Special documentation

LoRaWAN® communication specification, models PGU23.100, PGU26.100 for connection to NETRIS®3

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Special documentation
Models PGU23.100, PGU26.100

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Prior to starting any work, read the operating instructions!
Keep for later use!

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Firmware version history

The firmware version of the device is transferred to the IIoT plattform via LPWAN with the “Extended identification message”.

Firmware version	Initial release / Modifications
Starting from firmware version 3.1.9	Initial release

Supplementary documentation:

- This special documentation for the LoRaWAN® communication specification applies in conjunction with the operating instructions "Radio unit with LoRaWAN® for WIKA measuring instruments, model NETRIS®3" (article number 14521664) and "Bourdon tube pressure gauge, model PGU23.100 and PGU26.100" (article number 14520946).

1. General information

1.1 Abbreviations, definitions

LPWAN	Low-power wide-area network, a category of wireless digital data network.
Network	In this document, LPWAN for which a specific radio unit is designed, and configured to communicate with.
Packet	A unit of radio transmission; it can contain LPWAN network management data, as well as zero, one, or several messages following the application protocol described in the present document.
Instrument	PGU23.100 and PGU26.100 (simply referred to as PGU2x.100 in the rest of the document), physical object in charge of measuring one or several physical parameters.
Radio unit	NETRIS®3, physical electronics object in charge of the LPWAN communications.
Platform	Generic term for the data processing and storage system that will bring meaning to the data sent by a radio unit.
Channel	Each parameter measured by an instrument is associated with a channel. Channels are defined by a channel number, the physical parameter they measure and a physical unit.
Alarm	In this document, "alarm" is used as a generic technical term for condition-based packets sent by the radio unit and do not assume any level of severity.
Process alarm	Alarm related to the value of measurements on a channel (see sec. 2.5).
Technical alarm	Alarm related to the overall instrument status as well as the quality and reliability of the measurements of each channel (see sec. 3.4).
Radio unit alarm	Alarm related to the system health in general (see sec. 3.5).

1.2 Scope of this document

This technical guide gives a description of the wireless communication protocol used by the NETRIS®3 radio unit connected to a PGU2x.100. It is targeted towards developers who wish to design a driver for the product, and users that want to get a deeper understanding of the capabilities of this WIKA product.

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1.3 Conventions

As a convention, all the traffic that is sent wirelessly from a connected radio unit to the network (via one or several gateways) is called “upstream traffic”, and all the traffic that is sent wirelessly by the network to a radio unit is called “downstream traffic”.
Multi-byte fields are encoded following a “big-endian” convention (“network order”). The order for the transmission of bytes is the same as the left-to-right reading order, and bytes are numbered starting with 0.
Bits are numbered from left-to-right, starting at 7 and ending at 0, with bit 7 representing the most significant bit (MSB).

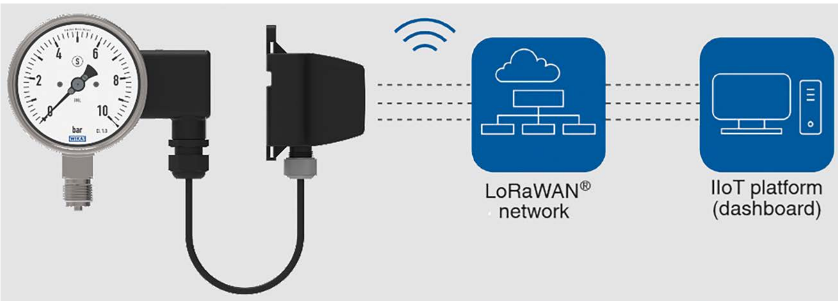
Example

Bytes	0								1								2		
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	...
Value	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	...

2. Applicative protocol description

2.1 Purpose

The purpose of the application protocol is to enable the radio unit to communicate with an IIoT platform in order that one or several users are able to use all the features of the radio unit remotely.



The protocol was designed to be compact in order to minimise the energy consumption (for longer battery life) and also use the shared radio spectrum more efficiently to enable more instruments to be connected to a given network.

The translation, in the upstream and downstream directions, between this optimised, binary, context-dependent protocol, and a more versatile high-level protocol chosen by the customer for data processing, storage and display is carried out by a software component called a “driver”. This document contains all the information that is needed by a customer to implement the “radio unit application protocol” driver.

2. Applicative protocol description

Here are the key points of the functional model for the application protocol:
- A single radio unit is connected to an LPWAN network, and to an instrument that has 1 or more data channel(s), each measuring a physical value.
- The radio unit “wakes up” at a fixed period (user defined) to take a set of measurement points, one on each enabled data channel, more or less at the same time. After that, all channels are checked for specific user-defined conditions (process alarms). Should the instrument encounter any anomaly, technical or radio unit alarms can be generated and transmitted.
- 1 out of every N (user defined) set of measurement points is transmitted to the platform.
- The radio unit and instrument sleep most of the time to save power; the radio unit can receive one or more user-defined commands to change its configuration at the end of each transmission.

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2.2 Data channels

For PGU2x.100 instrument, the channels are defined as follows:

Channel number	Physical measurement	Note
0	Pressure	Main channel: measurement provided by the mechanical pressure gauge. Its measurement parameters are defined.
1	Temperature	Secondary channel: temperature inside the case of the pressure gauge. Note: This is neither a process temperature nor an ambient temperature!

Both channels are enabled by default.

2.3 Instrument measurement encoding

Channel data, i.e. instrument measurements, are expressed on a generic unitless scale [2,500; 12,500] (encoded as a 16-bit integer) corresponding to the measurement range of the instrument. One unit of measurement is equivalent of 0.01 % of the span of the instrument. Process alarm thresholds are expressed on the same scale.

The conversion between unitless digital data and the real physical value is performed using the following formula:

$$real\ physical\ value = \left(\left(\frac{digital\ value - 2{,}500}{10{,}000}\right) * span\right) + start\ of\ measuring\ range$$

Where the span of an instrument channel is defined using the following formula:

$$span = end\ of\ measuring\ range - start\ of\ measuring\ range$$

From a protocol standpoint, data is considered valid between 0 and 15,000 (decimal) allowing values of -25 % to 125 % of the instrument’s measurement range to be encoded.

