Telit Wireless M-Bus 2013 Part 4 User Guide

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Making machines talk.

APPLICABILITY TABLE

PRODUCT
ME50-868
ME50-169
ME70-169

SW Version
GC.U03.01.05
GI.U03.01.05
GL.U03.01.09

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Contents

1. Introduction

1.1. Scope

Scope of this document is to present the features and the application of the Wireless M-Bus EN 13757-4:2013 embedded stack available on ME50-868, ME50-169 and ME70-169.

1.2. Audience

This document is intended for software developers and system integrators using MEx0 modules with Wireless M-Bus EN 13757-4:2013 firmware.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-SRD@telit.com
TS-NORTHAMERICA@telit.com
TS-LATINAMERICA@telit.com
TS-APAC@telit.com

Alternatively, use:

http://www.telit.com/en/products/technical-support-center/contact.php

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

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Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4. Document Organization

This document contains the following chapters:

"Chapter 1: "Introduction" provides a scope for this document, target audience, contact and support information, and text conventions.

"Chapter 2: "Wireless M-Bus Overview" gives an overview of the Wireless M-Bus protocol.

"Chapter 3: "Software Operation" describes the operation of the Wireless M-Bus EN 13757-4:2013 firmware and how it interfaces with an external host.

"Chapter 4: "Power Consumption" provides information on the module power consumption in different operating conditions.

1.5. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

1.6. Related Documents

- EN 300 220-2 v2.4.1
- ERC Recommendation 70-03
- IEC 60870-5-2
- EN 13757-3:2012
- EN 13757-4:2013
- Open Metering System Specification – Primary Communication – Issue 2.0.0
- Dutch Smart Meter Requirements v4.0 – P2 Companion Standard
- Telit xE50-433/868 RF Module User Guide, 1VV0300905
- Telit ME50-169 RF Module User Guide, 1VV0300981
- Telit ME70-169 RF Module User Guide, 1VV0301021
- CIG Interchangeability Task Force TS 11291-11-4 & TS 11291-11-7

2. Wireless M-Bus Overview

2.1. Definition of Wireless M-Bus

M-Bus (Meter-Bus) is a European Standard for remote reading of gas, water or electricity meters. M-Bus is also usable for other types of consumption meters. The M-Bus interface is made for communication on two wires, making it very cost effective.

This protocol exists with several physical layers such as paired wires, optical fiber or radio link.

The radio variant of M-Bus is called Wireless M-Bus and is specified in EN 13757-4. It is dedicated to the European ISM frequency bands at 169, 433 and 868 MHz.

It means that modules embedding the Wireless M-bus stack must comply with the general SRD standard EN 300 220.

2.2. Wireless M-Bus Presentation

Devices communicating with Wireless M-Bus technology are classified as either meters or ‘other’ devices: the role of meters is to transmit utility consumption data, while ‘other’ devices (also referred to as concentrators) are in charge of collecting those data and can optionally send commands to meters.

The Wireless M Bus specification EN 13757-4:2013 defines six different ways to exchange data with remote meters:

- Mode S ‘Stationary’
- Mode T ‘frequent Transmit’
- Mode R2 ‘frequent Receive’
- Mode C ‘Compact’
- Mode N ‘Narrowband VHF’
- Mode F ‘Frequent receive and transmit’

ME50-868 with the firmware described in this document supports all the modes designed for the 868 MHz frequency band, namely modes S, T, R2 and C, while ME50-169 and ME70-169 support mode N at 169 MHz.

2.2.1. Mode T

In mode T, the meter sends spontaneously data, either periodically or stochastically. Frame transmission from meters to other devices uses a bit rate of 100 kbps, while communication in the opposite direction is carried out at 32.768 kbps.

- In Mode T1 the meter doesn’t care if any receiver is present or not. The meter sends data and returns immediately in power-save mode without waiting for a response. This is a unidirectional communication.

- In Mode T2 the meter sends its data and stays awake during a short time immediately after transmission to listen to a possible response frame. If no response is received, the meter returns in power-save mode. If a response is received, then a bidirectional communication link is opened between meter and concentrator.

2.2.2. Mode R2

In Mode R2 the meter doesn't send spontaneously data. The meter wakes up periodically in Rx mode and waits for a wakeup frame received from concentrator. If no frame is received, the meter returns in power-save mode. If a valid wakeup frame is received, a bidirectional link is then opened between meter and concentrator. The bit rate used in this mode is 4.8 kbps.

2.2.3. Mode S

The bit rate for radio communication is 32.768 kbps. The following two sub-modes are defined:

- Mode S1 operates exactly as Mode T1 (unidirectional spontaneous transmission) but uses a different radio link.
- Mode S2 is similar to Mode T2 (meter sends a frame and waits for a response during a short interval) but also with a different physical link.

2.2.4. Mode C

This mode is similar to mode T but uses a different encoding scheme (NRZ); communication from meters to other devices is at 100 kbps, while in the opposite direction a 50 kbps bit rate is used. Two sub-modes are defined, C1 for unidirectional communication from meters to other devices and C2 for bidirectional communication.

2.2.5. Mode N

It uses narrowband communication in the 169 MHz frequency band; the two sub-modes N1 and N2 are for unidirectional and bidirectional communication, respectively. The standard Wireless M-Bus defines different channels, with different bit rates and modulation types, as listed below:

- Channel 1a: 4.8 kbps, GFSK modulation
- Channel 1b: 4.8 kbps, GFSK modulation
- Channel 2a: 2.4 kbps, GFSK modulation
- Channel 2b: 2.4 kbps, GFSK modulation
- Channel 3a: 4.8 kbps, GFSK modulation
- Channel 3b: 4.8 kbps, GFSK modulation
- Channel 0: 19.2 kbps, 4-GFSK modulation

Additionally, the CIG interchangeable Task Force defines that channels 2a and 2b can be accessed at 2.4 kbps or 4.8 kbps.

2.2.6. Mode F

It is a bidirectional mode operating at 2.4 kbps in the 433 MHz frequency band; communication can be initiated by either the meter (similar to Mode T2) or the concentrator (using a wakeup frame as is done in Mode R2).

2.3. Data Format on RF Link

EN 13757-4:2013 defines two different packet formats, namely format A and B. Multi-byte fields described in the following subsections are transmitted least significant byte first, except the CRC fields, which are transmitted most significant byte first.

2.3.1. Frame Format A

This format can be used in any of the Wireless M-Bus modes listed in Section 2.2. Radio frames with this format are composed of a number of blocks, as illustrated in the figure below.

