

Joint Appendix JA5

California Energy Commission

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JA 5.1 Introduction	2
JA5.2 Required Functional Resources	3
JA5.2.1 Setback Capabilities	3
JA5.2.2 Communication Capabilities	3
JA5.2.3 OCST Messages and Attributes	3
JA5.2.3.1 Demand Responsive Control Price Signals	3
JA5.2.3.2 Demand Response Periods	3
JA5.2.4 Event Response	4
JA5.2.5 Other Required Capabilities	4
JA5.3 Functional Descriptions	5
JA5.3.1 Communication Interface	5
JA5.3.2 Expansion/Communication Port	6
JA5.3.3 Onboard Communication Devices	6
JA5.3.4 User Display & Interface	7
JA5.3.5 Required Functional Behavior	7
JA5.3.6 Restoring Factory Installed Default Settings	8
JA5.3.7 Security	8
JA5.4 The HVAC System Interface	9
JA5.5 Terminology	9

JA 5.1 Introduction

The Occupant Controlled Smart Thermostat (OCST)²¹ shall be self-certified by the manufacturer to the Energy Commission to meet the requirements described in this section. This document provides a high level technical specification for an OCST. All OCSTs shall comply with the specifications set forth in this document or a specification approved by the Executive Director. This specification focuses on three interfaces that the Energy Commission has determined shall be supported by all OCSTs:

- (a) Communications Interface
- (b) User Display and Interface
- (c) HVAC System Interface

Sections within this document address each interface in terms of its hardware and software characteristics. This specification is intended to be compatible with [National Electrical Manufacturers Association \(NEMA\) Standards Publication DC 3-2008– “Residential Controls – Electrical Wall-Mounted Thermostats”](#)³² unless otherwise specified.

The Communications Interface is comprised of the (1) physical communication interface and the (2) logical communication interface.

- (a) The physical communication interface describes the physical connection that enables receipt of Demand Response signals or price signals.
- (b) The logical communication interface describes the information model and its messaging protocol used for representation and interpretation of signals received by the OCST.

See Section 5.3.1 for a more detailed explanation of these communication interfaces.

~~defined as a set of logical services that may be performed over a physical network interface connected to either an expansion port or an internal communications device. The communications interface is designed to permit a variety of intended uses for OCSTs including remote energy management services, to the extent that occupants voluntarily enable such services. To the extent possible, this document strives to be compatible with related efforts underway (e.g. National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (SGIP), Open Smart Grid, etc.).~~

~~The following elements are addressed in this document:~~

- ~~(a) Support for the basic HVAC terminal interface specification~~
- ~~(b) Support for an internal communications device for an expansion port that will allow for the installation of a removable module to enable communications with the thermostat.~~

~~The following sections describe these and other elements of the specification in more detail.~~

¹ A networked system of devices which is capable of receiving and responding to Demand Response Signals and provides equivalent functionality as required by Reference Joint Appendix JA5, shall be considered equivalent to an OCST.

² NEMA DC 3-2008 - <http://www.nema.org/Standards/Pages/Residential-Controls-Electrical-Wall-Mounted-Room-Thermostats.aspx>

JA5.2 Required Functional Resources

JA5.2.1 Setback Capabilities

All OCSTs shall meet the requirements of Section 110.2(c). Thermostats for heat pumps shall also meet the requirements of Section 110.2(b).

JA5.2.2 Communication Capabilities

OCSTs shall include communication capabilities compliant with section 5.3.1 and be enabled through either:

- (a) At least one expansion port ~~which will allow for the installation of with~~ a removable module containing a radio ~~or physical connection port~~ to enable communication; or
- (b) Onboard communication device(s)

See Sections 5.3.2 and 5.3.3 for a more detailed description of expansion port and onboard communication device, respectively.

JA5.2.3 OCST Messages and Attributes

The OCST communications capabilities shall enable Demand Responsive Control through receipt of Demand Response Signals or price signals. After OCST communication is enabled and the occupant has enrolled in a Demand Response program or subscribed to receive demand response or pricing related messages or information updates, the OCST shall be capable of both receiving and responding to Demand Response Signals. The OCST with communications enabled recognizes two basic system event modes: price response and Demand Response Periods. Both basic system event modes can be overridden by the occupant.

JA5.2.3.1 Demand Responsive Control Price Signals

The OCST shall be capable of Demand Responsive Control for the Demand Response Period upon receipt of a Demand Response Signal, which is a signal sent by the local utility, Independent System Operator (ISO), or designated curtailment service provider or aggregator, to a customer, indicating a price or a request to modify electricity consumption, for a limited time period. A price signal is a type of Demand Response signal.

