Single-pair Ethernet, the future of industrial communications
10BASE-T1L IEEE 802.3cg single-pair Ethernet PHY
By the end of this webinar, you will learn:

- Where Ethernet fieldbuses exist in industrial applications today

- What is single-pair Ethernet and how it compares with standard Ethernet that exists today

- How single-pair Ethernet supports smart factories by moving data faster and farther than ever before

- What resources are available to help you along your design journey
Ethernet is an established, easy-to-use, robust, fast, price-competitive communication protocol that enables easy connection to internet (industry 4.0), scales from factory floor to enterprise and beyond.
Industrial and standard Ethernet in factory automation

- **Wireless Technologies**
  - Bluetooth
  - Wi-Fi
  - NFC

- **Wired Technologies**
  - IEEE TSN
  - PROFINET
  - EtherCAT
  - Ethernet/IP

- **Process Automation**
  - Fieldbus
  - Point to point
  - Wireless Sensors

- **Factory Automation**
  - Industrial Ethernet
  - Fieldbus
  - 4-20 mA
  - HART
  - TD-link

- **Motion and Robotics**
  - Industrial Ethernet
  - Multi-axis Drive
  - Motor integrated drive
  - conveyor belt with e.g. 16 motors
  - 6-axis robot arm

- **Control Level**
  - PLC
  - RIO
  - Gateway

- **Factory Level**
  - ERP
  - MES
  - Gateway

- **Field Level**
  - PLC

- **Time**
  - 100 ms
  - 1 ms
  - 31.25 μs

**Input Output Cycle Time**
Industrial and standard Ethernet in factory automation

- **Process Automation**
  - Sensor HUB
  - Industrial Ethernet
  - Gateway
  - Profibus PA
  - ASi
  - DeviceNet
  - Fieldbus
  - Wireless Sensors
  - 4-20 mA
  - Point to point

- **Factory Automation**
  - PLC
  - Industrial Ethernet
  - Gateway
  - RIO
  - RIO
  - Line
  - Wireless
  - NFC
  - Product

- **Motion and Robotics**
  - Motion
  - Vision
  - IPC
  - 6-axis robot arm
  - Multi axis Drive
  - 1-3 axis drive
  - Motor integrated drive conveyor belt with e.g. 16 motors

Input Output Cycle Time
- 100 ms
- 1 ms
- 31.25 us
What is single-pair Ethernet?

Single-pair Ethernet is Ethernet, but over a single twisted-pair of wires.

- Industry 4.0 / IIoT driving all parts of a system to “connectedness”
- Significant systems savings in copper and potential re-use of existing wiring harnesses
- DP83TD510 supports power over data line (PoDL), APL power, and intrinsic safety
Single-pair Ethernet benefits over field buses

- Constant bandwidth with cable reach
- Low power dissipation
- Secured communication
- Reduced gateways for cloud connectivity
- Reduced cable weight & cost
- Re-use of existing two-wire cable infrastructure
- Small form-factor
- Shortened firmware development cycles
  - TCP/IP based socket programming

<table>
<thead>
<tr>
<th>Field bus</th>
<th>Longest reach</th>
<th>Highest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFIBUS DP</td>
<td>9.6Kb/s @ 1200m</td>
<td>12Mb/s @ 100m</td>
</tr>
<tr>
<td>CANopen</td>
<td>10Kb/s @ 5000m</td>
<td>1Mb/s @ 20m</td>
</tr>
<tr>
<td>Modbus RTU</td>
<td>100Kb/s @ 1200m</td>
<td>2Mb/s @ 50m</td>
</tr>
<tr>
<td>CC-Link</td>
<td>156Kbps @ 1.2km</td>
<td>10Mb/s @ 100m</td>
</tr>
<tr>
<td>HART</td>
<td>1200 baud @ 1524m (24AWG)</td>
<td>No enhanced rate</td>
</tr>
<tr>
<td>PROFIBUS PA</td>
<td>31.25Kb/s @ 1900m</td>
<td>No enhanced rate</td>
</tr>
<tr>
<td>INTERBUS</td>
<td>500Kb/s @ 400m</td>
<td>No enhanced rate</td>
</tr>
<tr>
<td>IEEE802.3cg 10BASE-T1L</td>
<td>10Mb/s @ 200m (1V)</td>
<td>No enhanced rate</td>
</tr>
<tr>
<td></td>
<td>10Mb/s @ 1000m (2.4V)</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.3bw 100BASE-T1</td>
<td>100Mb/s @ 50m</td>
<td>No enhanced rate</td>
</tr>
<tr>
<td>IEEE 802.3bp 1000BASE-T1</td>
<td>1000Mb/s @ 15m</td>
<td>No enhanced rate</td>
</tr>
</tbody>
</table>
Industry 4.0 over existing wires

In many cases, new wire does not need to be pulled – existing cabling can be used for SPE

