Demand Response Socket Interface Specification

Revision History

Version 1.0	Original	
Version 1.1	6/26/10	Added AC connector hardware specifics, Addressing byte
Version 1.2	7/10/10	Added ClimateTalk harmonization description
Version 1.3	7/19/10	Clarified definition of 120/240V wiring, clarified definition of high and normal price to cover run/shed DLC. Added “usage” column to the simple serial table and indicated mandatory commands. Added Length and Number fields to align with other protocols closer.
Version 1.4	7/28/10	Added Length and Number fields to closer align with ClimateTalk and other protocols.
Version 1.5	8/6/10	Revised the simple serial table to align with NIST H2G DEWG, added price event description field.
Version 1.6	8/19/10	Re-organized. Moved form-factor details into two appendices. Added example communication exchanges. Expanded the introduction section. Inserted Table of Contents.
Version 1.7	9/6/10	Re-titled and reorganized to recognize that the specification covered more than the serial protocol, but also the physical and electrical aspects.

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1 Introduction

This paper is a product of an EPRI collaborative research project that has studied the concept of a standardized socket interface for residential devices that would allow them to work with any demand response communication system. The project has engaged a large number of residential device manufacturers (water heaters, HVAC, pool equipment, white-goods, consoles, etc.) and communication technology providers (Wi-Fi, AMI, PLC, HAN, Cellular, etc.) The project was initiated in Q4 2008 and regular team meetings have been held since Q4 2009.

This paper presents the culmination of this work thus far, in the form of a proposed socket interface specification. This specification incorporates features from a variety of sources and information compiled from several existing protocols and requirements, including:

1. A simple option for devices with limited memory and/or processing capability
2. The USNAP interface protocol
3. The ClimateTalk protocol
4. The Smart Energy Profile
5. Advanced Internet / Web Interfacing (IP)
6. Numerous contributions from individual companies

This specification describes how these interface ideas have been harmonized into a single approach that allows for simple devices, but is also extensible to allow for pass-through of a number of existing protocols. A method is provided that allows manufacturers the flexibility to choose which protocols they will support, and yet guarantees interoperability of all systems by requiring universal support of a minimal set of demand response indicators.

The project team wishes to expresses thanks to the organizations and individuals who made these contributions.

1.1 The Basic Concept

Although not an exact representation, Figure 1.1 illustrates what is meant by the term “socket interface” in the context of this document. It is not a specification for any end device, nor is it a specification for any particular type of communication system (architecture) or module. The specification only defines the connector at which the two pieces meet, and the details of how information may be exchanged across this connector to achieve a demand response.