Preamble	Block 1	Block 2	Block n	Postamble

The preamble is used for synchronization between transmitter and receiver; the EN 13757-4 specification imposes a minimum limit for preamble length, which depends on the mode used:

- Mode S: 6 bytes if short preamble is used, otherwise 72 bytes (long preamble); refer to Section 3.2 for information on how to select short or long preamble
- Mode T: 6 bytes
- Mode R2: 12 bytes
- Mode C: 8 bytes
- Mode N: preamble length is configurable (value required by EN 13757-4 is 2 bytes)
- Mode F: 12 bytes

MEx0 modules always use the minimum required preamble length when transmitting frames.

Block 1 format:

L-field	C-field	M-field	A-field	CRC-field
1 byte	1 byte	2 bytes	6 bytes	2 bytes

Block 2 format:

CI-field	Data-field	CRC-field
1 byte	15 bytes or (((L – 9) mod 16) – 1) bytes	2 bytes

Block n format:

Data-field	CRC-field
16 bytes or ((L – 9) mod 16) bytes	2 bytes

Block 2 and Block n are optional. A frame can have multiple blocks with the format of Block n; their number depends on the length of the data field. The postamble is a short bit sequence added at the end of frames in modes S, T and R2.

2.3.2. Frame Format B

This format can optionally be used in Modes C, N and F; frames with this format are composed of the following blocks:

Preamble	Block 1	Block 2	Block 3

The preamble is needed for synchronization between transmitter and receiver; its length is 8 bytes for Mode C, 4 or 8 bytes for Mode N (depending on the modulation) and 12 bytes for Mode F.

Block 1 format:

L-field	C-field	M-field	A-field	CRC-field
1 byte	1 byte	2 bytes	6 bytes	2 bytes

Block 2 format:

CI-field	Data-field	CRC-field
1 byte	115 bytes or (L – 12) bytes	2 bytes

Block 3 format:

Data-field	CRC-field
(L – 129) bytes	2 bytes

Block 2 and Block 3 are optional. Block 3 is present only if the length of the data field is bigger than the number of bytes allowed in Block 2. The CRC field of Block 2 is calculated on the concatenation of Block 1 and Block 2 data.

2.3.3. Field Definitions

Frame fields referred to in Sections 2.3.1 and 2.3.2 are defined as follows:

- **L-field** is the length indication: the difference between frame format A and B is that in the former case this field does not include the length of CRC-fields, while in format B frames it includes the length of CRC-fields

- **C-field** is the communication indication (request, send, response expected, ACK…)
- **M-field** is the Manufacturer ID of the sending device
- **A-field** is the address of the sending device and is composed of the concatenation of an identification number (4 bytes), a version code (1 byte) and a device type code (1 byte)
- **CI-field** is the Control Information to indicate the protocol used to the upper layer
- **CRC-field** is the Cyclic Redundancy Check

Wireless M-Bus uses an unbalanced transmission as described in IEC 60870-5-2; the format of the C-field (or control field) is described below:

RES	**PRM**	**FCB** / **ACD**	**FCV** / **DFC**	**Function**			
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

The meaning of bits 5 and 4 depends on the value of bit 6 (**PRM**): when **PRM** is set to 1, bits 5 and 4 are interpreted as **FCB** and **FCV** fields respectively, otherwise the same bits carry **ACD** and **DFC** fields.

- **RES** is a reserved bit and should be set to 0
- **PRM** indicates if the frame is being sent from a primary to a secondary station (when set to 1) or vice versa (when set to 0); the role of meters and concentrators as primary or secondary stations is defined by the application
- **FCB** (Frame Count Bit) is used to detect frame duplication: its value should alternate between 0 and 1 for successive frames sent from a primary station to the same secondary station; in order to set a common starting value of this bit for a given pair of stations, a link reset frame is defined (function code 0) which indicates to the receiving secondary station that the next frame from the primary station will have **FCB** set to 1
- **FCV** (Frame Count Valid) in frames sent from a primary station indicates whether the duplication detection mechanism of the frame count bit is used (when set to 1) or not (when set to 0)
- **ACD** (ACcess Demand), if set to 1, indicates that the sending secondary station has high priority data available, which should be requested by the primary station
- **DFC** (Data Flow Control), if set to 1, indicates that the sending secondary station may not be able to process further frames sent by the primary station; it can be used as a flow control mechanism to prevent data overflow at the secondary station
- **Function** is a numeric code indicating the type of frame being sent; its meaning depends on the direction of communication (primary to secondary or vice versa)

2.3.4. Extended Link Layer

When the CI-field assumes the values 0x8C, 0x8D, 0x8E or 0x8F, the first bytes of the Data-field contain an extended link layer, which is followed by another CI-field and then the application data.

The format of the extended link layer depends on the CI-field value. When the CI-field is set to 0x8C, the format is as illustrated below:

CC	ACC
1 byte	1 byte

When the CI-field is set to 0x8D, the format is as follows:

CC	ACC	SN	PayloadCRC
1 byte	1 byte	4 bytes	2 bytes

With the CI-field set to 0x8E, the extended link layer has the following fields:

CC	ACC	M2	A2
1 byte	1 byte	2 bytes	6 bytes

Finally, with a CI-field value of 0x8F, the format is as illustrated below:

CC	ACC	M2	A2	SN	PayloadCRC
1 byte	1 byte	2 bytes	6 bytes	4 bytes	2 bytes

In the above formats, **CC** is a communication control field and is coded using the following bitmask:

B-field	D-field	S-field	H-field	P-field	A-field	R-field	Reserved
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

- **B-field**, when set to 1, indicates that the sending device implements bidirectional communication
- **D-field** controls the response delay of the responding device, indicating whether a fast (D-field set) or slow (D-field cleared) response delay should be used
- **S-field**, when set to 1, indicates a synchronized frame
- **H-field**, when set to 1, indicates that the frame has been relayed by a repeater
- **P-field**, when set to 1, indicates a high priority frame
- **A-field** (Accessibility) is used in conjunction with the B-field to specify when a meter enables radio reception after a frame transmission

- **R-field** (Repeated Access) is used by single hop repeaters according to the rules in the EN 13757-5 specification

ACC is the access number and is used to detect duplicate frames and to associate request and response frames.

SN (Session Number) is a 4 byte field (transmitted least significant byte first) with the following content:

ENC-field	Time-field	Session-field
Bits 31 – 29	Bits 28 – 4	Bits 3 - 0

- **ENC-field** specifies the encryption method, with the value 0 meaning no encryption and the value 1 meaning AES-128 Counter Mode encryption; other values are reserved for future use. If AES-128 Counter Mode is used, the remaining bytes of the frame, from and including the PayloadCRC field (but excluding the CRC fields), will be encrypted.
- **Time-field** is a relative minute counter and is used together with the Session-field to ensure that the encrypted transmission is protected from replay attacks
- **Session-field** is a zero-based index of the communication session within the minute specified by the Time-field

PayloadCRC is a cyclic redundancy check covering the remainder of the frame (excluding the CRC fields).

