ANR001 - METIS-II / 260702118301X

REPEATER MODE

VERSION 1.2

OCTOBER 21, 2019
## Revision history

<table>
<thead>
<tr>
<th>Manual version</th>
<th>FW version</th>
<th>HW version</th>
<th>Notes</th>
<th>Date</th>
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<tbody>
<tr>
<td>1.0</td>
<td>2.8.0</td>
<td>2.0</td>
<td>• Initial version</td>
<td>November 2018</td>
</tr>
<tr>
<td>1.1</td>
<td>2.8.0</td>
<td>2.0</td>
<td>• Updated file name to new AppNote name structure. Updated important notes, legal notice &amp; license terms chapters.</td>
<td>June 2019</td>
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<tr>
<td>1.2</td>
<td>2.8.0</td>
<td>2.0</td>
<td>• Updated address of Division Wireless Connectivity &amp; Sensors location in Trier</td>
<td>October 2019</td>
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1 Introduction

Starting with firmware version 2.8.0 the Metis-II include a feature to enable receiving, buffering, delaying and forwarding radio frames better known as single-hop unidirectional repeater functionality.

<table>
<thead>
<tr>
<th>WE order code</th>
<th>Former order code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>260702118300x</td>
<td>AMB8626-M-TR</td>
<td>868 MHz wM-BUS module 14dBm, T&amp;R, Firmware 2.7.0</td>
</tr>
<tr>
<td>260702118300x</td>
<td>AMB8626-M-DEV</td>
<td>Development kit, 3 modules Metis-II, Firmware 2.7.0</td>
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<tr>
<td>260702118301x</td>
<td>AMB8626-M-RP-TR</td>
<td>868 MHz wM-BUS module 14dBm, T&amp;R, Firmware 2.8.0</td>
</tr>
<tr>
<td>260702118301x</td>
<td>AMB8626-M-RP-DEV</td>
<td>Development kit, 3 modules Metis-II with Firmware 2.8.0</td>
</tr>
</tbody>
</table>

Table 1: Metis-II Ordering information

The European Standard EN13757 and the OMS Group Specification give information on how a single-hop unidirectional repeater shall be implemented and what radio frames shall be supported by the repeater.

Our implementation will enable the repeater mode only on a very specific configuration set of the wM-Bus module as introduced later.

Using the repeater mode requires careful attention of the user regarding local regulatory requirements. Especially the duty cycle requirements need to be adhered to.

For example by realizing a suiting host implementation in the user’s end system that implements duty cycle restriction.

2 Motivation

By means of the repeater mode a module or USB stick can be utilized to enhance the effective radio range of wireless M-BUS meters within the repeater’s range. This will happen for frames that follow EN13757-3:2013 and EN13757-4:2013 as well as OMS Specification Volume 2 Generation 4 V4.1.2. In essence this applies to all wM-BUS frames that have a hop counter field at a location described in the standard and also have a C-Field of either SND-NR or SND-IR, which are only to be used in direction meter to other (uplink).

As the size of the hop counter field is limited to 1 bit it is not possible to provide multiple hops in a standard compliant way. Therefore the hop counter must be ‘0’ in the received frame and will be set to ‘1’ by the repeater to indicate that the message was repeated.

A frame already having the hop counter ‘1’ when being received by a repeater will be discarded.
To be able to find the hop counter inside a frame the repeater parses and checks parts of the radio frame upon reception. Currently the following frame structures and conditions are implemented in the firmware, listed in the order of priority they will be tested and applied:

- Frames that have an Extended Link Layer (ELL) as first Control Information Field (Ci-Field). This ELL has a Communication Control Field (CC-Field) which provides a Hop Count Subfield (H-Field). The first Ci-Field can be followed by one or multiple further Ci-Field(s).

- Frames that have exactly one Ci-Field in the entire frame, indicating either a "short data header" or a "long data header", with encryption modes in the Configuration Field being either 0 or 5 and the Configuration field providing a hop counter at a well-known location within the field.