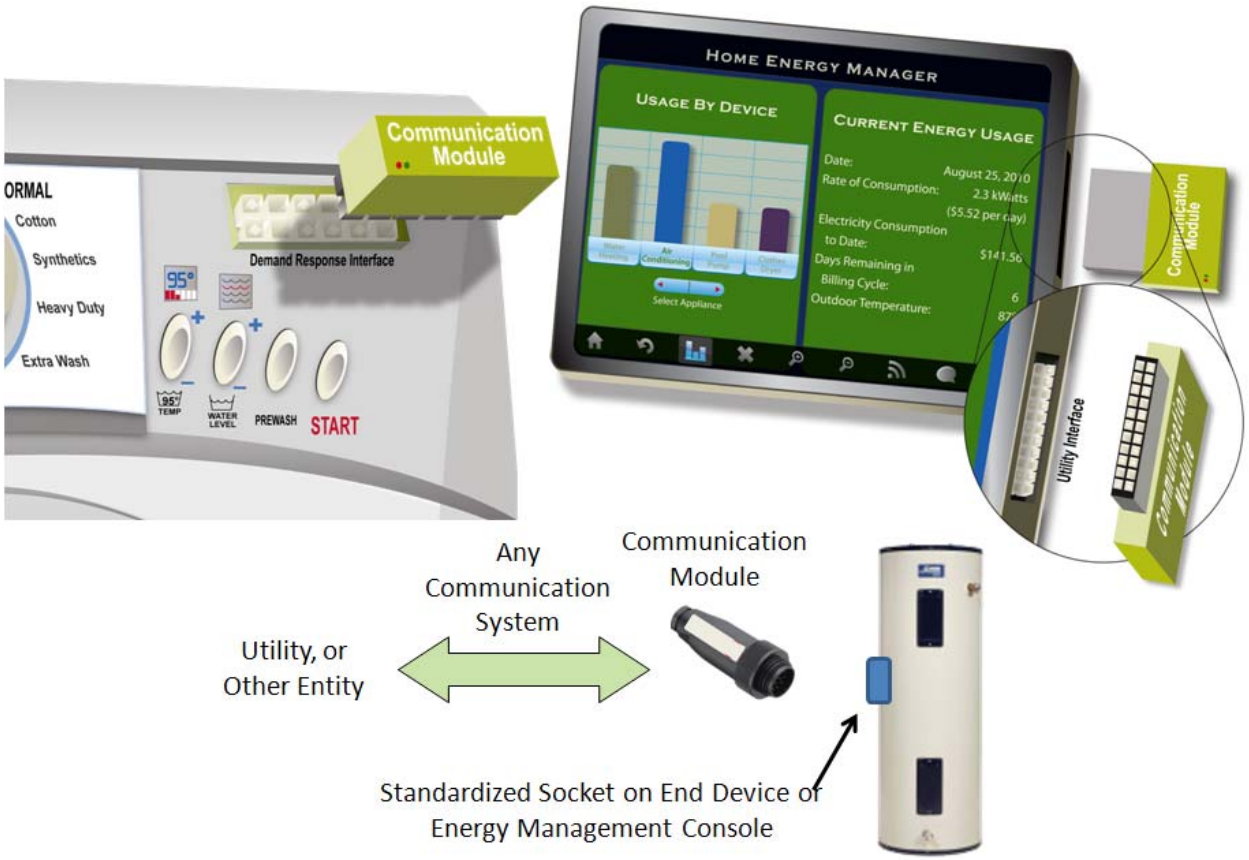


Figure 1.1 – Demand Responsive Appliance Interface Socket Concept

The concept provides product manufacturers with a means by which they may decouple communication devices from their products altogether, or embed certain communication technologies inside their products while retaining the ability to support other communication types.

1.2 Supporting the Simplest Devices

During the course of the project, the participants moved away from the early idea of Boolean pins to a very simple serial information exchange for supporting the most limited devices. This move was based on vendor's indication that the same products that would have electronic controllers (and therefore could process Boolean pin indications) could also handle a very limited serial communication protocol. In these discussions, the messages of the Smart Energy Profile 1.0 & 2.0 were considered but were deemed too complex for certain products.

One contribution suggested twelve messages that might be sent to an end device from a communication module and 10 responses that might be sent from the end device. It was concluded that the needed commands could easily be represented in a single byte (0-255), even with significant review and expansion. The need for a very simple starting point and the corresponding proposal for a short set of basic commands have been developed into a "simple serial" option that is included in the harmonized design along with other protocols.

1.3 Extending to Support Advanced and Future Devices

Discussions on the topic of interfacing with appliances included the idea of internet-connectivity or internet browsing capability on appliances. While such advanced functionality is not required of an appliance or a communication module, the project team determined that the interface specification would make provision for how IP packets could be exchanged whenever both the comm module and the end device both support it.

1.4 Enabling Architectural Diversity

An important principle of this project has been to remain agnostic to how communication systems and DR programs are architected. Specifically, it is intended to be equally supportive of:

1. Two-tiered systems where the customer devices are on a local network (HAN) and utility information enters that HAN through a meter or other device serving as a gateway.

2. One-tiered systems where communication signals from a distant source propagate wirelessly or via wires directly to the customer device that is being informed of grid conditions.

3. The use of energy management consoles that receive utility signals and manage one or more downstream devices. In this case, the need for communication diversity may be at the console as opposed to the actual load devices as illustrated in Figure 1.2. This principle is expounded upon in EPRI Whitepaper 1020432, available at EPRI.com.

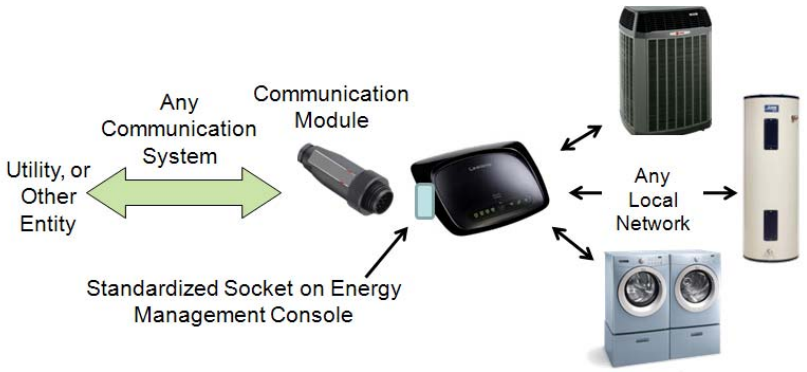


Figure 1.2 – Communication Via Console

1.5 Enabling Communication System Evolution

It was recognized that the service life of a given communication technology and that of an end device may radically differ. For example, a certain networking technology may only be of interest to a homeowner or utility for 5 years, but an end device such as a freezer may serve for 30 years.

A goal of the project team, through the general concept of modularity, was to prevent obsolescence of consumer devices by making the communication technology replaceable.

1.6 The Principle of Consumer Control

If a communication module is consumer installable, then it is also consumer removable. Even without removal, the manufacturers of end devices made it clear that they would always provide the consumer with a local override capability that would enable the equipment to resume whatever operation the consumer desired. This is a departure from some utility load control programs that were based on a fixed-credit, assumed participation, and took advantage of the fact that by-passing or disabling an inline relay was not something most homeowners would try to do.

The project team was presented with a whitepaper by the Association of Home Appliance Manufacturers (AHAM) that established certain Smart Grid perspectives. In addition to the idea that consumers will always have override capability, this document suggested that utilities should be able to learn everything they need regarding verification of DR participation by reading their meter.

