TEKTELIC Communications Inc.
7657 10th Street NE Calgary, Alberta
Canada, T2E 8X2

LoRa IoT AC Outlet and Switch

Technical Reference Manual

Document Type:	Technical Reference Manual
Document Number:	T0006375_TRM
Document Version:	0.2
Product Name:	AC OUTLET & AC SWITCH, GEN 2
Product Codes:	T0006623 (AC Receptacle Module, Gen 2) Rev B
	T0006624 (AC Switch Module, Gen 2) Rev C
Release Date:	November 13, 2020

Revision History

Version	Date	Editor	Comments
0.1	September 11, 2020	C. Providenti	Created document.
0.2	November 13, 2020	L. Morrison	• Updated formatting. • Clarified relay push button descriptions.

Table of Contents

List of Tables

Acronyms and Glossary

$0xX_1X_2$ .... a (1-byte) hexadecimal number with the value denoted by the hexadecimal digits X1X2 (e.g., 0x2A = 42); a 2- or 4-byte number would have correspondingly more digits, of course
AC .... alternating current
actuating element .... a sensor component that converts digital data into physical (real-world) outputs (e.g., relay closure or motor rotation speed)
ADR .... adaptive data rate
ABP .... activation by personalization
CRC .... cyclic redundancy check
DL .... downlink
downlink .... a transmission to (i.e., received by) a LoRa node
DR .... data rate
EIRP .... effective isotropic radiated power
flash .... the specific non-volatile storage technology used by the applicable sensors
ID .... identity or identifier
IoT .... Internet of Things
LoRa .... a patented long-range radio technology targeted at IoT and owned by Semtech.
LoRa node .... a device at the edge of a LoRaWAN network that communicates with the network using LoRa (e.g., a sensor)
LoRaMAC .... LoRaWAN MAC
LoRaWAN .... wide area network (protocol) based on LoRa
LoRaWAN commissioning ... the IDs and encryption keys assigned to a LoRa node that enable it to communicate over a LoRaWAN network
LoRaWAN region .... a LoRaWAN channel plan and other rules applicable to a specific (RF) regulatory region
LSB .... least significant byte
LSb .... least significant bit
MAC .... media access control
MCU .... microcontroller unit
MSB .... most significant byte
MSb .... most significant bit
N/A .... not applicable
NA .... North America
NS .... network server
OTA .... over-the-air
OTAA .... over-the-air activation
RFU .... reserved for future use
RMS .... root mean square
RO .... read-only
R/W .... read/write
Rx .... receive or receiver

sensing element .... a sensor component that converts physical (real-world) inputs (e.g., temperature, humidity) into digital data

sensor .... LoRa node supporting one or more transducers (and insofar as this document is concerned, the specific sensors listed in Table 1 1: Applicable Sensor Models)

TBD .... to be determined

transducer .... a sensing or actuating element

TRM .... Technical Reference Manual (e.g., this document)

Tx .... transmit or transmitter

UL...................................... uplink

uplink .... a transmission from (i.e., transmitted by) a LoRa node

virtual transducer .... sensor functionality that is represented in the same way as a transducer (e.g., the status of a fault reported as if it were a GPIO input)

WO.................................... write-only

1 Overview

1.1 Applicable Sensor Models

This Technical Reference Manual (TRM) describes the LoRaWAN payload protocol and associated configuration options supported by the sensor models listed in Table 1-1.

Table 1-1: Applicable Sensor Models

Product Code	Revision	Description	RF Region
T0006623	B	AC Receptacle Module, NA, LoRa, Gen 2	US 902-928MHz ISM Band
T0006624	C	AC Switch Module, NA, LoRa, Gen 2	US 902-928MHz ISM Band

Unless otherwise noted, the features described herein are supported by versions 0.7 and later of the corresponding sensor software.

1.2 Information Streams

These sensor models provide the following information streams to application servers:

1. An operational stream over which the sensor transducer data may be exchanged.
2. A management stream over which the sensor configuration data may be exchanged.

1.3 Default Configuration

The default configuration for these sensor models is as follows:

- Operate as a LoRa Class C device.
- Report (AC) energy consumption once per hour.
- Report other measurements (e.g., power) on demand.
- Report relay (AC load control) actuation (on/off) when it occurs.
- Report status (e.g., Energy Consumption Meter running/stopped) when it changes.

