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Demand Response-Ready Variable-Speed Pool Pump Specification

Preliminary Requirements for CEA-2045 Field Demonstration

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NOTE

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ABSTRACT

This document is a specification for variable-speed pool pumps with built-in demand response (DR) capabilities and a standard communication interface port. The context for the development of this specification is a field demonstration project that EPRI is facilitating regarding the ANSI/CEA-2045 modular communication standard. In this project, utilities are fielding consumer end-use products and integrating them into a wide range of demand response systems in order to assess the communication standard and determine the degree to which interoperability is achieved.

The project plan requires that all of the field tests of a given product type be carried out using the same design, so that there is no regional customization and the concept of a mass-producible product is directly evaluated. This required that utilities work together to develop a common set of requirements that are sufficient for supporting a wide range of DR programs. This collaborative process was conducted early in the project, resulting in the preliminary specification represented in this document. The project plan anticipates updating this specification later in order to incorporate any new requirements or adjustments that are identified during the field testing.

Keywords
CEA-2045
CTA-2045
Pool pump
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Smart grid
Communication port
Demand response
Modular interface
DR ready

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
INTRODUCTION

In 2013 the Consumer Electronics Association[1] released the ANSI/CEA-2045 standard. This standard defines a modular communication interface intended to be designed into end-use loads to enable demand response (DR). The CEA-2045 standard has been described in detail in EPRI report 3002004020, *Introduction to the CEA-2045 Standard*[2].

Utilities and manufacturers are assessing this new standard to determine the degree to which it meets the needs of consumers, aggregators, and utilities. EPRI is facilitating a collaborative project that is specifically studying the extent to which CEA-2045 provides compatibility and interoperability with the wide range of systems into which consumer loads might be connected. If a modular interface works as intended, achieving interoperability and being self-installable by consumers, it could significantly advance the state of demand response worldwide. A detailed description of the CEA-2045 Field Demonstration project, including its goals and plan, has been provided in EPRI report 3002004009, *ANSI/CEA-2045 Field Demonstration Project Description*[3].

The project plan requires that all of the field tests of a given product type be carried out using the same design, so that there is no regional customization and the concept of a mass-producible product is directly evaluated. This required that utilities work together to develop a common set of requirements that are sufficient for supporting each DR program. This collaborative process was conducted early in the project, resulting in the preliminary pool pump specification represented in this document. The project plan anticipates updating this specification later in order to incorporate any new requirements or adjustments that are identified during the field testing.

[1] Now known as the Consumer Technology Association.

[2] http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004020

[3] http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004009

2
MECHANICAL AND ELECTRICAL REQUIREMENTS

REQ.ME1 The pool pump shall be a residential type, operating from 240VAC, with a capability of up to 120 GPM at 60 feet of head. The pump must have an internal clock and built-in time-of-day scheduling capability. The pump must be ENERGY STAR-certified.

REQ.ME2 The pool pump shall be a standard pad-mount device.

REQ.ME3 The pool pump controller shall be a variable speed type, capable of any number of up/down regulation responses per day.

CEA-2045 Port Characteristics

This specification acknowledges that the port could be located either on the pump itself or in a separate box that combined with the pump itself collectively comprise a pool pump system.

REQ.ME5 The pool pump system's CEA-2045 control box shall include the AC form factor as described in Appendix B of the CEA-2045 standard.

REQ.ME6 The pool pump system's CEA-2045 control box shall provide a watertight cover/compartment in which the CEA-2045 port exists and modules are housed. This is required for the outdoor environment because the CEA-2045 connector is not self-sealing.

REQ.ME7 Placement of the CEA-2045 port shall allow for good RF propagation of wireless communication modules, such that communication modules are not obscured by metal cover plates or other RF-attenuating materials.

REQ.ME8 The pool pump system's CEA-2045 control box will allow space for any AC communication module up to the maximum size specified by the CEA-2045 standard.