2 Physical/Electrical Interface

There are two physical form factors for the interface. End device manufacturers may choose either, and communication module providers who wish to cover all products will offer two module versions. In both cases, the communication protocol is the same, as described herein. Also in both cases, the power for the communication module is provided by the end device. One form factor provides a low-voltage DC supply and an SPI serial data interface. This form factor has been adopted from the mechanical aspects of the USNAP specification and the use is described in more detail in **Appendix A** of this document. This option might be attractive in cases where the end device has no AC power source or when smaller socket size is required.

The other form factor provides AC service voltage (120/240V) and an RS-485 based serial interface. This form factor is described in more detail in **Appendix B** of this document. This option might be attractive in cases where the end device does not provide a DC power supply, where compatibility with PLC communication modules is desired, or where communication module access to line frequency is needed.

Figure 2.1 – PLC Communication Module Example

3 Harmonized Serial Protocol

Contributions from both USNAP and ClimateTalk indicated that it is possible to define an extensible serial protocol that is both manageable by the simplest of devices and also capable of being extended to accommodate the more complex. This harmonized protocol is one such scheme – based on combining the basic concept set forth in those contributions. The general message format is as follows:

Address	Message Type	Packet Number	Payload Length	Payload	Checksum
1 Byte	1 Byte	1 Byte	1 Byte	Variable	2 Bytes

Figure 3.1 – Harmonized Protocol Data Unit Format

The idea here is that the middle part of the message, the "payload" can be a wide range of other protocols, with the "Message Type" byte indicating what protocol and the checksum being added at the end so as not to presume that the payload has basic data integrity built-in. The upside of such a scheme is the high level of flexibility and extensibility that it provides. The downside is that there must be a way for appliances and communication modules to discover which protocols one another support – more on this in the following sections. The following "Message Type" values have been identified as a starting set:

1 = Simple Serial (at least partially supported by all devices)

2 = USNAP 1.0

3 = ClimateTalk Pass-through

4 = Smart Energy Profile 1.0 Pass-through

5 = Smart Energy Profile 2.0 Pass-through

6 = IP Pass-through

7 = OpenADR

8 = AHAM Standard Communication Messages (may include maintenance, etc.)

9 = ASHRAE defined messages

10 to 249 other future message standards

250 to 255 Vendor proprietary message types

The "Vendor Proprietary" message types allow for vendors to make use of the serial interface for any purpose they wish. This includes manufacturing processes, field diagnostics, etc.

3.1.1 Address Byte

The "Address" byte is included for those cases where the appliance has many internal subsystems sharing the serial bus. The default value for this address is "1". Communication modules that know nothing of the inner workings of the appliance may always use a "1" in this field. Appliances that do not require any address can simply ignore this byte.

In the case of appliances that do have an internal bus, messages with an address of "1" would be handled by whichever subsystem is responsible for demand-response functionality. During the appliance manufacturing process, or when a manufacturer's field diagnostic tool is connected, any range of addresses could be used to reach other subsystems within the appliance.

3.1.2 Packet Number Byte

The "Packet Number" is normally 1, but could be used in the future for longer messages. It may be used to enable sequences of packets or as an extension to the length byte to allow for longer single packets.

3.1.3 Payload Length Byte

The "Payload Length" is the number of bytes in the Payload field. The Simple Serial messages fix this length at 2 bytes. Other message types may have variable payload lengths and may also include another length byte somewhere in the message payload as defined by the other protocol's spec.

3.1.4 Checksum Bytes

The checksum is calculated starting with the "Address" byte through to the end of the payload. Checksum calculation and encoding is to be done according to the ClimateTalk specification.

Because there is no special start character, bus idle (logic "1" state) for 2 or more byte times shall indicate the start of a new message. At the default baud rate of 19.2Kbaud, this is ~ 1.1[mS]. During a single packet transfer, the inter-character delay must be less than this time.

4 Simple Serial

This section defines the "Simple Serial" commands and explains how they would be supported by the interface. Because these commands are not adopted from another existing specification, it is necessary to fully document them here. Understanding the simple serial commands is important, because even advanced communication modules and devices, that will normally use more advanced protocols, are required to fall back to a few required simple serial commands in the event that the device to which they are connected is not capable of the same advanced functionality.

Each simple serial command will be formatted as follows, with the message type being a "1" and the payload being a one byte opcode and a one byte operand.

Address = 1	Message Type = 1	Packet Number = 1	Payload Length = 2	Opcode	Operand	Checksum

1 Byte	1 Byte	1 Byte	1 Byte	1 Byte	1 Byte	2 Bytes

Figure 4.1 – Simple Serial Data Format

The Simple Serial message payloads are defined as follows:

				Mandatory?	
Opcode Byte	**Operand Byte**	**Description**	**Usage**	**for DR Modules**	**for Appliances**
1	Not Used	Simple Off	Sent once from the module to the appliance when a direct load control curtailment period begins. The period is terminated by Opcode 2 (Run Normal). If NAK'ed by the appliance, comm modules must send Opcode 3. Use of this message informs appliances that the program is one of a direct load control nature. Advanced appliances might offer users separate preference settings for this type of message.		
2	Not Used	Price is Normal / Run Normal	Sent once from the module to the appliance when price / curtailment status becomes normal	✓	✓
3	Optional Price Detail (see next section)	Price is High / Shed Load	Sent once from the module to the appliance when price / curtailment status becomes high. Use of the "price detail" field is optional for both communication modules and appliances.	✓	✓
4	Optional Price Detail (see next section)	Price is Low	Sent once from the module to the appliance <u>if</u> price becomes extraordinarily low or a preferred time to use energy is otherwise indicated. Use of the "price detail" field is optional for both communication modules and appliances.	✓	
5	Not Used	Critical Peak Price is in Effect (few times a year, 5 hours max)	Sent once from the module to the appliance when a critical peak price event goes into effect. If NAK'ed, send Opcode 3.		
6	Not Used	Grid	Sent once from the module to the		

		Emergency is in effect (do what you can, however long or short)	appliance when a grid emergency event goes into effect. If NAK'ed, send Opcode 3.		
7	Not Used	2-hr advanced notice of price increase	Sent from the module to the appliance 2 hours before a known price increase or start of a curtailment period		
8	Not Used	2-hr advanced notice of price decrease	Sent from the module to the appliance 2 hours before a known price decrease or end of a curtailment period		
9	Not Used	Communication Module is Communicating Successfully to Outside World	Sent from the module to the appliance when successful communication has just been established. When in the "communicating" state, this command is resent every 1 to 5 minutes so that appliances may know that the communication module is still attached.	✓	
10	Not Used	Communication Module is NOT Communicating to Outside World	Sent from the module to the appliance when communication loss has just been detected (speed of loss detection is system dependent). When in the "not communicating" state, this command is resent every 1 to 5 minutes so that appliances may know that the communication module is still attached.	✓	
11	Not Used	It is Sunday morning at 00:00:00AM (weekly time synch)	Sent from the module to the appliance.		
12	Not Used	It is 4:00AM (daily time synch)	Sent from the module to the appliance.		
13	Previous Opcode	Acknowledge successful receipt and support of previous	Returned immediately for all supported message Opcodes except 13 (do not ACK an ACK).	✓	✓

		message			
14	Prev Msg Type	NAK - Do not support previous message type	Sent from either appliance or module to the other when a message with an unsupported message type is received	✓	✓
15	Previous Opcode	NAK - Do not support previous Opcode	Sent from either appliance or module to the other when a message with an unsupported Opcode is received	✓	✓
16	Not Used	Customer Override	Sent from the appliance to the communication module when a customer chooses to override a load reduction process. Also sent immediately after acknowledging receipt of a load reduction message if the customer's override preference is permanently set.		
17	Not Used	Query: What is your operational state?	Sent from the module to the appliance.		
18	Operatin g State Code	(See description in next section - could define up to 255 states)	Sent from the appliance to the communication module in response to an Opcode 17 query		
19	Not Used	Reboot Request	May optionally be sent from the appliance to the communication module.		
20	Message Type	Query: Do you support this Message Type?	Sent from either appliance or communication module to the other. Results in an ACK or NAK. Acknowledging support of an indicated message type.	✓	✓
21	Not Used		Project work in process: Consider adding a query for max power available in order to support the USNAP DC interface spec.		
22			Project work in process: Bit-rate Negotiation? Max payload size		

			negotiation?		

Figure 4.2 – Simple Serial Command Set

After power-up, communication modules and end devices will begin communication assuming only that the mandatory functions of the simple serial protocol are supported. This requires the ability to handle only 8 byte messages, parsing of only a short list of payloads (3 required commands), and allows NAK'ing of any unsupported commands.

After power-up or upon receipt of a message from the outside world, the communication module could send Opcode 20 queries to discover what types of advanced message types the appliance or console is capable of supporting. Alternatively, it could just figure it out by trying and getting ACK'ed/NAK'ed.

Communication modules may be developed with the ability to receive more advanced protocols, like Smart Energy Profile or OpenADR over a network, and then either pass the messages through to the appliance if it supports them, or interpret the messages and translate into simple-serial. This interface specification makes no assumptions or requirements of the communication systems themselves.

Message Length (Byte Count)

Simple Serial messages are always fixed at 8 bytes, because the payload always consists of one opcode byte and one operand byte. This makes message parsing simple because processors can shift over a known number of bytes and always find the opcode.

4.1 Price Detail Field

As indicated in Figure 4.2, the "High Price" (Opcode 3) and "Low Price" (Opcode 4) commands may optionally include an operand that provides additional information about the price signal. Appliances may choose to use or ignore this field. The Operand is a single octet (8 bits) interpreted as two nibbles (4 bits).

Event Duration Indication (most significant nibble)

As indicated in figure 4.3, the most significant 8 bits indicate the event duration in hours.

MS 4 bits	Implied Event Duration [Hours]
0000	Duration Unknown
0001	< 0.33
0010	.33 to 0.75
0011	>.75 to 1.4
0100	1.4 to 2.4
0101	2.4 to 3.5
0110	>3.5 to 4.5
0111	>4.5 to 6

1000	>6 to 9
1001	>9 to 11
1010	>11 to 14
1011	>14 to 17
1100	>17 to 22
1101	>22 to 30
1110	>30 to 54
1111	>54

Figure 4.3 – Event Duration Indication Nibble

Relative Price Indication (least significant nibble)

As indicated in figure 4.4, the least significant 4 bits indicate the ratio of the price during this period to the normal or average price.