M2 and **A2** are used with CI-field values 0x8E and 0x8F, typically for transmissions from a concentrator to a meter device, and indicate the Manufacturer Id and address of the destination node of the frame. The format of the **M2** and **A2** fields is the same as that of the **M-field** and the **A-field**, respectively.

2.3.5. Data Header

If the application layer defined by EN 13757-3 is used, depending on the value of the CI-field, the first bytes of the Data-field may contain a data header as specified in this section. Two types of data header (short and long) are defined. The short data header is present when the CI-field assumes one of the following values: 0x5A, 0x61, 0x65, 0x6A, 0x6E, 0x74, 0x7A, 0x7B, 0x7D, 0x7F and 0x8A; it is formatted as illustrated below:

ACC	STS	Conf
1 byte	1 byte	2 bytes

The long data header is present when the CI-field has one of the values 0x5B, 0x60, 0x64, 0x6B, 0x6C, 0x6D, 0x6F, 0x72, 0x73, 0x75, 0x7C, 0x7E, 0x80, 0x84, 0x85 and 0x8B; it is formatted as follows:

Identification Number	Manufacturer ID	Version	Device Type	ACC	STS	Conf

4 bytes	2 bytes	1 bytes	1 byte	1 byte	1 byte	2 bytes

Identification Number is a unique device identifier coded as 8 BCD digits.

Manufacturer ID is the identifier of the device manufacturer.

Version specifies the version number of the device.

Device Type specifies the functionality of the device (for example, electricity meter).

The set of **Identification Number**, **Manufacturer ID**, **Version** and **Device Type** fields identify the Application Layer Address, which is used as described later in this section.

ACC is the access number and is used to detect duplicate frames and to associate request and response frames.

STS is the status byte and its meaning depends on whether the frame is sent by a meter or a concentrator.

Conf is the configuration word, whose primary purpose is to specify the encryption method used to encrypt the frame.

Two encryption algorithms are defined in EN 13757-3:2012, namely DES and AES-128; for both algorithms, Cipher Block Chaining (CBC) is used as mode of operation. Four different encryption methods are identified by codes 2, 3, 4 and 5. Methods 2 and 3 use DES encryption, while methods 4 and 5 use AES-128. Method 3 needs the long data header to initialize the CBC algorithm, therefore it can be used only together with this header type; the other methods can be used with either the short or long data header.

The P2 Companion Standard of Dutch Smart Meter Requirements defines an additional encryption method (with code 15), which uses AES-128 with CBC. This method differs from those defined in EN 13757-3 in that it requires a 32-bit frame counter to initialize the CBC algorithm. The frame counter is transmitted unencrypted with least significant byte first, is preceded by the fixed 3-byte header [0x04, 0xFD, 0x08] and is inserted at the end of the encrypted frame.

The configuration word of the data header contains the length of encrypted content (in the first byte) and the encryption method code (in the 4 least significant bits of the second byte). Since encryption and decryption can only be performed in blocks, the number of encrypted bytes is a multiple of the block size (8 for DES and 16 for AES-128). Therefore, the 3 or 4 least significant bits of the first byte of the configuration word do not enter in the count of encrypted bytes, and can be used for other purposes.

The link layer header of Wireless M-Bus frames carries the manufacturer ID and address of the sending device in the M-field and A-field, respectively, as described in Section 2.3.3; the set of these two fields is referred to as Link Layer Address (LLA). In frames sent from concentrators, additional fields are needed to identify the receiving meter; for this purpose, the Application Layer Address (ALA) is used, as defined above in the long data header. Please note that LLA and ALA differ in the relative position of their sub-fields: in the LLA the manufacturer ID is the first sub-field, while in the ALA the manufacturer ID is inserted between the identification number and the version code.

3. Software Operation

The module can operate in two different modes:

- The configuration mode which allows to parameter the module. It is set through the use of Hayes commands sent on the serial link.
- The operating mode which is the functional mode for data transmission.

3.1. Configuration Mode

Hayes or 'AT' commands comply with Hayes protocol used in PSTN modem standards. This 'AT' protocol or Hayes mode is used to configure the modem parameters, based on the following principles:

- A data frame always begins with the two ASCII 'AT' characters, standing for 'ATtention'
- Commands are coded over one or several characters and may include additional data
- A given command always ends with a <CR> Carriage Return

A	T	Command	Additional data	<CR>

The only exception to this data-framing rule is the switching command from the operating/communication mode to 'AT Mode'. In this case only, the escape code ('+++') must be started and followed by a silent time at least equal to the serial time out, and <AT> and <CR> shall not be used.

Commands are parsed by the module only after <CR> is sent, except for the escape sequence '+++' which is acted upon when the serial timeout expires after the last character of the sequence.

Below is the complete list of the 'AT' commands available on the module.

Command	Description
+++	'+++' command gives an instant access to the modem's parameters configuration mode (Hayes or AT mode), whatever the current operating mode might be. '+++' command should be entered as one string, i.e. it should not be preceded by 'AT' and followed by <CR> but two silent times whose duration is configurable via register 431 (Serial time-out). The time between two '+' characters must not exceed the time-out value. Hayes mode inactivates radio functions. Answer : OK
ATO	'ATO' command gives an instant access to the modem's operating mode, configured in register 400. 'ATO' command is used to get out of Hayes mode. Answer : OK
AT/V	'AT/V' command displays the modem's firmware and bootloader version number as follows:

	pp.UP3.MM.mm-Bbbb<CR>pp.B00.NN.nn With: pp indicating the hardware platform (GC for ME50-868, GI for ME50-169, GL for ME70-169) UP3: U means M-Bus stack, P=0 for OEM boards, P=1 for USB dongle MM: major version number of firmware mm: minor version number of firmware Bbbb: build number of firmware NN: major version number of bootloader nn: minor version number of bootloader Example: GC.U03.01.02-B011<CR>GC.B00.01.10 indicates an EN 13757-4:2013 stack V1.02 (Build 011) for a ME0-868 module in an OEM board, plus a bootloader V1.10
ATSn?	'ATSn?' command displays the content of Hayes register number n (refer to the register description table). Answer : Sn=x or ERROR if syntax problem or invalid register
ATSn=m	'ATSn=m' command configures Hayes register number n with the value m, e.g. ATS400=4<CR> enters the value '4' in the register 400. Answer : OK or ERROR
ATR	'ATR' command resets all modem's parameters to their default values. This command also resets the registered meters list. Answer : OK
ATM	'ATM' command resets the registered meters list. Answer : OK
ATBL	'ATBL' command exits from the main program and runs the bootloader. This command is useful to update the firmware by serial or radio link. Answer : OK
ATDT=MMDDhhmmYYss	Set current date and time. • MM is the month number, from 1 to 12 • DD is the day number, from 1 to 31 • hh is the current hour, from 0 to 23 • mm is the current minute, from 0 to 59 • YY is the current year, from 5 to 99 (corresponding to years from 2005 to 2099) • ss is the current second, from 0 to 59 Answer: OK if command format is correct, ERROR otherwise
ATDT?	Get current date and time. Answer: MMDDhhmmYYss, where: • MM is the month number, from 1 to 12 • DD is the day number, from 1 to 31 • hh is the current hour, from 0 to 23 • mm is the current minute, from 0 to 59 • YY is the current year, from 5 to 99 (corresponding to years from 2005 to 2099) • ss is the current second, from 0 to 59

Specific ‘AT’ commands have been integrated in order to make measurements and tests.