User Interface Characteristics

The pool pump shall provide a user interface supporting the following items. This interface must be locally available to the consumer at the home, but can be provided by whatever means the pool pump manufacturer prefers, including on the pool pump system, via remote interface console, smart phone application, etc.

REQ.UI1 An indicator of successful communication connection (based on the CEA "Outside Comm Connection Status" message)

REQ.UI2 An indicator of when any kind of curtailment is in effect.

REQ.UI3 The pool pump must include a mechanism to override an event. (Note also monitoring requirement of override occurrences in REQ.M2)

Other Standards

- Pool pumps must be certified to UL-1081 and NSF-50 standards.
- For pools located in California, they must also be compliant the Title-20 Appliance efficiency standard.
- Installations must be compliant with local electrical codes.
- Installations must be compliant with the Virginia Graeme Baker Pool and Spa Safety Act.
- This specification is intended to complement the EPA ENERGY STAR Connected pool pump specification.

3
CEA-2045 COMMUNICATION REQUIREMENTS

Included in this section are messages that the end-use device must support. A key factor in the development of these requirements was consistency with specifications that have been established for thermostats, water heaters, electric vehicle supply equipment and other end-use device types. In some utility scenarios, the same communication systems will be connecting to multiple end device types, and it is necessary that the different types of devices respond to DR signals in a consistent and predictable way.

The communication requirements are described in three subsections: Link-Layer, Control, and Monitoring; as detailed in the following sub-sections. The full usage formats and understanding of these messages can be gained from the CEA-2045 standard.

Link-Layer Requirements

Table 3-1
Link-Layer Requirements

Requirement	CEA-2045 Message	Pool Pump Implementation
REQ.LL1	Link ACK	Supported. Required per the standard.
REQ.LL2	Link NAK	Supported. Required per the standard. The pool pump shall detect and report all of the standard NAK codes.
	Request Different Power Mode	Not supported. Not applicable with the AC interface.
	Request Different Bit Rate	Not required. Default Bit Rate is acceptable.
REQ.LL3	Query & Response: Maximum Payload Length	Supported. In order to support the messages identified herein (Get_Information is the longest), the unit must support negotiation of up to 64-byte message length.
	Query & Response: Get SGD Slot Number	Not supported. Not applicable with only one slot on the device.
	Query and Response: Get Available Slot Numbers	Not supported. Not applicable with only one slot on the device.
	Send Next Command to Slot	Not supported. Not applicable with only one slot on the device.

Control Requirements

This section identifies the CEA-2045 control messages that must be supported and the associated pool pump responses. Any one of these message/response combinations may be utilized in any number of utility program strategies. Several examples of such strategies are identified in a later section of this document.

The responses defined herein are designed to achieve a somewhat predictable behavior so that the contribution of pool pumps can be properly valued. It is understood that a pool pump may, for any number of reasons, have to operate at certain times and at certain levels independent of controls that may be in effect.

REQ.C1 The pool pump logic shall be such that all control requests defined herein expire and the pool pump returns to normal operation after 12 hours, unless another request is received within that time.

REQ.C2 The pool pump logic shall be such that upon power cycle, all operational settings shall return to normal. Return to normal may include a time delay. Any non-default settings must be renegotiated upon power restoration by the communication module.

Curtailment Based on Specific Current Limits

The required response strategies identified in the following table are based on curtailment to specific pumping levels. Multiple options were considered by the utility group prior to selection of this approach, including:

- Curtailment to a percentage of the pool pump maximum capability. This approach is complicated by the difference in the maximum capability from one pump to another.
- Curtailment to a percentage of the pumping rate at the time that the demand response event goes into effect. This approach is complicated by the uncertainty of timing of pumping and events, and by time-varying pumping profiles.
- Curtailment to a predetermined power level. This approach has the potential to mitigate pump size variability

Pool pump schedules and pumping profiles can vary widely. All things considered, the utility group chose not to base curtailment on the observed pumping level at any one point in time. This avoids the need to make assumptions regarding pumping profile shapes and respects the freedom of pool pump manufacturers to innovate in the design of their pumping strategies.