2 Operational (Transducer) Information Stream

The operational (transducer) information stream provides for the exchange of transducer data (signals) between a sensor and an application server via LoRaWAN. Uplinks will normally contain signals from sensing elements (measurement data); downlinks will normally contain signals to actuating elements (control data).

Subject to the restrictions imposed by LoRaWAN, either end may initiate the exchange. Moreover, the exchange is essentially open loop (unidirectional), there being no protocol-specified (universal) mechanism for the receiver to acknowledge (or otherwise respond to) the receipt of (any) transducer data, other than those specified by LoRaWAN. E.g., a downlink from the application server may cause the sensor to close a relay whose (unintended) side effect is to trigger a fault that the sensor then reports via an uplink. The fact that the former (downlink) triggered the latter (uplink) is coincidental insofar as this information stream protocol is concerned: that the one triggered the latter is not inherent to the protocol, but to the physical nature of the sensor and the conditions under which it was operating. If closing the relay were not to have triggered the fault, the downlink would not (necessarily) have been followed by an uplink reporting the absence of the fault.

Note: This TRM *does* specify that some downlinks will trigger (elicit) a corresponding uplink, but such behaviour is specific to the downlink in question, and applies only if documented *explicitly*.

The payload portion of a LoRaWAN packet carries the transducer data. Such payloads are always transmitted on ***LoRaWAN port 10***. The same payload format is used for both up- and downlinks (ULs and DLs).

Each payload comprises one or more (multi-byte) transducer data frames, with each such frame having the format shown in Table 2-1. There is no guarantee on the type, number, or relative order of the frames within the payload, save that the relative order of the frames in the payload should be the order in which the receiver processes the frames. Only whole (complete) frames may appear within a payload: a frame that does not fit within the remaining payload space must be transmitted in a subsequent payload.

Table 2-1: Transducer Frame Format

Offset (Bytes)	Length (Bytes)	Field	Description
0	1	Data Channel	Identifies the instance of the data type specified in the data type field.
1	1	Data Type	Identifies the type of transducer data provided in the data value field.
2	≥0	Data Value	Transducer data whose length and interpretation depends on the values that appear in the data channel and type fields.

The data channels and data types that may appear in an uplink payload are not necessarily the same as those that may appear in a downlink payload. The following subsections identify the data channels and data types supported by the applicable sensors.

The data value may comprise zero or more (≥0) bytes, and consist of zero or more distinct values (e.g., latitude, longitude, and altitude for a GPS location co-ordinate). Unless otherwise indicated:

- Distinct values appear in sequence with no intervening (padding) bytes.
- Multi-byte values (e.g., 2-byte integers) are in big-endian order (MSB first, LSB last).
- Signed integer values are 2's complement.

- Floating point values are in IEEE 754 format.
- Text values are fixed-length ASCII, and padded to the specified length with ASCII space characters (0x20).
- Values (including bitfields within a bitmap value) documented as RFU must be zero (0) unless otherwise indicated.

2.1 Uplink Transducer Frame Formats (Data Types and Channels)

The possible transducer frame formats (data types and channels) for uplinks are outlined in Table 2-2, and further described in the notes that follow.

Table 2-2: Uplink Transducer Frame Formats

Name	Data Channel	Data Type	Data Value(s)	Description
Energy Consumption Meter	0x00	0xFE	4-byte unsigned integer	Total elapsed time (seconds)
			4-byte signed integer	Total energy consumed (W-h)
Energy Consumption Meter Status Indicator	0x00	0x00	1-byte Boolean	Energy consumption meter (operational) status: • 0x00: Idle (stopped) • 0xFF: Active (running)
Voltmeter	0x00	0x74	2-byte unsigned integer	RMS voltage (×0.1 V_{RMS}), or 0xFFFF to indicate the measurement is not available or outside the supported range (0.0–6553.4 V_{RMS})
Ammeter	0x00	0x75	2-byte unsigned integer	RMS current (×0.1 A_{RMS}), or 0xFFFF to indicate the measurement is not available or outside the supported range (0.0–6553.4 A_{RMS})
Power Meter (Active Power)	0x00	0x80	2-byte signed integer	Active power (×0.1 W), or 0x8000 to indicate the measurement is not available or outside the supported range (-3276.7–+3276.7 W)
Power Meter (Apparent Power)	0x01	0x80	2-byte unsigned integer	Apparent power (×0.1 W), or 0xFFFF to indicate the measurement is not available or outside the supported range (0.0–6553.4 W)
Power Meter (Reactive Power)	0x02	0x80	2-byte signed integer	Reactive power (×0.1 W), or 0x8000 to indicate the measurement is not available or outside the supported range (-3276.7–+3276.7 W)
Power Factor Meter	0x00	0x81	1-byte unsigned integer	Power factor: • 0-100: Power factor (×0.01) • 101-254:RFU • 255: Not available/valid
Relay (AC Load Control) Status	0x00	0x01	1-byte Boolean	Relay status: • 0x00: Open (AC load disconnected) • 0xFF: Closed (AC load connected)