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Please be aware: This does not imply the instrument is actually capable of covering this extended span.
Accuracy outside of the instrument's measurement range will typically be degraded or unspecified.
For PGU2x.100, the span and start of measurement range for channel 0 is variable, depending on the pressure range ordered by the customer. The span and start of measurement range of channel 1 are fixed.

As an example, for a pressure range of -1 … 9 bar and a digital value of 0x2DD2, the data is interpreted as follows:

$$span = (9\ bar) - (-1\ bar) = 10\ bar$$
$$digital\ value = 0x2DD2 = 11{,}730$$
$$real\ physical\ value = \left(\left(\frac{11{,}730 - 2{,}500}{10{,}000}\right) * 10\ bar\right) + (-1\ bar)$$
$$real\ physical\ value = 8.23\ bar$$

The following table gives more examples of data interpretation:

Instrument measurement range	**16-bit data value (or alarm threshold)**			
	0x09C4 = 2,500 decimal	**0x30D4 = 12,500 decimal**	**0x099E = 2,462 decimal (2,462 – 2,500) * 0.01 % = -0.38 % of span**	**0x2DD2 = 11,730 decimal (11,730 – 2,500) * 0.01 % = 92.30 % of span**
0 … 10 bar gauge	min = 0 bar	max = 10 bar	(-0.38 % * span) + min. = -0.038 bar	(92.3 % * span) + min. = 9.23 bar
-1…0 bar vacuum gauge	min = -1 bar	max = 0 bar	(-0.38 % * span) + min. = -1.0038 bar	(92.3 % * span) + min. = -0.077 bar
-300 … 400 kPa gauge	min = -300 kPa	max = 400 kPa	(-0.38 % * span) + min. = -302.66 kPa	(92.3 % * span) + min. = 346.1 kPa
0 … 20,000 psig gauge	min = 0 psig	max = 20,000 psig	(-0.38 % * span) + min. = -76 psig	(92.3 % * span) + min. = 18,460 psig

2.4 Resolution and accuracy

The resolution of the encoding used for data transmission (expressed in 0.01 % of span) is generic and must not be confused with the resolution and accuracy of the instrument.

Refer to the documentation of your instrument for technical specifications and information about accuracy, usable range, safety limits, etc.

2.5 Process alarms

Process alarms is a feature of the radio unit: each time a valid measurement is taken on a data channel, the measured value and slope (defined as current measured value-previous value) can be compared to user-defined thresholds. In the event of a value exceeding a threshold, with the configured dead band being taken into account, a message will immediately be transmitted to the network without waiting for the normal transmission period.

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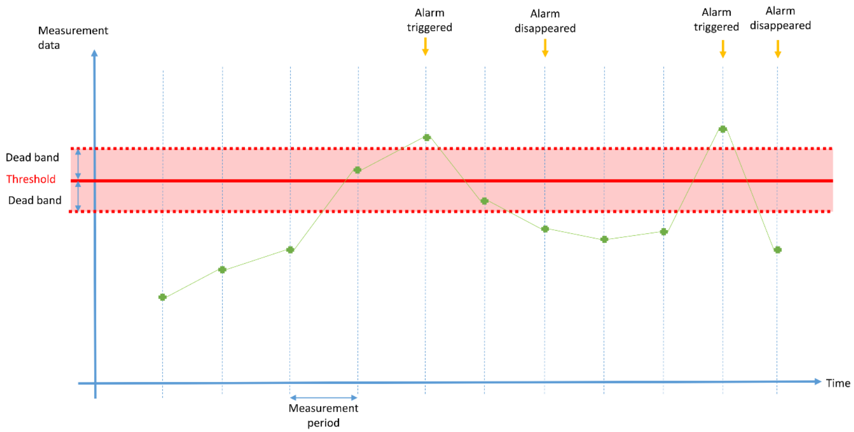
As taking a measurement requires only a fraction of the energy needed for transmitting it, the use of process alarms in combination with measurement and transmission periods that are different from each other enables energy-saving strategies. Configuring alarms when the measurement and transmission periods are the same provide little to no benefit since all measurement points will be available on the platform, and various condition-based triggers can be implemented there. Similarly, configuring different periods for measurement and transmission, without configuring any process alarms, increases energy usage with little or no gain.

There are 3 types of process alarms, each in 2 “directions” that can be configured for each data channel. This section gives a description of the 3 types of alarms and corresponding parameters:

Process alarm	Parameters		
	Threshold	Dead band*	delay
High threshold	Value [2,500 – 12,500] 0.01% of span	Value [0 – 10,000] 0.01% of span	n/a
Low threshold			n/a
High threshold with delay			Value [1 – 65,535] in units of 1 s
Low threshold with delay			
Rising slope	Value [0 – 10,000]** 0.01% of span/minute	n/a	n/a
Falling slope		n/a	n/a

*: dead band setting is common to all alarms for a given channel
**: slope threshold is defined as an absolute value, and the direction defined by the rising/falling alarm