ATT	Continuous modulated carrier, simulating transmission of ‘01’ data (or ‘0111’ data if 4GFSK modulation is used in Mode N). Answer : OK This command is stopped by sending a character on the serial link Answer: No answer when exiting ATT.
ATT0	Pure carrier transmission at center frequency Answer : OK This command is stopped by sending a character on the serial link Answer: No answer when exiting ATT0 This command is only available for ME50-169 and ME70-169.
ATT1	Continuous modulated carrier, simulating transmission of ‘01110010’ data if 4GFSK modulation is used in Mode N. Other modulations simulate transmission of ‘01’ data. Answer : OK This command is stopped by sending a character on the serial link Answer: No answer when exiting ATT1 This command is only available for ME50-169 and ME70-169.
ATT2	This command works just the same as the ATT command. This command is only available for ME50-169 and ME70-169.
ATT3	Continuous modulated carrier, simulating transmission of random data. Answer : OK This command is stopped by sending a character on the serial link Answer: No answer when exiting ATT3 This command is only available for ME50-169 and ME70-169.

After an AT command (ended by <CR>), the serial link gives back result code, “OK” or “ERROR”; the response string contains <CR> as trailing character.

“+++” command gives back “OK”.

3.2. Register List

Numbers in **bold** indicate the default value

<table>
<tr><th>Access</th><th>Register</th><th>Name</th><th>Description</th></tr>
<tr><td>R</td><td>192</td><td>Serial Number</td><td>Serial number of the module, the one present on the sticker. Read-only register.
Ex: GCAJ4400001<CR></td></tr>
<tr><td>R/W</td><td>400</td><td>M-Bus Mode</td><td>Indicates the M-Bus mode on which the module works.
Valid values for ME50-868:
’0’: Mode S1-meter (default)
‘1’: Mode S1-other
‘2’: Mode S2-meter
‘3’: Mode S2-other
‘4’: Mode T1-meter
‘5’: Mode T1-other
‘6’: Mode T2-meter
‘7’: Mode T2-other
‘8’: Mode R2-meter
‘9’: Mode R2-other
‘10’: Mode C1-meter
‘11’: Mode C1-other
‘12’: Mode C2-meter
‘13’: Mode C2-other
‘15’: Mode T1/C1-other
Note: to activate Mode S1-m, select S1 in this register and then act on preamble length in register 421.
Mode T1/C1-other allows receiving simultaneously frames from T1 and C1 meters.
Valid values for ME50-169 and ME70-169:
’14’: Mode N1-meter (default)
‘15’: Mode N1-other
‘16’: Mode N2-meter
‘17’: Mode N2-other</td></tr>
<tr><td>R/W</td><td>401</td><td>Serial Rx Format</td><td>Indicates the serial format options for serial frames sent from user to RF module
<table><tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr><tr><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>CI-field</td><td>A-field</td><td>M-field</td><td>C-field</td><td>Length</td></tr></table>Default value : 0
Bit 0: indicates if Length field is activated (1) or not (0)
Bit 1: indicates if C-field is activated (1) or not (0)
Bit 2: indicates if M-field is activated (1) or not (0)
Bit 3: indicates if A-field is activated (1) or not (0)
Bit 4: indicates if CI-field is activated (1) or not (0)</td></tr>
</table>

<table>
<tr><td rowspan="2">R/W</td><td rowspan="2">402</td><td>Serial Tx Format</td><td>Indicates the serial format options for serial frames sent from RF module to user</td></tr>
<tr><td colspan="2">
<table>
<tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>RSSI</td><td>Wakeup character</td><td>LQI</td><td>CI-field</td><td>A-field</td><td>M-field</td><td>C-field</td><td>Length</td></tr>
</table>
Default value : 0

• Bit 0: indicates if Length field is activated (1) or not (0)
• Bit 1: indicates if C-field is activated (1) or not (0)
• Bit 2: indicates if M-field is activated (1) or not (0)
• Bit 3: indicates if A-field is activated (1) or not (0)
• Bit 4: indicates if CI-field is activated (1) or not (0)
• Bit 5: indicates if LQI field is activated (1) or not (0)
• Bit 6: indicates if Wakeup character is activated (1) or not (0)
• Bit 7: indicates if RSSI field is activated (1) or not (0)
</td></tr>
<tr><td rowspan="2">R/W</td><td rowspan="2">403</td><td>TX/RX Pin</td><td>Indicates the TX and RX pins.
TX pin is an output signal set to VCC during radio transmission. The signal returns to GND as soon as the transmission is finished.
RX pin is an output signal set to VCC as soon as a radio frame is detected with correct preamble/sync word. The signal returns to GND as soon as the frame reception is finished.
This register is only available for ME70-169.</td></tr>
<tr><td colspan="2">
<table>
<tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>Reserved (Write 0)</td><td colspan="3">TX Pin</td><td>Reserved (Write 0)</td><td colspan="3">RX Pin</td></tr>
</table>
Default value : 0

Valid values for TX Pin and RX Pin:
• ’0’: J1 – Radio Status (default)
• ‘1’: J3
• ‘2’: J4
• ‘3’: J5
• ‘4’: J6
• ‘5’: J7
• ‘6’: J8
• ‘7’: J9
</td></tr>
</table>