Table 3-2
Control Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.C3	<Basic> Application ACK	As Specified	The pool pump will support the application ACK as described in the CEA-2045 specification.
REQ.C4	<Basic> Application NAK	As Specified	The pool pump will support the application NAK as described in the CEA-2045 specification.
REQ.C5	<Basic> Outside Comm Connection Status	As Specified	The pool pump must monitor for this “heartbeat” signal which is sent from the communication module. If the pool pump is processing a curtailment request and the heartbeat is not received within 15 minutes, the pool pump will return to normal operation.

Table 3-2 (continued)
Control Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.C6	<Basic> Shed	The optional "Event Duration" field may be provided by a UCM. If supported see REQ C14	"Shed" events are used as part of fixed-incentive based programs and typically require a predictable response: If pumping is in process, or is set to begin during the Shed event, the pool pump will act to avoid pumping or reduce the rate of pumping to the minimum possible level that can be sustained for the duration of the event.
REQ.C7	<Basic> End Shed/Run Normal	As Specified	The end-shed/run normal event is used to inform the pool pump to run normally. If received during a curtailment event, the event shall immediately end.
REQ.C8	<Basic> Present Relative Price	As Specified	The Relative Price command is used in association with a range of price-based programs and lends strongly to consumer-configurability of response (i.e., no particular response is mandatory from a utility perspective) This demonstration product DOES require support of this message and a response to it, but the pool pump manufacturer may propose the response and method by which customer adjustability is provided (if any). A simple example of how a pool pump could respond to the relative price signal is as follows: Offer consumers configurability of a "Low Price Threshold" and a "High Price Threshold". If Present Relative Price is < "Low Price Threshold": pool pump immediately acts to maximize the rate of circulation and continues until the Low Price ends or the required daily circulation is accomplished. If Present Relative Price is between "Low Price threshold" and "High Price Threshold": pool pump behaves normally, the same as when a "Run Normal" message has been received. If Present Relative Price is above "High Price Threshold": pool pump will defer circulation altogether, or circulate at the minimum rate possible.

Table 3-2 (continued)
Control Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.C9	<Basic> Critical Peak Event	The optional "Event Duration" field may be provided by a UCM. If supported see REQ C14	Critical Peak Events are typically used as part of fixed-incentive based programs and require a predictable response. These Events are typically infrequent (only a few times a year) so responses may be more aggressive. Customers generally have day-ahead notification of Critical Peak events. The pool pump response to Critical Peak Events may be the same as that for a "Shed" event or may be more aggressive, depending on the design preferences of the pool pump manufacturer. For example, a pool pump may perform less than the required average daily circulation in cases where Critical Peak Events rarely occur.
REQ.C10	<Basic> Grid Emergency	The optional "Event Duration" field may be provided by a UCM. If supported, see REQ C14	During an emergency event, the pool pump shall stop circulation until the event has ended. Customer overrides shall be allowed, even for Grid Emergencies.
REQ.C11	<Basic> Request for Power Level		This message passes the pool pump a request for operation at a particular power level, represented by a setting between 0% and 100% of maximum consumption. The % value passed to the pool pump in this message relates to energy consumption, not circulation rate, understanding that the relationship between the two may or may not be linear. The command format allows for use from +100% to -100%, but for a pool pump, only positive values, 0 to 100% are appropriate. Negative values, if presented, should be responded-to with an Application NAK with reason code0x02 (Opcode 2 not supported). If the pool pump is multi-speed rather than variable speed, responses to this command may be made in steps of 25%. Note: This request may be preceded by other requests that result in deferring circulation so that the pool pump system is available to consume energy when called upon to do so by this command.