Frequency Meter (Line Frequency)	0x00	0x76	2-byte unsigned integer	Line frequency (×0.1 Hz), or 0xFFFF to indicate the measurement is not available or outside the supported range (0.0–6553.4 Hz)

Note:

3. Many of the above are *virtual* sensing elements (virtual transducers).
4. Data channels are *not* unique across different data types.
5. Most (if not all) data type IDs are as per reference **[3]**, or augmented as explained therein using the (other) IPSO object IDs described in references **[4]** and **[5]**.
6. Data value(s) need *not* be the same for different data channels of the same data type ID.
7. The sensor can be configured to report some of the above periodically: see section 3.3.1 Periodic Reporting Configuration. The others must be requested explicitly: see section 2.2 Downlink Transducer Frame Formats (Data Types and Channels).

2.2 Downlink Transducer Frame Formats (Data Types and Channels)

The possible transducer frame formats (data types and channels) for downlinks are outlined in Table 2-3, and further described in the notes that follow.

Table 2-3: Downlink Transducer Frame Formats

Name	Data Channel	Data Type	Data Value(s)	Description
Energy Consumption Meter Measurement Push Button	0x00	0x93	[none]	Elicits an Energy Consumption Meter uplink.
Energy Consumption Meter Reset Push Button	0x01	0x93	[none]	Resets (restarts) the Energy Consumption Meter.
Energy Consumption Meter Status Push Button	0x02	0x93	[none]	Elicits an Energy Consumption Meter Status Indicator uplink.
Voltmeter Measurement Push Button	0x03	0x93	[none]	Elicits a Voltmeter uplink.
Ammeter Measurement Push Button	0x04	0x93	[none]	Elicits an Ammeter uplink.
Power Meter (Active Power) Push Button	0x05	0x93	[none]	Elicits a Power Meter (Active Power) uplink.

Power Meter (Apparent Power) Push Button	0x06	0x93	[none]	Elicits a Power Meter (Apparent Power) uplink.
Power Factor Meter Push Button	0x07	0x93	[none]	Elicits a Power Factor uplink.
Relay Control Push Button	0x00	0x01	1-byte Boolean	Changes the Relay status: • 0x00: Open (AC load disconnected) • 0xFF: Closed (AC load connected)
Relay Status Push Button	0x08	0x93	[none]	Elicits a Relay (AC Load Control) Status uplink.
Power Meter (Reactive Power) Push Button	0x09	0x93	[none]	Elicits a Power Meter (Reactive Power) uplink.
Frequency Meter (Line Frequency) Push Button	0x0A	0x93	[none]	Elicits a Frequency Meter (Line Frequency) uplink.

Note:

8. This downlink format is *not* as per reference **[3]**, but modeled on the uplink format described therein.
9. Many of the above are *virtual* actuating elements (virtual transducers).
10. Data channels are *not* unique across different data types.
11. Most (if not all) data type IDs are as per reference **[3]**, or augmented as explained therein using the (other) IPSO object IDs described in references **[4]** and **[5]**.
12. Data value(s) need *not* be the same for different data channels of the same data type ID.

3 Management (Configuration) Information Stream

The management (configuration) information stream provides for the exchange of configuration data (settings) between a sensor and an application server via LoRaWAN.

Subject to the restrictions imposed by LoRaWAN, the application server always initiates the exchange, and the sensor always responds accordingly. The application server specifies (in the downlink) the configuration data to be transferred and the direction of the transfer (*up* or *down*):

1. A transfer in the *up* direction corresponds to a *read* operation, enabling the application server to *get* (inspect) the specified configuration data. In this case, the corresponding uplink from the sensor will contain the specified configuration data.
2. A transfer in the *down* direction corresponds to a *write* operation, enabling the application server to *set* (modify) the specified configuration data. In this case, the corresponding uplink from the sensor will contain an acknowledgment.