2.5.1 High threshold



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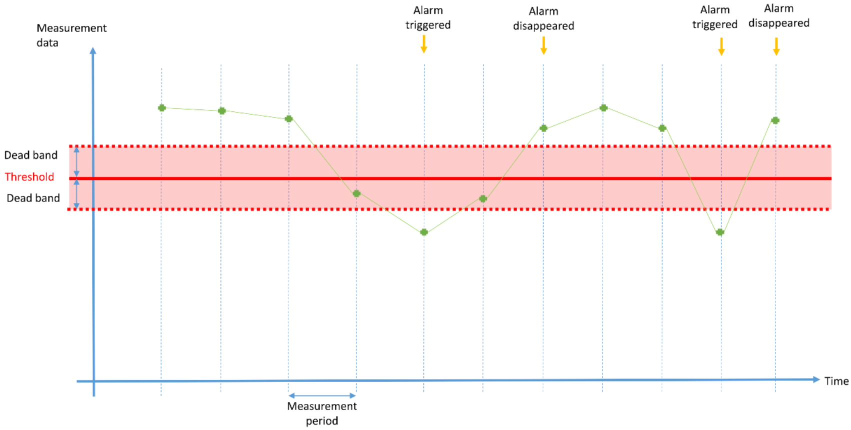
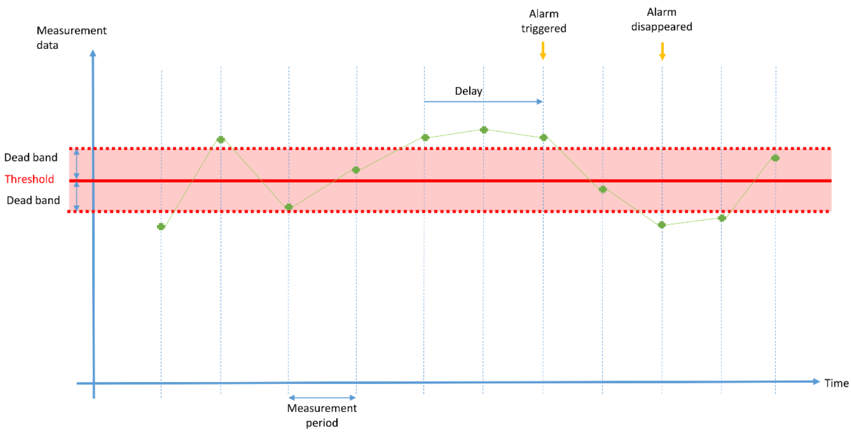
2.5.2 Low threshold



2.5.3 High threshold with delay



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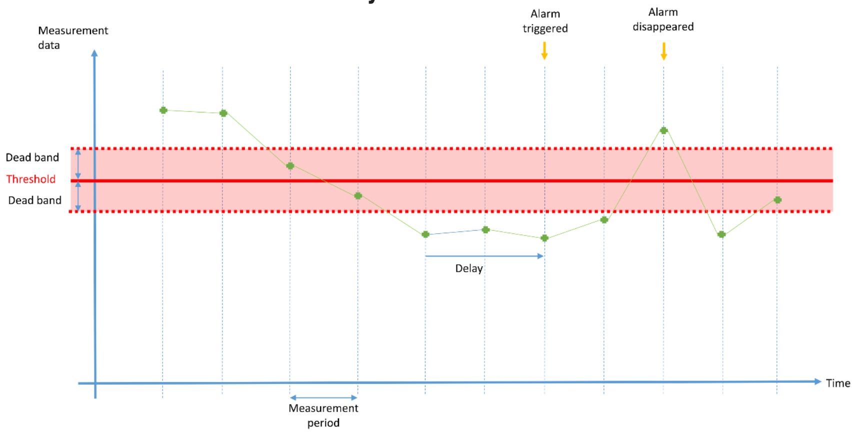
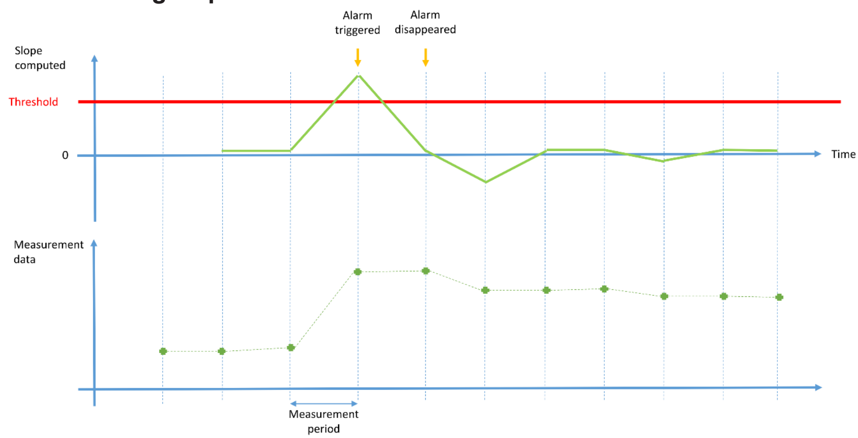
2.5.4 Low threshold with delay



2.5.5 Rising slope



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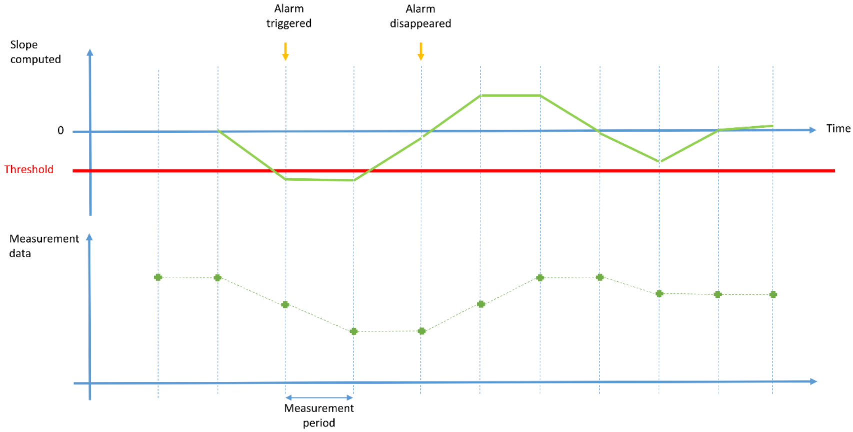
2.5.6 Falling slope



2.6 Configuration identifier

A radio unit can be configured remotely by the end user to suit the application, and several parameters can be set such as measurement period, transmission period, alarms, etc.