Price signals allow the utility or another entity selected by the occupant to send a signal or message to the occupant's OCST to provide pricing information to the occupant and initiate Demand Responsive Control for the Demand Response Period utilizing a Demand Response Signal.

Price signal attributes and requirements shall be specified within the messaging protocol utilized by the utility or other entity selected by the occupant.

JA5.2.3.2 Demand Response Periods

This event class allows the utility or another entity selected by the occupant to initiate Demand Responsive Control for the Demand Response Period utilizing a Demand Response Signal.

Demand Response Signal attributes and requirements shall be specified within the messaging protocol utilized by the utility or other entity selected by the occupant.

If a price signal or Demand Response Signal is received and validated, but conflicts with a prior message, the newer message shall supersede the previous message and any continuing action

for the prior message is automatically terminated by the OCST (unless the subsequent message attempts to initiate an action that has been disapproved by the occupant).

JA5.2.4 Event Response

Event response, unless overridden by the occupant or modified by an energy management control system or service, may be triggered by price signals or Demand Response Signals. The OCST shall provide one set of event responses for price signals and one set of event responses for Demand Response Signals. The responses may be common for both types of events.

~~OCSTs, with communications enabled,~~ shall be capable of receiving and automatically responding to the Demand Response Signals as follows:

- (a) A Demand Response Signal shall trigger the OCST to adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.
- (b) When a price signal indicates a price in excess of a price threshold established by the occupant, the OCST shall adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.
- (c) In response to price signals or Demand Response signals, the OCST shall default to an event response that initiates setpoint offsets of +4°F for cooling and -4°F for heating relative to the current setpoint.
- (d) The OCST shall have the capability to allow occupants or their representative to modify the default event response with occupant defined event responses for cooling and heating relative to the current setpoint in response to price signals or Demand Response Signals.
- (e) Override Function: Occupants shall be able to change the event responses and thermostat settings or setpoints at any time, including during price events or Demand Response Periods.
- (f) The Demand Response Signal shall start the Demand Response Period either immediately or at a specific start time as specified in the event signal and continue for the Demand Response Period specified in the Demand Response Signal or until the occupant overrides the event setpoint.
- (g) The thermostat's price response shall start either immediately or at a specific start time as specified in the pricing signal and continue for the duration specified in the pricing signal or until the occupant overrides the event setpoint.
- (h) The OCST shall have the capability to allow occupants to define setpoints for cooling and heating in response to price signals or Demand Response signals as an alternative to the default event response.
- (i) At the end of a price event or Demand Response Period, the thermostat setpoint shall be set to the setpoint that is programmed for the point in time that the event ends or to the manually established setpoint that existed just prior to the Demand Response Period.

JA5.2.5 Other Required Capabilities

~~(a) Demand Response Event Restoration Delay: Unless the messaging protocol contains randomization or restoration delay logic, OCSTs shall provide a mechanism, such as a randomized delay, to prevent all of the OCSTs within a demand-response area from ending~~

~~the demand-response event at the same time. This mechanism can be implemented within the control logic of the OCST, within the control logic of the demand-response signaling system, or within the control logic of the communication network between the OCST and the demand-response signaling system. The display of the thermostat shall accurately indicate the end of the event, accounting for any delays or advances provided by this mechanism. The specific maximum restoration delay for restoration after a Demand Response Period shall be 30 minutes or alternatively can be defined within the Demand Response Signal for that event.~~

- ~~(a) Default Restart Settings: In the event of a disruption of power to the device that results in power-off or restart, upon device restart, the device shall automatically restore the most recently programmed settings, including reconnection to a network, if the device was previously enabled and network connectivity is available.~~
- ~~(b) Automatic Rejoin: OCST's are expected to connect, and remain connected in its communication path and control end point. The OCST shall incorporate an automatic rejoin function. When physical and/ or logical communication is lost, the OCST shall trigger its automatic rejoin function to restore the physical and/or logical communication connection.~~

JA5.3 Functional Descriptions

JA5.3.1 Communication Interface

The communications interface has two aspects – the physical interface and the logical interface.

The physical communications interface describes the physical connection through which event signals are received, and shall meet the following requirements:

1. The OCST shall be capable of connecting to a Wi-Fi network compliant with Institute of Electrical and Electronics Engineers (IEEE) Standard 802.11, and/or a Zigbee network compliant with IEEE 802.15.4. Manufacturers may choose to include additional physical communication interfaces compliant with open-based standards.
2. The physical communication interface shall be capable of bi-directional exchange of information over its communication path.

