

IEEE Guide for Electric Transportation Fast Charging Station Management System Functional Specification

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

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STANDARDS

IEEE Guide for Electric Transportation Fast Charging Station Management System Functional Specification

Developed by the

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

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IEEE SA Standards Board

Abstract: A guide for the development of a functional specification for electric transportation fast charging station management and control systems, including the energy management and grid interaction functions, is provided in this document. The fast charging station may incorporate local energy sources, including renewable energy resources such as solar photovoltaic (PV) generation, and battery energy storage systems. The document develops guiding principles for the implementation and deployment of fast charging station control systems and the basic functional requirements for the control system and presents a set of core functions. These include electric transportation energy storage discovery and evaluation of charging requirements; monitoring and control of charging profiles; charging station energy estimation, energy scheduling, and management; and charging station grid interaction and grid power exchange management. Grid code requirements and ancillary services provision are addressed.

Keywords: ancillary services, battery energy storage system, charge management system, distributed energy resources, electric power system interconnection, electric transportation system, electric vehicle battery charging, energy management system, fast charging station, fast charger, grid services, IEEE 2030.7, IEEE 2030.11, IEEE 2030.13, microgrid

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Introduction

This introduction is not part of IEEE Std 2030.13-2024, IEEE Guide for Electric Transportation Fast Charging Station Management System Functional Specification.

A key enabler for fast charging a number of electric vehicles (EVs) at a given location and time, particularly larger vehicles such as long-haul trucks and buses, is to group a number of fast chargers into fast charging stations (FCS). An effective approach to set up an FCS is to aggregate multiple fast chargers and local resources and to coordinate their operation and energy management. The FCS can then operate as a system that interacts with the electric power grid, optimizes the charging of individual EV batteries, and manages the energy drawn from the grid. The FCS may incorporate local energy sources, including generation from renewable energy resources such as solar photovoltaic (PV) generation, and other distributed energy resources (DER), such as battery energy storage systems and controllable loads. The inclusion of power generation and storage resources allows the FCS to be configured as a microgrid and the FCS to be islanded if required. However, the FCS need not be configured as a microgrid.

The purpose of this guide is to propose a structured approach for the development of a functional specification for an FCS in the form of sets of core functions. One set of core functions is associated with the energy management system (EMS) of the FCS as an entity, including the management of the fast chargers and local energy resources. The EMS is also responsible for the grid interaction, including meeting grid interconnection requirements, and for the provision of grid and ancillary services. Another set of core functions defines the EV charge management system (CMS), responsible for the aggregate management of fast EV chargers. EMS and CMS core functions can be organized and controlled in different ways, depending upon configuration and implementation choices.

The guide draws from information available in published standards and guides, particularly for the internal structure of the FCS and its core functions. IEEE Std 2030.7™-2017 provides the basis for the EMS core functions for an FCS configured as a microgrid.¹ IEEE Std 2030.11™-2021 provides the basis for the aggregation of DER within the FCS and for the specification of grid services.

The guide describes possible implementation and deployment approaches and provides examples. It addresses interoperability requirements with reference to a smart grid interoperability reference model. The model codifies the interaction of the FCS with different elements of the smart grid environment, including the electric power system hardware, the communication and information systems, and the business and regulatory environment.

The guide is intended to provide a common language and define core functionalities for an FCS to a wide range of stakeholders, including owners, operators, and vendors of electric transportation systems, consultants, and electric power system operators and regulators.

¹Information on references can be found in [Clause 2](#).

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1. Overview

1.1 Scope

This document provides a guide for the development of a functional specification for electric transportation fast charging station management and control systems, including the energy management and grid interaction functions. The fast charging station may incorporate local energy sources, including renewable energy resources such as solar photovoltaic (PV) generation, and battery energy storage systems. The document develops guiding principles for the implementation and deployment of fast charging station control systems and the basic functional requirements for the control system and presents a set of core functions. These include electric transportation energy storage discovery and evaluation of charging requirements; monitoring and control of charging profiles; charging station energy estimation, energy scheduling, and management; and charging station grid interaction and grid power exchange management. Grid code requirements and ancillary services provision are addressed.