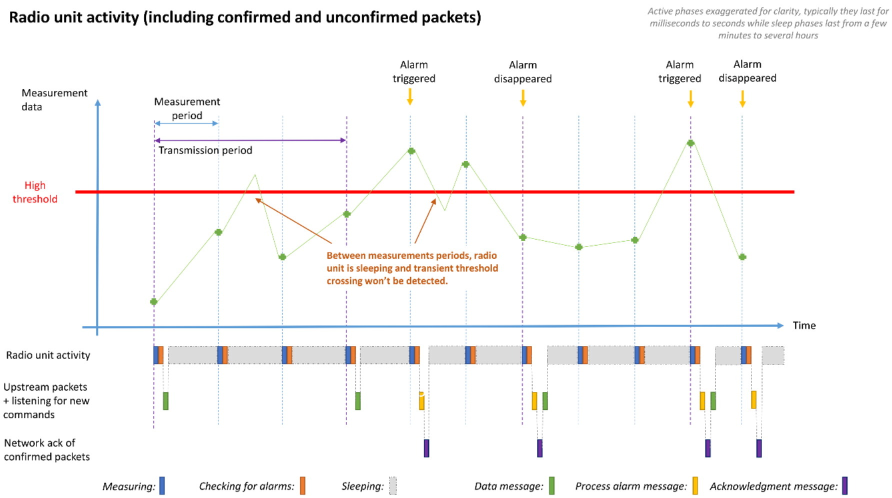
To interpret the meaning of some upstream messages, the IIoT platform needs to know the configuration currently active on the radio unit. This is why all upstream messages include a “configuration identifier” (or “config ID” for short) and all downstream packets, that can contain several commands changing the radio unit configuration include a “transaction identifier” (“transaction ID”).

When a downstream packet with transaction identifier X results in a change of configuration of the radio unit (configuration successful) then all the following upstream packets will use value X as config ID.

Thus, when sending a new configuration, the platform should pick a value of transaction ID between 1 and 31 that is different from the current radio unit config ID. Using a sequential value is convenient but not mandatory. Value 0 is, by convention, used to indicate the “factory configuration”, and thus shall be used as a transaction ID when sending a “reset to factory configuration” command. Values above 31 are reserved and must be avoided. After value 31 is reached, next value should be 1 (roll-over) by convention.

2.7 Typical product behaviour

As a summary, the figure follows represents the temporal behaviour of a NETRIS®3 radio unit when a measured value for a data channel is fluctuating and a high threshold process alarm is configured:



It shows that, in practice, a radio unit sleeps most of the time and wakes up only for short moments in order to assess the measured value, check if user-defined alarm conditions are matched or not, and periodically send and receive data from the LPWAN network.

3. Upstream format

3.1 General format

Upstream messages are messages sent wirelessly by the radio unit to the network and interpreted by the IIoT platform. Each upstream LPWAN packet contains a single message as its “payload”.

The packet format is as follows:

Byte	Size (bytes)	Note
0	1	Message type, see next table for details
1	1	Current configuration identifier (config ID)*
2 ...	0 or more	Content of the message, depending on message type

*: for the “configuration status” message (see sec. 3.6), the radio unit uses the transaction ID of the packet it is responding to, instead of the current configuration ID.

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The first byte of the message describes its type:

Value (hex)	Upstream message types
0x01	Data message with no alarm ongoing
0x02	Data message with at least one alarm ongoing
0x03	Process alarm message
0x04	Technical alarm message
0x05	Radio unit alarm message
0x06	Configuration status message
0x07	Radio unit identification message
0x08	Keep alive message
0x09	Extended radio unit & instrument identification message

3.2 Data message with or without ongoing alarm

The data message contains the latest values measured on the data channels.

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	Data message type	In accordance with upstream messages type table (0x01, 0x02)
1	1	Config ID	Current configuration identifier
2	1	0x00	Reserved
3 ...	2 or 4	Data (16b)	1 or 2 data fields, depending on configuration

The “data” bytes contain the respective value for each enabled channel, in the order channel 0 and then channel 1. If a channel is disabled, its data will not be present in the message. If neither of the channels are enabled, the data message is not sent.

If two channels are enabled and, during one measurement, one channel cannot get a valid measurement data, while the other can, then the data of the invalid channel is replaced by the special value 0xFFFF. A technical alarm message will detail the cause of error. The IIoT platform should filter these out as invalid measurement points.

3.2.1 Example

Upstream packet: 0x01 00 00 2E97 1253

Decoding	
01	Data message, no alarm ongoing
00	Configuration ID = 0, the radio unit is using the factory configuration, both channels are transmitted
00	Reserved
2E97	Channel 0 was measured at 94.27 % of span
1253	Channel 1 was measured at 21.91 % of span

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Upstream packet: 0x02 07 00 1EB0

Decoding	
02	Data message, at least one alarm is active
07	Configuration ID = 7 In this example channel 0 was disabled by the user, so only channel 1 is transmitted. The driver has to keep track of which channel is enabled for upstream messages interpretation, it cannot be inferred from the content of the data message alone.
00	Reserved
1EB0	Channel 1 was measured at 53.56 % of span

3.3 Process alarm message

A process alarm message contains one or more process alarms that have been triggered or disappeared after a measurement. The message is event-based, and depends on user configuration.

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x03	Process alarm has been triggered and/or disappeared
1	1	Config ID	Current configuration identifier
2	1	0x00	Reserved
3	1	Alarm type	See alarm type table follows
4-5	2	Related value	See related value table follows
X	1	Alarm type	If there is more than 1 process alarm that has been triggered or disappeared simultaneously
X+1, X+2	2	Related value	

Alarm type byte:

Byte	Description	Value
7	Sense	0: The latest measurement has triggered an alarm 1: The latest measurement has made an alarm disappeared
6-3	Channel ID	0 (0000b) or 1 (0001b)
2-0	Alarm type	0: Low threshold 1: High threshold 2: Falling slope 3: Rising slope 4: Low threshold with delay 5: High threshold with delay 6-7: Reserved

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Related value (always 2 bytes):

Process alarm type	Value
Low threshold	Triggering/disappearing value: 2,500-12,500 value (0.01 % of span)
High threshold	
Low threshold with delay	
High threshold with delay	
Falling slope	Triggering/disappearing slope, absolute value: 0-10,000 value (0.01 % span/minute)
Rising slope	

3.3.1 Example

Upstream packet: 0x03 11 00 00 0D73

Decoding	
03	Process alarm message
11	Configuration ID = 17
00	Reserved
00	An alarm was triggered on channel 0, of the “low threshold” type
0D73	The measurement on channel 0 that triggered the alarm was at 9.43 % of span