LS 4 bits	Implied Price Indication (relative to average)
0000	N/A or Unknown
0001	< 0.3
0010	0.3 to 0.45
0011	0.45 to .65
0100	0.65 to 0.8
0101	0.8 to 0.93
0110	0.93 to 1.06
0111	1.06 to 1.16
1000	1.16 to 1.3
1001	1.3 to 1.5
1010	1.5 to 1.85
1011	1.85 to 2.33
1100	2.33 to 3
1101	3 to 4.2
1110	4.2 to 6
1111	> 6

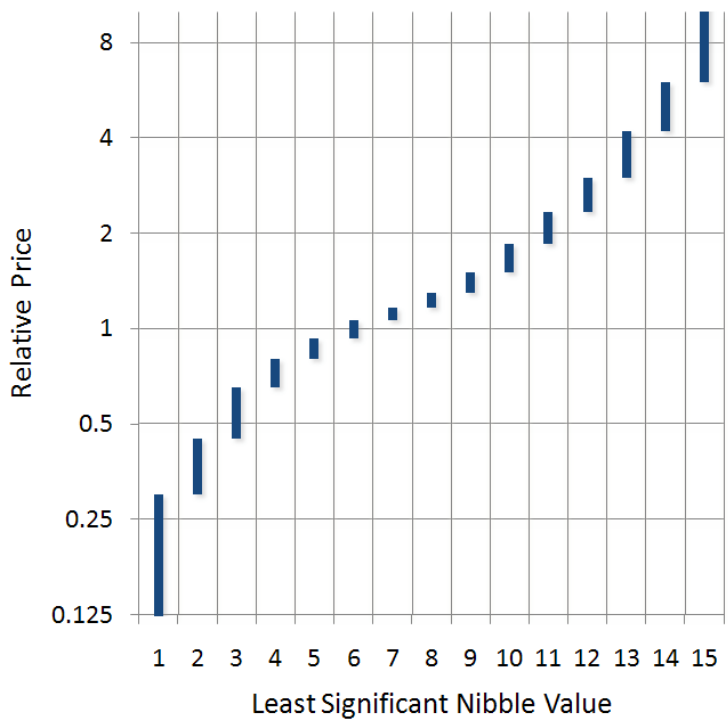


Figure 4.4 – Relative Price Indication Nibble

4.2 Operating State Codes

Opcode 17 requests the operational state of the appliance and Opcode 18 provides the response. The Opcode 18 response includes a single byte operand that describes the state of the device. The following may be extended in future versions. Up to 255 states may be defined.

Operating State Code	Meaning
0	Idle (a normal standby state)
1	Running (a normal operating state)
2	Running Curtailed (Grid)
3	Running Heightened (Grid)
4	Disabled (Grid)
5-255	Unused

Figure 4.5 – Operating State Codes

5 Smart Energy Profile

This section shows how the Smart Energy Profile 2.0 would be supported by the interface. The messages would look as follows, with the message type being a 4, 5, or other SEP type and the payload being defined entirely by the Smart Energy Profile specification.

Address = 1	Message Type = 5	Packet Number = 1	Payload Length	Smart Energy Profile Message	Checksum
1 Byte	1 Byte	1 Byte	1 Byte	Variable	2 Bytes

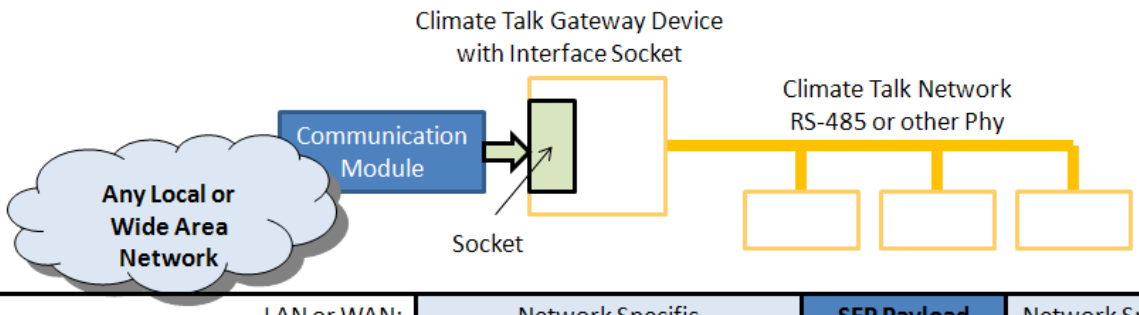
Figure 5.1 – SEP over Serial

Question: Does “Packet Number” need to become an extension of the “Message Length” for the SEP message types?

Similarly, using Message Type = 2 or Message Type = 3 would allow the conveying of USNAP and ClimateTalk messages, each being documented and controlled by their appropriate organizations. For these types of messages, when passed-through directly to the appliance, the payload does not have to be understood by the communication module. It can become simply a part of a conduit for conveying the messages from a host to an appliance who each understand the payload.