- Process automation
- Building automation
- Factory automation (IO-Link upgrade)

Need both long distance and short distance, single drop and multi-drop

<table>
<thead>
<tr>
<th>Fieldbus</th>
<th>Cable Type</th>
<th>Cable Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation H1</td>
<td>FF-844 specified</td>
<td>Yes</td>
</tr>
<tr>
<td>HART</td>
<td>Various</td>
<td>Yes</td>
</tr>
<tr>
<td>Profibus PA</td>
<td>IEC 61158 Type A</td>
<td>Yes</td>
</tr>
<tr>
<td>4-20 mA</td>
<td>SP-50 instrumentation cable</td>
<td>Yes</td>
</tr>
<tr>
<td>CANopen</td>
<td>EIA-485</td>
<td>Yes</td>
</tr>
<tr>
<td>Modbus RTU</td>
<td>EIA-485</td>
<td>No</td>
</tr>
<tr>
<td>CC-Link</td>
<td>CC-Link, Ver.1.10 specified shielded, 3- &amp; 5- core</td>
<td>No</td>
</tr>
<tr>
<td>DeviceNet</td>
<td>ODVA DeviceNet specified (5-core, various classes)</td>
<td>Yes</td>
</tr>
<tr>
<td>ControlNet</td>
<td>RG-6/U Coaxial</td>
<td>No</td>
</tr>
<tr>
<td>INTERBUS</td>
<td>3 / 6 no. twisted pairs, various</td>
<td>Yes</td>
</tr>
<tr>
<td>PROFIBUS DP</td>
<td>IEC 61158 Type A</td>
<td>No</td>
</tr>
</tbody>
</table>
Long reach Ethernet applications

Process automation
- Field instrumentation
  - Flow sensors
  - Level sensors
  - Pressure sensors
  - Temp sensors
  - Loggers
  - Field switches

HART + Other field buses $\rightarrow$ T1L Ethernet

Building automation
- Fire alarm control
- HVAC control
- Elevators
- Security controls

RS485 $\rightarrow$ T1L Ethernet

Factory automation
- Sensors
- Valves
- Encoders
- Motor starters
- Robotics

Various field buses $\rightarrow$ T1L Ethernet
Application example | Elevator communications

• Elevators require traveling cable for communications

• Both length and bandwidth limited

• New features pushing requirements

• SPE enables retrofitting, and future architectures

Existing infrastructure

Elevator controller
Traction Inverter

Travelling cable with CAN/LonWorks
Length up to 500 m
<500kbps

Up to 10 nodes
CAN

Sensors
Car operating panel
Door motor controller

Elevator Car

Elevator controller
Traction Inverter

4 U
Traction Inverter

Media converter

(4 pair to single pair Ethernet)

Travelling cable with CAN/LonWorks
Length up to 500 m
Upto 10 Mbps

Elevator Car

Elevator controller

Machine room
## TI’s Ethernet PHY key devices

<table>
<thead>
<tr>
<th>Standard ENET</th>
<th>1 GbE PHY</th>
<th>10/100 Mbps</th>
<th>1 GbE PHY</th>
<th>Single Pair ENET</th>
<th>10 Mbps</th>
<th>10 Mbps</th>
<th>10 Mbps</th>
<th>10 Mbps</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DP83869</strong> RGMII / SGMII</td>
<td>• Cu/Fiber, Robust, Media Converter, Bridge, Supports TSN</td>
<td>• Supports TSN</td>
<td>• Low latency, low jitter → real-time industrial Ethernet</td>
<td>• Small</td>
<td>• Single supply</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Cu/Fiber, Robust, low power</td>
</tr>
<tr>
<td><strong>DP83867</strong> RGMII / SGMII</td>
<td>• Supports TSN</td>
<td>• Low latency, low jitter → real-time industrial Ethernet</td>
<td>• Pin-to-pin with competitor</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83822</strong> RGMII / RMII / MII</td>
<td>• Cu/Fiber, Robust, low power</td>
<td>• Long cable reach</td>
<td>• Pin-to-pin with competitor</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83848</strong> RGMII / SGMII</td>
<td>• Low latency, low jitter → real-time industrial Ethernet</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83826</strong> RMII / MII</td>
<td>• Low latency, low jitter → real-time industrial Ethernet</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83825</strong> RMII</td>
<td>• Small</td>
<td>• Single supply</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83T510 (10BASE-T1L)</strong></td>
<td>• RMII / MII</td>
<td>• Low Power</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83TG720 (1000BASE-T1)</strong></td>
<td>• SGMII / RGMII</td>
<td>• P2P w/ DP83TC811</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DP83TC811 (100BASE-T1)</strong></td>
<td>• SGMII / RGMII / RMII / MII</td>
<td>• Low Latency</td>
<td>• Long Cable Reach</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td>• Pin-to-pin with competitor</td>
<td></td>
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</tr>
</tbody>
</table>

