Study of the Ethernet-APL Communication Standard: A New Revolution for Industrial Automation

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SUMMARY

The accelerated digital transformation of industrial automation, driven by Industry 4.0 and the Industrial Internet of Things (IIoT), has increased the demand for communication systems capable of providing high-speed, reliable, and secure connectivity in harsh industrial environments. Traditional industrial communication protocols, such as PROFIBUS-PA, HART, and Modbus, have been widely used in process industries; however, these technologies present limitations regarding bandwidth, interoperability, and integration with modern Ethernet-based infrastructures. In this context, Ethernet-APL (Advanced Physical Layer) emerges as a promising solution for process automation, especially in hazardous and classified industrial areas.

This study presents a comprehensive analysis of the Ethernet-APL communication standard, highlighting its technical characteristics, operational principles, advantages, and practical applicability in industrial automation systems. Ethernet-APL is based on the IEEE 802.3cg (10BASE-T1L) standard, enabling Ethernet communication over a single twisted pair of wires with distances reaching up to 1000 meters. In addition to data communication, the same cable can simultaneously provide power to field devices through Power over Data Lines (PoDL), significantly reducing infrastructure complexity and installation costs.

One of the main contributions of Ethernet-APL is its suitability for hazardous environments. The technology incorporates intrinsic safety concepts defined in the IEC TS 60079-47 standard, also known as 2-WISE (Two-Wire Intrinsically Safe Ethernet), ensuring safe operation in explosive atmospheres commonly found in oil and gas, chemical, pharmaceutical, mining, and food industries. By limiting the available electrical energy in communication circuits, Ethernet-APL minimizes ignition risks while maintaining reliable real-time communication.

The paper also discusses the principal technical features of Ethernet-APL, including 10 Mbps full-duplex communication, extended communication range, interoperability with industrial Ethernet protocols such as PROFINET and EtherNet/IP, and support for multiple industrial network topologies. The adoption of PAM-3 modulation and compatibility with existing fieldbus cabling further contribute to the practicality and scalability of Ethernet-APL implementations.

To validate the applicability of the technology, a practical case study involving temperature monitoring in an industrial automation environment was conducted. The experimental setup included a PT100 temperature sensor connected to an Ethernet-APL-compatible temperature transmitter integrated into a programmable logic controller (PLC) network through an Ethernet-APL field switch. The communication infrastructure employed a single pair of wires for both power supply and data transmission. Results demonstrated stable and reliable communication at 10 Mbps over distances close to 800 meters, confirming the feasibility of Ethernet-APL for long-distance industrial applications. Additionally, the use of industrial configuration software enabled simplified parameterization, diagnostics, and remote monitoring of field devices.

The study concludes that Ethernet-APL represents a major advancement in industrial communication systems by combining Ethernet performance, intrinsic safety, long-distance communication, and simplified infrastructure into a unified standard. Its adoption enables greater interoperability between Information Technology (IT) and Operational Technology (OT), supporting the transition toward fully connected smart factories and digital industrial ecosystems. Despite challenges related to implementation costs and migration from legacy systems, Ethernet-APL demonstrates significant potential to become a key enabling technology for future industrial automation applications, particularly in sectors requiring robust and secure communication in classified areas.

Next steps in research on Ethernet-APL should include an in-depth analysis of its performance in real production environments, especially in different types of hazardous areas. Studies on the energy consumption of the system are also necessary, considering that energy efficiency is a critical factor for sustainability in industrial environments.

Another point to be investigated is the interoperability with traditional industrial systems. Although Ethernet-APL offers a path for the modernization of industrial networks, integration with existing technologies may require intermediate solutions, such as the use of gateways.