1.2 Purpose

The purpose of the guide is to provide an effective approach to the aggregation and coordination of the energy management of multiple fast chargers and the energy resources incorporated in the station, coordinate their operation as a system interacting with the distribution grid, optimize the charging of individual transportation systems, and manage the energy drawn from the grid.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{2,3}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

²The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

³The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

1.4 Limitations

The guide is limited to discussing and proposing a functional specification for the management and control systems of electric transportation fast charging stations (FCS), including energy management within the FCS and grid interaction functions. Fast charging is used to provide short charging time for electric transportation systems, including cars, trucks and buses, and rail, mining, marine, and aircraft transportation systems.

The guide does not address the following issues:

- The guide does not define the individual or aggregate capacity of chargers connected to the FCS or the generation and storage installed, if present, in the FCS. It does not specify voltage levels at the point of connection of the FCS to the electric power system (EPS) nor within the charging station. Both dc and ac systems can be used within the FCS.
- The guide does not prescribe protection schemes deployed within the charging station, protection systems of individual components and assets, or protection coordination that may be required within the FCS and with the EPS protection systems.
- The guide does not address planning, designing, and operating the FCS, including the EPS interconnection requirements and electricity rate structures.
- The functional specifications apply to an FCS that has a single point of interconnection (POI) with the EPS, with fast EV chargers aggregated within the FCS.
- The guide proposes functional specifications for an FCS but does not specify any particular equipment or equipment type nor a specific hardware or software implementation for the FCS control system.
- The guide does not define the type of information and communication systems and the hardware, software, and protocols associated with the operation of the components and systems used in the FCS. These are chosen among the available systems to meet the requirements for interoperability between the FCS assets and the FCS and its environment, including the EPS, and the business and regulatory environments.
- The guide does not address FCS asset ownership and operation, and the business cases that define the cost benefits of operating the FCS and its assets.

1.5 Assumptions

The following assumptions are made in defining the functional specification of the FCS:

- Electric transportation systems covered in this guide deal with an array of on- and off-road systems, including wheeled, people movers, bus, truck (heavy duty), electric aircraft, marine, rail, mining, agriculture, and warehouse.
- The main purpose of the FCS is to charge the EVs as fast as permitted by the EV battery and the power capabilities of the FCS individual charger or group of chargers, if more than one is used to charge the EV battery.
- Electric vehicles (EVs) being charged are connected to one or more of the individual fast EV chargers or charging bays within the FCS.

- EVs that use the FCS only for fast charging of their onboard batteries and do not stay connected to the charger for any length of time may not be required to have vehicle-to-grid (V2G) capabilities.
- The EV charger V2G capabilities may be exploited if the FCS is designed to accommodate fleet parking slots, where the EV may be expected to be parked at a given time and for a specified length of time. The fast EV chargers can be designed to exploit V2G capabilities, allowing energy to be fed back to the EPS (bidirectional power flow). The V2G capability provides additional battery energy storage capacity to the FCS and, when aggregated, enables the FCS more flexibility in feeding power back into the EPS. This additional EV battery storage system can be exploited if there is excess energy available after all the FCS load requirements are met and if returning power to the grid is built into the agreement between the EPS operator and the FCS operator.
- The FCS grid interconnection requirements are dictated by the EPS operator.
- The FCS may interact directly with the EPS operator's advanced distribution management system (ADMS) or with a distributed energy resource (DER) management system (DERMS) operated by the EPS or a DER service provider, among other entities.
- EV load management, including charging curtailment, load shifting, peak shaving, and load curtailment algorithms, are functions of the FCS control system that may be requested by the EPS operator as part of the grid services provided by the FCS to the EPS.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 1547™-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.^{4,5}

IEEE Std 2030.4™-2023, IEEE Guide for Control and Automation Installations Applied to the Electric Power Infrastructure.

IEEE Std 2030.7™-2017, IEEE Standard for the Specification of Microgrid Controllers.

IEEE Std 2030.11™-2021, IEEE Guide for Distributed Energy Resources Management Systems (DERMS) Functional Specification—DER Management Systems (DERMS).

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁶

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⁵IEEE publications are available from The Institute of Electrical and Electronics Engineers (<https://standards.ieee.org/>).