The logical communication interface within the OCST hardware, which describes the messaging protocol and information model used in representation and interpretation of demand response signals, shall comply at minimum, with any individual or combination of the following open-based standards: OpenADR 2.0³ or Smart Energy Profile (SEP) 1.1⁴, which are listed in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards (CoS)⁵. Manufacturers may choose to provide additional logical communication protocols compliant with open-based standards. Builders, HVAC installers, architects, and all other Title 24 professionals should check with the local utility (where the property is located) on guidance when choosing the DR signal standard for the OCST.

Using receipt of a demand response signal via the physical communication interface, and interpretation of the signal via the logical communication interface, the OCST shall be capable of automatically initiating demand responsive control.

³ <http://www.openadr.org/>

⁴ <http://www.zigbee.org/Standards/ZigBeeSmartEnergy/Overview.aspx>

⁵ <http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIPCoSStandardsInformationLibrary>

~~The physical communications interface includes a one or two-way communications interface as selected and specified by the occupant's utility, information update service or Demand Response service provider and enabled by either onboard communications devices or a communications module in the case of an expansion/communication port. There is no mandated specification for the physical communications protocol. However, the communications capabilities shall enable Demand Responsive Control through receipt of Demand Response Signals based on communications standards (including but not limited to ZigBee (IEEE 802.15.4) or WiFi (IEEE 802.11)).~~

~~The logical interface consists of the information model used to represent messages sent to the OCST. There is no mandated specification for the logical interface, but direction is provided as "standards-based messaging protocols (including but not limited to Smart Energy Profile (SEP), OpenADR or others defined in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards (CoS))" or as defined by the occupant's information update service or Demand Response service provider.~~

JA5.3.2 Expansion/~~Communication~~ Port

~~The expansion port allows for the installation of a removable module to enable physical and logical communication as described in Section 5.3.1. This port is available to be used by a module supporting one-way or two-way communications using standards-based communication protocols as described in Section 5.3.1. The module shall also enable standards based messaging protocols (including but not limited to Smart Energy Profile (SEP), OpenADR or others defined in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards (CoS)) or as defined by the occupant's information update service or Demand Response service provider.~~

When the Expansion/~~Communication~~ port is unpopulated, the thermostat shall function as a programmable setback thermostat and shall meet the requirements of Sections 110.2(b) and (c).

The removable module may also provide a means of memory storage, logging, and firmware upgrade. The requirements associated with the expansion ~~port interface~~ are:

- (a) The expansion/~~communication~~ port shall be readily accessible to the occupant for installing and removing the communication module.
- (b) Installation of the module shall upgrade the programmable setback thermostat to an OCST.
- (c) After communications are enabled⁶ and the occupant has enrolled in a Demand Response program or subscribed to receive demand response related messages or information updates, the OCST shall be capable of both receiving and responding to Demand Response Signals.

The ~~OCST's~~ expansion port ~~interface~~ has no mandated configuration or design specification.

JA5.3.3 Onboard Communication Devices

When onboard communication devices are present, the thermostat or HVAC control system shall be equipped with the capability to enable or disable the onboard communication device(s).

⁶ The removable module, or gateway for a networked system of devices, for enabling communications can be selected and installed at the time of enrollment in a Demand Response program or subscription to receive demand response related messages or information updates.

The switch or interface to enable or disable onboard communications shall be readily accessible to the occupant.

When onboard communications are disabled, the thermostat shall function as a programmable setback thermostat and shall meet the requirements of Section 110.2(c). Thermostats for heat pumps shall also meet the requirements of Section 110.2(b).

JA5.3.4 User Display & Interface

The OCST shall have the capability to display information to the user. The following information shall be readily available whenever the OCST display is active:

- (a) Communications system connection status,
- (b) An indication that a Demand Response Period or pricing event is in progress,
- (c) Other maintenance-related information,
- (d) The currently sensed temperature,
- (e) The current setpoint.

JA5.3.5 Required Functional Behavior

- (a) Clock Operation. The clock mechanism enables the OCST to execute temperature setpoints scheduled by the occupant. It also supports other timing functions such as start-time, end-time and duration for coordination of Demand Response Periods and price signal response.

The OCST shall provide a pair of programmable thermostat setpoint time and temperature parameters for at least four operating periods that collectively govern thermostat operation during the 24-hour day.

Accuracy to a precision of one minute is acceptable for this operating environment and the applications being considered.

The clock in an OCST may be set by the occupant, using the OCST's human-machine interface. Alternatively, an OCST with communications enabled may be set or synchronized by the occupant's selected service provider.