Table 3-2 (continued)
Control Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.C12	<New Basic Message > Load Up (use Opcode1 0x17, Opcode2 = Duration)	See EPRI Publication 3002003988[4]	Sent from the UCM to request the pool pump, to the extent possible, go to its Maximum level. This message can be used in conjunction with other curtailment messages such as Shed. The Shed command can be used to maximize the energy storage level of the pool pump system. If the pump is safe to run, unit shall initiate pumping, and if active, shall increase its energy level or extend pumping duration within the requested response period. The assumption of this command is that energy is not wasted, but rather that devices will manage energy over a given period of time.

REQ.C13 If the UCM provides duration, the pool pump should use this field as a backup to the sequential messaging process defined in the CEA-2045. If a message to curtail is not followed by another curtailment message or an End Shed/Run Normal message within 15-minutes after the timed event, then the pool pump should revert to its normal mode of operations.

Monitoring Requirements

This section identifies the CEA-2045 monitoring messages that must be supported.

REQ.M1 The data update time of the following messages must be less than one second.

Table 3-3
Monitoring Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.M2	<Basic> Customer Override	As Specified	The pool pump must provide consumers with an event override option as noted previously. If pressed/activated, the pool pump must report the override to the UCM using this message. If an override occurs, the end device shall immediately return to normal operation and ignore any new curtailment messages for a period of 12-hours. The physical location of the override may be at the pool pump or provided through some remote means such as an in-home display or smart-phone application.

[4] http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002003988

Table 3-3 (continued)
Monitoring Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.M3	<Basic> Query & Response: What is your Operational State	As Specified	The pool pump shall support these messages. Reporting: 0 – Idle Normal, when the pool pump is not circulating, but is in a normal mode of operation 1 – Running Normal, when the pool pump is presently circulating, as part of normal operation. 2 – Running Curtailed Grid, when the pool pump is circulating, but at a rate less than the pool pump's normal level due to a curtailment event that is in effect. 3 – Running Heightened Grid, when the pool pump is circulating at a rate greater than the pool pump's normal level due to an event that is in effect such as a low energy price or a power level setting. 4 – Idle Grid, when the pool pump is not presently circulating, but would be if not for some grid curtailment signal. 5- SGD Error Condition, if anything is internally broken. 6 - Idle Heightened, Indicates that heightened-operation type of demand response event is in effect and the pump has no/insignificant energy consumption (i.e. speed has not increased) 7 - Cycling On, Indicates that a cycling type of demand response event is in effect and the pump has significant energy consumption (i.e. cycled on) 8 - Cycling Off, Indicates that a cycling type of demand response event is in effect and the pump has no/insignificant energy consumption (i.e. cycled off) 9 - Variable Following, Indicates that a variable-setting type of demand response event is in effect and the pump is presently following the specified setting. 10 - Variable Not Following, Indicates that a variable-setting type demand response event is in effect and the pump is presently not following the specified setting (e.g., the pump has no/insignificant energy consumption.) 11 - Idle Opted Out, Indicates that the pump is presently opted out of any demand response events and the pump has no/insignificant energy consumption. 12 - Running, Opted Out, Indicates that the SGD is presently opted out of any demand response events and the pump has significant energy consumption.

Table 3-3 (continued)
Monitoring Requirements

Requirement	CEA-2045 Message	Usage	Pool Pump Response
REQ.M4	<Intermediate> Query & Response: Info Request		The pool pump shall support, at a minimum, all mandatory device information plus the model number and serial number optional fields associated with the Info Request. Device Type shall be reported as a 0x0031 "Pool Pump – Variable Speed".
REQ.M5	<Intermediate> GetCommodity Read Request and GetCommodity Read Reply		The pool pump shall support Get Commodity requests. The following commodity codes must be supported. Electric power (present consumption rate W) and cumulative lifetime energy consumed W-h. Commodity Code = 0 "Electricity Consumed" *Total Energy Storage Capacity Commodity Code = 6 *Present Energy Storage Capacity Commodity Code = 7 * - Total Energy Storage Capacity and Present Energy Storage Capacity are new messages defined in the "Recommended Changes to the ANSI/CEA-2045 Standard." 5 The response will indicate if the values are Measured or Estimated

[5] New Energy Storage Commodity codes are included in the latest CEA-2045 draft. For details see: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002003988

4
EXAMPLE UTILITY CONTROL STRATEGIES

This section is included for informational purposes only. It describes example utility program types and identifies the messages that may be used in association with these programs. From a pool pump design perspective, this information is irrelevant. Only the message-to-response mappings provided in the previous sections matter.