The payload portion of a LoRaWAN packet carries the configuration data (and/or acknowledgment, in the case of an uplink). Such payloads are always transmitted on ***LoRaWAN port 100***. The payload format for uplinks is similar to, but not exactly the same as, that for downlinks.

The downlink payload comprises one or more configuration command frames, with each such frame having the format shown in Table 3-1. The sensor processes the frames within the payload in order of appearance, with all writes processed before any reads are processed. Thus, a downlink payload that specifies a read and write of the same configuration data will return the configuration data that was written unless the write failed.

Only whole (complete) command frames may appear within a payload: a frame that does not fit within the remaining payload space must be transmitted in a subsequent payload. The sensor ignores incomplete command frames, or command frames that specify invalid configuration data. E.g., configuration data documented as read-only (RO) would be invalid for a command frame that specifies a write.

Table 3-1: Command Frame Format

Offset (Bytes)	Length (Bytes)	Field	Description
0	1	Command	Value that specifies the configuration data to be transferred and the direction of the transfer.
1	≥0	Data	Configuration data to be transferred in the down direction (write) *only*. **Note:** This field is empty (i.e., omitted) if the transfer is in the up direction (read). This field *may* be empty when the transfer is in the down direction, depending on the nature of the configuration data specified by the command field.

The (1-byte) command field within such a command frame has the format shown in Table 3-2. The most significant bit in the field specifies the direction of the transfer (up/down). The remaining seven (7) bits identify the configuration data to be transferred.

Table 3-2: Command Field Format

Offset (Bits)	Length (Bits)	Field	Description
0	6	Address	ID of the configuration data to be transferred.
7	1	Direction	Direction of the transfer: • 0: Up (read) • 1: Down (write)

As can be inferred from the name of the latter (address) field, the configuration data is organized as a set of (heterogeneous) pseudo-registers with addresses in the range 0-127 (0x00-0x7F).

The uplink payload comprises the following:

1. An optional 4-byte field acknowledgment field.
2. Zero or more response frames.

The sensor transmits the former (1) in response to a downlink payload that contains one or more command frames that specify a down (write) transfer. The value of this field is the 32-bit CRC of the (entire) downlink payload. In the case of the latter (2), the sensor transmits one response frame for each command frame in the downlink payload that specifies an up (read) transfer. These response frames contain the configuration data to be transferred.

Note: The 32-bit CRC used is the standard CRC-32, except with an initial value of 0x0000000 (instead of 0xFFFFFFFF).

Either one or the other will be present in such an uplink payload. In other words, the payload will not be empty. Only whole (complete) response frames may appear within a payload: a frame that does not fit within the remaining payload space will be transmitted in a subsequent payload (with one exception, explained below). In this case, only the first uplink payload will contain the (optional) 4-byte acknowledgment field (CRC).

Exception: If the response frame does not fit in the payload, and if it would exceed the minimum LoRaWAN payload size for the applicable LoRaWAN region (e.g., 11 bytes in the US915 region), the sensor will *not* transfer that response frame (i.e., it quietly ignores the corresponding downlink command frame). Payload size is determined by the LoRa datarate (DR), and there is no guarantee that the LoRaMAC would ever select a DR that allows the response frame to be transmitted.

The format of a response frame is shown in Table 3-3.

Table 3-3: Response Frame Format

Offset (Bytes)	Length (Bytes)	Field	Description
0	1	Response	Value that specifies the configuration data transferred.
1	≥0	Data	Configuration data.

The (1-byte) response field within such a response frame has the format shown in Table 3-4.

Note: A comparison of the response frame and field formats to the command frame and field formats makes it clear that the response frame is the same as the command frame that specified the up (read) transfer, except that it contains the configuration data. In this sense, the uplink payload format is similar to that of the downlink payload.

Table 3-4: Response Field Format

Offset (Bits)	Length (Bits)	Field	Description
0	6	Address	ID of the configuration data to be transferred.
7	1	RFU	Always 0.

The following subsections describe the configuration data (pseudo-registers) supported by the applicable sensors. Register addresses not described herein are RFU.

