Simplifying Smart Industrial Connectivity with Single Pair Ethernet

Introduction

As the industrial internet of things (IIoT) continues evolving in real time, it's actively illustrating the benefits of intelligent, connected equipment. In a similar way, the industrial metaverse — which uses digital twins to virtually replicate those smart industrial systems — is demonstrating tremendous value in how it enables simulated 3D testing prior to full-scale production. These pre-emptive assessments help engineers evaluate the impact of planned designs and manufacturing strategies in great detail, facilitating proactive adjustments that can dramatically reduce incurred costs and time to market.

Both of these Industry 4.0 ecosystems are interrelated: Cloud-based artificial intelligence (AI) models influence real-life decisions on the factory floor, while data gathered by smart factory equipment helps industrial metaverse models to continue refining their accuracy. A critical piece tying both of these worlds together is sensing technology, which serves as the virtual eyes and ears that inform process improvements.

Unfortunately, most industrial sensors currently reside on non-Ethernet fieldbuses situated at the outer edge of these systems. To help interdependent Industry 4.0 technologies attain their full potential, a more streamlined and efficient means of sensor-to-cloud connectivity is needed — and that's where Single Pair Ethernet (SPE) technology is changing the game.

Addressing Last Things First

Today's logistics industry has identified a dynamic known as the "last mile" delivery challenge. In terms of the total distance a product travels to reach a customer, the last leg from warehouse to doorstep is susceptible to a variety of unpredictable issues including traffic jams, road construction, detours and inclement weather. These factors can introduce substantial delays that impact cost and customer satisfaction. In fact, it's estimated that this final trek accounts for more than 50% of total delivery expenditure.

The same analogy applies to industrial Ethernet networks like the metaverse. Key elements such as production cells, manufacturing execution systems (MES) and machine-level controls typically connect to the cloud via transmission control protocol/internet protocol (TCP/IP)-based Ethernet technology. Yet these systems normally rely on sensors and actuators that are individually wired to a separate fieldbus, which transmits data via Ethernet through a bridge or gateway. Carrying data to these distributed network extremities usually means relying on a plethora of cabling, connector and hardware providers, plus extra programming. This can result in unpredictable expenses deemed "last meter" costs, which can limit the implementation of smart technologies.

Shifting to SPE

SPE is uniquely poised to resolve this last meter issue, because it utilizes a *single* twisted pair instead of two or more. This significant wire reduction decreases the weight and diameter of SPE cables, which are also exceptionally flexible for easier routing. This facilitates more data and power across fewer and lighter wires than preceding technologies.

SPE also employs compact connector receptacles, while supporting cable runs that are 10 times longer than industrial Ethernet. A single SPE cable can enable speeds up to 1 Gbps at up to 40m in length — and Power over Data Line (PoDL) delivery up to 50W. All this solves what has traditionally represented a

primary barrier to putting sensors on Ethernet networks: the physical space occupied by cables and connectors.

Additionally, SPE is optimized for harsh industrial environments. The baseline T1 SPE IP20 cabling system features an IP20 protection rating, an operating temperature range of -40°C to +85°C and the ability to withstand up to 1,000 mating cycles. For especially demanding conditions, the ruggedized M12 T1 SPE IP67 variant employs an IP67-rated connector designed by Molex.

Enhancing Success Through Standardization

Molex is highly involved in SPE connector design because SPE's importance to IIoT efficiency is exceedingly clear. Molex is also a premium member of the SPE Industrial Partner Network for that same reason. This consortium, formed in 2019 and currently representing nearly 60 prominent cable and connector suppliers, helps oversee SPE standardization to avoid the fragmentation that has occurred with previous industrial network communication approaches. Toward this end, the SPE Industrial Partner Network collaborates with an array of influential standards committees, including:

- IEEE 802.3 – transmission methods
- IEC SC46C – symmetrical copper cables
- IEC SC 48B – connectors
- ISO/IEC JTC 1/SC 25/WG3 – wiring
- IEC SC65C – industrial networks
- ANSI/TIA TR-42 – cabling systems

IEEE = Institute of Electrical and Electronics Engineers
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
ANSI = American National Standards Institute
TIA = Telecommunications Industry Association
JTC = Joint Technical Committee

These purposeful standardization initiatives are already positioning SPE as a premier Industry 4.0 network architecture by:

1. Eliminating the costly need for additional interfaces across existing Ethernet environments
2. Supporting efficient consolidation of fragmented legacy networks to facilitate smoother communication and faster response times
3. Enabling the seamless connection of smart sensors, valves, actuators, drives, control panels and more

Conclusion: Focusing on the Future

As Industry 4.0 keeps advancing and smart industrial environments follow suit, SPE is making robust industrial interconnectivity and cloud-to-device communication easier. Implementing SPE helps facilitate:

- Faster data speeds over longer distances, with a reduced number of wires
- Simplified, end-to-end Ethernet connectivity and TCP/IP-based communication
- Optimized performance in harsh-duty environments

The Molex SPE product portfolio includes off-the-shelf and prefabricated cable assemblies, plugs, jacks and field attachable connectors with leading-edge capabilities that continue to evolve. TTI stocks all these Molex offerings in its 3.5 million square feet of dedicated warehouse space — not to mention other Molex industrial automation solutions such as cordsets, EtherNet/IP harsh I/O modules, network

interface cards, harsh-duty unmanaged Ethernet switches, Brad industrial Ethernet products, Ultra-Lock (M12) Ethernet receptacles and more. These innovations as well as SPE are helping design engineers create an IIoT and industrial metaverse that are more agile, adaptable and effective than ever.

# # #