**IEEE 802.24**

**Smart Grid TAG**

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| Abstract | [DRAFT DOCUMENT: Not approved by IEEE 802. This document provides a list of 802 and related standards that provide solutions for smart grid networks.] | |
| Purpose | [] | |
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IEEE 802 recommendations on IEEE 802 related Smart Grid standards

13 May 2025

# Executive Summary

This document solely represents the views of IEEE 802 and does not necessarily represent a position of either the IEEE or the IEEE Standards Association.

This document provides a list of standards related to Smart Grid. Initially the IEEE 802.24 group focused on PHY and MAC standards related to the Smart Grid, to recommend to the IEEE-SA, so the standards can be formally documented and publicized by the IEEE. When this document was first created in 2013, it was intended to provide guidance to NIST’s Smart Grid Interoperability Panel (SGIP) that was establishing Smart Grid Catalog of Standards (CoS). This document will continue to help in the following areas:

* IEEE-SA activities relating to Smart Grid Standards and Technologies
* IEEE 802 activities in the Smart Grid area

This document will be updated on an as needed basis to reflect the on-going work in IEEE 802. Future work will include identifying standards applicable to higher layers for each Smart Grid application area that can be combined with the PMGs.

Each group is numbered for reference as 802.<working group#>. Some working groups have multiple standards.

# IEEE 802.24 Scope

IEEE 802.24 Vertical Applications Technical Advisory Group (TAG) was initially formed with a scope exclusively dedicated to Smart Grid. Although the scope has been expanded to other vertical applications, the Smart Grid scope remains in the Smart Grid Task Group. The charter is:

* Acts as a liaison and point of contact with regulatory agencies, industry organizations, other SDOs, government agencies, IEEE societies, etc., for questions regarding the use of 802 standards in Smart Grid applications.
* Facilitate coordination and collaboration among 802 groups.
* Provides speakers as needed and available to present on 802 standards in Smart Grid applications.
* Develops white papers, guidelines, presentations and other documents that do not require a PAR that describe the application of 802 standards to Smart Grid applications.
* Acts as a resource for understanding 802 standards for certification efforts by industry bodies.

# Background

Standards play a key role in the development, deployment and operation of smart grid worldwide. They are a proven tool to safeguarding interoperability, enabling the different components of a grid to exchange information.

Various standards development organizations (SDOs) have developed/developing standards related to Smart Grid. Within IEEE 802, working groups including 802.1, 802.3, 802.11, 802.15, 802.16, 802.18, 802.19, 802.21, and 802.22, were active in smart grid standards area. Since the inception of 802.24, some of these WGs have entered hibernation. There are also various smart grid related activities going on in other SDOs with whom IEEE 802 has a collaborative relationship, such as Telecommunication Industry Association (TIA), European Telecommunications Standards Institute (ETSI), Internet Engineering Task Force (IETF), International Telecommunication Union (ITU), and others.

# Listing of Groups

The groups in this clause are listed in numerical order of the working group.

## Applicable to all PMGs

These standards are applicable to all PMGs for Smart Grid applications.

**802.1:**

**802 LAN/MAN architecture, internetworking among 802 LANs, MANs and other wide area networks, 802 overall network management, and protocol layers above the MAC & LLC layers**

* **IEEE Std 802.1Q™-2022 Bridges and Bridged Networks**  
  This standard specifies Bridges that interconnect individual LANs, each supporting the IEEE 802 MAC Service using a different or identical media access control method, to provide Bridged Networks and VLANs.
* **IEEE Std 802.1AX™-2014 Link Aggregation**  
  Link Aggregation provides protocols, procedures, and managed objects that allow:

1. One or more parallel instances of full duplex point-to-point links to be aggregated together to form a Link Aggregation Group, such that a Medium Access Control (MAC) Client can treat the Link Aggregation Group as if it were a single link.

2. A resilient interconnect using multiple links among one or more nodes in a network and one or more nodes in another, separately administered, network, along with a means to ensure that frames belonging to any given service will use the same physical path in both directions between the two networks.

**Security**

* **IEEE Std 802.1X™-2020 Port-based Network Access Control**  
  For the purpose of providing compatible authentication, authorization and cryptographic key agreement mechanisms to support secure communication between devices connected by IEEE 802 Local Area Networks (LANs), this standard  
  a) Specifies a general method for provision of port-based network access control.  
  b) Specifies protocols that establish secure associations for IEEE Std 802.1AE MAC Security  
  c) Facilitates the use of industry standard authentication and authorization protocols.
* IEEE Std 802.1AE™-2018 Media Access Control (MAC) Security  
  IEEE 802 Local Area Networks (LANs) are deployed in networks that support mission-critical applications and a wide variety of devices, implemented and administered by different organizations, and serving customers with different economic interests. The protocols that configure, manage, and regulate access to these networks typically run over the networks themselves. Preventing disruption and data loss arising from transmission and reception by unauthorized devices is a required network capability, as it is usually not practical to secure an entire network against physical access.

This standard (MACsec) specifies provision of connectionless user data confidentiality, data integrity, and data origin authenticity by media access independent protocols and entities that operate transparently to MAC Clients. The MACsec Key Agreement Protocol (MKA) specified in IEEE Std 802.1X discovers mutually authenticated MACsec peers, and elects one as a Key Server that distributes the symmetric Secure Association Keys (SAKs) used by MACsec to protect frames.

* IEEE Std 802.1AR™-2018 Secure Device Identity  
  This standard specifies unique per-device identifiers (DevID) and the management and cryptographic binding of a device to its identifiers, the relationship between an initially installed identity and subsequent locally significant identities, and interfaces and methods for use of DevIDs with existing and new provisioning and authentication protocols.