Note: Encryption mode 0 is not described in the standard but from our experience with different manufacturers mode 0 is used by them with the same structure as mode 5. This means the Configuration Field Bit 0 is the Hop Counter Field.
3 Using the included wireless M-BUS repeater

The repeater mode runs in parallel to the normal module functions as sending and receiving frames without interfering the normal operations of the module or the reachability of the module via UART. To achieve this, the frames to be repeated are queued in a non-shared buffer so the normal shared buffer is not blocked by the repeater.

The repeater mode is enabled by setting the UserSetting (US) parameter `Repeater_Enable` at index 82 (0x52) from 0x00 (= disabled) to 0x01 (= enabled) via the `CMD_SET_REQ` as shown below in the example configuration in chapter 3.1.

But even though this enables the repeater mode of the module there are further configurations required for the activation to take effect.

Please refer to the wM-Bus module reference manual or the following example section on how to use `CMD_SET_REQ` and `CMD_GET_REQ` commands accordingly.

If any of the parameters or requirements are not fulfilled the unidirectional repeater functionality may cause critical malfunctions of the module.

The following table shows the UserSetting parameters to configure the module as a repeater:

<table>
<thead>
<tr>
<th>US Parameter</th>
<th>Required value</th>
<th>US Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART_CTL0</td>
<td>0x00</td>
<td>0x00</td>
</tr>
<tr>
<td>UART_CTL1</td>
<td>0x80</td>
<td>0x01</td>
</tr>
<tr>
<td>UART_BR0</td>
<td>0x34</td>
<td>0x02</td>
</tr>
<tr>
<td>UART_BR1</td>
<td>0x00</td>
<td>0x03</td>
</tr>
<tr>
<td>UART_MCTL</td>
<td>0x20</td>
<td>0x04</td>
</tr>
<tr>
<td>UART_CMD_Out_Enabled</td>
<td>0x01 (enabled)</td>
<td>0x05</td>
</tr>
<tr>
<td>APP_AES_Enable</td>
<td>0x00 (disabled)</td>
<td>0x0B</td>
</tr>
<tr>
<td>MBUS_B1_ADD_Disable</td>
<td>0x01 (disabled)</td>
<td>0x30</td>
</tr>
<tr>
<td>RF_AutoSleep</td>
<td>0x00 (disabled)</td>
<td>0x3F</td>
</tr>
<tr>
<td>Mode_Preselect</td>
<td>0x03 or 0x08 or 0x09 or 0x0E</td>
<td>0x46</td>
</tr>
<tr>
<td>Repeater_Enable</td>
<td>0x01 (enabled)</td>
<td>0x52</td>
</tr>
</tbody>
</table>

Table 2: UserSettings Requirements

An additional requirement is that no frame preloading shall be used when the repeater mode is enabled. If the preloading is or was used since the latest restart of the module the user is required to use the `CMD_DATA_CLR_PRELOAD_REQ` command (0xFF 31 00 CE) in order to clear
the preloaded frame from the queue.

Preloading is obsolete since firmware version 2.8.0 and shall not be used anymore.

The command `CMD_SET_MODE_REQ` shall never be used when the repeater mode is active. Doing so will disable the repeater function.
3.1 Configuration using CMD_SET_REQ

By using the following CMD_SET_REQ sequence followed by a CMD_RESET_REQ the settings to enable the repeater mode will be applied to the non-volatile memory of the module.

Because of the nature of the firmware design radio packets have the highest priority in the shared buffer. Please perform such setting sequences only in non radio polluted environments or by using the ACC PC Software.

You are encouraged to check the currently configured values by using CMD_GET_REQ before using a CMD_SET_REQ to avoid unnecessary flash erase/write cycles as this resource is limited by the hardware.

First check the firmware version of the module by executing CMD_GET_FWVERSION_REQ (0xFF 0C 00 F3). If the response indicates firmware version 2.8.0 (0x02 08 00) or higher you are good to proceed.

If you still have an old firmware version use ACC to update to the most recent firmware before proceeding.

**Revert to factory defaults**
CMD_FACTORYRESET_REQ: 0xFF 11 00 EE
All UserSettings are reverted to factory defaults.

**Restart module to apply factory defaults**
CMD_RESET_REQ: 0xFF 05 00 FA
The Factory defaults are loaded into RuntimeSettings, the UART is now using 9600 baud 8n1.