Upstream packet: 0x03 0F 00 8B 00D9

Decoding	
03	Process alarm message
0F	Configuration ID = 15
00	Reserved
8B	Alarm disappeared, on channel 1, of the “rising slope” type
00D9	Slope on channel 1 that made the alarm disappear = +2.17 % of span/minute

Upstream packet: 0x03 0F 00 05 2CA8 09 26B8

Decoding	
03	Process alarm message
0F	Configuration ID = 15
00	Reserved
05	Alarm triggered, channel 0, “high threshold with delay” type
2CA8	Channel 0 measurement that triggered the alarm = 89.32 %
09	Alarm triggered, channel 1, “high threshold” type
26B8	Channel 1 measurement that triggered the alarm = 74.12 %

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3.4 Technical alarm message

Technical alarms are related to the overall instrument status as well as the quality and reliability of the measurements of each channel. They are always enabled. Technical alarms are generated by the instrument itself and forwarded by the radio unit.

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x04	Technical alarm has been triggered
1	1	Config ID	Current configuration identifier
2	1	0x00	Reserved
3	1	Alarm type	See alarm type table follows
4-5	2	Related value	See related value table follows, always 2 bytes
X	1	Alarm type	If there is more than 1 technical alarm, simultaneously
X+1, X+2	2	Related value	

Alarm type byte interpretation:

Value (decimal)	Description	Note
0	MV_STAT channel 0	Channel 0 measurement is invalid
1	MV_STAT channel 1	Channel 1 measurement is invalid
4	STAT_DEV	Instrument signalled a general error

Related value (always 2 bytes):

Value (decimal)	Description
MV_STAT channel 0 or 1	MSB = 0x00, LSB = MV_STAT of the channel X
STAT_DEV	MSB = 0x00, LSB = STAT_DEV

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MV_STAT byte interpretation:

Bit	Description	Value
7-2	Reserved	000000
1	MV_STAT_WARNING	Measurement warning: value uncertain / inaccurate Measurement is still being determined, but no longer conforms to the specified accuracy; instrument is operated out of the specifications Measurement is out of the measuring range
0	MV_STAT_ERROR	Measurement error: value invalid Mesurement could not be determined; e.g. sensor break, device defect

STAT_DEV byte interpretation:

Bit	Description	Value
7-3	Reserved	00000
2	STAT_DEV_RESTARTED	Instrument restarted
1	STAT_DEV_WARNING	Instrument warnig: problem that does not manifest itself as a measured value error
0	STAT_DEV_ERROR	Instrument error: instrument is defective

3.4.1 Example

Upstream packet: 0x04 00 00 04 0001

Decoding	
04	Technical alarm message
00	Configuration ID = 0
00	Reserved
04	General instrument error
0001	STAT_DEV = 1 (STAT_DEV_ERROR bit set)

Upstream packet: 0x04 03 00 00 0001 01 0002

Decoding	
04	Technical alarm message
03	Configuration ID = 3
00	Reserved
00	Issue on channel 0
0001	MV_STAT = 1 (MV_STAT_ERROR bit is set)

Decoding	
01	Issue on channel 1
0002	MV_STAT = 2 (MV_STAT_WARNING bit is set)

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3.5 Radio unit alarm message

Radio unit alarms are always enabled. They are radio-unit-specific and do not relate directly to the measurement channels but to the system health in general.

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x05	Radio unit alarm has been triggered
1	1	Config ID	Current configuration ID
2-3	2	Alarm status	See alarm status table follows

Alarm status bits:

Bit	Description	Value
15-9	Reserved	0000000
8	UART alarm	1: Radio unit failed to communicate with instrument
7-3	Reserved	00000
2	Duty cycle alarm	1: RF emission duty cycle exceeded
1	Temperature alarm	1: Radio unit temperature out of expected range
0	Low battery	1: Low battery condition

3.5.1 Example

Upstream packet: 0x05 13 0005

Decoding	
05	Radio unit alarm message
13	Configuration ID = 19
0005	Battery is low and RF duty-cycle limit was exceeded

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Upstream packet: 0x05 03 0100

Decoding	
05	Radio unit alarm message
03	Configuration ID = 3
0100	UART communication error

3.6 Configuration status message

The configuration status message is sent by the radio unit after receiving a command in order to inform the platform whether the command received was valid or not.

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x06	Configuration status
1	1	Transaction ID	Transaction identifier used by the downstream packet of the radio unit is responding to
2	1	Status	0x20: Configuration successful 0x30: Configuration rejected, one or more parameters are incorrect

3.6.1 Example

Upstream packet: 0x06 0F 20

Decoding	
06	Configuration status message
0F	Transaction ID = 15
20	Status = “Configuration successful”

Upstream packet: 0x06 0A 30

Decoding	
06	Configuration status message
0A	Transaction ID = 10
30	Status = “Configuration rejected”; in this case the config ID will stay the same as before

3.7 Radio unit identification message

After attaching to a network, the radio unit transmits a message that contains all the metrology information needed to decode data packets, and some identifying information about the radio unit and instrument.

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3. Upstream format

The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x07	Radio unit identification message
1	1	Config ID	Current configuration identifier
2	1	0x0F	WIKA wireless product ID for NETRIS®3 = 15
3	1	Wireless product sub-ID	0: LoRaWAN® version 1-255: Reserved
4-5	2	Instrument type ID	
6	1	Channel 0 measurand	See measurand table follows for channel 0
7-10	4	Channel 0 min. range	Lower bound of measurement range (32b IEEE 754 floating-point number, big-endian)
11-14	4	Channel 0 max. range	Upper bound of measurement range (same as above)
15	1	Channel 0 unit ID	See unit table follows for channel 0
16	1	0x01	Measurand for a temperature channel
17-20	4	Channel 1 min. range	Lower limit of measurement range (32b IEEE 754 floating-point number, big-endian)
21-24	4	Channel 1 max. range	Upper limit of measurement range (same as above)
25	1	Channel 1 unit ID	See unit table follows for channel 1

Table of measurand for pressure (channel 0):