The configuration data may comprise zero or more (≥0) bytes, and consist of zero or more distinct values (e.g., latitude, longitude, and altitude for a GPS location co-ordinate). Unless otherwise indicated:

- Distinct values appear in sequence with no intervening (padding) bytes.
- Multi-byte values (e.g., 2-byte integers) are in big-endian order (MSB first, LSB last).
- Signed integer values are 2's complement.
- Floating point values are in IEEE 754 format.
- Text values are fixed-length ASCII, and padded to the specified length with ASCII space characters (0x20).
- Portions (e.g., bitfields) of the configuration data that are not described herein are RFU. Such bitfields are ignored by the sensor in downlink payloads (i.e., in *write* command frames), and set to zero (0) in uplink payloads (i.e., in response frames).
- Values (including bitfields within a bitmap value) documented as RFU must be zero (0) unless otherwise indicated.

The configuration data read/written via this information stream corresponds to the "live" or "active" settings in volatile storage (RAM). Unless otherwise stated, changes to these settings take effect immediately. Such changes will not be preserved across sensor restarts unless they are explicitly saved to non-volatile storage (flash) as outlined in section 3.4: Sensor Command and Control.

3.1 LoRaWAN Commissioning

LoRaWAN commissioning as described in reference [1] can be retrieved via the registers listed in Table 3-5.

WARNING: LoRaWAN security guarantees for a sensor may be compromised by retrieving these values. Avoid doing so unless absolutely necessary.

Table 3-5: LoRaWAN Commissioning Registers

Address	Value(s)	Access	Description
0x00	8-byte unsigned integer	RO	DevEUI
0x01	8-byte unsigned integer	RO	AppEUI
0x02	16-byte unsigned integer	RO	AppKey
0x03	4-byte unsigned integer	RO	DevAddr
0x04	16-byte unsigned integer	RO	NwkSKey
0x05	16-byte unsigned integer	RO	AppSKey

Note: The values in registers 0x02, 0x04, and 0x05 exceed the minimum payload size in some LoRaWAN regions. E.g., the payload size for LoRa DR0 in the US915 region is 11 bytes.

3.2 LoRaMAC Options

LoRaMAC options as described in reference **[1]** can be configured via the registers listed in Table 3-6.

WARNING: Changing these values may introduce a mismatch with the corresponding Network Server (NS) settings for that sensor that leaves the sensor stranded. Ensure that the new (changed) values are compatible with the NS settings, and if not, change the NS settings accordingly.

Table 3-6: LoRaMAC Options Registers

Address	Value(s)	Access	Description
0x10	2-byte bitmap	R/W	Bits 0-14: RFU Bit 15: Join mode: • 0: ABP • 1: OTAA
0x11	2-byte bitmap	R/W	Bit 0: UL confirmation: • 0: Disable • 1: Enable Bit 1: Sync word • 0: RFU • 1: Public Bit 2: Duty cycle: • 0: Disable • 1: Enable Bit 3: ADR: • 0: Disable • 1: Enable Bits 4-11: RFU Bits 12-15: LoRa Class • 0xC: Class C • Otherwise: RFU
0x12	2-byte bitmap	R/W	Bits 0-3: Default Tx power number Bits 4-7: RFU Bits 8-11: Default DR number Bits 12-15: RFU
0x13	4-byte unsigned integer	R/W	RX2 window channel frequency (Hz)
	1-byte bitmap	R/W	Bits 0-3: RX2 window default DR number Bits 4-7: RFU
0x14	2-byte unsigned integer	R/W	RX1 window delay (milliseconds) Note: The RX2 window delay is always 1000 milliseconds greater than (after) the RX1 window delay.
0x15	2-byte unsigned integer	R/W	Join Accept 1 window delay (milliseconds) Note: The Join Accept 2 window delay is always 1000 milliseconds greater than (after) the Join Accept 1 window.
0x18	2-byte unsigned integer	R/W	RX window maximum duration (milliseconds)

0x19	2-byte unsigned integer	R/W	Most significant (2-byte) word (MSW) of the (4-byte) Net ID
0x1A	2-byte unsigned integer	R/W	Least significant (2-byte) word (LSW) of the (4-byte) Net ID

Note: DR and Tx power numbers are as documented in reference [2].

The factory default values for these registers are shown in Table 3-7.