Please adjust the UART baudrate of your host to 9600 baud after the reset to be able to still communicate with the module.

Set the UART speed to 115200 baud 8n1
CMD_SETUARTSPEED_REQ: 0xFF 10 00 07 E9
All UART speed related UserSettings are updated by this command accordingly.
Factory default: 9600 baud 8n1

**Revert to factory defaults**
CMD_RESET_REQ: 0xFF 05 00 FA
The UART baudrate is now using 115200 baud 8n1.

Please adjust the UART baudrate of your host to 115200 baud after the reset to be able to still communicate with the module.
Set the Mode_Preselect to either S2 or C2_T2_Other
For using S2 mode a reconfiguration is not required.
For C2_T2_Other mode use CMD_SET_REQ: 0xFF 09 03 46 01 09 BB
Factory default: S2 mode

Enable Command Output mode
CMD_SET_REQ: 0xFF 09 03 05 01 01 F0
Factory default: disabled

Your host needs to implement the Command Interface as specified in the wM-BUS manual plus the additional command CMD_RP_DATA_IND defined in chapter 4 in this document.

Enable repeater mode
CMD_SET_REQ: 0xFF 09 03 52 01 01 A7
Factory default: disabled

Reset module
CMD_RESET_REQ: 0xFF 05 00 FA
This will reset the module and activate the settings done above.
3.2 Supported wireless M-BUS modes for the repeater

The single-hop unidirectional repeater requires to receive radio frames. For example all wM-BUS modes containing a "1" are send-only modes and can therefore not be used when the repeater mode shall be enabled. Thus we limited the wM-BUS modes to the following set to provide the functionality of the repeater mode.

- S2 mode, Mode_Preselect value 0x03
- T2-Other mode, Mode_Preselect value 0x08
- C2-T2-Other mode, Mode_Preselect value 0x09
- C2-Other mode, Mode_Preselect value 0x0E

By using these modes the repeater receives as if it would be a data collector or Smart Meter Gateway and repeats the frames as if it would be a meter, so that the repeated frames (with hop counter changed to '1') can be received by other data collectors and Smart Meter Gateways.

3.3 Energy consumption

By its very nature the repeater has the radio receive mode activated permanently when not sending a frame. In regard to a battery operated device this means that the battery will be drained quite fast. The typical RX current is around 30 mA and the typical TX current is around 53 mA.

Therefore the recommendation for a repeater is to be used in mains-powered devices and products only.
4 CMD_RP_DATA_IND

This UART frame will indicate towards the host that a frame was successfully repeated.

4.1 Example 1

The indication will share further parameters that can be used by the host system to trace the utilization of the buffers as well as to trace the duty cycle used by the repeater mode. The 1 byte buffer ID is an unsigned buffer index number indicating which internal buffer of the module the repeated frame was using. The 2 byte parameter duration states the TX duration in milliseconds of the repeated frame which successful transmission is indicated by this indication message. The module calculates this value dependent on the wireless M-BUS mode, radio frame length and frame format used to repeat this frame. CS is as usual in the command mode the XOR concatenation of all preceding bytes starting with the start signal 0xFF.

<table>
<thead>
<tr>
<th>start signal</th>
<th>command</th>
<th>length</th>
<th>buffer ID</th>
<th>duration</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xFF</td>
<td>0x07</td>
<td>0x03</td>
<td>&lt;buf ID&gt;</td>
<td>&lt;LSB, MSB&gt;</td>
<td>&lt;cs&gt;</td>
</tr>
</tbody>
</table>

start = signal
command
length
buffer ID
duration
CS

0xFF
0x07
0x03
<buf ID>
<LSB, MSB>
<cs>
5 Duty cycle requirements

Citation from ETSI EN 300 220-1 V3.1.1 (Feb 2017) chapter 5.4.1, which is required to conform to the RED and CE, at the time this Application Note was written:

*Duty cycle is the ratio expressed as a percentage, of the cumulative duration of transmissions $T_{on\_cum}$ within an observation interval $T_{obs}$.*

$$DC = \left( \frac{T_{on\_cum}}{T_{obs}} \right) \frac{1}{F_{obs}}$$

*Unless otherwise specified, $T_{obs}$ is 1 hour and the observation bandwidth $F_{obs}$ is the operational frequency band. Each transmission consists of an RF emission, or sequence of RF emissions separated by intervals $< T_{Dis}$. The manufacturer of the end product has sole and ultimate responsibility for the conformity of the end product to the applicable directives, whether he designed and manufactured the product himself or is considered as a manufacturer because the product is placed on the market "under his name".*

The following table shows the duty cycle for the frequency bands supported by our 868 MHz wireless M-BUS modules. The wireless M-BUS standard does specify the channel access to be random. But it does not not specify to implement any channel access methods and due to timing parameters this would cause a EN13757 compliance problems. Thus polite spectrum accesss (PSA) of the RED cannot be applied to increase the duty cycle. For the repeater functionality only the role "meter to other" is used for TX operations.

<table>
<thead>
<tr>
<th>wM-BUS mode</th>
<th>wM-BUS role</th>
<th>Frequency</th>
<th>Duty cycle</th>
<th>Time per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>meter to other</td>
<td>868.300 MHz</td>
<td>1 %</td>
<td>36s</td>
</tr>
<tr>
<td>S</td>
<td>other to meter</td>
<td>868.300MHz</td>
<td>1 %</td>
<td>36s</td>
</tr>
<tr>
<td>T</td>
<td>meter to other</td>
<td>869.950 MHz</td>
<td>0.1 %</td>
<td>3.6s</td>
</tr>
<tr>
<td>T</td>
<td>other to meter</td>
<td>868.300 MHz</td>
<td>1 %</td>
<td>36s</td>
</tr>
<tr>
<td>C</td>
<td>meter to other</td>
<td>869.950 MHz</td>
<td>0.1 %</td>
<td>3.6s</td>
</tr>
<tr>
<td>C</td>
<td>other to meter</td>
<td>869.525 MHz</td>
<td>10 %</td>
<td>360s</td>
</tr>
</tbody>
</table>

Table 3: Duty cycle as required by ETSI EN 300 200-2 V3.1.1 for all wM-BUS modes in 868 MHz Bands
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6.2 Customer responsibility related to specific, in particular safety-relevant applications

It has to be clearly pointed out that the possibility of a malfunction of electronic components or failure before the end of the usual lifetime cannot be completely eliminated in the current state of the art, even if the products are operated within the range of the specifications. The same statement is valid for all software sourcecode and firmware parts contained in or used with or for products in the wireless connectivity and sensor product range of Würth Elektronik eiSos GmbH & Co. KG. In certain customer applications requiring a high level of safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health, it must be ensured by most advanced technological aid of suitable design of the customer application that no injury or damage is caused to third parties in the event of malfunction or failure of an electronic component.

6.3 Best care and attention

Any product-specific data sheets, manuals, application notes, PCN’s, warnings and cautions must be strictly observed in the most recent versions and matching to the products firmware revisions. This documents can be downloaded from the product specific sections on the wireless connectivity homepage.

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7 Legal notice

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The incorporated Firmware created by Würth Elektronik eiSos is and will remain the exclusive property of Würth Elektronik eiSos.

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You have the opportunity to request the current and actual Firmware for a bought wireless connectivity Product within the time of warranty. However, Würth Elektronik eiSos has no obligation to update a modules firmware in their production facilities, but can offer this as a service on request. The upload of firmware updates falls within your responsibility, e.g. via ACC or another software for firmware updates. Firmware updates will not be communicated automatically. It is within your responsibility to check the current version of a firmware in the latest version of the product manual on our website. The revision table in the product manual provides all necessary information about firmware updates. There is no right to be provided with binary files, so called "Firmware images", those could be flashed through JTAG, SWD, Spi-Bi-Wire, SPI or similar interfaces.

8.5 Disclaimer of warranty

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8.9 Miscellaneous

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