⁶*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

3.2 Acronyms and abbreviations

ADMS	advanced distribution management system
BESS	battery energy storage system
CMS	charging management system
DER	distributed energy resource
DERMS	distributed energy resources management system
DSO	distribution system operator
EMS	energy management system (of the FCS)
EPS	electric power system
EV	electric vehicle
EVSE	electric vehicle supply equipment
FCS	fast charging station
IBR	inverter-based resource
LV	low voltage (ac or dc)
MV	medium voltage (ac or dc)
P	active power
PCS	power conversion system
POI	point of interconnection (FCS)
PV	solar photovoltaic
Q	reactive power
RES	renewable energy resource
SCADA	supervisory control and data acquisition
SoC	battery state of charge
V2G	vehicle-to-grid (capabilities)

4. FCS functions and structure

4.1 Interactions with the EPS

The FCS is assumed to be connected to an EPS, managed by an EPS operator, [Annex B](#). The EPS operator functions can be carried out by any one of the following entities: distribution system operator (DSO), transmission system operator (TSO), transmission operator (TO), regional transmission operator (RTO), independent system operator (ISO), independent energy system operator (IESO), or a balancing authority (BA). It may be part of the portfolio of a load serving entity (LSE).

The FCS can interact with an electricity market operator. This role can be assumed by the EPS operator (TSO, RTO, ISO, IESO), and by an emerging set of actors that match EPS operator service requests with DER service providers.

The DER service provider responds to energy service requests either directly or through a third party. It may be a charge station operator (CSO), a charge network operator (CNO), a DER portfolio manager, or a DER

aggregator. It can also be a non-wires load serving entity (LSE). Terms associated with EV charging are defined in [Annex C](#).

4.2 Characteristics and features

Given the fast-evolving EV offerings and charging requirements, the FCS described in this guide does not refer to charging requirements for specific types of EVs.

An FCS can host any number of fast EV chargers with any number of EV connectors.

In this context and for the purposes of this guide, an FCS is defined as a facility with the following features:

- The FCS is designed to charge EVs in the shortest design time, relative to the EV battery energy capacity, and have the power capability and/or capacity to do so. It can charge light, medium, and heavy-duty EVs including offroad, marine, aircraft, and rail applications. Annex F.2 and [Table F.1](#) provide information on charging rates and propose definitions for slow, average, fast, and ultrafast charging.
- The FCS can host as many EV chargers as it can accommodate, based on the amount of power that can be drawn from EPS and on the power available from the local generation and storage assets, if present and operational at the time the EV charging takes place.

[Annex F](#) summarizes typical EV charging requirements, charger capabilities, and multiport charging systems currently available.

The FCS is comprised of one or more fast EV chargers and the associated EV supply equipment (EVSE) installed in charging bays. The FCS control system is comprised of a charge management system (CMS) and an energy management system (EMS). In the discussion of core functions, the CMS is assumed to be controlled by the EMS. An alternative configuration is discussed in [B.3](#). The EV chargers managed by the CMS are considered to be the main load of the FCS. The EMS dispatches the generation and storage assets to meet the CMS and EV charging requirements.

Other control configurations can be implemented. If the CMS is the main FCS control system, the control system becomes the charge station management system (CSMS), see [Annex C](#) for definitions. Similarly, if the EMS and CMS functions are decoupled and independent, the term charge station management system (CSMS) is used instead of the CMS to describe the management system of EV chargers.

The implementation of CMS and EMS functions, which depends on the design of the FCS, can be distributed in separate physical units or combined in a centralized control system. The fast EV chargers can be either locally or remote controlled.

4.3 Elements

The main elements of an FCS include the following:

- Charger and charge hub/bay/port/stall/depot
- Electric vehicle supply equipment (EVSE)
- Charging management system (CMS)
- Energy management system (EMS) for the FCS as an entity

[Annex C](#) provides a set of definitions of the elements of an FCS. These definitions have been proposed by other entities and are used in this guide as appropriate.

4.4 Structure

The main function of the FCS is to manage fast EV chargers. FCS implementations can take many forms, see [B.4](#).