R/W	404	Estimated Frequency Offset	Enables or disables the indication of the estimated frequency offset when a frame is received from radio. Valid values: 0 (disable), 1 (enable) **Default: 0** **This register is only available for ME70-169.**
R/W	405	Remote AT Commands	Enables or disables the remote AT commands Valid values: 0 (disable), 1 (enable) **Default: 0** **This register is only available for ME70-169 and ME50-868.**
R/W	410	C Field	Indicates the C-field value when not activated on serial format (Bit 1 of register 401). From 0 to 255. **Default : 68**
R/W	411	M Field Byte0	Indicates the M-field value (Byte 0) when not activated on serial format (Bit 2 of register 401). From 0 to 255. **Default : 174**
R/W	412	M Field Byte1	Indicates the M-field value (Byte 1) when not activated on serial format (Bit 2 of register 401). From 0 to 255. **Default : 12**
R/W	413	A Field Byte0	Indicates the A-field value (Byte 0) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 120**
R/W	414	A Field Byte1	Indicates the A-field value (Byte 1) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 86**
R/W	415	A Field Byte2	Indicates the A-field value (Byte 2) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 52**
R/W	416	A Field Byte3	Indicates the A-field value (Byte 3) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 18**
R/W	417	A Field Byte4	Indicates the A-field value (Byte 4) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 1**
R/W	418	A Field Byte5	Indicates the A-field value (Byte 5) when not activated on serial format (Bit 3 of register 401). From 0 to 255. **Default : 7**
R/W	419	CI Field	Indicates the CI-field value when not activated on serial format (Bit 4 of register 401). From 0 to 255. **Default : 120**

R/W	420	Radio Channel	Indicates the radio channel (for R2 and N modes only). Valid values for R2 mode: from 0 to 9 Valid values for N mode when multichannel is disabled: from 0 to 8, corresponding to the channels listed below: • **'0': 1a @ 4800 bps (default)** • '1': 1b @ 4800 bps • '2': 2a @ 2400 bps • '3': 2b @ 2400 bps • '4': 3a @ 4800 bps • '5': 3b @ 4800 bps • '6': 0 @ 19200 bps • '7': 2a @ 4800 bps • '8': 2b @ 4800 bps **Default : 0**
R/W	421	Preamble Length	**ME50-868:** Indicates if the preamble of the radio frame is short or long (for Mode S only): **'0': short preamble (default)** '1': long preamble Note: When using Mode S1, this register allows the module to work either in sub-mode S1-m (short preamble) or in normal Mode S1 (long preamble).
			ME70-169: Indicates the length of the preamble in bytes. Valid values: 1, 2, 3, 4, 5, 6, 7, 8, 12, 24, 30 **Default: 2**
R/W	422	Radio Output Power	Indicates the output power of the RF module: '0': 0 dBm (ME50), +21 dBm (ME70) '1': +5 dBm (ME50), +24 dBm (ME70) '2': +10 dBm (ME50), +27 dBm (ME70) '3': +14 dBm (ME50-868), +15.5 dBm (ME50-169), +30 dBm (ME70-169) '4': +18 dBm (ME70-169) '5': +15 dBm (ME70-169) '6': +12 dBm (ME70-169) **For ME50-868 and ME50-169, default value is '3', For ME70-169, the default value is '2'; changes in this register are also reflected in the register 425.**
R/W	423	Channel Plan	8 bits mask containing the list of channels that can be used for multichannel mode (for N mode only); • Bit 0: 1a @ 4800 bps • Bit 1: 1b @ 4800 bps • Bit 2: 2a @ 2400 bps • Bit 3: 2b @ 2400 bps • Bit 4: 3a @ 4800 bps • Bit 5: 3b @ 4800 bps • Bit 6: 2a @ 4800 bps • Bit 7: 2b @ 4800 bps Refer to Section 3.5.12 for details about multichannel mode. **Default: 0** **This register is only available for ME70-169.**

R	424	Current Channel	Indicates the current channel (useful when multichannel mode is enabled, for N mode only): • '0': 1a @ 4800 bps • '1': 1b @ 4800 bps • '2': 2a @ 2400 bps • '3': 2b @ 2400 bps • '4': 3a @ 4800 bps • '5': 3b @ 4800 bps • '6': 0 @ 19200 bps • '7': 2a @ 4800 bps • '8': 2b @ 4800 bps Refer to Section 3.5.12 for details about multichannel mode. **This register is only available for ME70-169.**
R/W	425	Radio Output Power dBm	Indicates the output power of the RF module expressed in dBm: Valid values: 12, 15, 18, 21, 24, 27, 30 (dBm) **Default: 27** **This register is only available for ME70-169; changes in this register are also reflected in the register 422.**
R/W	426	Set Frequency Offset	Indicates the offset compared to the nominal frequency, expressed in ppm, in order to change the central frequency in TX and RX. Valid values: from -128 to 127 (ppm) **Default: 0** **This register is only available for ME70-169.**
R/W	427	Preamble Word	Indicates the preamble byte configuration (for Mode N only): **'0': 0x55 (default)** '1': 0xAA **This register is only available for ME50-169 and ME70-169.**
R/W	428	Postamble Length	Indicates the length of the postamble in bytes. Valid values: from 0 to 10 **Default: 0** **This register is only available for ME70-169.**
R/W	429	TX Datarate for Mode T Meter to Other	Indicates the datarate in kbps for mode T1-meter and mode T2-meter. Valid values: from 90 to 110 (kbps) **Default: 103** **This register is only available for ME50-868**
R/W	430	Serial Speed	Indicates the speed on the serial link : • '1': 1200 bits/s • '2': 2400 bits/s • '3': 4800 bits/s • '4': 9600 bits/s • **'5': 19200 bits/s (default)** • '6': 38400 bits/s • '7': 57600 bits/s • '8': 115200 bits/s

<table>
<tr><td>R/W</td><td>431</td><td>Serial Time-Out</td><td>Indicates the value of the time-out on the serial link when Length field is not activated.
Between 2 and 100 milliseconds
Default : 5
The time out value must be compatible with the serial speed.
<table>
<tr><th>Min. timeout</th><th>Serial speed</th></tr>
<tr><td>17 ms</td><td>1200 bits/s</td></tr>
<tr><td>9 ms</td><td>2400 bits/s</td></tr>
<tr><td>5 ms</td><td>4800 bits/s</td></tr>
<tr><td>3 ms</td><td>9600 bits/s</td></tr>
<tr><td>2 ms</td><td>≥ 19200 bits/s</td></tr>
</table></td></tr>
<tr><td>R/W</td><td>432</td><td>CTS Management</td><td>Enables or disables the CTS management when a frame is received from radio.
Valid values: 0 (disable), 1 (enable)
Default: 0
This register is only available for ME70-169.</td></tr>
<tr><td>R/W</td><td>433</td><td>CTS Time-out</td><td>Indicates the value of the time-out in seconds when CTS Management is enabled. The frame received from radio will be sent on the serial link when CTS is asserted or when this time-out expires. When this register is set to 0, frame will send on the serial only when CTS is asserted.
Between 0 and 20 seconds.
Default: 5
This register is only available for ME70-169.</td></tr>
<tr><td>R/W</td><td>440</td><td>Wake-Up options</td><td>Indicates the different ways to wake-up the RF module.
<table>
<tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Timer</td><td>Serial</td><td>Low Power Enable</td></tr>
</table>
Default value : 0 (No stand-by)
• Bit 0: sets this bit to ‘1’ to activate low power
• Bit 1: activates wake-up on serial character
• Bit 2: activates wake-up on timer (only for ME50-868); the timer period is set in register 442
Note: if bit 0 is set while bits 1 and 2 are both reset to ‘0’, the only way to wake up the module is to use hardware wakeup pin J18. If one of bits 1 and 2 is set, bit 0 must also be set, otherwise an error response is returned.</td></tr>
<tr><td>R/W</td><td>441</td><td>Wakeup Time Out</td><td>Defines the duration between the end of an event (radio or serial exchange) and the return to stand-by. This is useful to keep the module awake after frame transmission when the module is configured as bidirectional meter. For unidirectional meters this register may be set to zero to save power.
Each time a new event happens, the timer is restarted with the specified value.
More details in Section 3.4.1.
Between 0 and 255 milliseconds.
Default : 0</td></tr>
</table>

