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Wireless M-Bus Range Extender

User Manual

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History

Version	Date	Comment
1.0	June 2020	Initial Version
1.1	October 2020	Updates with respect to firmware version 1.0
1.2	February 2021	<ul style="list-style-type: none">Missing Status Bit 3 for LoRaWAN Activation Procedure added to Range Extender Status InformationChapter Packet Decoding and Reassembly removed, see AN036 for further details
1.3	April 2021	Missing LED signal "LoRaWAN activation successful (3 x Green)" in chapter LED Usage added
1.4	September 2021	Updates with respect to firmware V1.1 <ul style="list-style-type: none">Status Message extended by battery voltage (Range Extender Status Information)New WM-Bus Message upload including RSSI (Application Messages and LoRaWAN® Ports, WM-Bus Packet Message with RSSI)
1.5	October 2021	Chapter Default Settings added
1.6	November 2021	Adjusted technical characteristics
1.7	April 2022	Update of Step 3 LoRaWAN Stack Activation in chapter Range Extender Startup
1.8	January 2023	Updates with respect to firmware V1.3 <ul style="list-style-type: none">Status Message extended by minimum battery voltage (Range Extender Status Information)
1.9	January 2024	<ul style="list-style-type: none">Chapter Automatic LoRaWAN 'Re-Join' addedChapter Battery Voltage Measurement added

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General User Information / Disposal

This document has to be treated confidentially. The content must not be published, duplicated or passed to third parties without our express permission.

Read this documentation attentively before initial operation or use of the Wireless M-Bus Range Extender.

Observe the safety instructions and warnings in this documentation.

Keep the user manual for future reference.

Product Information

Device: Wireless M-Bus Range Extender

Proper use: The Wireless M-Bus Range Extender is a compact and cost-effective device that collects wireless M-Bus messages from utility meters and forwards them to a LoRaWAN® network.

Order Number: 404600

Manufacturer:

IMST GmbH

Carl-Friedrich-Gauss-Str. 2-4, 47475 Kamp-Lintfort, Germany

Disposal of the Device



Do not dispose this product at the end of its life in the household waste, but in the designated places for recycling old electrical equipment.

Do not dispose the battery cell in the household waste, but in the designated areas for recycling old batteries.

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Safety

General

Read this safety information attentively before using and operation of the Wireless M-Bus Range Extender

Do not make any changes to the product. The housing may only be opened for the initial configuration of the Wireless M-Bus Range Extender and only by qualified specialist personnel. The housing must then be closed again for further operation.

Please do not use the device, if it appears to be damaged.

Battery Instructions

The Wireless M-Bus Range Extender is equipped with a non-rechargeable, 3.6V lithium battery cell with a typical capacitance of 19Ah. The battery must be treated as **dangerous good**.



Please note the following information.

- Only use the admitted battery cell (see [Technical Characteristics](#))
- Battery cells with a nominal voltage of more than 3.6V are not allowed.
- Do not recharge the battery cell.
- Do not disassemble the battery cell.
- Do not heat the battery cell above 100 °C.
- Keep batteries away from the reach of children.

Transport Notes

The Wireless M-Bus Range Extender is equipped with a non-rechargeable 3.6V lithium battery cell with a typical capacitance of 19Ah. The battery must be treated as **dangerous good**, UN3091 Class 9.



Please note the following information regarding transport of the Wireless M-Bus Range Extender.

- Certain transport and packaging regulations must be observed.
 - Use special packaging (Best case the same package where you received the Wireless M-Bus Range Extender with).
 - Mark the package with a appropriate sticker regarding the mode of transportation (street, train, ...).
- Disconnect the battery cell connector from the power supply connector of the PCB.
- Place a protection tape at the battery cell connector to avoid short circuit.
- If you are uncertain about the transport please contact the vendor.
- Transport within Airplanes is not allowed

Overview

The Wireless M-Bus standard (EN 13757-4) is used in many wireless sensor and smart meter applications. These meters and sensors are communicating according to defined radio operation modes based on a standard FSK modulation with more or less range to the corresponding receiving unit.

The LoRa® modulation has become the standard wireless technology for outdoor and indoor applications which require a perfect trade-off among communication range and battery life. Therefore it is a perfect means to increase the range of wireless communication systems. The Wireless M-Bus Range Extender in the following referred to as Range Extender combines the two modulation technics and communication protocol stacks in one single device.

A typical usecase for the Range Extender is the forwarding of Wireless M-Bus messages of a configurable group of sensor / meter devices. The Range Extender offers a flexible way to define hourly, daily, weekly or monthly reception windows for sampling of WM-Bus messages and a large data memory for temporary buffering. Even large WM-Bus messages with maximum payload size can be forwarded within LoRaWAN® radio packets by means of an integrated segmentation & reassembly protocol.

Configuration of firmware parameters like LoRaWAN® settings, calendar events, packet filters can be easily managed via serial USB link and PC-Tool. Calendar events and packet filters can furthermore be updated over the air.