Direct Load Control

Utility Direct Load Control programs have traditionally used external relays to control the power to end-use devices. These are simple control methods and are commonly used for water heating and pool pump control. A predictable response is needed for these programs. Messages potentially used in conjunction with this control strategy include:

Table 4-1
Example Messages Related to Direct Load Control

CEA-2045 Message	How Used
<Basic> Shed	To inform devices that a control event is in effect
<Basic> End Shed/Run Normal	To inform devices to return to normal operation at the close of an event.

Time of Use (TOU)

Utility Time-of-Use programs involve an energy price that varies with time. For residential programs, the schedules for these price variations are fixed and known to consumers in advance. Advanced meters capture and report the consumption during each time interval of the day, allowing for bill calculation.

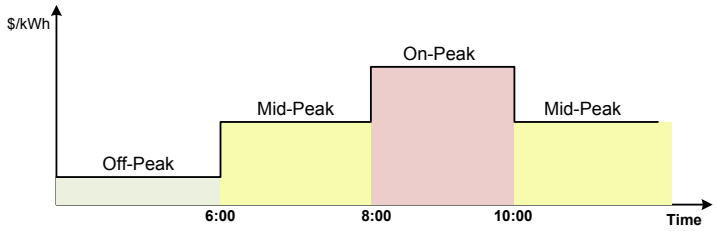

Figure 4-1
Time-of-Use Example

To aid consumers in managing their consumption patterns, price information can be provided to end-use devices. Messages potentially used in conjunction with this control strategy include:

Table 4-2
Example Messages Related to Time-of-Use

CEA-2045 Message	How Used
<Basic> Present Relative Price	The Present Relative Price signal to the pool pump is varied according to what is currently in effect.

Critical Peak Pricing (CPP)

Critical Peak Pricing programs are a dispatchable form of Time of Use. Critical Peak events are called, usually with day-ahead notification to the consumer. Typically, CPP program agreements limit the number of event days per year to a small number (e.g., 10) and involve prices that are substantially higher than normal.

Critical peak events may be used in conjunction with regular daily TOU. Messages potentially used in conjunction with this control strategy include:

Table 4-3
Example Messages Related to Critical Peak Pricing

CEA-2045 Message	How Used
<Basic> Critical Peak Event	To inform devices that an infrequent Critical Peak event is in effect
<Basic> End Shed/Run Normal	To inform devices to return to normal operation at the close of an event.

Grid Emergencies

Grid emergencies are not a part of any normal program. Grid emergency messages would only be sent to end devices during emergency situations when complete power outages are the alternative. Messages potentially used in conjunction with this control strategy include:

Table 4-4
Example Messages Related to Grid Emergencies

CEA-2045 Message	How Used
<Basic> Grid Emergency	To request that devices shut down due to a grid emergency
<Basic> End Shed/Run Normal	To inform devices to return to normal operation once the emergency condition is over.

Cycling-Based Managed-Load Operation

Managed-Load Operation represents a number of control strategies in which the pool pump may be requested to operate at particular times (to absorb energy) in addition to avoiding operation at other times. Use cases associated with this kind of management include following variable

generation resources such as wind energy. Messages potentially used in conjunction with this control strategy include:

Table 4-5
Example Messages Related to Cycling-Based Managed-Load Operation

CEA-2045 Message	How Used
<Basic> Shed	To put the pool pump in a state such that its capacity to store energy is increased or maximized
<Intermediate> Autonomous Cycling	To request that the pool pump absorb energy at an average rate (over a one hour cycle) determined by the specified duty cycle
<Basic> End Shed/Run Normal	To inform the pool pump to return to normal operation, once the managed load operation is past.

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