R/W	442	Sleep Time	Defines sleep time in seconds between 2 wake-up events when wake-up timer option is activated in register 440. Between 0 and 255. 0 indicates a sleep duration of 500 milliseconds. Other values indicate directly the sleep duration in seconds. **Default : 1** **This register is only available for ME50-868.**
R/W	452	Rx Filter	8 bits mask indicating whether received radio frames are filtered based on their M-field and A-field. Enables/disables reception of multicast and broadcast frames (ME70-169). More details in Section 3.5.6. • Bit 0: enables Rx filter • Bit 1: enables multicast when Rx filter is enabled (only for ME70-169) • Bit 2: enables broadcast when Rx filter is enabled (only for ME70-169) • Bit 3-7: reserved **Default : 0**
R/W	453	Tx Options	8 bits mask containing options for Wireless M-Bus frame transmission. • Bit 0: reserved • Bit 1: enables Listen Before Talk • Bit 2: enables frame format B (only for Modes C and N) • Bit 3: enables automatic frame transmission • Bit 4: enables synchronized frame transmission • Bit 5: enables multi-frame operation • Bit 6: enables serial acknowledge • Bit 7: enables immediate tx serial frame (only for ME70-169 and ME50-868) Refer to Section 3.5 for details on transmission options. **Default: 0**
R/W	454	Repeater	Enables or disables repeater operation in Mode S or T. Refer to Section 3.5.11 for details on repeater functionality. Valid values: 0 (disable), 1 (enable) **Default: 0** **This register is only available for ME50-868.**

<table>
<tr><td rowspan="2">W</td><td rowspan="2">460</td><td>Registered Meter Options</td><td>Command options for registered meters (write-only register)</td></tr>
<tr><td colspan="2">
<table>
<tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Reserved (Write 0)</td><td>Automatic ACK</td><td>Automatic CNF-IR</td><td>Enable encryption</td><td>Do not filter</td><td>Add/remove meter</td></tr>
</table>

Bit 0: sets this bit to ‘1’ to add or edit a registered meter, set to ‘0’ to remove a registered meter
Bit 1: sets this bit to ‘1’ in concentrators to enable sending to the serial port frames received from the registered meter
Bit 2: activates encryption and decryption to frames exchanged with the registered meter
Bit 3: enables automatic generation of CNF-IR frames to registered meter (only for ME50-868, refer to Section 3.5.9 for more details)
Bit 4: enables automatic generation of ACK frames to registered meter (only for ME50-868, refer to Section 3.5.9 for more details)

</td></tr>
<tr><td>R/W</td><td>461-468</td><td>Meter Address</td><td>Contain the manufacturer ID (registers 461-462) and address (registers 463-468) of a registered meter. Both fields are stored least significant byte first.
Values from 0 to 255</td></tr>
<tr><td>R/W</td><td>470-485</td><td>Meter Key</td><td>Contain the encryption key for communication with a registered meter, stored most significant byte first. If DES is used, the key is 8 bytes long and is stored in the first 8 registers (470 to 477), while the remaining registers are unused; if AES-128 is used, the key is 16 bytes long and is stored in registers 470 to 485.
Values from 0 to 255</td></tr>
<tr><td>R/W</td><td>490</td><td>Indications</td><td>Enables or disables indications. Refer to Section 3.5.13 for more details.
Valid values: 0 (disable), 1 (enable)
Default: 0
This register is only available for ME70-169.</td></tr>
<tr><td>R/W</td><td>500</td><td>LBT threshold</td><td>Indicates the LBT threshold in dBm.
Refer to Section 3.5.2 for more details.
Values from 50 (-50 dBm) to 110 (-110 dBm).
Default: 99 (-99dBm)
This register is only available for ME50-169 and ME70-169.
ME50-868 has a fixed LBT threshold compliant with EN300-220-1.</td></tr>
</table>

R/W	501	LBT advanced options	8 bits mask containing LBT advanced options. Refer to Section 3.5.2 for more details. • Bit 0: enables ALOHA LBT • Bit 1: enables AFA LBT • Bit 2: enables override • Bit 3: enables LBT reattempt • Bit 4: enables different frames between an LBT reattempt and the next one • Bit 5-7: reserved Both of bits 0 and 1 cannot be set to 1 at the same time. Bit 2 can be set to 1 only if one of the bits 0 and 1 are set to 1. Bit 3 can be set to 1 only if bit 0 is set to 1. Bit 4 can be set to 1 only if bit 3 is set to 1. **Default: 0** **This register is only available for ME70-169.**
R/W	502	Single channel LBT BO max	Indicates the maximum value of the LBT backoff count that is allowed for ALOHA LBT operation. Refer to Section 3.5.2 for more details. Values from 3 to 8. **Default: 5** **This register is only available for ME70-169.**
R/W	503	Single channel LBT BO flat	Indicates the value to keep the LBT backoff exponential flat for ALOHA LBT operation. Refer to Section 3.5.2 for more details. Values from 1 to 8. **Default: 3** **This register is only available for ME70-169.**
R/W	504	Single channel LBT delay	Indicates the maximum amount of total time allowed for ALOHA LBT operation. Refer to Section 3.5.2 for more details. 16-bit register: values from 250 to 1000 milliseconds. **Default: 750** **This register is only available for ME70-169.**
R/W	506	Single channel LBT BO period	Indicates the multiplier period of time for the backoff calculation for ALOHA LBT operation. Refer to Section 3.5.2 for more details. 16-bit register: values from 0 to 65535 milliseconds. **Default: 20** **This register is only available for ME70-169.**
R/W	508	Multichannel LBT BO max	Indicates the maximum value of the LBT backoff count that is allowed, the number of total available channels to use for AFA LBT operation. Refer to Section 3.5.2 for more details. Values from 1 to 6. **Default: 6** **This register is only available for ME70-169.**

