LoRaWAN payload decompression - RFU Disclosure [DRAFT]

ASYSTOM

Abstract

This document is a currently draft intended to disclose active RFU values from the original document named 'Payload_Decompression.pdf'. The RFU disclosure is meant to provide any 3rd party the knowledge of hidden parameters which can alter or severely degrade the basic function of an Asystom beacon. Even with the knowledge of the contents for those RFU values, we remind that it is strongly unadvised to change any of the disclosed parameters.

The remaining RFU fields throughout this document are either impossible to set (only belonging to uplink frames) or are effectively unused fields which should not alter in any way the bacon.

As a safety measure, we still strongly recommend to keep all the RFU fields from the initial document as they originally are.

This document replaces chapter 4 "UPLINK EXAMPLES" as well as chapter "6 DOWNLINK PACKET FORMAT" from the initial document, where it adds a new payload type for fetching device settings.

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Changelog

Version number	Written by	Revision date	Note
1.0	Piotr Diop	11/09/2021	Initial draft

1 UPLINK EXAMPLES

1.1 System status report

Lets take the following of a payload received on port 67 (we split the payload into chunks for easier visualization in the next parts:

```
FF 00000082 76342E3336 054114001E001E006801
0F000000401F0000D00700001C00160005003200000000000B3009101000000002B000700100E
000001000300D00700000000000000200000000000000000000000
```

This frame totals 168 characters i.e 84 Bytes.

1.1.1 System status id (1 byte)

Is and will aways be 1 byte: 0xFF

1.1.2 RFU1 (4 bytes)

Its typical value is "00000082". The content is irrelevant to the purpose of this document.

1.1.3 Beacon version (5 bytes)

Can be directly translated into ascii. For example 76342e3336 -> v4.36

1.1.4 Scheduling Settings (10 bytes)

For devices using version 4.36, the default value is 054114001e001e006801

There are four parameters:

- Activation Bitmask. This setting defines what features are active. The bitmask is defined by offsetting the active bit by the index of the features below:

```
BATTERY_LEVEL = 0,
HUMIDITY = 2
PRESSURE = 6
WAKE_ON_EVENT = 8
SIGNATURE = 11
TEMPERATURE = 14
AMBIENT_AGGREGATOR = 18
LORA_LINK = 20
```

  This means that for the 05411400 value (LE) we have all the above features active. To prevent disabling all features, battery indicator will always be scheduled at the general stack periodicity frequency (see next parameter)

  Toggling bits offset by any other value than the ones above will not have an effect of the current software.

- General stack periodicity. This setting tells how often the system will evaluate features related to the general stack. Currently the general stack covers Battery level, Temperature and Humidity sensors. The value is expressed in 10*seconds. This means a value of 30 must be interpreted as 300s i.e 5 minutes.
- Predictive stack periodicity. This setting tells how often the system will schedule vibration & ultrasonic sensors to do predictive maintenance computations, i.e. to generate either a standard signature or a FFT zoom based on settings. The value is also expressed in 10*seconds.

- Introspection stack periodicity. As of v4.57, this setting tells how often the system will schedule LoRa linkcheck verification. The default value is expressed in 10*seconds. This means a value of 360 must be interpreted as 3600s i.e the linkckeck validation will be done by the system every hour.

  WARNING: This does not set the frequency at which the linkcheck is performed by the LoRaWAN module. It sets how often the system will probe the radio module registers for a linkcheck success. The parameter to set the frequency of lickcheck MAC commands is specified in the Radio Settings the the chapter below.

Message	Size	Default value (hex LE)	Decimal value	Real value
Activation Bitmask	4 Bytes	05411400		
General stack periodicity	2 Bytes	1e00	30	300s
Predictive stack periodicity	2 Bytes	1e00	30	300s
Introspection Periodicity	2 Bytes	6801	360	3600s

1.1.5 Advanced Settings (38 Bytes)

In the example, the value is

0f000000401f0000d00700001c0016000500320000000000b3009101000000002b000700100e

Message	Size	Default value (hex LE)	Decimal value	Scaling	Real value
RFU1	12 Bytes	0f000000401f0000d0070000	-	-	-
RPM Max	2 Bytes	1c00	28	x60	1680 RPM
RPM Min	2 Bytes	1600	22	x60	1320 RPM
RFU2	8 Bytes	0500320000000000	-	-	-
Synchronization settings	4 Bytes	b3009101	see next chapter	-	-
Synchronization delay	2 Bytes	0000	see next chapter	-	-
Synchronization timeout	2 Bytes	0000	see next chapter	-	-
Radio Settings	6 bytes	2b000700100e	-	-	-

The RFU1 parameter is defined as follows:

- The first 4 bytes are a bitmask for 'Sensor enumeration' (8 bits -> 0x0f) and 'Sensor orientation' (24 bits -> 0x000000)

Valid parameters for Sensor enumeration are

```
Accelerometer = 0x3
Microphone = 0xc
```

These values are not exclusive. The value 0xf means that both accelerometer and microphone sensors are active.