Table 3-7: Default LoRaMAC Options

Address	Value(s)	Description
0x10	0x8000	Join mode: OTAA
0x11	0xC00E	UL confirmation: Disabled Sync word: Public Duty cycle: Enabled ADR: Enabled LoRa Class: Class C
0x12	0x0000	Default Tx power number: 0 (max. EIRP) Default DR number: DR0
0x13	[see description]	[depends on LoRaWAN region]
0x14	0x03E8	RX1 window delay: 1000 milliseconds RX2 window delay: 2000 milliseconds
0x15	0x1388	Join Accept 1 window delay: 5000 milliseconds Join Accept 2 window delay: 6000 milliseconds
0x18	0x0BB8	RX window maximum duration: 3000 milliseconds
0x19	0x0000	Net ID: 0x00000000
0x1A	0x0000	

As noted therein, the exception is register 0x13, whose default value depends on the sensor's LoRaWAN region. The possible default values for this register are shown in Table 3-8.

Table 3-8: Default RX2 Window Options

Region	Value(s)	Description
EU868	0x33D3E608	RX2 window channel frequency (Hz): 869525000
	0x00	RX2 window default DR number: DR0
US915	0x370870A0	RX2 window channel frequency (Hz): 923300000
	0x08	RX2 window default DR number: DR8
AS923	0x3706EA00	RX2 window channel frequency (Hz): 923200000
	0x02	RX2 window default DR number: DR2
AU915	0x370870A0	RX2 window channel frequency (Hz): 923300000
	0x08	RX2 window default DR number: DR8
IN865	0x33A680F0	RX2 window channel frequency (Hz): 866550000
	0x02	RX2 window default DR number: DR2
CN470	0x1E1E4420	RX2 window channel frequency (Hz): 505300000
	0x00	RX2 window default DR number: DR0
KR920	0x36F313E0	RX2 window channel frequency (Hz): 921900000
	0x00	RX2 window default DR number: DR0

RU864	0x33CD69E0	RX2 window channel frequency (Hz): 869100000
	0x00	RX2 window default DR number: DR0

3.3 Sensor Application Configuration

3.3.1 Periodic Reporting Configuration

Periodic sensor reporting (i.e., via uplink transducer frames) is configurable in multiples of a *tick*, where a tick is itself a configurable time interval, as outlined in Table 3-9.

Table 3-9: Periodic Reporting Configuration Registers

Address	Value(s)	Access	Description
0x20	4-byte unsigned integer	R/W	Reporting tick period: • 0: Disable (all) periodic reporting • 1-86400: Reporting period (seconds) • Otherwise: RFU
0x21	2-byte unsigned integer	R/W	Energy Consumption Meter reporting period: • 0: Disable periodic reporting • ≥1: Reporting period (ticks)

The minimum configurable reporting tick period of one second (1 s) is intended to permit fine-grained control of the measurement reporting period(s), and in theory, permits one to configure a measurement reporting period as low as one second. In practice, the effective measurement reporting period will be greater than this minimum due to the timing restrictions imposed by the LoRaWAN specification (e.g., the values of RECEIVE_DELAY1 and RECEIVE_DELAY2). Moreover, in the case where multiple measurements are to be reported periodically, LoRa payload size restrictions may further reduce the rate (i.e., increase the period) at which the sensor can report these measurements.

Note: The measurement reporting periods are not necessarily related to the measurement sensing intervals, which are determined by the capabilities of the sensing element. E.g., energy consumption is necessarily sensed (and accumulated) once per second, but by default, reported no oftener than once per hour.

The factory default values for these registers are shown in Table 3-10.

Table 3-10: Default Periodic Reporting Configuration

Address	Value(s)	Description
0x20	3600	Duration of a reporting tick: 3600 seconds (i.e., 1 hour)
0x21	1	Energy Consumption Meter reporting period: 1 tick (i.e., 1 hour)

3.4 Sensor Command and Control

Sensor command and control is via the registers listed in Table 3-11.

Table 3-11: Sensor Command and Control Registers

Address	Value(s)	Access	Description
0x70	2-byte bitmap	WO	Bit 0: Restart (reboot) sensor: • 0: No effect • 1: Restart sensor Bits 1-12: RFU

			Bit 13: Save sensor application configuration: • 0: No effect • 1: Save to non-volatile storage (flash) Bit 14: Save LoRaMAC options: • 0: No effect • 1: Save to non-volatile storage (flash) Bit 15: RFU
0x71	1-byte unsigned integer	RO	Sensor application version major number
	1-byte unsigned integer	RO	Sensor application version minor number
	1-byte unsigned integer	RO	Sensor application version revision number
	1-byte unsigned integer	RO	LoRaMAC version major number
	1-byte unsigned integer	RO	LoRaMAC version minor number
	1-byte unsigned integer	RO	LoRaMAC version revision number
	1-byte unsigned integer	RO	LoRaMAC LoRaWAN region number: • 0: EU868 • 1: US915 • 2: AS923 • 3: AU915 • 4: IN865 • 5: CN470 • 6: KR920 • 7: RU864
0x72	1-byte unsigned integer	WO	Reset configuration to factory defaults and reboot the sensor: • 0x0A: Reset sensor application configuration • 0xB0: Reset LoRaMAC options • 0xBA: Reset both • Otherwise: No effect