In addition to fast EV chargers, the FCS can manage other types of assets, including generation from renewable energy resources (RESs), battery energy storage systems, and controllable loads, collectively referred to as DER, as per IEEE Std 2030.11-2011. Controllable loads may enable demand response. The FCS can also host and manage conventional dispatchable generation. Possible implementations of an FCS based on a microgrid topology are given in [B.1](#). Microgrids are defined in IEEE Std 2030.7-2017. In these implementations, the FCS manages fast EV chargers and other DER assets, including dispatchable generation.

The following two structures for the FCS connected to an ac EPS are described in [Annex B](#):

- AC grid-connected, typically the MV ac distribution system, with a local ac MV or LV distribution system within the FCS, [Figure B.1](#).
- AC grid-connected, typically the MV ac distribution system, with a local LV dc distribution system within the FCS, [Figure B.2](#).

The FCS may manage any number of DER including the following:

- Local generation from renewable energy resources (RES), in the form of solar PV generation.
- Electric energy storage systems in the form of one or more battery energy storage systems (BESSs).
- Other energy sources, in the form of diesel or gas-powered generators, fuel cells, or combined heat and power generators; these may be required if the FCS needs to be operated in islanded mode, either during a blackout or at the request of the grid operator, or in normal operation if economically justified.
- Auxiliary loads as required to operate the FCS.

The FCS is normally connected to the EPS at a single POI through a disconnect device, a breaker, or a contactor, or through an ac/dc power electronic interface.

In the event the disconnect device opens, the FCS can be operated in islanded mode if the sizing of the generation assets allows this mode of operation, and the FCS control system can operate in islanded mode.

4.5 Charging capacity requirements

The FCS power capabilities are determined by the following:

- The maximum instantaneous and the average EV charging load considered.
- The maximum instantaneous and average power that can be drawn from the EPS, negotiated with the EPS operator.
- The maximum instantaneous and average power that can be drawn from the assets installed within the FCS premises, on a continuous basis (from dispatchable power generation) and short time basis (from the energy storage systems).

The FCS power requirements can be used to define the following:

- The amount of solar PV generation to be installed. This amount depends upon the land availability and the business case associated with PV generation (cost of the kWh produced relative to alternative sources of power, including power from the EPS); the power capability of the PV installation is defined in terms of peak power, the available power depends upon the irradiance and time of day, and average power over a period of time varies over seasons; the PV power production is typically balanced using a battery electric storage system (BESS), either associated with the PV generator, or using a service provided by the central BESS; the size of required BESS depends the correlation between generation and demand (charging requirements).
- The amount of BESS required to meet maximum and average charging requirements (kW and kWh).
- The amount of conventional dispatchable generation to complement RES generation and BESS.

The total EV charger loading of the FCS is impacted by the EV charging approaches, including the use of the following charging algorithms, unmanaged or managed:

- First come, first serve maximum power charging of the EV as it connects.
- Multiplexing and sequential charging of EVs to allow a number of EVs to be charged simultaneously; power supplied to the EVs may have to be curtailed.
- Scheduling (priority-based) and charge reservation.
- Limiting/curtailing of the power provided to individual EVs.

The available power for EV charging may be limited by the following constraints:

- Solar irradiance, particularly during cloudy or night operation. A BESS with a larger energy capacity may be required to compensate for the reduction or absence of PV power.
- The amount of energy stored in the BESS (indicated by the battery SoC), based on past uses (power drawn over previous periods).
- The available instantaneous power that can be provided by the EPS.
- The power available from standby/backup generators (gas/diesel driven generators, fuel cells).

EV charging requirements are key to sizing the FCS assets described previously.

4.6 Interconnection to the EPS

The requirements for interconnection to the EPS depend on the structure and implementation of the FCS.

If the FCS is configured as a microgrid, it is connected to the EPS at the POI. The power exchanges between the EPS and the FCS occur only at POI. The power flow across the POI may be bidirectional:

- With power flowing into the FCS: This power is provided by the EPS to complement the local power generated, for charging a large number of EVs.
- With power fed back (reverse power flow) into the EPS: This can be implemented in agreement with or at the request of the EPS operator; this can occur if the FCS produces excess power or power can be drawn from the local BESS.

The microgrid operating modes are defined in IEEE Std 2030.7-2017.

The EPS interconnection requirements for a microgrid structure are managed by an FCS control system. They are addressed in 6.4. The EPS interconnection agreements are discussed in 6.5.