6 Climate Talk Harmonization

This section shows how a ClimateTalk device with a socket interface could act as a gateway to a ClimateTalk network. Figure 6.1 provides some example scenarios.



Scenario 1	LAN or WAN:	Network Specific	**SEP Payload**	Network Specific
	Socket Interface:	Harmonized Interface Header	**SEP Payload**	Checksum
	ClimateTalk Network:	ClimateTalk Addressing & Header	**SEP Payload**	CT Footer
Scenario 2	LAN or WAN:	Network Specific	**SEP Payload**	Network Specific
	Socket Interface:	Harmonized Interface Header	**Simple**	Checksum
	ClimateTalk Network:	ClimateTalk Addressing & Header	**SEP Translation**	CT Footer
Scenario 3	LAN or WAN:	Network Specific	**Proprietary**	Network Specific
	Socket Interface:	Harmonized Interface Header	**SEP Translation**	Checksum
	ClimateTalk Network:	ClimateTalk Addressing & Header	**SEP Translation**	CT Footer
Scenario 4	LAN or WAN:	Network Specific	**Proprietary**	Network Specific
	Socket Interface:	Harmonized Interface Header	**Simple**	Checksum
	ClimateTalk Network:	ClimateTalk Addressing & Header	**SEP Translation**	CT Footer

Figure 6.1 – ClimateTalk Harmonization Examples

In Scenario 1, the local area or wide area network that conveys energy-related information utilizes the Smart Energy Profile at the application layer. This is illustrated by the "SEP Payload" with some network-specific header and footer around it in the message datagram. In this Scenario, the Gateway Device accepts and acknowledges SEP messages on the socket interface; therefore the communication module passes the SEP payload across the socket interface without any translation framed by the Harmonized header and footer. Once the message is received by the gateway device, it may optionally forward the message to other devices on the ClimateTalk network. Assuming that the ClimateTalk network's energy-related messages are SEP over ClimateTalk, then this forwarding would likewise not require any translation and the SEP payload would have been passed through seamlessly (i.e. end to end application layer transparency)

Scenario 2 envisions the same LAN/WAN, but assumes that the Gateway Device does not support (i.e. NAK's) SEP messages on the socket interface. In this case, the communication module is forced to translate the network messages into "Simple Serial". As in the previous case, the Gateway Device may be designed to create ClimateTalk messages to share received energy-related information. If done, this would require re-translation into "SEP over ClimateTalk", making it an odd scenario because it would

seem logical that any Gateway Device prepared to send out “SEP over ClimateTalk” would also accept incoming “SEP over Serial” messages.

Scenario 3 is like Scenario 1, except the LAN/WAN uses a vendor-specific protocol. In this case, the communication module may either translate received information into Simple Serial messages, which it would be assured that all devices could support, or, since the Gateway Device supports SEP on the socket interface, then the communication module may translate the proprietary messages into SEP as indicated.

Scenario 4 is like Scenario 2, in that the Gateway Device does not support SEP messages on the socket interface. But in this case, as with Scenario 3, the LAN/WAN is vendor-specific. In this case, the communication module would have no option but to translate the proprietary messages into Simple Serial. The Gateway Device could then translate the Simple Serial messages into SEP over ClimateTalk if desired. This and other scenarios, while unattractive due to translations, is a necessary part of allowing any communication module to work on any end device.

Although not shown in Figure 6.1 a 5th scenario is the case where a complete ClimateTalk message (not SEP or energy related) is sent over the LAN/WAN network in its payload. In this case, if the Gateway Device indicates that it can support ClimateTalk, then the message could be passed across the socket interface in the same fashion as an SEP message, but with the “Message Type” byte set to 3 instead of 4, and then passed on out on the ClimateTalk network as appropriate.

7 Advanced Internet Pass-through

This section shows how the interface could be extended even to the point of supporting communication systems and appliances that are capable of web access.

Using the initial simple serial commands at power-up, either the appliance or the communication module can probe the other to see what protocols it supports. Whenever a communication module that supports internet pass-through and an appliance that supports internet access are connected together, they can detect it and activity can begin just the same as-if the appliance were directly connected via an Ethernet cable. When passing an IP packet over the serial interface, the communication module or appliance will add a leading Message Type = 6 byte and a trailing checksum.

Question: Does “Packet Number” need to become an extension of the message length for this message type?

Question: Does the IP Pass-through mechanism need to drop the surrounding bytes and go to pure IP packet exchange (i.e involve “state”), or are these six leading and following bytes tolerable – much like channel training bytes on a radio signal ?

Need Cisco / Google / Others to lead the detailed definition in this area.

8 Example Communication Exchanges

Simple Serial, Request Operating State

Comm Module to End Device	→ 01 01 01 02 11 00 00 16	Opcode 17, what is your state?
End Device to Comm Module	← 01 01 01 02 0D 00 00 12	Opcode 13, Acknowledge prev. msg.
End Device to Comm Module	← 01 01 01 02 12 02 00 19	Opcode 18, End device is curtailed
Comm Module to End Device	→ 01 01 01 02 0D 00 00 12	Opcode 13, Acknowledge prev. msg.

