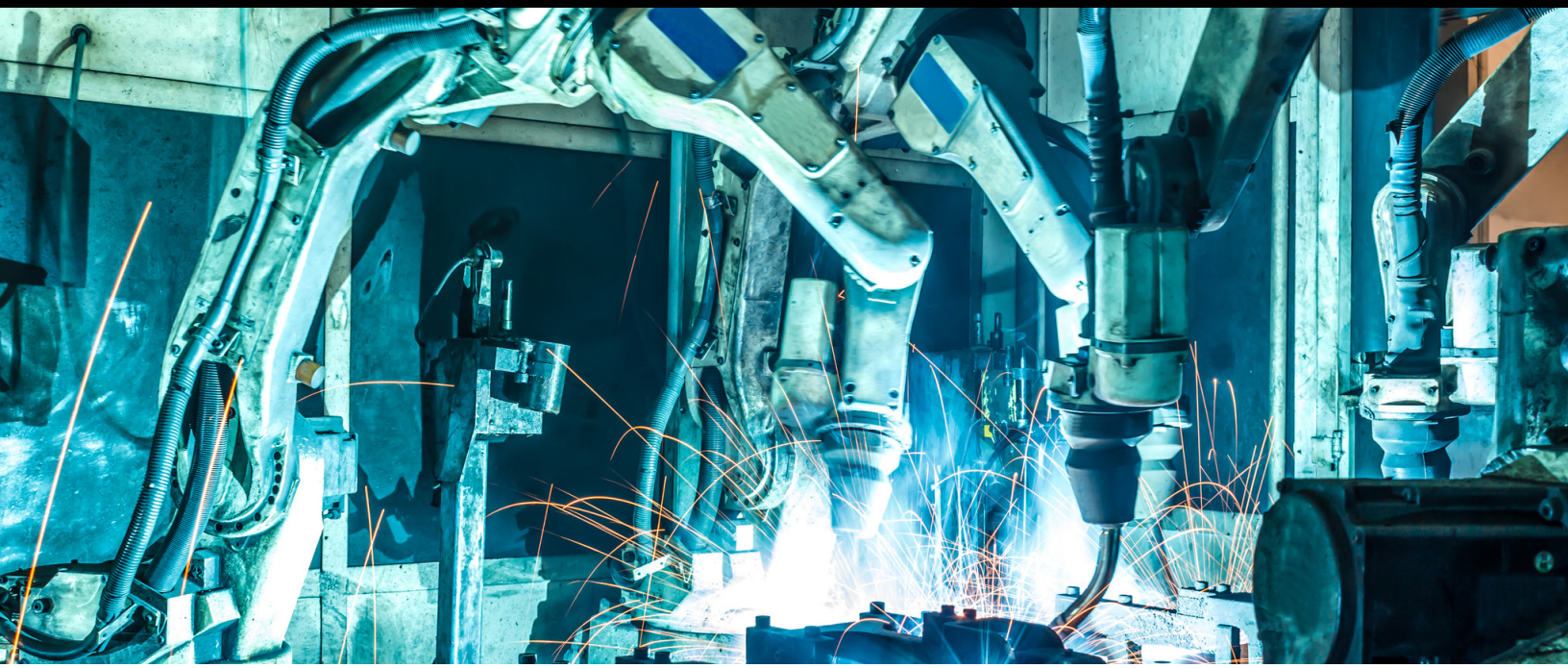
IEEE SA STANDARDS ASSOCIATION

TSN FOR INDUSTRIAL AUTOMATION

IEEE 802 Standards for Time-Sensitive Networking



Network Convergence for Industrial Automation Requires Time-Sensitive Networking (TSN)

IEEE 802.1 Time-Sensitive Networking (TSN) is an enabler of network convergence, which is required in industrial automation, e.g., for Industry 4.0 and smart factories of cyber-physical systems. TSN provides connectivity and real-time quality of service to time and mission-critical industrial applications. TSN is the foundation for converged networks of operations technology and information technology by supporting multiple independent applications in a single standard Ethernet network to provide real-time communication on the same infrastructure (cables, bridges). Even more, TSN provides a common management scheme and converged security via open standards, which is essential for interoperability, automation of network management (potentially facilitated by a digital twin of the network), etc.

The IEEE Standards Association (IEEE SA) and the International Electrotechnical Commission (IEC) have established the IEC/IEEE 60802 Joint Project to develop the IEC/IEEE 60802 "Time-Sensitive Networking Profile for Industrial Automation".

This Joint Project brings industry and networking experts together to specify the use of TSN for industrial automation.