**Time-Sensitive Networking (TSN)**

The charter of the TSN Task Group is to provide deterministic connectivity through IEEE 802 networks, i.e., guaranteed packet transport with bounded latency, low packet delay variation, and low packet loss. The core TSN standards include IEEE 802.1Q and IEEE 802.1AX (above) and these TSN-specific standards:

* IEEE Std 802.1AB-2016: Station and Media Access Control Connectivity Discovery   
  (specifies the Link Layer Discovery Protocol (LLDP)
* IEEE Std 802.1AS-2020: Timing and Synchronization for Time-Sensitive Applications
* IEEE Std 802.1CB-2017: Frame Replication and Elimination for Reliability
* IEEE Std 802.1CS-2020: Link-local Registration Protocol

The 802.1 TSN Task Group also develops and maintains profiles to support the use of TSN in specific application areas.

## IEEE 802.3 groups

**802.3 Ethernet**

* **IEEE Std 802.3™‐2022 Ethernet**  
  This standard defines Ethernet local area, access and metropolitan area networks. Ethernet is specified at selected speeds of operation; and uses a common media access control (MAC) specification and management information base (MIB). The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) MAC protocol specifies shared medium (half duplex) operation, as well as full duplex operation. Speed specific Media Independent Interfaces (MIIs) provide an architectural and optional implementation interface to selected Physical Layer entities (PHY). The Physical Layer encodes frames for transmission and decodes received frames with the modulation specified for the speed of operation, transmission medium and supported link length. Other specified capabilities include: control and management protocols, and the provision of power over selected twisted pair PHY types.

## IEEE 802.11 groups

**802.11 Wireless Local Area Networks**

* **IEEE Std 802.11™-2024 - Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications**The scope of this standard is to define medium access control (MAC) and physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area.

IEEE 802.11 operates in the following frequency bands (depending on region and regulatory domain) See IEEE 802.11 Annex D for specific details.

* + Sub-1 GHz band (Approximately 900 MHz)
  + 2.4 GHz band
  + 5 GHz band
  + DSRC V2X 5.9 GHz band
  + 6 GHz band
  + Millimeter wave bands (60 GHz and others globally)
  + Light communication (visible and infrared)
  + Operation in TV White Space (802.11af), and 3.65 GHz Shared Spectrum bands (801.11y) were defined, but have been deprecated.

## IEEE 802.15 groups

**802.15 Wireless Specialty Networks**

* **IEEE Std 802.15.4-2024 - Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs).**

The standard provides for ultra low complexity, ultra low cost, ultra low power consumption, and low data rate wireless connectivity among devices typically found in sensor and control networks. The raw data rate is high enough to satisfy a variety of lower data rate applications but is also scaleable down to the needs of sensor and automation needs for wireless communications. In addition, one of the alternate PHYs provides precision ranging capability that is accurate to one meter. Multiple PHYs are defined to support a variety of frequency bands including

* + 868–868.6 MHz
  + 902–928 MHz
  + 2400–2483.5 MHz
  + 314–316 MHz, 430–434 MHz, and 779–787 MHz band for LR-WPAN systems in China
  + 950–956 MHz in Japan

The O-QPSK PHY specified in Clause 10 of this standard is widely deployed for home area networking and smart metering applications.

The following amendments, Included in the above standard, are of particular interest to Smart Grid networks:

* **IEEE Std 802.15.4g™-2012 (PHY) - Amendment 3: Physical Layer (PHY) Specifications for Low-Data-Rate, Wireless, Smart Metering Utility Networks**IEEE 802.15.4g defines a PHY amendment to IEEE 802.15.4 wireless standard to address outdoor Smart Utility Network (SUN). IEEE 802.15 working group formed the 802.15.4g task group for the purpose of standardizing the SUN physical layer protocol for Smart Grid. IEEE 802.15.4g standards effort was to establish industry-wide compatibility at the physical layer for SUN and remove the limitations imposed by the then-current IEEE 802.15.4-2006 standard.

## IEEE 802.16

**IEEE Std 802.16™-2017 - Air Interface for Broadband Wireless Access Systems**  
This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support the WirelessMAN-SC, WirelessMAN OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment. This standard includes the 802.16s amendment which adds support for channel bandwidths greater than or equal to 100 kHz and less than 1.25 MHz.

* **IEEE Std 802.16t-2025 – Licensed Narrowband Amendment**This project specifies operation in licensed spectrum with channel bandwidths greater than or equal to 5 kHz and less than 100 kHz

## IEEE 802.20

* **IEEE Std 802.20™-2008 - Air Interface for Mobile Broadband Wireless Access Systems Supporting Vehicular Mobility — Physical and Media Access Control Layer Specification**This standard specifies the physical and medium access control layers of an air interface for interoperable mobile broadband wireless access systems, operating in licensed bands below 3.5 GHz. The system is optimized for IP-data transport, with peak data rates per user in excess of 1 Mbps.
* **IEEE 802.20 is inactive and withdrawn. The 802.20 working group is disbanded.**

## IEEE 802.21

* **IEEE Std 802.21™-2017 - Media Independent Handover Services**  
  This standard defines extensible IEEE 802® media access independent mechanisms that enable the optimization of handover between heterogeneous IEEE 802 networks and facilitates handover between IEEE 802 networks and cellular networks.
* **IEEE 802.21-2017 is an active standard. The 802.21 working group is in hibernation**

## IEEE 802.22

* **IEEE Std 802.22™-2019 - Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands**  
  This standard specifies the air interface, including the cognitive medium access control layer (MAC) and physical layer (PHY), of point-to-multipoint wireless regional area networks comprised of a professional fixed base station with fixed and portable user terminals operating in the VHF/UHF TV broadcast bands between 54 MHz to 862 MHz.
* **IEEE 802.22-2019 is an active standard. The 802.22 working group is in hibernation**