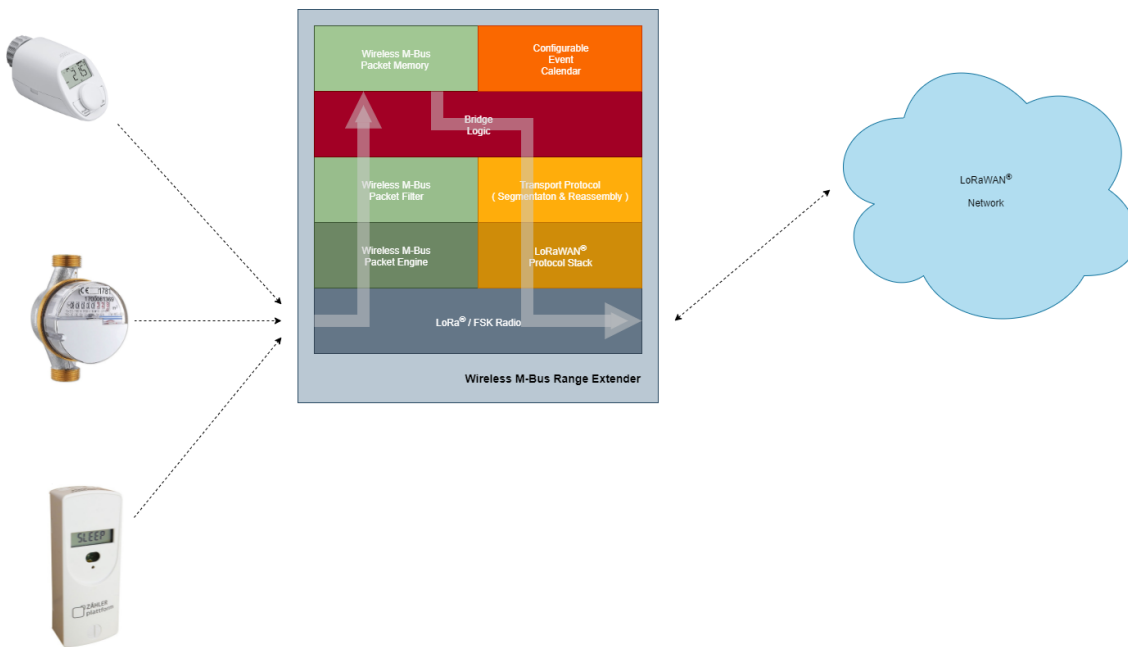


Figure: Overview

Range Extender Hardware



Figure: Wireless M-Bus Range Extender without cover

Hardware Features

- Power Supply via Battery.
- Radio module including TRX, μ C and additional PCB antenna.
- Data memory
- User Interface for configuration and signalling

The following explains some hardware features, necessary for the user to power and configure the Range Extender.

Power Supply

Power for the Range Extender is supplied via the 2-pin connector JST B2B-PH-K-S.



Figure: Power Connector

Default power source is one non-rechargeable 3.6V LTC (Lithium-Thionylchlorid, Li-SOCl₂) battery cell. It is equipped with a cable and the 2-pin connector JST PHR-2.

Battery Notes	
	Battery cells with a nominal voltage of more than 3.6V are not allowed.
	Do not recharge the battery cell.
	Do not disassemble, or heat the battery cell above 100 °C.
	Dispose the battery cell only in designated areas for recycling old batteries.



User Interface

Reed Sensor: to be used as magnetic switch with a simple magnet for external user actions, without a need to open the housing.

LED for signalling.

Internal Reset Button for manual Reset after configuration of LoRaWAN® settings.

Internal Configuration Interface:

- Serial Configuration Interface (UART):
 - configuration of calendar events for WM-Bus reception intervals.
 - configuration of device filtering by Manufacturer ID, Device ID, ... (whitelist).
 - firmware upload via integrated bootloader (see [Firmware Update via Bootloader - Old](#)).
 - pin compatible to FTDI's **TTL-232R-3V3** (TTL to USB serial converter cable).
- 2 Pin-Header for activating the internal bootloader.

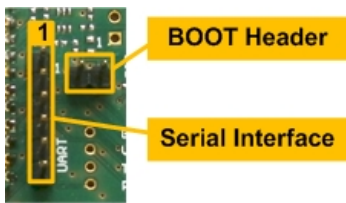


Figure: Configuration Interface

Serial Configuration Interface			
Pin	Name	Type	Description
1	GND	GND	
2	NC	-	currently not connected
3	NC	-	currently not connected
4	RxD	Input	UART receive data input of the radio module
5	TxD	Output	UART transmit data output of the radio module
6	NC	-	currently not connected

Initial Setup

The Wireless M-Bus Range Extender requires an initial configuration before usage. This configuration can be done by means of a PC-Tool called **WS Configurator** which is connected via serial interface to the device.

The configuration includes the following steps:

1. Setup of LoRaWAN[®] protocol parameters including activation type for Over The Air Activation (**OTAA**) or Activation by Personalization (**ABP**) and the corresponding keys and identifiers
2. Reset of connected Range Extender
3. Synchronize the embedded RTC with the local PC time
4. Setup of calendar events which control the runtime behaviour of this device
5. Configuration of Wireless M-Bus address parameters for packet filtering

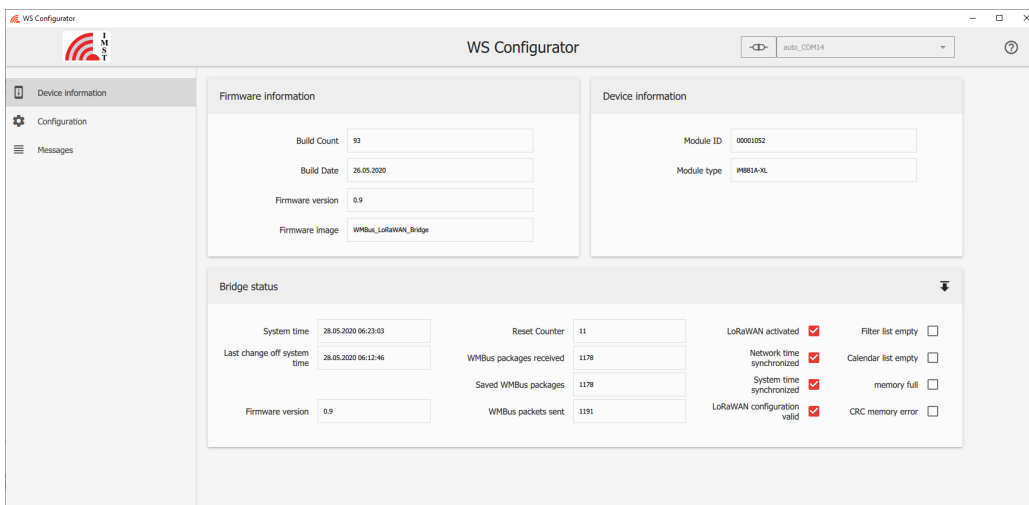


Figure : WS Configurator

For firmware V0.9 it is recommended to perform a reset whenever the LoRaWAN[®] settings have been updated.