- (b) Normal Operation. Normal operation of an OCST is defined to be the OCST's prevailing mode of operation as determined by the occupant's prior settings and use of features⁷ provided by the OCST manufacturer's design. Aspects of normal operation of an OCST may be modified or interrupted in response to occupant subscribed price signals or when Demand Response Periods are in progress, but only to the extent specified by occupants or their representatives.

Unless an occupant has elected to connect the OCST to an energy management control system or service that provides for alternate strategies, the OCST shall provide a mode of operation whereby it controls temperature by following the scheduled temperature setpoints.

Occupants shall always have the ability to change OCST settings or use other features of an OCST during an event. Those changes may alter what is considered to be the prevailing mode of operation when a Demand Response Period is terminated and the OCST returns to normal operation.

⁷ The specific design of such features (e.g. HOLD, OVERRIDE) is defined by individual manufacturers and not by this document.

- (c) Demand Responsive Control. Upon receiving a price signal or a Demand Response Signal, OCSTs shall be capable of automatic event response by adjusting the currently applicable temperature setpoint by the number of degrees indicated in the temperature offset (heating or cooling, as appropriate).

Override: OCSTs shall allow an occupant or their representative to alter or eliminate the default response to price signals or Demand Response Signals, and to override any individual price response or Demand Responsive Control and allow the occupant to choose any temperature setpoint at any time including during a price event or a Demand Response Period.

When the price signal changes to a non-response level or the Demand Response Period is concluded, OCSTs shall return to normal operation. The thermostat setpoint shall be set to the setpoint that is programmed for the point in time that the event ends or to the manually established setpoint that existed just prior to the Demand Response Period.

The OCST shall also be equipped with the capability to allow occupants to define setpoints for cooling and heating in response to price signals or Demand Response Signals as an alternative to the default event response. The default setpoint definitions unless redefined by the occupant shall be as follows:

1. The default price response or Demand Response Period setpoint in the cooling mode for OCSTs shall be 82°F. The OCST shall allow the occupant to change the default event setpoint to any other value.
2. The default price response or Demand Response Period setpoint in the heating mode for OCSTs shall be 60°F. The OCST shall allow the occupant to change the default event setpoint to any other value.
3. The OCST shall ignore price response or Demand Response Period setpoints that are lower (in cooling mode) or higher (in heating mode) than the programmed or occupant selected prevailing setpoint temperature upon initiation of the price event or Demand Response Period.
4. By default, thermostats shall not be remotely set above 90°F or below 50°F. Occupants shall have the ability to redefine these limits. This measure protects occupant premises from extreme temperatures that might otherwise be imposed by event responses, should the occupant already have a very high or low temperature setpoint in effect.

The occupant may still override or change the setpoint during all price events and Demand Response Periods. Price signal response and Demand Responsive Control only modify the operating range of the thermostat. They do not otherwise affect the operation and use of features provided by the manufacturer's design.

JA5.3.6 Restoring Factory Installed Default Settings

The OCST shall include the capability to allow the occupant to restore the factory installed default settings.

JA5.3.7 Security

Demand Response Signal security attributes and requirements shall be specified within both the communications standard and the messaging protocol utilized by the utility or other entity

selected by the occupant. The OCST communication system shall consider relevant security issues and potential cyber-attacks⁸.

JA5.4 The HVAC System Interface

HVAC wiring terminal designations shall be clearly labeled. OCSTs shall use labels that comply with Table 5-1 in NEMA DC 3-2008. It is noted that OCSTs using wired or wireless digital data interfaces do not directly follow NEMA DC 3-2008

JA5.5 Terminology

Current Setpoint	The setpoint that existed just prior to the price event or Demand Response Period.
Demand Response	See Joint Appendix JA1- Glossary.
Demand Response Period	See Joint Appendix JA1- Glossary.
Demand Response Signal	See Joint Appendix JA1- Glossary.
Demand Response Control	See Joint Appendix JA1- Glossary.
Energy Management Control System	See Joint Appendix JA1- Glossary.
Override	Refers to an occupant adjusting thermostat settings to either not respond to a Demand Response Signal or adjusting the setpoint compared to the OCST's programmed response to a price signal or Demand Response Signal.
Price Signal	is a signal sent by the local utility, Independent System Operator (ISO), or designated curtailment service provider, information update service or aggregator, to an enrolled or subscribed customer, indicating a price or other economic indicator that can trigger OCST Demand Responsive Control.
Price Event	Refers to a change in pricing sent to the OCST from the utility or the occupant's selected demand response provider.

⁸ A thorough discussion of security issues may be found at: <http://collaborate.nist.gov/twiki-ssggrid/bin/view/SmartGrid/CyberSecurityCTG>