Measurand ID	Meaning
0x03	Gauge pressure
0x04	Absolute pressure
0x05	Differential pressure

Table of unit identifiers for pressure (channel 0):

Unit ID	Name	Conversion factor
0x07	[bar] bar	
0x08	[mbar] millibar	
0x09	[µbar] microbar	
0x0A	[Pa] Pascal (N/m2)	0.00001 bar
0x0B	[hPa] hectopascal	0.001 bar
0x0C	[kPa] kilopascal	0.01 bar
0x0D	[MPa] mega pascal	10 bar
0x0E	[psi] pound per square inch (lbf/in^2, lb/in^2)	0.06894757 bar
0x0F	[lbf/ft^2] pound per square foot	0.0004788026 bar

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3. Upstream format

Unit ID	Name	Conversion factor
0x10	[kN/m^2] kilo newton / square metre	0.01 bar
0x11	[N/cm^2] newton / square centimetre	0.1 bar
0x12	[atm] standard atmosphere	1.01325 bar
0x13	[kg/cm^2] (kp/cm^2, at) technical atmosphere	0.980665 bar
0x14	[kg/mm^2] (kp/mm^2)	98.0665 bar
0x15	[µmHg] micrometre of mercury (micron, milli-Torr)	1.333224E-06 bar
0x16	[mmHg] millimetre of mercury (Torr)	0.001333224 bar
0x17	[cmHg] centimetre of mercury	0.01333224 bar
0x18	[inHg] inch of mercury	0.03386389 bar
0x19	[mmH_2O] millimetre of water	9.80665E-05 bar
0x20	[mH_2O] metre of water	0.0980665 bar
0x21	[inH_2O] inch of water	0.002490889 bar
0x22	[ftH_2O] foot of water	0.02989067 bar

Table of unit identifiers for temperature (channel 1):

Unit ID	Name	Conversion factor
0x01	[°C] degree Celsius	
0x02	[°F] degree Fahrenheit	°F = °C * 1.8 + 32
0x03	[K] Kelvin	
0x04	[°R] degree Rankine	°R = °K * 1.8

3.7.1 Example

Upstream packet: 0x07 11 0F 00 0015 03 00000000 41200000 07 01 C2200000 42700000 01

Decoding	
07	Radio unit identification message
11	Configuration ID = 17
0F	WIKA wireless product ID for NETRIS®3
00	LoRaWAN® version
0015	Instrument type ID = 21
03	Channel 0 measurand = “gauge pressure”
00000000	Channel 0 lower limit = 0.0

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Decoding	
41200000	Channel 0 upper limit = 10.0
07	Channel 0 unit = bar
01	Channel 1 measurand; always the same for temperature
C2200000	Channel 1 lower limit = -40.0
42700000	Channel 1 upper limit = 60.0
01	Channel 1 unit = Celsius

Note: in case of failure to establish communication between the radio unit and the instrument, no identification message is transmitted.

3.8 Keep alive message

The keep-alive frame is transmitted periodically every 24 hours. This setting is not adjustable. This guarantees that the radio unit will be reachable at least once a day no matter what the configuration is.

The message is formatted as follws:

Byte	Size (bytes)	Value	Note
0	1	0x08	Keep-alive message
1	1	Config ID	Current configuration identifier
2-5	4	Number of measurements	Both counters are never reset and are used for radio unit diagnostics.
6-9	4	Number of transmissions	

3.8.1 Example

Upstream packet: 0x08 1F 00C781A1 006CA4F8

Decoding	
08	Keep alive message
1F	Configuration ID = 31
00C781A1	Number of measurements = 13,074,849
006CA4F8	Number of transmissions = 7,120,120

3.9 Extended radio unit & instrument identification message

The extended radio unit and instrument identification message is transmitted just after the radio unit identification message and contains miscellaneous information that can be used for radio unit and instrument identification and traceability.

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The message is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x09	Extended identification message
1	1	Config ID	Current configuration identifier
2	1	0x0F	Bitmask, all optional fields are present for PGU2x.100
3-14	12	WIKA instrument serial number	ASCII string (no null termination)
15-18	4	Instrument LUID	
19-21	3	Instrument hardware version	major.minor.patch (1 byte each)
22-24	3	Instrument device version	major.minor.patch (1 byte each)
25-27	3	Instrument firmware version	major.minor.patch (1 byte each)
28-31	4	Radio unit serial number	First 3 bytes = unsigned 6-digit number, 4th byte = ASCII letter; human-readable format = the letter followed without separator by the number
32-38	7	Radio unit product code	ASCII string (no null termination)
39-41	3	Radio unit firmware version	major.minor.patch (1 byte each)

3.9.1 Example

Upstream packet: 0x09 0A 0F 50484F454E49585F464E424E 00BC614E 000000 000001 000008 00353E4E 4E364555535832 030106

Decoding	
09	Extended radio unit & instrument identification message
0A	Configuration ID = 10
0F	Bitmask, all optional fields are present for PGU2x.100
50484F454E49585F464E424E	Instrument serial number = "PHOENIX_FNBN"
00BC614E	Instrument LUID = 12,345,678
000000	Instrument hardware version = 0.0.0
000001	Instrument device version = 0.0.1
000008	Instrument firmware version = 0.0.8
00353E4E	Radio unit serial number = N013630 (6-digit number, add leading zeros if needed)
4E364555535832	Radio unit product code = "N6EUSX2"
030106	Radio unit firmware version = 3.1.6

4. Downstream format

4.1 General format

Downstream packets are sent by the IIoT platform to the radio unit via the network in “store and forward” mode: they are scheduled in advance by the platform, stored in the LPWAN central server, and are transmitted to the radio unit just after it sends an upstream packet. They are then interpreted by the radio unit, which is expected to send a “configuration status” response (see section 3.6).

Downstream packets are identified using a transaction ID and can contain several commands.