Do not forget to synchronize the embedded RTC of the Range Extender with the PC time afterwards.

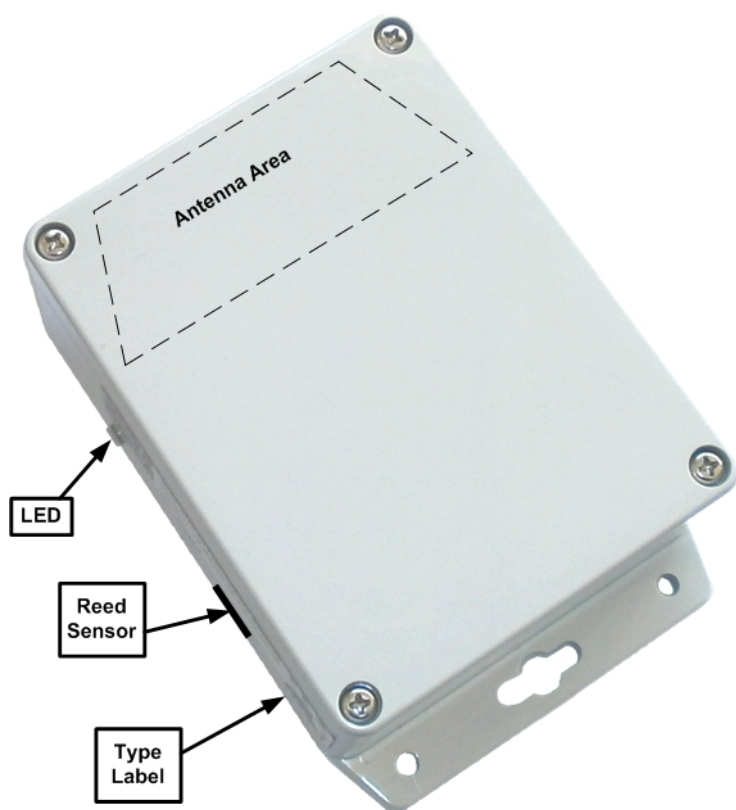
Installation

The Wireless M-Bus Range Extender housing consists of mounting brackets for fastening on a flat surface. Installation height must not be higher than 2 meters above ground to avoid any risks in case of falling down.

The figure below shows the positions of the LED, the Reed Sensor and especially the integrated PCB antenna.

For optimal RF performance please avoid any metal obstacles near the antenna area.

If possible, avoid to install the module directly next to other radio equipment.



After powering up the Wireless M-Bus Range Extender by connecting the battery cell to the power connector the Range Extender performs its startup procedure and starts working depending on the current configuration.

Device activation and visualization of internal firmware status can be triggered by a magnet via reed sensor and will be signaled via led

For more details, please read the chapter [Functional Description](#).

Functional Description

The following chapters explain the firmware features in more detail.

- Range Extender Startup
- Calendar Events
- Real Time Clock Synchronization
- Wireless M-Bus Packet Filter
- Recording of Wireless M-Bus Packets
- Upload of Application Data
- Automatic LoRaWAN 'Re-Join'
- Battery Voltage Measurement
- LED Usage

Range Extender Startup

After a power cycle or reset the Range Extender performs a startup procedure which includes the following steps:

- **Step 1 : System Startup & Software Module Configuration**

After successful system startup the Range Extender reads and validates the required configuration settings. In case of valid settings the corresponding firmware's modules LoRaWAN® Stack, Wireless M-Bus Packet Filter, Event Calendar will be configured. In case of missing LoRaWAN® settings the Range Extender enters a sleep mode and waits for further configuration (**Step 2**).

Every LoRaWAN® device must be activated before usage. If not already activated, the Range Extender enters sleep mode and waits for a trigger signal to start the LoRaWAN® activation procedure (**Step 3**). This trigger signal can be issued as follows:

- by means of a magnet and a pulse from the reed switch
- by means of an application event sent from a PC-Tool via local serial interface

- **Step 2 : Range Extender Configuration**

The initial Range Extender configuration must be handled via serial connection and PC-Tool. During configuration phase several parameters for LoRaWAN® activation, Calendar Events and WM-Bus Packet Filters have to be set to change the Range Extender behaviour.

Note: the LoRaWAN® Stack can be deactivated and reactivated again.

- **Step 3 : LoRaWAN® Stack Activation (OTAA or ABP)**

In case of Over The Air Activation (**OTAA**) the Range Extender initiates the LoRaWAN® join procedure. On success the Range Extender continues with the next step. In case of a failed over the air activation the system will repeat the join procedure after 12 hours. The join procedure and it's final result will be signaled via **LED**. If Activation By Personalization (**ABP**) is selected the LoRaWAN® Stack will be activated and the next step is directly initiated.

Note: from firmware version v1.1 ABP should only be used for test purpose.

- **Step 4 : Real Time Clock Synchronization**

For proper calendar operation the Range Extender requests the LoRaWAN® network time and synchronizes the internal real time clock (RTC).

- **Step 5 : Time Correction of Calendar**

In this final step the calendar unit is updated to handle the configured events which control the subsequent application behaviour.

The following flow chart outlines the Range Extender startup procedure and it's single steps.