R/W	510-517	Multicast address	Contain the multicast address: manufacturer ID (registers 510-511) and 6-byte address (registers 512-517). Both fields are stored least significant byte first. More details in Section 3.5.6. Values from 0 to 255. **Default: M Field Byte1 (register 511) is set to 128; the other registers are set to 0.** **These registers are only available for ME70-169.**
R/W	520	Single channel LBT RA max	Indicates the maximum number of single channel re-attempts. Refer to Section 3.5.2. Values from 3 to 10. **Default: 3** **This register is only available for ME70-169.**
R/W	521	Single channel LBT RA flat	Indicates the value to keep the LBT backoff exponential flat for single channel reattempt operation. Refer to Section 3.5.2 for more details. Values from 1 to 10. **Default: 3** **This register is only available for ME70-169.**
R/W	522	Single channel LBT RA period	Indicates the multiplier period of time in 100's of milliseconds for the backoff calculation for single channel reattempt operation.. Refer to Section 3.5.2 for more details. Values from 0 to 255 (25.5 sec). **Default: 16 (1.6 sec)** **This register is only available for ME70-169.**
R/W	530	FAC options	8 bits mask containing the Frequent Access Cycle options. Refer to Section 3.5.14 for more details. • Bit 0: enables Frequent Access Cycle • Bit 1: set the fast response delay as default • Bit 2-7: reserved **Default: 0** **This register is only available for ME70-169.**
R/W	531	FAC fast tROmin	Indicates the minimum of the fast response delay for tRO. Refer to Section 3.5.14 for more details. 16-bit register: values from 0 to 1000 milliseconds. **Default: 100** **This register is only available for ME70-169.**
R/W	533	FAC fast tROmax	Indicates the maximum of the fast response delay for tRO. Refer to Section 3.5.14 for more details. 16-bit register: values from 0 to 1000 milliseconds. **Default: 101** **This register is only available for ME70-169.**
R/W	535	FAC slow tROmin	Indicates the minimum of the slow response delay for tRO. Refer to Section 3.5.14 for more details. 16-bit register: values from 0 to 4000 milliseconds. **Default: 1100** **This register is only available for ME70-169.**
R/W	537	FAC slow tROmax	Indicates the maximum of the slow response delay for tRO. Refer to Section 3.5.14 for more details. 16-bit register: values from 0 to 4000 milliseconds. **Default: 1101** **This register is only available for ME70-169.**

R/W	539	FAC txD	Indicates the transmission delay for FAC. Refer to Section 3.5.14 for more details. Values from 1 to 15 seconds. **Default: 5** **This register is only available for ME70-169.**
R/W	540	FAC timeout	Indicates the timeout for FAC. Refer to Section 3.5.14 for more details. Values from 20 to 255 seconds. **Default: 30** **This register is only available for ME70-169.**

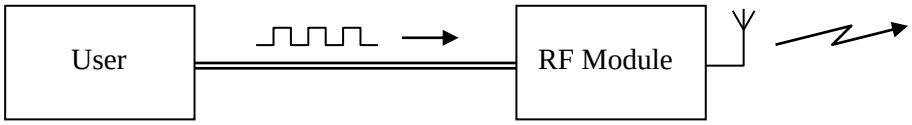
3.3. Operating Mode

When the module is in operating mode, each frame arriving on the serial link is sent on the radio link, and each valid Wireless M-Bus frame received on the radio link is sent on the serial link. These rules do not apply when repeater operation is enabled; refer to Section 3.5.11 for information on repeater operation. If indications are enabled, serial frame has an additional header to distinguish MBUS frames from indications; refer to Section 3.5.13 for more details.

Data transmitted or received over the serial port will have a specific format depending on the module configuration defined through the different registers. It allows a high flexibility in the use of the module in a Wireless M-Bus application.

A module configured as unidirectional meter (register 400 set to 0, 4, 10 or 14) does not activate frame reception on the radio interface. As a result, no frames will be sent to the serial link by modules with these configuration settings.

3.3.1. Serial Frame on Transmission



Serial frames arriving on the serial link of the RF module can have the following fields:

Wakeup	Length	C	M	A	CI	Data

with:

Field	Length	Description
Wakeup	1	**Wakeup character** If wakeup on serial character is activated, the RF module can be triggered by starting the serial frame with a 0xFF or 0x00 character.

Length	1	**Length of frame** Giving the serial frame length to the RF module shortcuts the serial time out at the end of RX, leading in a very short wake up duration and very low power results. Using this field allows to save at least 2 ms for each wake up cycle. The RF module considers that the serial frame is complete as soon as the specified length is reached. Length value should count all subsequent bytes, including other serial options fields if any. Only Wake-up and Length bytes don't enter in the calculation of Length.
C	1	**C-field** It specifies the role of the frame (Request, ACK …).
M	2	**Manufacturer ID and Address fields** Use this option to simplify the maintenance: in case of radio module replacement, the ID is already specified in the host and doesn't need to be set through registers. However this option makes the serial frame longer and increases the work duration (more power consumption). M and A can be activated separately.
A	6	
CI	1	**Control Information field.** Option to be used if several applicative layers use the wireless M-Bus link. If only one application is running, the CI-field can be fixed and specified in the corresponding register.
Data	Variable	**Data field.** User application data; its minimum length is 0 bytes and its maximum length is 245 for frame format A and 241 for frame format B.

The optional header depends on the different settings of module registers:

- **Wakeup** is necessary if bit 1 of register 440 is set to 1
- **Length** is necessary if bit 0 of register 401 is set to 1
- **C** is necessary if bit 1 of register 401 is set to 1
- **M** is necessary if bit 2 of register 401 is set to 1
- **A** is necessary if bit 3 of register 401 is set to 1
- **CI** is necessary if bit 4 of register 401 is set to 1

When the Length field is activated in the serial Rx format options, if the value of the field received by the module is outside the range of values allowed to build a valid data frame, the received byte is discarded.

When automatic frame transmission and multi-frame operation are enabled, the serial frame has an additional field: the command byte, which is inserted as the first byte of the serial frame (after the wakeup character, if enabled). Refer to Section 3.5.9 for more details.

When indications are enabled in ME70-169, the serial frame has an additional field: the header-data byte, which is inserted as the first byte of the serial frame (after the wakeup character, if enabled). When automatic frame transmission, multi-frame operation and indications are enabled, only the command byte is inserted as the first byte of the serial frame (after the wakeup character, if enabled). Refer to Section 3.5.13 for more details.