The packet format is as follows:

Byte	Size (bytes)	Note
0	1	Transaction identifier (see sec. 2.5)
1	1	For command type, see next table
2, n+1	n (can be 0)	Command options (size depends on the command type)
n+2	1	Additional commands can be concatenated, one after another.
n+3…	m	

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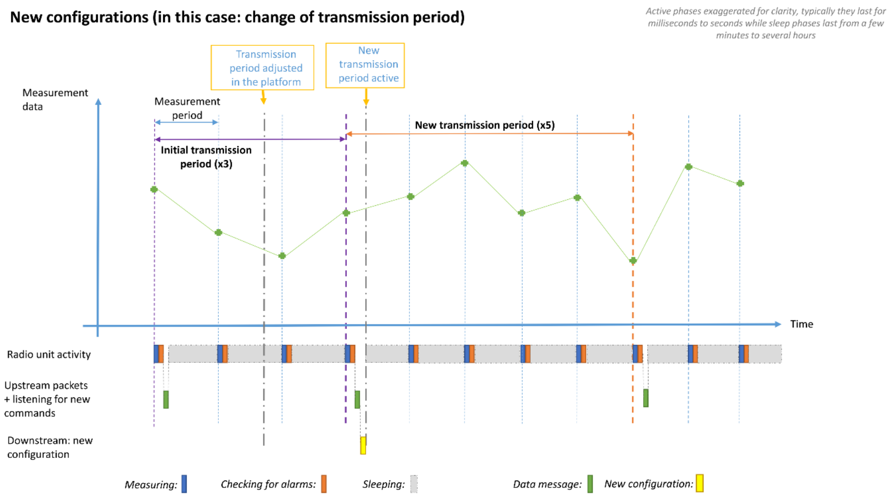
The first byte of the command describes its type:

Value (hex)	Upstream command types	Option size (bytes)
0x01	Reset to factory configuration	0
0x02	Set main configuration	13
0x11	Disable channel	2
0x20	Set process alarm	5 to 21
0x30	Set channel property	4



4.2 Reset to factory configuration command

This command will force the radio unit to return to the factory configuration that is defined in the table below. It must not be sent with other commands in the same packet.

The command is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x01	Reset to factory configuration command

The radio unit factory configuration is:

Parameter	"Factory" configuration
Measurement period, no alarm active	7200 seconds (2 hours)
Transmission multiplier, no alarm active	1x (2 hours)
Measurement period, ≥1 alarm active	7200 seconds (2 hours)
Transmission multiplier, ≥1 alarm active	1x (2 hours)
Data channel(s)	All enabled
Process alarms, for each data channel	All disabled
Offset, for each data channel	0

4.2.1 Example

Downstream packet: 0x00 01

Decoding	
00	Transaction ID = 0; by convention, used as transaction/config ID for factory configuration
01	Reset to factory configuration command

4.3 Set main configuration command

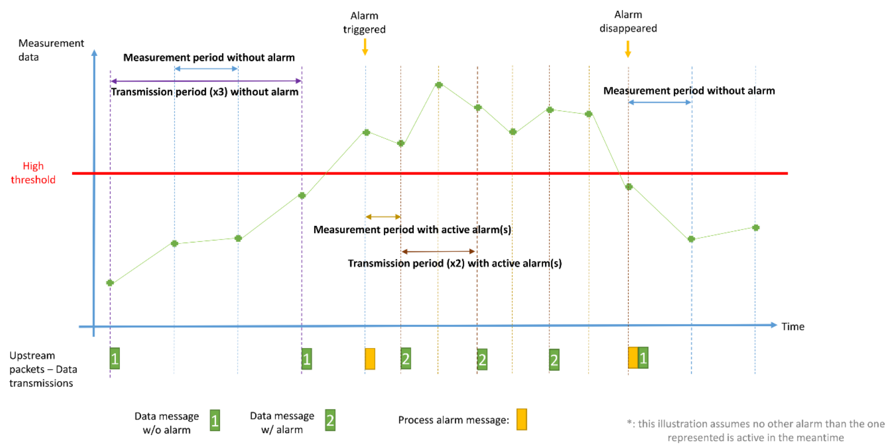
The main configuration of a radio unit defines how often it wakes up to take a measurement, and what ratio of the measurements shall be transmitted to the platform as data messages.

4. Downstream format

The command is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x02	Set main configuration command
1-4	4	Measurement period when no alarm is active	Period in seconds Min. value = 60 s ; max. value = 86,400 s (1 day)
5-6	2	Transmission multiplier when no alarm is active	Transmission period = measurement period * transmission multiplier Value = [1; 2,880], transmission period = 172,800 s max.
7-10	4	Measurement period when ≥1 alarm is active	Same unit, and min./max. values as above
11-12	2	Transmission multiplier when ≥1 alarm is active	
13	1	0x00	Reserved

Measurement and transmission periods (different setting when at least one alarm is active or not)*



4.3.1 Example

Downstream packet: 0x12 02 00000E10 0002 00000258 000C 00

Decoding	
12	Transaction ID = 18
02	Set main configuration command
00000E10	3,600 s, measurement every hour when no alarm is active
0002	x2, transmission every 2 hours (2 * 3,600 s) when no alarm is active
00000258	600 s, measurement every 10 minutes when one or more alarm is active

Decoding	
000C	x12, transmission every 2 hours (12 * 600 s) when one or more alarm is active
00	Reserved

4.4 Disable channel command

This command will disable a given data channel. This channel will no longer generate measurement data, nor any process or technical alarm.

The command is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x11	Disable channel command
1	1	0x00	Reserved
2	1	Channel ID (0 or 1)	Channel to disable

To reactivate a channel, send a process alarm configuration command to that channel. This command can possibly be “empty”, with all alarm enabling bits set to 0. See example follows.

4.4.1 Example

Downstream packet: 0x01 11 00 00

Decoding	
01	Transaction ID = 1
11	Disable channel command
00	Reserved
00	Channel 0 shall be disabled

Disabling channel 1 and re-enabling channel 0 in a single packet:

Downstream packet: 0x04 11 00 01 20 00 00 0032 00

Decoding	
04	Transaction ID = 4
11	Disable channel command
00	Reserved
01	Channel 1 shall be disabled
20	Set process alarms

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Decoding	
00	Reserved
00	Process alarms for channel 0
0032	Dead band of 0.5 % of span; value is meaningless as there are no alarms
00	Do not configure any alarm, just enable the channel

4.5 Set process alarm command

This command will activate the channel (measure and alarm). All previous alarm configurations on this channel are replaced. Parameters for alarms must be present only if the corresponding alarm is enabled.