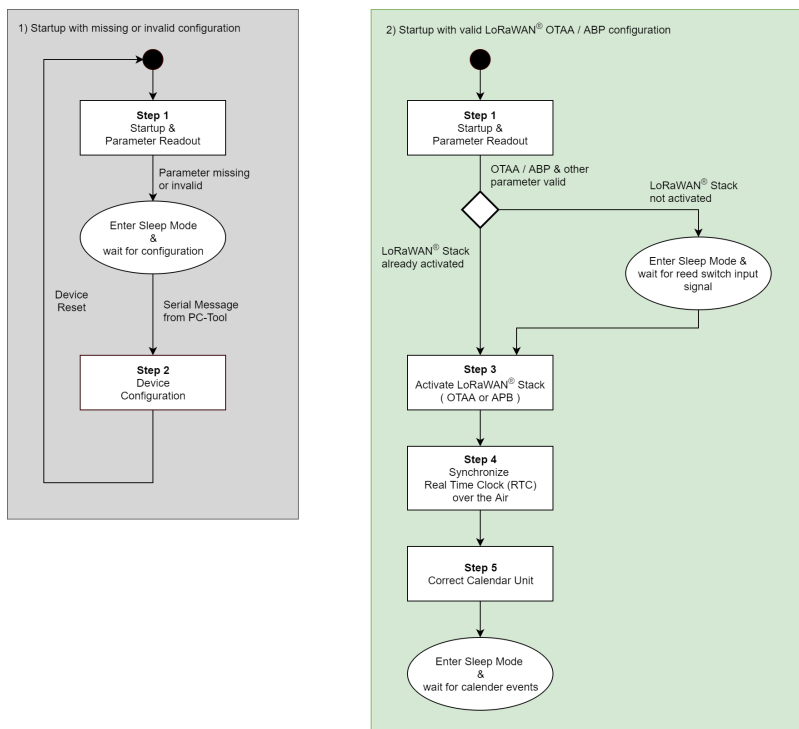


Figure : Range Extender Startup with invalid & valid configuration

Calendar Events

Calendar Events are used to define the runtime behaviour of this application. The firmware provides space for up to 32 configurable Calendar Events.

A single Calendar Event item consists of the following three or four elements:

- 1. Event Type**
The event type defines the kind of action to be performed, e.g. "Record Wireless M-Bus Packets in S-Mode"
- 2. Repetition Type**
The repetition type defines the periodicity of an event e.g. monthly, every 2 weeks, daily, every 4 hours or none.
- 3. Date / Time**
The date / time element defines when an event should be scheduled for the first time. This information is stored in 32-Bit **unsigned integer** UTC format.
- 4. Filter Group ID**
This element defines a group of filters which are active during a Wireless M-Bus packet capture phase (see [Wireless M-Bus Packet Filter](#)).
Note: this element is currently only used for Wireless M-Bus reception event types. A value of 255 (0xFF) is reserved and means that all configured Wireless M-Bus filters should be applied for that Calendar Event.

Event Types

The following main event types are configurable:

- Enable recording of Wireless M-Bus packets in S-Mode or combined C-/T-Mode ^{1) 2)}
- Stop recording and start upload of recorded Wireless M-Bus packets ¹⁾
- Enable Wireless M-Bus reception in S-Mode or C-/T-Mode without recording but with filtering and direct packet forwarding over the local serial interface ²⁾
- Disable Wireless M-Bus reception
- Get & Synchronize Network Time over LoRaWAN[®] ¹⁾
- Send Range Extender Status over LoRaWAN[®] ¹⁾
- Set LED on / off / blinking for simple Range Extender and calendar test purpose

¹⁾ Note: this event type requires an activated LoRaWAN[®] Stack.

²⁾ Note: it is possible to change between S-Mode and C-/T-Mode on the fly without stopping a reception phase.

The Calendar module itself is connected to the embedded Real Time Clock (RTC) . Please refer to chapter [Real Time Clock Synchronization](#) for further information.

Real Time Clock Synchronization

The Range Extender features an embedded Real Time Clock (RTC) which is used to schedule configurable Calendar Events. For proper operation it is highly recommended to synchronize the RTC. The initial synchronization can be done by means of the WS-Configurator PC-Tool. On every synchronization the current time stamp is stored in the non volatile memory of the embedded radio module. After a power-cycle or system reset this stored value is used to initialize the RTC. If the value is invalid or less than 01.01.2000 00:00:00 the RTC will start at 01.01.2000 00:00:00.

After startup the device starts with a LoRaWAN[®] activation procedure (OTAA or ABP) and initiates a LoRaWAN[®] uplink MAC command to get the current data and time from the LoRaWAN[®] server. On success the received value is used to configure the RTC and is finally stored in the NVM for later usage after a system reset.

Due to the fact that some LoRaWAN server do not support the "Get Time MAC Command" a new fall back mechanism is implemented in firmware version V1.0. In case of no MAC command response the firmware transmits a "Get Date Time Request" application command via LoRaWAN[®] to the connected Application Server which might be able to answer this request. This request is transmitted 5 times.

The new "Get Date Time Request" looks as follows;

LoRaWAN Port: 32

LoRaWAN Payload Syntax:

Request < Get > < Resource ID >

Example:

< Get > < DateTime >

< 01_h > < 01_h >

The corresponding Get Date Time response must look like this:

LoRaWAN Port: 32

LoRaWAN Payload Syntax:

Response < Get Response > < Resource ID > < data >

Example:

< Get Response > < DateTime > < current date time as seconds since (1.1.1970, midnight UTC/GMT), 00:00:00 as **unsigned** 32-Bit integer, LSB first , e.g.: "2020-09-18 11:46:33 >

< 02_h > < 01h > < (19 9E 64 5F)_h >

Due to the fact that the clock crystal frequency can drift over temperature it is recommended to synchronize the RTC via LoRaWAN[®] from time to time (e.g. once per week).