WARNING: As currently implemented, a DL that restarts (reboots) the sensor will not be confirmed. Ensure such DLs are always sent as unconfirmed to prevent the NS from endlessly resending the DL (and as a result, restarting the sensor) each time the sensor reboots and rejoins the LoRaWAN.

Processing of a write to register 0x70 occurs after all other writes in the same downlink payload, making it possible to change the configuration, save the changes to non-volatile storage, and restart the sensor using a single DL. (It is also possible to change the configuration and restart the sensor *without* saving the changes to non-volatile storage using a single DL. Why one would want to do so is less clear, however.)

4 Examples

4.1 Operational (Transducer) Information Stream

The following are examples of uplink payloads containing transducer data from the sensor (to the application server):

- 0x00 0xFE 0x00 0x01 0x51 0x80 0x00 0x00 0x6A 0x50 0x00 0x00 0x00:
    - Energy Consumption Meter:
        - Total elapsed time: 86400 seconds (= 24 hours)
        - Total energy consumed: 27216 W-h (= 27.216 kW-h)
    - Energy Consumption Meter Status Indicator:
        - Status: Idle (stopped)
- 0x00 0x80 0xCB 0x75 0x01 0x80 0x41 0x5C 0x00 0x81 0xFF
    - Power Meter (Active Power):
        - Power: -1345.1 W
    - Power Meter (Apparent Power):
        - Power: 1673.2 W
    - Power Factor Meter:
        - Power Factor: N/A

The following is an example of a downlink payload containing transducer data from the application server (to the sensor):

- 0x00 0x01 0xFF:
- Relay (AC Load Control) Control:
- Relay status: Closed (= AC load connected)

If the relay were to have been open before this downlink was sent, and if the downlink were to have had the intended effect, the following uplink could be expected to follow soon thereafter:

- 0x00 0x01 0xFF:
- Relay (AC Load Control) Status:
- Relay status: Closed (= AC load connected)

Note: All of the above ULs and DLs would be transmitted on ***LoRaWAN port 10***.

4.2 Management (Configuration) Information Stream

The following provides an example of how to configure the sensor’s LoRaMAC options:

- Configure Join Mode: *ABP*.
- DL payload: 0x90 0x00 0x00

- UL payload: 0x02 0xEC 0x47 0x0F
- Configure default Tx power number: *15*; default DR number: *15*. Also configure RX2 window defaults: channel frequency: *923.3 MHz*; DR number: *4*.
- DL payload: 0x92 0x0F 0x0F 0x93 0x37 0x08 0x70 0xA0 0x04
- UL payload: 0x3B 0x3C 0xBC 0xB9
- **Note:** The DL payload contains two (2) command frames.
- Save LoRaMAC options to non-volatile storage (flash).
- DL payload: 0xF0 0x40 0x00
- UL payload: 0xBA 0x42 0xC3 0x2A
- Restart (reboot) sensor [and apply the saved LoRaMAC options].
- DL payload: 0xF0 0x00 0x01
- UL payload: [none]

Note: All of the above ULs and DLs would be transmitted on ***LoRaWAN port 100***.

References

[1] LoRa Alliance: *LoRaWAN Specification*, V1.0.2 (Final), 2016 July.

[2] LoRa Alliance: *LoRaWAN 1.0.2 Regional Parameters*, Revision C (Released), 2018 January.

[3] myDevices: "Cayenne Low Power Payload," in the "LoRa" section of the *Cayenne Docs* website (https://mydevices.com/cayenne/docs), downloaded 2018-08-16.

[4] IPSO Smart Object Committee: *IPSO Smart Object Guideline—Smart Objects Starter Pack 1.0*, Technical Guideline, 29 May, 2017, © 2017, IPSO Alliance.

[5] IPSO Smart Object Committee: *IPSO Smart Object Guideline—Smart Objects Expansion Pack*, Technical Guideline, 29 May, 2017, © 2017, IPSO Alliance.