Valid parameters for Sensor orientation are

```
No preferred orientation = 0x0
X axis preferred = 0x1
Y axis preferred = 0x2
Z axis preferred = 0x4
```

Next we have four 16-bit values defining the active range for each sensor type, expressed in 10*Hz

- Upper bound for sound analysis (2 Bytes) 401f -> 80000Hz
- Lower bound for sound analysis (2 Bytes) 0000 -> 0Hz
- Upper bound for vibration analysis (2 Bytes) d007 -> 20000Hz
- Lower bound for vibration analysis (2 Bytes) 0000 -> 0Hz

The second RFU2 parameter is used for configuring a currently inactive secondary feature which will be documented at a further date.

1.1.6 Synchronization settings & modes

There are 5 modes a Beacon can be configured into. Each one of them uses a specific synchronization method.

The modes are Inactive, Wake-on-Motion, Wake-on-Scheduler, Wake-on-Analog and Wake-on-Contact.

The synchronization settings block is a 32-bit Little Endian field composed of three publicly available elements.

- Wakeup threshold (14 bits). Defines the vibration threshold in mg above which the machine is assumed to be running. The value is expressed in mg and comprised between 0 and 1 g. Default value is 100 mg.
- Wakeup profile: (2 bits) Corresponds to the power profile to be used for wakeup. This feature is experimental and shall not be changed. If improperly set, il will result in noticeable battery consumption.
- Special parameters (11 bits). This field's meaning depends on the used mode. currently it only applies to Wake on Analog mode.
- Flag | 1 bit |. Defines a boolean value switching between different modes (see table below)
- Mode (4 bits). Sets the Beacon into one of the above mentioned modes.

In practice, the interpretation of a payload presented in the above table as "b3009101" would go as follows:

Hex (LE)	Binary Form	wakeup threshold	Prof	Special	flag	mode
b3009101	00000001100100010000000010110011	00000001100100	01	00000000101	1	0011

For more information in the physical interpretation of these parameters, please refer to the AsystomView User Guide documentation.

The next table specifies how flags are interpreted for each selected mode.

Mode	Sync mode	flag interpretation
Inactive	0000	-
Wake on Motion	0001	0: No visual cue if motion is detected
		1: Red led on the side of the device will blink if motion is detected
RFU	0002	RFU
Wake on Scheduler	0003	RFU
Wake on Analog	0004	0: Outside selected region (see AsystomView User Guide for more details)
		1: Inside selected region (see AsystomView User Guide for more details)
Wake on Contact	0005	0: Trigger on signal falling edge
		1: Trigger on signal rising edge

The following table will specify the signification of different fields depending on the chosen mode

Mode	Sync mode	wakeup threshold	special parameter	sync delay	sync timeout
Inactive	0000	-	-	-	-
Wake on Motion	0001	Value in mg	-	In seconds	In seconds
RESERVED	0002	-	-	-	-
Wake on Scheduler	0003		-	-	-
Wake on Analog	0004	-	Value in %*	In seconds	-
Wake on Contact	0005	-	-	In seconds	-

- Wake on Analog is the only case where the special parameter is currently relevant. It represents the allowed variation around the values delimited by the wakeup threshold. Please refer to AsystomView User Guide documentation for more details.

1.1.7 Radio Settings

In the example, the value is "2b000700100e". It is composed of a 16-bit mask (2b00) followed by two 16-bit values for Special frequency parameters and linkcheck period.

Bit	size	Value	Comment
ADR Active	1 bit	1	Activates ADR
Tx Ack	1 bit	1	Activates uplink acknowledgement
Private Network	1 bit	0	If '0', sets the syncWord to 0x34 If '1' -> 0x12
Coding Rate Flag	1 bit	1	0 = 4/5, 1 = 4/8
Dwell time active	1 bit	0	Enables dwell time (Region Specific)
Retx Twice	1 bit	1	Forces double retransmission for ACK packets
Packet Split Active	1 bit	0	Activates packet split feature for low data rates
RFU	9 bits	0	Unused
Special Freq Param	2 bytes	0700	Used only in applicable regions to force FSB (eg. US915). Not read otherwise
Linkcheck Period	2 bytes	100e	In seconds from 0 to 65535. Set the frequency of lickcheck MAC commands. Must be set accordingly with Introspection Periodicity parameter. 100e(LE) equals 3600 seconds.