Wireless M-Bus Packet Filter

The firmware allows to define up to 32 Wireless M-Bus address filter items which should help to focus on those devices of interest during a Wireless M-Bus capture phase. The header fields mentioned here are present in the data link layer fields of each Wireless M-Bus packet.

A single packet filter item consists of the following fields:

1. **Manufacturer ID**
Contains the 2 octet unique User/Manufacturer ID of the sender of a packet
2. **Device ID**
Containing the first 4 octets of the address field which carry a 32-Bit unique device address
3. **Version**
Single octet, containing a version number
4. **Type**
Single octet, containing the type of the sender e.g. E-meter, Gas-meter, ...
5. **Filter Mask**
Single octet, defines which of the given 8 octets of packet header must match exactly and which should be treated as "don't care"
6. **Filter Group ID**
Single octet (range 0 - 255), defines a group to which this filter item belongs, see also [Calendar Events](#)

The Filter Group ID of a calendar event item must match with the Filter Group ID of a filter item to enable the filter during a capture phase.

The value 255 is reserved and means that a filter with this ID will be applied in every Wireless M-Bus reception phase.

Recording of Wireless M-Bus Packets

Two calendar event types are used to start a Wireless M-Bus packet capture phase either in S-Mode or combined C- / T-Mode. The received packets will be decoded according to the defined physical layer encoding Manchester, Three Out Of Six or NRZ. Every packet will be checked for CRC errors and only valid packets will be decoded according to the given frame format A or B. The Wireless M-Bus CRCs are stripped of to save memory and LoRa upload airtime. In the next step the packet has to pass the first filter stage which compares the WM-Bus packet header fields with a set of configured addresses. With firmware version 1.0 a second filter stage for removing duplicated packets has been introduced. Finally the accepted packets are stored into an embedded flash memory. The flash memory will be automatically erased after each LoRa upload session.

The following figure outlines the connection between WM-Bus reception Calendar Events, Filter Group ID and the Wireless M-Bus Device Filters. The Duplicate Filter will be "emptied" on every reception window start and is updated automatically with information from the WM-Bus packet header of every new received packet. The filter compares the WM-Bus-Packet Header Fields and optionally a computed 16-Bit CRC to identify duplicated WM-Bus packets. For performance reasons the Duplicate Filter uses the internal RAM and is limited to max. 16 entries.

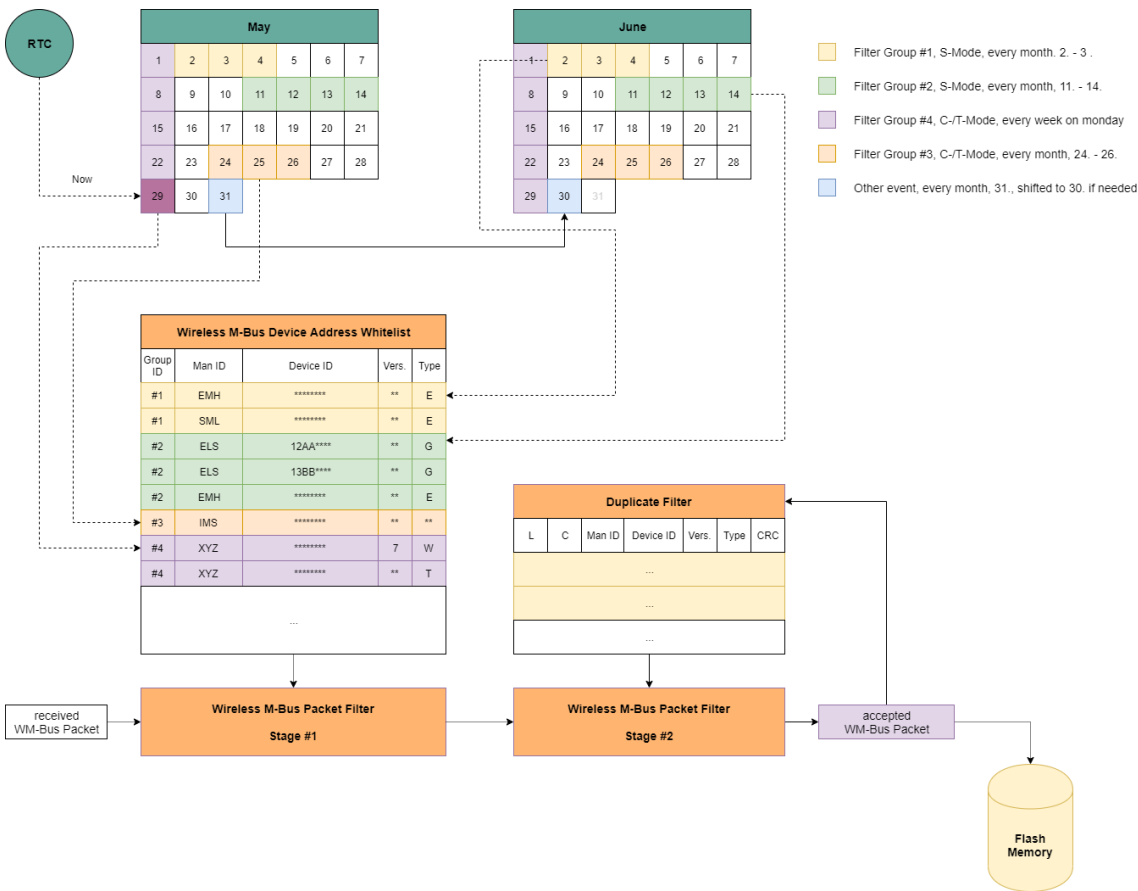


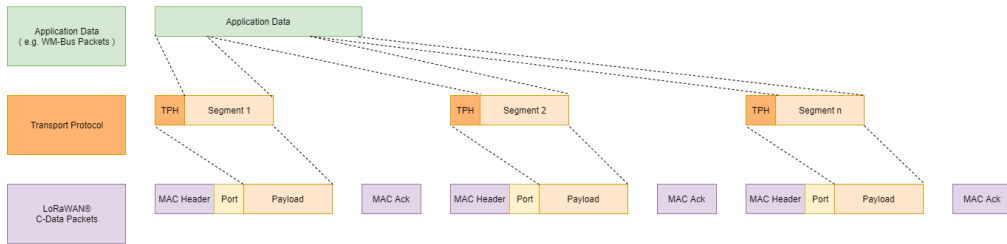
Figure : Example of Wireless M-Bus packet reception, Wireless M-Bus Address Whitelist and Calendar Events