By selecting TSN features, a common management scheme, converged security, and defaults, the IEC/IEEE 60802 standard will benefit vendors offering and/or developing TSN products as well as industrial automation technology users.

TSN Time-Sensitive Networking
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For more information on the IEEE 802.1 Working Group, visit ieee802.org/1

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TSN FOR INDUSTRIAL AUTOMATION

SECURE CONVERGED NETWORKS IN SMART FACTORIES

TSN provides guaranteed data transport with bounded low latency, bounded low jitter and zero congestion loss.

- **TIME SYNCHRONIZATION:** IEEE 802.1AS maintains synchronized time (+/- 1 µsec worst case in this application) end-to-end, i.e., including the devices running the control applications. Time synchronization is the basis of multiple TSN Quality of Service (QoS) solutions, e.g., time-based scheduling.
- **BOUNDED LOW LATENCY:** TSN includes multiple solutions to provide bounded low latency, e.g., time-scheduling, preemption, and traffic shaping mechanisms. Time synchronization and TSN QoS solutions can reduce packet delay variation (jitter).
- **RESOURCE MANAGEMENT:** Standardized management for bridges and end stations allows network convergence via standard protocols, data models, and interfaces. This allows dedicating resources for time and mission critical traffic.
- **ZERO CONGESTION LOSS:** TSN provides zero congestion loss via its bounded low latency and resource management solutions.
- **HIGH AVAILABILITY/ULTRA-RELIABILITY:** TSN provides ultra reliability and high availability in the network for seamless communication over redundant paths (frame replication and elimination), protection from errant devices (ingress policing), and backup for network timing.
- **SECURITY MANAGEMENT:** Standardized common solutions for authentication of installed devices, segregation of traffic types and flows between authorized devices, message integrity, and authenticity are possible.
- **CONVERGED NETWORK:** TSN supports multiple traffic classes that may have very different requirements. Thus, control data traffic in real-time and multiple independent applications using the same network can be managed and carried together with best-effort traffic in the same network infrastructure, increasing the economic feasibility of the network.
- **INTEROPERABILITY:** TSN leverages the benefits of existing IEEE 802.3 Ethernet, e.g., diagnostics, multiple link speeds and precise timestamping. A common information model for the network resources enables common TSN engineering and diagnostics. The harmonized interfaces and the protocols for stream setup support interoperability. Variants are limited by the IEC/IEEE 60802 TSN profile for industrial automation to enable multi- vendor networking interconnecting the different bus types used in end stations.

For a complete list of TSN projects, visit ieee802.org/1/tsn

PROJECTS CURRENTLY IN PROGRESS

- **IEC/IEEE 60802** TSN Profile for Industrial Automation
- **IEEE P802.1Qdx™-**Draft Standard for Local and Metropolitan Area Networks–Bridges and Bridged Networks Amendment: YANG Data Models for the Credit-Based Shaper
- **IEEE P802.1ASdm™-**Draft Standard for Local and Metropolitan Area Networks–Timing and Synchronization for Time-Sensitive Applications Amendment: Hot Standby
- **IEEE P802.1ASdn™-**Draft Standard for Local and Metropolitan Area Networks–Timing and Synchronization for Time-Sensitive Applications Amendment: YANG Data Model

STANDARDS

- **IEEE 802.1CB™-2017** Standard for Local and Metropolitan Area Networks–Frame Replication and Elimination for Reliability
- **IEEE 802.1CBcv™-2021** Standard for Local and Metropolitan Area Networks–Frame Replication and Elimination for Reliability Amendment 1: Information Model, YANG Data Model and Management Information Base Module
- **IEEE 802.1CBdb™-2021** Standard for Local and Metropolitan Area Networks–Frame Replication and Elimination for Reliability Amendment 2: Extended Stream Identification Functions
- **IEEE 802.1Q™-2022** Standard for Local and Metropolitan Area Networks–Bridges and Bridged Networks
- **IEEE 802.1Qcw™-2023** Standard for Local and Metropolitan Area Networks–Bridges and Bridged Networks Amendment: YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing
- **IEEE 802.1Qdj™-2024** Standard for Local and Metropolitan Area Networks–Bridges and Bridged Networks Amendment: Configuration Enhancements for Time-Sensitive Networking
- **IEEE 802.1AS™-2020** Standard for Local and Metropolitan Area Networks–Timing and Synchronization for Time-Sensitive Applications
- **IEEE 802.1ASdr™-2024** Standard for Local and Metropolitan Area Networks–Timing and Synchronization for Time-Sensitive Applications Amendment: Inclusive Terminology

Visit standards.ieee.org for more information.