1.1.8 Signature settings (26 bytes)

These settings allow to configure the device to either generate a standard signature or a FFT zoom signature when measurements are triggered.

In the example, the value is 000001000300d0070000000000000200000000000000000000000

The format is as follows:

Message	Size	Default value (hex LE)	Decimal value
handle	1 Byte	00	0
activation	1 Byte	00	0
steps	1 Byte	01	1
algorithm	1 Byte	00	0
sensor	1 Byte	03	3
orientation	1 Byte	00	0
param_1	4 Bytes	d0070000	2000
param_2	4 Bytes	00000000	0
param_3	4 Bytes	02000000	2
param_4	4 Bytes	00000000	0
param_5	4 Bytes	00000000	0

The handle shall be an incremental server-side generated value ranging from 1 to 255. It shall be incremented each time new FFT zoom settings get sent to the device. When a FFT zoom is computed, this handle is appended to the payload. Server-side, it allows matching the payload data with their corresponding settings.

The activation field can take the following values:

- 0: no FFT zoom, only the standard signature gets computed when measurements get triggered.
- 1: periodic scheduling of FFT zoom versus standard signature (with a 1/steps duty cycle)
- 2: burst scheduling of FFT zoom versus standard signature for a number of consecutive measurements defined by the steps parameter.

The steps parameter is used by the activation mode as defined above.

The algorithm parameter tells which algorithm is currently used. Today only FFT Zoom is available, hence 0x0

The sensor parameter specifies either the accelerometer (0x3) or the microphone (0xc).

The orientation parameter only applies to the acelerometer and can take the following values:

- 0: averaging of the three axis of the accelerometer
- 1: X axis
- 2: Y axis
- 4: Z axis

Additional parameters are given below:

param_1: upper bound for the FFT zoom window (in Hz)

param_2: lower bound for the FFT zoom window (in Hz)

param_3: compression as defined below:

- 0: 50 frequency bands encoded as 8 bits
- 1: 50 frequency bands encoded as 16 bits
- 2 | 1 bit |00 frequency bands encoded as 8 bits
- 3 | 1 bit |00 frequency bands encoded as 16 bits
- 4: 200 frequency bands encoded as 8 bits

param_4 and param_5 are only meaningful for device versions strictly greater than 4.40

param_4: spectrum type as defined below:

- 1: RMS spectrum
- 2: Peak spectrum
- 3: RMS velocity spectrum (vibration sensor only)
- 4: Peak velocity spectrum (vibration sensor only)
- 5: RMS Envelope spectrum (vibration sensor only)
- 6: Peak Envelope spectrum (vibration sensor only)

param_5: high pass filer cut-off frequency (envelope spectrum only).

2 DOWNLINK PACKET FORMAT

There are 4 types of messages that can be sent to the Beacon:

FPort	Payload (string)	Request
64	00	Request the device to Reboot
70	<array>	Update scheduling settings
71	<array>	Update advanced settings
74	<array>	Update signature settings
81	00	Starting with v4.49, this command requests the device to replace next uplink with its current settings

The request to initiate a reboot is simply defined by the FPort used. The payload is “00”.

To update scheduling, advanced or signature settings, please refer to Uplink Examples section above.

IMPORTANT: Before sending any updates to a device, your first step shall be to read the last settings updated by the said device, then to only update the fields related to the changes you want to make. Modifying RFU fields may generate undefined behaviors.

2.1 Example 1: Updating General or Predictive Stack periodicity

Get the current settings value by reading the last data uploaded on FPort 67 from the right offset (see Uplink chapter to identify the right offset)

Let’s assume the payload we have is 054114001e001e006801

Predictive stack periodicity is 1e00 -> 300s -> 5 minutes.

If you want to update it to e.g 2 hours = 7200s. You need to write 720 in the right offset.

720 = 0x2D0. In Little endian, we’ll have to write ‘D002’ two bytes (4 characters) from the right.

Thus, the final payload will be 054114001e00d0026801

2.2 Example 2: Updating Advanced settings

The steps are the same as in the 1st example.

You need to read the existing value first, update the values you want to set and send them back using the relevant port.

Make sure to keep the fields you have not updated intact.