### Status
- **Production**
- **Pre-Production**
DP83TD510 IEEE 802.3cg – low power, long reach
Single twisted-pair Ethernet PHY (10BASE-T1L)

Features

• Very Low Power consumption (45mW)

• Cable reach: 1000 meter, 200 meter. Strap configurable modes
  • Cable Reach Extender Support, >1000 meters Cable Reach
  • MDI Amplitude Level: 2.4v p2p (1000 meter) or 1v p2p (200 meter)

• Robust
  • 8 kV HBM ESD Protection on MDI lines
  • Industrial Temperature Range support: -40 to 105C
  • MDC/MDIO Interface

• Diagnostics:
  • Active Link Cable Diagnostics
  • TDR Based Open and Short
  • Built In Packet Generator
  • IEEE Test Mode Support

Benefits

• Supports Ethernet-APL intrinsic safety implementation

• Flexible cable lengths, reduced cabling costs or cable reuse

• Assures performance in harsh environments

• Simplifies maintenance & lowers costs

Applications

• Factory Automation: PLC and IO Communication modules

• Process Automation: Sensor Nodes, Field Switches, Transmitters

• Building Automation: HVAC Controls, Fire Safety, Escalators
DP83TD510 IEEE 802.3cg – low power, long reach
Single twisted-pair Ethernet PHY (10BASE-T1L)

- Power consumption results

<table>
<thead>
<tr>
<th>Specification</th>
<th>Config. 1</th>
<th>Config. 2</th>
<th>Config. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature</td>
<td>1V p2p, 200 meters</td>
<td>1V p2p, 200 meters</td>
<td>2.4V p2p, 1000 meters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1V p2p, 200 meters</td>
</tr>
<tr>
<td>AVDD</td>
<td>1.8V</td>
<td>1.8V, 1V</td>
<td>3.3V</td>
</tr>
<tr>
<td>VDDIO</td>
<td>1.8V</td>
<td>1.8V</td>
<td>1.8V</td>
</tr>
<tr>
<td>Status</td>
<td>Target</td>
<td>Measured</td>
<td>Target</td>
</tr>
<tr>
<td>Typical Power Dissipation (25C)</td>
<td>70mW</td>
<td>52 mW</td>
<td>65mW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
DP83TD510 IEEE 802.3cg – low power, long reach
Single twisted-pair Ethernet PHY (10BASE-T1L)

<table>
<thead>
<tr>
<th></th>
<th>1V p2p</th>
<th>2.4V p2p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable</td>
<td>Auto-Neg</td>
<td>Force Mode</td>
</tr>
<tr>
<td>#1</td>
<td>1.2 km</td>
<td>1.7 km</td>
</tr>
<tr>
<td>#2</td>
<td>300 meters</td>
<td>550 meters</td>
</tr>
</tbody>
</table>

Tested across temperature

[Image of circuit board and cables]
Summary

• DP83TD510E 10BASE-T1L IEEE 802.3cg PHY:

  – Exceeds standards’ specifications, enabling data to travel faster and farther

  – Eases upgrade by supporting reuse of existing cabling where possible, and migration to more economical copper where fibre has been used before

  – Mitigates the need for protocol conversion by gateways
Key features:

1. Media Convertor
2. Option to use on board LDO or external Power Rails
3. MDI : Terminations and CMC on the board.
4. RGMII/MII/RMII interface on the connector
5. Jumpers for strapping
Single-pair Ethernet tools

IEEE 802.3cg / 10BASE-T1L:
- Product Folders / Datasheets DP83TD510EVM DP83TD510E-EVM

IEEE 802.3bw / 100BASE-T1:
- Product Folders / Datasheets DP83TC811R DP83TC811S EVM DP83TC811EVM

IEEE 802.3bp / 1000BASE-T1:
- Product Folders / Datasheets DP83TG720SS EVM DP83TG720EVM

Additional resources
Single-pair Ethernet
- Low-power operation
- Diagnostic toolkit
- Systems and reference schematics for configurable MAC interfaces
- Compliance & debug
- How 10Base-T1 single-pair Ethernet PHYs help bring more data farther in long-distance applications technical article
- Extend network reach with IEEE 802.3cg 10BASET1L Ethernet PHY application report
- Previous new product webinar: Industrial Ethernet

Development Support
- EVM GUI
- Linux drivers
- Ethernet schematic checklists
- E2E™ support forums
- Technical articles > Industrial

Learning Tools
- TI training and videos
- Engineering thought leadership

TIDA-010076: Daisy-chained power and data over single-pair Ethernet (T1)
TIDA-01020: Automotive domain controller for gateway, assisted & automated driving systems
Visit www.ti.com/npu

For more information on the New Product Update series, calendar and archived recordings
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