceeding 50 V due to potential shock hazard - especially true for wet installations

PoDL-bypass Considerations - Misapplication

- Instruments should not be used outside their intended location (hazardous or non-hazardous)

- The possibility of misapplication is reduced by:
  - Packaging and labelling without hazardous area approval markings
  - Avoiding reuse of the Ethernet-APL specified M8 and M12 connectors

Conclusions

- GPSPE continues the trend of using SPE to displace fieldbus, sensor, and device networks - and enabling networking of hardwired devices and point-point links

- A complete portfolio of EtherNet/IP instruments is desirable
  - Hazardous locations (Ethernet-APL)
  - Non-hazardous locations (GPSPE)

- GPSPE is anticipated to bring advantages to Process Instruments in non-hazardous locations:
  - Reduced wiring
  - Lower cost by eliminating Intrinsic Safety
  - Significant power

- There is advantage in allowing Ethernet-APL instruments to be interoperable with GPSPE
  - They must be designed appropriately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