Simple Serial, Unsupported Messages Followed by High Price

Comm Module to End Device	→ 01 01 01 02 0C 00 00 11	Opcode 12, It is 4:00AM
End Device to Comm Module	← 01 01 01 02 0F 00 00 14	Opcode 15, Prev Opcode Not supported
Comm Module to End Device	→ 01 01 01 02 05 00 00 0A	Opcode 5, Critical Peak in Effect
End Device to Comm Module	← 01 01 01 02 0F 00 00 14	Opcode 15, Prev Opcode Not supported
Comm Module to End Device	→ 01 01 01 02 03 00 00 12	Opcode 3, High Price in effect
End Device to Comm Module	← 01 01 01 02 0D 00 00 12	Opcode 13, Acknowledge prev. msg.

Query, Then Use, of Smart Energy Profile 2.0

Comm Module to End Device	→ 01 01 01 02 14 05 00 1E	Opcode 20, Do you support SEP2?
End Device to Comm Module	← 01 01 01 02 0D 00 00 12	Opcode 13, Acknowledge prev. msg.
Comm Module to End Device	→ 01 05 01 3D <SEP msg> CS CS	SEP2 msg, length only an example
End Device to Comm Module	← 01 05 01 28 <SEP msg> CS CS	SEP2 msg, length as an example

* Note that the simple-serial ACK (Opcode 13) is only used in response to simple serial commands (message type 1). Once SEP2 is used (message type 5), then the acknowledge, if any, is up to the SEP2 specification.

IP Pass-through

End Device to Comm Module	← 01 06 01 A3 <IP pkt> CS CS	IP initiated from the appliance
Comm Module to End Device	→ 01 06 01 3D <IP pkt> CS CS	IP pkt to the appliance

Notes:

1. The comm module does not have to initiate communications. As shown in this example, the appliance can initiate an IP-based exchange of information.
2. In this example, the appliance chose not to query the comm module (opcode 20) to see if IP is supported. Instead, it just tried an IP packet, risking a simple serial message-type NAK (opcode 14). Should this be disallowed to prevent long messages from being sent to devices not capable of supporting them?
3. Several issues need addressing for IP pass-through – comments are welcome.

a. How to handle message length? Should devices that accept IP as a message-type automatically support up to 2048bytes?

b. Use of the packet number, payload length, and checksum fields? Should they be used differently for the case of IP message types?

c. Baud rate. IP pass-through brings to mind higher-performance applications. At what level should the bit rate be negotiable between the two devices?

9 General Security Principles

Based on prior team discussions, the serial interface between a communication module and the appliance may not be encrypted (is not encrypted in the simple serial case) and is treated as a naturally secured interface like a connection between circuit boards inside a product. If the communication on the communication network (PLC, wireless, etc) is encrypted, as it may be in a secured Zigbee HAN for example, the decryption could occur in the communication module and only the unencrypted SEP message passed to the appliance.

In the case of more advanced protocols, like internet pass-though, encryption may exist within the IP packet embedded in the serial message. For example, if the communication network is Wi-Fi, then a Wi-Fi communication module may receive an IP packet wirelessly, strip-off any 802.11 phy/mac part, insert the IP packet as the "Payload" in the message structure shown in Figure 3.1, and send it on through to the appliance. In this case, the comm module would be serving as a phy/mac translator and would know nothing of the packet's content, which may or may not be encrypted. The comm module would know whether or not the appliance is accepting or NAK'ing the messages.

10 Appendix A – Low Voltage DC Form Factor

The low voltage DC form factor utilizes the entirety of the physical layer specification from USNAP 2.0. This layer is described in section 4 of the USNAP specification, available at: www.usnap.org

This section includes the following:

1. The DC power supply voltage level and the limitations on current consumption through the interface.
2. The board and module dimensions, including both standard and elongated package sizes.
3. The electrical connector type and pinout.
4. The communication signal voltage levels and timing.
5. The basic use of the various serial communication pins to frame message transfers.

The protocol (message format) sent across this interface is the same as that on the AC form factor as described in the main body of this document.

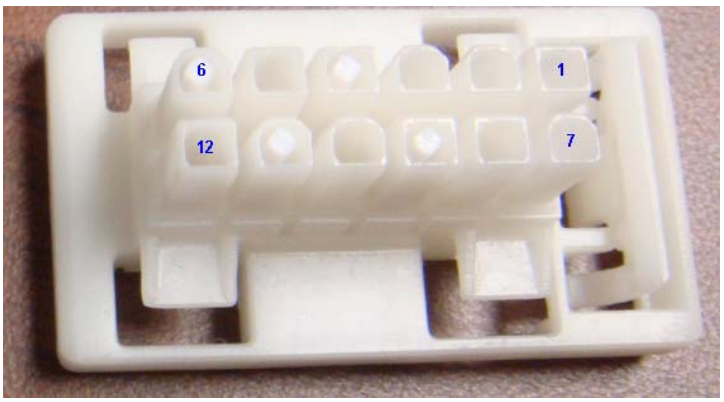
For reference, the pin-out on this interface is:

Pin	Signal "A" Device
1	SELECT, must be held high when not communicating with UCM
2	ATTENTION
3	SCLK
4	MOSI
5	MISO
6	RESET*
7	+3.3V Power
8	Signal Ground
9	Reserved
10	Reserved

11 Appendix B – AC Voltage Form Factor

11.1.1 Physical Form

The connector shown in Figure 10.1 provides sufficient clearance for the 120/240Vac signals. In the case of 120V appliances, AC+ is the hot connection and AC- is the neutral connection. In the case of 208/240V three wire appliances, AC+ is phase A and AC- is phase B. The connector includes protective sleeves to cover the energized pins, has some circuits removed to increase clearance around the AC power, and is polarized so that the mating device can only be plugged-in one way. The part that would go on an appliance is available from Molex as 44516-006. The mating part, which could be used on a communication module that plugged-in at a right angle, is Molex RSD-43459-001.