1. It is recommended to reserve some time after a reception phase for uploading of captured messages via LoRaWAN® network.
2. Monthly events which are scheduled for days that are not present in the current month e.g. 29.2, 30.2, 31.2, 31.4, 31.6, 31.9, 31.11 are scheduled for the last day of the month. Thus it is highly recommended not to schedule a Wireless M-Bus capture start or stop event for one of these days.

Upload of Application Data

The upload of application data like captured Wireless M-Bus packets is implemented by means of confirmed LoRaWAN® uplink packets. Due to the adaptive payload capacity of LoRaWAN® packets a complete Wireless M-Bus packet may require more than one LoRaWAN® uplink packets. In this case a simple segmentation protocol with minimal overhead of one single byte is used. The protocol supports both, spreading of WM-Bus packets over multiple LoRaWAN® packets and transmitting of multiple WM-Bus packets in a single LoRaWAN® packet.

WM-Bus Packet spreaded over several LoRaWAN Packets (in case of large spreading factors)



Multiple WM-Bus Packets transmitted in one LoRaWAN Packet (in case of small spreading factors)

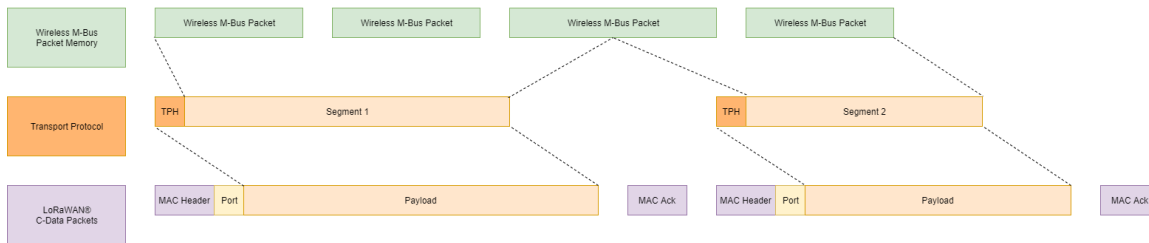


Figure : Application Data Upload

The following sub chapters describe the implemented application messages and the transport protocol in more detail.

- [Application Messages and LoRaWAN® Ports](#)
- [Transport Protocol Details](#)

Application Messages and LoRaWAN® Ports

The LoRaWAN® Protocol supports port numbers which are used within this application to identify different kind of messages.

The following ports are used for unsegmented messages:

LoRaWAN® Port	Message Type
03 _h	Range Extender Status Information
04 _h	WM-Bus Packet Message without RSSI
0B _h	WM-Bus Packet Message with RSSI (Firmware Version V1.1 ff.)
20 _h	Remote Access Services (see WMBus RangeExtender Remote Access Protocol.pdf)

Table : LoRaWAN Ports for unsegmented messages

Note: unsegmented messages do not include a segmentation protocol header byte. The application data follows immediately after the port number.

The following ports are used for segmented messages:

LoRaWAN® Port	Message Type
43 _h	Range Extender Status Information
44 _h	WM-Bus Packet Message without RSSI
4B _h	WM-Bus Packet Message with RSSI (Firmware Version V1.1 ff.)
60 _h	Remote Access Service (see WMBus RangeExtender Remote Access Protocol.pdf)

Table - LoRaWAN Ports for segmented messages

Implemented Application Messages

- Range Extender Status Information
- WM-Bus Packet Message without RSSI
- WM-Bus Packet Message with RSSI

Range Extender Status Information

The Range Extender maintains some status information elements which can be transmitted over LoRaWAN[®] or requested via local serial interface. The transmission can be initiated by means of a calendar event.

System Time		Firmware Version		Last Sync		Status		WM-Bus Packet Counter			Firmware V1.1 ff.		Firmware V1.3 ff.
UTC Format LSB first	Minor Version	Major Version	UTC Format LSB first	Reset Counter LSB first	Status Bits	Received Packets LSB first	Recorded Packets LSB first	Uploaded Packets LSB first	Battery Voltage in mV LSB first	Firmware Type	Minimum Battery Voltage in mV LSB first		
32 Bit	8 Bit	8 Bit	32 Bit	32 Bit	16 Bit	32 Bit	32 Bit	32 Bit	16 Bit	8 Bit	16 Bit		

Figure: Range Extender Status Format

The Range Extender Status consists of the following elements:

- **Range Extender System Time (from embedded RTC)**
- **Firmware Version**
- **Time of last Synchronization**
- **Reset Counter**
- **Status / Error Bits**
 - Bit 0: LoRaWAN[®] Activation State
1 = LoRaWAN[®] Stack is not activated
0 = Stack is activated
 - Bit 1: Network Time Synchronization State
1 = No synchronization via LoRaWAN[®]
0 = Synchronized via LoRaWAN[®]
 - Bit 2: System Time Synchronization State
1 = RTC not synchronized at all
0 = RTC synchronized (via local serial interface or LoRaWAN[®])
 - Bit 3: LoRaWAN Activation Procedure State
1 = Activation Procedure active
0 = Procedure not active
 - Bit 4: LoRaWAN Configuration State
1 = Configuration is invalid Activation not possible
0 = Configuration is valid
 - Bit 5: Wireless M-Bus Address Filter List Configuration State
1 = Whitelist is empty no recording possible
0 = Whitelist contains at least one item
 - Bit 6: Calendar Event List Configuration State
1 = List is empty in this case a default "Get Network Time" event is scheduled every hour at 05:00min for RTC synchronization
0 = List contains at least one item
 - Bit 8: Flash Memory Full State
1 = A flash memory full condition has been detected during capture phase this bit will be automatically cleared during the next recording phase
0 = No error
 - Bit 9: Flash Memory CRC Error State
1 = A file CRC error has been detected during read & upload operation this bit will be automatically cleared during the next recording phase
0 = No error
- **Wireless M-Bus Packet Counters**
 - Number of received packets
 - Number of filtered and recorded packets
 - Number of uploaded packets

Note: these counters can be resetted via local serial interface
- **Battery Voltage**
The battery voltage is measured just before transmitting this status message. The value is returned in Millivolts.

- **Firmware Type**

This element indicates different types of firmware version: e.g. official released version or field test beta version:

0 = Release

1 = Field Test Beta Version

X = Reserved

- **Minimum Battery Voltage (Firmware 1.3 ff.)**

This field contains the minimum measured battery voltage. The voltage is periodically measured during WM-Bus Receiving / WM-Bus Recording windows. The value is returned in Millivolts.

WM-Bus Packet Message without RSSI

The following figure outlines the WM-Bus Packet Message format in more detail:

Timestamp Field	WM-Bus Packet Field						
UTC Format LSB first	Length Field	C Field	Man ID	Device ID	Version	Type	...
32 Bit	8 Bit	8 Bit	16 Bit	32 Bit	8 Bit	8 Bit	n * 8 Bit

Figure: Wireless M-Bus Packet Message Format

Timestamp Field

Every recorded Wireless M-Bus packet is stored with a 32-Bit UTC timestamp derived from the internal RTC which indicates the time of reception.

WM-Bus Packet Field

This field includes the WM-Bus Packet starting with original Length-Field. The original CRC fields for WM-Bus telegram format A and B has been removed, since LoRaWAN provides an own protection mechanism.

WM-Bus Packet Message with RSSI

This message format is available in firmware version V1.1

The following figure outlines the WM-Bus Packet Message format with RSSI in more detail:

Timestamp Field	RSSI Field	WM-Bus Packet Field						
UTC Format LSB first	RSSI in dBm	Length Field	C Field	Man ID	Device ID	Version	Type	...
32 Bit	8 Bit	8 Bit	8 Bit	16 Bit	32 Bit	8 Bit	8 Bit	n * 8 Bit

Figure: Wireless M-Bus Packet Message Format including RSSI

Timestamp Field

Every recorded Wireless M-Bus packet is stored with a 32-Bit UTC timestamp derived from the internal RTC which indicates the time of reception.

RSSI Field

This field includes an RSSI value in dBm for the following WM-Bus Packet

WM-Bus Packet Field

This field includes the WM-Bus Packet starting with original Length-Field. The original CRC fields for WM-Bus telegram format A and B have been removed, since LoRaWAN provides an own protection mechanism.

Transport Protocol Details

The transport protocol is used in uplink- and downlink direction on several LoRaWAN® ports which indicate the type of message content. The protocol uses a single octet header field with following format:

TP Header	
Bit 7	Bit 6 ... Bit 0
Last Segment	Segment Number 0 .. 127

Figure : Transport Protocol Header

- Last Segment Indicator (Bit 7)
This bit indicates the last segment of a transmission if set to "1".
- Segment Number (Bit 0 .. 6)
The segment number starts at zero for every new transmission and will be incremented by "1" for every new segment. On receiver side it might happen that duplicated segment number will appear due to missing downlink acknowledgements. In this case the receiver should simply ignore the duplicated segments. The segment number can wrap around from 127 to 0 in case of very large transmissions and tiny segments.

The following figure outlines a transmission consisting of four different segments and one re-transmitted segment.

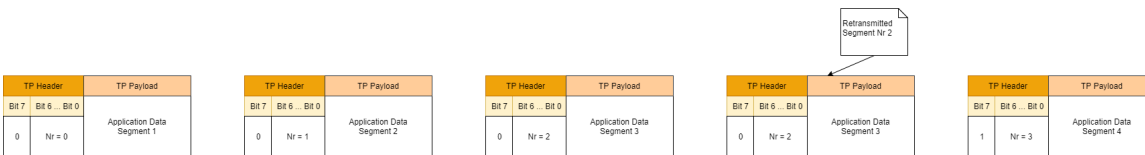


Figure : Example transmission sequence with four segments and one retransmission

Note

1. Due to the fact that the LoRaWAN protocol can change the uplink spreading factor the transport protocol handles automatically the resulting payload capacity changes.
2. A reliable serie of segments is ensured even if data needs to be retransmitted and payload capacity is changed at the same time.

Automatic LoRaWAN 'Re-Join'

The firmware initiates a process called LoRaWAN 'Re-Join' automatically. This typically involves a device re-establishing its connection with the LoRaWAN network. The trigger for this automatic Re-Join procedure is when no acknowledgment (downlink ack) is received after a maximum number of retransmissions. If the Re-Join procedure fails (presumably if the device is unable to re-establish a connection), the firmware schedules the next Re-Join attempt. In this case, it is set to occur after a specific time period of 12 hours.

Battery Voltage Measurement

The firmware provides two means to monitor the battery voltage:

1. The battery voltage is measured just before the transmission of a ['Range Extender Status Report'](#) to inform about the current battery voltage.
Please note: this voltage might be higher than the minimum voltage due to internal battery recovery processes.
2. The battery voltage is measured periodically during each WM-Bus Packet Receiving or Recording window.
This second algorithm has been added to improve the 'minimum voltage detection' during phases with higher battery load.

