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 difficult 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?

**Fieldbuses**
- Multiple network types
- Technologies not familiar to graduates
- Limited data flow (gateways)
- Lack of security

**Industrial Ethernet with SPE**
- Single network type
- Ethernet is familiar
- Free flow of information
- Security

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Wired Network Market Share
(Source HMS)

**Slowing**
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
• 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

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

- Wet environments and typical industrial voltages
- More power over longer distance with smaller wires

Source: IEEE Std 802.3-2022
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
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.
# Comparison of GPSPE with Ethernet-APL for Process Instruments

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<td>10BASE-T1L</td>
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<tr>
<td>Connectors and bulkheads</td>
<td>Terminal blocks and cable glands</td>
</tr>
<tr>
<td>No IS certification or marking</td>
<td>IS certification and marking</td>
</tr>
</tbody>
</table>
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
    • 9.5Ω 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