Pin	Usage	Pin	Usage
1	Data-	7	Data+
2	+5V ref	8	N/C
3	Signal Ground	9	N/C
4	N/C	10	120VAC Line 2
5	Earth Ground	11	N/C
6	N/C	12	120VAC Line 1

Figure 10.1 – AC Connector Form Factor (Appliance Side Shown) and Pin-Out

11.1.2 AC Power

Communication modules must be designed to operate normally over a voltage range from 10% under the nominal service voltage to 20% over the nominal voltage. This equates to 96 to 288Vac. They must be auto-ranging. Current consumption on these AC lines may not exceed 50[mArms] average, 100[mArms] peak (100mS max, 10% duty cycle). Appliances and other end devices providing this connection may optionally choose to limit the current to this level.

11.1.3 Serial Electrical Interface

This is an EIA RS-485 2-wire connection on pins 7 (Data+) and 1 (Data-). Although RS-485 requires a driver IC that is generally separate from the microcontroller, the use of such a driver provides protection against ESD and other transients and potential noise problems. RS-485 is also multi-drop capable, allowing the serial port going into the appliance to connect to multiple sub-systems inside the appliance if desired. The default state for this bus is a logic “1”, with a 1K ohm pull-up resistor on the Data+ line to 3.3V and a 1K pull-down resistor to GND on Data- provided by the appliance.

The default baud rate on the interface is 19.2KBaud with one start bit (0), eight data bits, no parity, and two stop bits (1's). The data is sent LSB first.

These options are adopted from the MODBUS over serial line specification, RTU mode, currently at Version 1.02[1].

[1] Available online at: http://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf

12 Appendix C – Reference Serial Protocols from Related Bodies of Work

The following were studied and leveraged to varying extents during the formation of this specification.

12.1 USNAP

The USNAP message structure was presented as shown in Figure 11.1.

Byte 1	First Command Byte	See Application Layer
Byte 2	Secondary Command Byte	See Application Layer
Byte 3	Count Byte (0 – 125)	Count of # of Data Bytes
	First Data Byte (*optional)*	First Data
	. . .	
Byte N-2	Data byte M-1 *(optional)*	
Byte N-1	Data byte M *(optional)*	last byte of message
Byte N	Checksum Byte	Sum of Byte 1 through byte N-1.

Figure 11.1 – USNAP Message Structure

In the Version 2 specification, currently being publicly reviewed, the data portion of the message may be either the original USNAP commands or Smart Energy Profile 1.0 commands, with the distinction between them being indicated by the first command byte. If the first command byte is 0x70, then the data bytes are an SEP 1.0 message. In similar fashion, other protocols could be supported.

12.2 ClimateTalk

The presentation from ClimateTalk made several interesting points. One of the most significant take-aways was that each industry segment will have a range of communication needs that are unique to that segment. For example, we see that the HVAC industry has communication needs related to air handlers, air vents/dampers, compressors, etc. that are not covered in other standards and probably never will be. It is not reasonable to think that one document would capture and codify the superset of these functions.

The protocol specifics were presented and showed several options, each being appropriate for a specific scenario. In the case of a connection between a communication module and an appliance, a point to point connection exists and the simpler of the options was recommended.

ClimateTalk does not currently include demand-response related messages and the alliance's strategy for adding them is to align with other standards, like the Smart Energy Profile, rather than creating new messages. Figure 11.2, taken from the ClimateTalk presentation, illustrates how an "APP" byte near the

front of the packet is used to identify the remainder of the payload as being either ClimateTalk, Smart Energy Profile, or other message types.

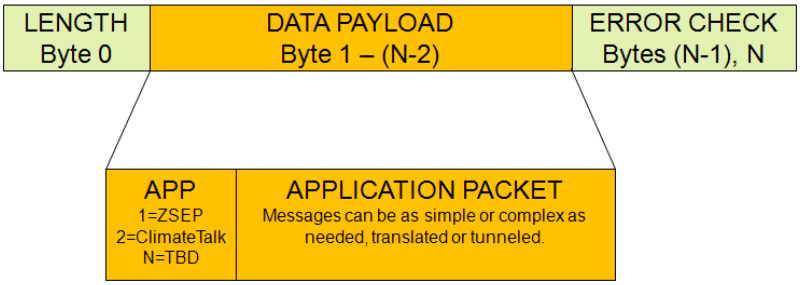


Figure 11.2 – ClimateTalk Accommodation of Multiple Application Types