The command is formatted as follows:

Byte	Size (bytes)	Bit	Value	Note
0	1		0x20	Set process alarm command
1	1		0x00	Reserved
2	1		Channel ID (0 or 1)	Channel for which alarms shall be configured
3-4	2		Dead band, common to all non-slope alarms	0-10,000 in increments of 0.01 % of span; common to all non-slope alarms
5	1	7	Alarm 1: Low threshold	For each alarm, the bit value means: 1> enabled 0> disabled
		6	Alarm 2: High threshold	
		5	Alarm 3: Falling slope	
		4	Alarm 4: Rising slope	
		3	Alarm 5: Low threshold with delay	
		2	Alarm 6: High threshold with delay	
		1-0	0	Reserved
6…	2		Threshold value for alarm 1	Included only if alarm 1 is enabled
	2		Threshold value for alarm 2	Included only if alarm 2 is enabled
	2		Slope value for alarm 3	Included only if alarm 3 is enabled
	2		Slope value for alarm 4	Included only if alarm 4 is enabled
	2		Threshold value for alarm 5	Included only if alarm 5 is enabled
	2		Delay value for alarm 5	Included only if alarm 5 is enabled
	2		Threshold value for alarm 6	Included only if alarm 6 is enabled
	2		Delay value for alarm 6	Included only if alarm 6 is enabled

See table in sec. 2.5 for the definition of threshold, slope and delay.

The slope value parameter is always positive but is interpreted differently for rising and falling slopes. For a rising slope, the alarm will be triggered if the value rises quicker than the value. For a falling slope, the alarm will be triggered if the value falls quicker than the value.

4.5.1 Example

Downstream packet: 0x18 20 00 00 0032 80 12FA

Decoding	
18	Transaction ID = 24
20	Set process alarms
00	Reserved
00	Process alarms for channel 0
0032	50 = dead band of 0.5 % of span
80	Low threshold alarm only
12FA	Threshold of 23.58 % of span; alarm will be triggered follows 23.58 - 0.5 = 23.08 % of span

Downstream packet: 0x0F 20 00 01 0032 08 1964 00B4 20 00 00 0000 70 2EE0 02D0 0064

Decoding	
0F	Transaction ID = 15
20	Set process alarms
00	Reserved
01	Process alarms for channel 1
0032	Dead band of 0.5 % of span
08	Low threshold with delay alarm
1964	6,500 = threshold at 40 % of instrument span
00B4	180 s delay (multiple of the measurement period)
20	Set process alarms (2nd command)
00	Reserved
00	Process alarms for channel 0
0000	Dead band of 0 % of span
70	High threshold and rising slope and falling slope alarms
2EE0	12,000 = high threshold at 95 % of the instrument's span (alarm 2 parameter)

Decoding	
02D0	720 = alarm triggered if value drops faster than 7.2 % of span/min. (alarm 3 parameter)
0064	100 = alarm triggered if value increases faster than 1 % of span/min. (alarm 4 parameter)

4.6 Set channel property command

This command is used to set miscellaneous properties of a measurement channel. For NETRIS®3, the off-set is the only property available.

The command is formatted as follows:

Byte	Size (bytes)	Value	Note
0	1	0x30	Set channel property command
1	1	0x00	Reserved
2	1	Channel ID (0 or 1)	Channel to configure
3-4	2	Measure offset	16 bit signed value in 0.01 % of span

The offset is a value (in 0.01 % of the instrument's span) that is added to a measured value before evaluating alarms or transmitting a measurement data. Each time this command is used, the previously configured offset is replaced by the new value, this command is not accumulative.

It allows for user-defined, application-specific correction of measured values. The default offset is 0.

4.6.1 Example

Downstream packet: 0x0C 30 00 01 FF19

Decoding	
0C	Transaction ID
30	Set channel property
00	Reserved
01	Set properties for channel 1
FF19	-231 -> set offset to -2.31 % of the channel's span

5. Connectivity protocol: LoRaWAN®

5.1 Radio unit network integration

NETRIS®3 is a "class A" battery-powered LoRaWAN® radio end-device using version 1.0.3 of the protocol and EU868 regional parameters.
NETRIS®3 uses the OTAA "over–the-air activation" LoRaWAN® procedure. Each radio unit comes config-ured at the factory with a securely generated random 128-bit secret key. Knowledge of this key is required to enable a network to communicate with the radio unit.

5.2 Join procedure

At power-up, the module will start a LoRaWAN® join sequence. If joining fails, the radio unit will do 5 retries with 1 minute interval between. If none of them succeeds, the radio unit will retry every 24 hours, indefinitely.

After joining a network, the radio unit will send 5 messages with a 1 min. delay between them:
- Radio unit identification
- Extended radio unit and instrument identification
- 3 data messages, with or without alarm ongoing

After those 5 packets, the normal configuration for measurement and transmission period will apply.

Every 14 days, the radio unit will automatically re-join the network. Current configuration and alarms (if any) are kept unmodified. Identification and extended identification packets are not sent.

5.3 Classes of traffic

All upstream traffic generated by the radio unit is sent on LoRaWAN® port 10.

The radio unit will only process data downstream traffic sent on port 10 and LoRaWAN® MAC traffic sent on port 0. Downstream traffic sent on other ports will be ignored.

The following upstream messages are sent as "confirmed" LoRaWAN® packets:

- Process, technical and radio unit alarms
- Radio unit identification and extended radio unit & instrument identification
- Configuration status
- Keep alive

The network should send an acknowledgement to confirm reception of "confirmed" packets. If the network is too busy to confirm, the packets will be sent several times by the radio unit to increase the probability of being received at least once.

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WIKA Alexander Wiegand SE & Co. KG
Alexander-Wiegand-Strasse 30
63911 Klingenberg • Germany
Tel. +49 9372 132-0
Fax +49 9372 132-406
info@wika.de
www.wika.de

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