Both the latest and minimum measured voltage values are included in the ['Range Extender Status Report'](#) to indicate the battery state.

Note

It is highly recommended to schedule a ['Range Extender Status Report'](#), for example once per week, to monitor the battery state.

LED Usage

The Wireless M-Bus Range Extender features a dual color led which is used to signal multiple states and activities. Most of time the Range Extender will stay in a power saving state in which the led is switched off to save current. Visualization of internal Range Extender firmware state is done after power-up and can be triggered by means of a magnetic input signal via reed switch.

The following table outlines the Range Extender firmware states and the corresponding led signal:

State	Color	Timing	Action
LoRaWAN® stack activated, RTC synchronized, Calendar & Filter Lists configured	Green	2 x	nothing, Range Extender is ready
LoRaWAN® stack activated, RTC not synchronized	Red	1 x	synchronize RTC by means of local PC Tool or retry via LoRaWAN®
LoRaWAN® stack not activated, RTC not synchronized	Yellow	2 x	activate LoRaWAN® stack by means of magnetic input signal on reed switch
LoRaWAN® configuration, Calendar Configuration or WM-Bus Address Whitelist not valid	Red	3 x	connect Range Extender to PC and start configuration tool for settings update

The following table outlines the led usage during firmware activities:

Activity	Color	Timing
Startup	Off	none
LoRaWAN® activation	Red	continuously blinking
LoRaWAN® activation successful	Green	3 x
LoRaWAN® Network Time Synchronization	Yellow	continuously blinking
LoRaWAN® Network Time Synchronization successful	Green	2 x
LoRaWAN® Network Time Synchronization failed	Red	1 x
Wireless M-Bus capture phase	Off	none
Wireless M-Bus packet received	Green	1 x per packet
Wireless M-Bus packet received but not accepted by filter stage	Yellow	1 x per packet
Wireless M-Bus packet received but not stored due to memory full condition	Red	1 x per packet
Power Saving in Sleep Mode	Off	none

Default Settings

The following table lists the default factory settings:

Parameter	Value
Calendar Event List	empty, no LoRaWAN uplinks
WM-Bus Filter List	empty, WM-Bus packet reception not possible
Duplicate Filter	enabled with additional 16 Bit CRC check
LED Status signaling	enabled
WM-Bus Message upload / output with RSSI	disabled
LoRaWAN Connection Settings <ul style="list-style-type: none"> • Activation Type • 64-bit Device EUI • Application EUI / Join EUI • 128-bit Device Key 	Over The Air Activation (OTAA) pre-programmed valid IEEE Device EUI 00-00-00-00-00-00-00-00 _h 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00 _h
LoRaWAN Stack Settings <ul style="list-style-type: none"> • Adaptive Data Rate • Private / Public LoRaWAN Network • Duty Cycle check • Initial Data Rate • Initial Power Level • Number of Retransmission • MAC Header Command Capacity 	enabed public enabled SF12 13 dBm 12 15 bytes



Firmware Update

Updating the Range Extender firmware can be managed very easily by means of the provided PC tool called **WS Configurator**.

Technical Characteristics

Unless otherwise specified, all characteristics are applied for T = 25°C, VDD = 3.6V and are typical consumption values.

Electrical Characteristics	
Power Supply (VDD)	Lithium battery (Li-SOCI2) SL-2880 with connector PHR-2 3.6V, 19Ah, Size D
Current Consumption (typ.)	Transmit Mode: 45mA Receive Mode: 13mA ; 20mA during active packet reception Sleep Mode: 3µA (RTC on)
Data Memory	8 MBit Flash
Interface Characteristics	
Digital Input Voltage	high level: 0.7 x VDD to VDD low level: GND to 0.3 x VDD
Digital Output Voltage	high level: VDD - 0.45V to VDD low level: GND to 0.45V
UART Parameter	115.2 kbps, 8N1
RF Characteristics	
Frequency range	863 MHz to 870 MHz
RF output power	< 14 dBm ERP
Modulation	LoRa® Spread-Spectrum (G)FSK
Antenna	Integrated PCB antenna
LoRa® Protocol Characteristics	
LoRaWAN®	Certified and compliant to V.1.0.2 (firmware v1.0) Certified and compliant to V.1.0.4 (firmware v1.1)
Activation type	ABP ¹⁾ (activation by personalization) OTAA (over the air activation)
Frequencies	Standard LoRaWAN frequencies Additional frequencies depend on LoRaWAN® network server
Wireless M-Bus Protocol Characteristics	
Operation Modes	S mode and combined C/T mode according to EN 13757-4
Frequencies	868.3 MHz, 868.95 MHz
General Characteristics	
Product	Wireless M-Bus Range Extender
Operating Temperature	typ. 5°C to 55°C
Dimension	145mm x 92mm x 55 mm
Installation Height	max. 2 m above ground

Housing	Material: Polycarbonate UL94-HB, UV stabilized, gray, -40°C to +120°C
	NEMA 1, 2, 4, 4X, 12, 13
Certification	RED (2014/53/EC)
	RoHS Directive (2011/65/EC)
	LoRaWAN® 1.0.2 / LoRaWAN® 1.0.4

¹⁾ Note that from firmware v1.1 ABP should only be used for test purpose.

FAQ

No.	Question	Answer
1	Range Extender LED blinks 2 x yellow after startup, but packet recording or upload is not possible	The Range Extender seems not be activated with respect to LoRaWAN. Please configure and activate the Range Extender first.
2	Range Extender LED blinks red and did not stop	The Over The Air Activation is active but it seems that no server response can be received. Please check if a LoRaWAN Gateway is in range.
3	Range Extender is receiving packets but no packet is stored or uploaded	Please verify the WM-Bus packet filter settings. The current configuration might not fit to the received packets.