Examples:

S401 = 31 and S440 = 3 or 7

Serial frame must have this format:

Wakeup	Length	C	M	A	CI	Data

S401 = 30 and S440 = 3 or 7

Serial frame must have this format:

Wakeup	C	M	A	CI	Data

S401 = 17 and S440 = 3 or 7

Serial frame must have this format:

Wakeup	Length	CI	Data

S401 = 31 and S440 = 1 or 5

Serial frame must have this format:

Length	C	M	A	CI	Data

Whatever is the serial frame format, data on RF link will always have the same format, described in Section 2.4. In case of one or several fields (except Wakeup) is not activated on the serial frame, the RF module will use the value defined in the corresponding register.

Example:

If serial frame has this format:

Length	Data (10 bytes)

On the RF link, the frame will have the following format (assuming frame format A is used):

Preamble

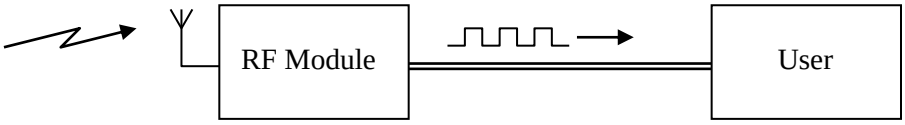
L-field	**C-field**	**M-field**	**A-field**	**CRC-field**

Length	Register 410	Registers 411 - 412	Registers 413 - 418	2 bytes

CI-field	Data-field	CRC-field
Register 419	Data (10 bytes)	2 bytes

Postamble

3.3.2. Serial Frame on Reception



Serial frames sent on the serial link by the RF module can have the following fields:

0xFF	Length	C	M	A	CI	Data	LQI	RSSI	FreqOffset

with:

Field	Length	Description
0xFF	1	**Wakeup character** Very useful especially in Mode R2 to work as "Wake On Radio" way. With this character the user can be woken up by serial if a valid radio frame is received. This option comes in addition to the STANDBY STATUS signal.
Length	1	**Length of frame** Indicates to the user the length of serial frame he is receiving. Length value takes into account the subsequent bytes, including other serial options fields if any, but excluding LQI and RSSI fields.
C	1	**C-field** Specifies the role of the frame (Request, ACK, ...).
M	2	**Manufacturer ID and Address fields** Indicate the M-field and A-field of the received frame. M and A can be activated separately.
A	6	
CI	1	**Control Information field.** Option to be used if several applicative layers use the wireless M-Bus link.
Data	Variable	**Data field.** User application data; its minimum length is 0 bytes and its maximum length is 245 for frame format A and 241 for frame format B.
LQI	1	**LQI** This byte indicates the level of radio reception, from 0 (poor) to 3 (excellent).

RSSI	1	**RSSI** Received Signal Strength Indicator, containing the input power of the received radio frame expressed in dBm as a signed 8 bit number.
FreqOffset	1	**Estimated Frequency Offset (only for ME70-169)** This byte indicates the estimated frequency offset of the received signal compared to the module frequency, expressed in ppm as a signed 8 bit number.

The optional header and footer depend on the different settings of module registers:

- **Wake-up** will be added if bit 6 of register 402 is set to 1
- **Length** will be added if bit 0 of register 402 is set to 1
- **C** will be added if bit 1 of register 402 is set to 1
- **M** will be added if bit 2 of register 402 is set to 1
- **A** will be added if bit 3 of register 402 is set to 1
- **CI** will be added if bit 4 of register 402 is set to 1
- **LQI** will be added if bit 5 of register 402 is set to 1
- **RSSI** will be added if bit 7 of register 402 is set to 1
- **FreqOffset** will be added if register 404 is set to 1 (only for ME70-169)

If automatic frame transmission with multi-frame operation and serial acknowledge is enabled (i.e., the module is configured as concentrator and bits 3, 5 and 6 of register 453 are set), an additional header byte with value 0x00 is transmitted by the module before the serial frame (after the wakeup character if enabled). This header byte is needed in order to distinguish serial frames from serial acknowledge messages. Refer to Section 3.5.9 for additional information on the serial acknowledge option.

When indications are enabled in ME70-169, the serial frame has an additional field: the header-data byte, which is inserted as the first byte of the serial frame (after the wakeup character, if enabled). If automatic frame transmission, multi-frame operation, serial acknowledge and indications are enabled, only one additional header byte with value 0x00 is transmitted by the module before the serial frame (after the wakeup character if enabled); if an indication is received on the serial link, only one additional header byte with value 0xFF is transmitted by the module. Refer to Section 3.5.13 for more details.

Examples:

S402 = 127

Serial frame will have this format:

Wakeup	Length	C	M	A	CI	Data	LQI

S402 = 126

Serial frame will have this format:

Wakeup	C	M	A	CI	Data	LQI

S402 = 209

Serial frame will have this format:

Wakeup	Length	CI	Data	RSSI

S402 = 31

Serial frame will have this format:

Length	C	M	A	CI	Data

3.4. Stand-by Mode

A key functionality available into the Wireless M-Bus stack is the ability to have RF modules in stand-by mode. During this mode, the RF module has very low power consumption. Stand-by mode is not activated when repeater operation is enabled (refer to Section 3.5.11): in this case, the configuration options set in register 440 do not have effect and the module remains always active.

3.4.1. Wakeup of the Module

There are 3 different ways to wake up the module, defined by value of register 440.

- Wakeup on hardware, using wakeup signal J18: it is always possible to wake up the module by applying a logical ‘1’ to the ‘WAKEUP’ signal. When serial transmission is finished, ‘WAKEUP’ signal must be put back to a logical ‘0’ to allow the module returning in stand-by; else the module is kept awake while the WAKEUP pin is maintained to ‘1’. When wakeup on serial character is not activated, there must be at least a 90 µs delay between the positive edge of the WAKEUP pin and the first character sent on the serial port.
- Wakeup on serial character: it is possible to wake up the module by sending a wakeup character at the beginning of the serial frame to send (refer to Section 3.3.1); although any character can awaken the module, either 0xFF or 0x00 must be used as wakeup character, otherwise the module serial port might receive corrupted bytes. After sending this frame on the air, the module will stay awake until a new radio or serial event occurs or until timeout defined by register 441 is reached.
- Wakeup on timer (only for ME50-868): it is possible to force the module to wake up periodically. This cyclic wakeup option is activated by bit 2 of register 440 and the time between two wakeup events is defined by the value of register 442. When waking up, the module will check the radio link for a valid frame preamble. If nothing is detected on the

air, the module returns immediately to stand-by. Otherwise, it will wait for a valid frame and then automatically go back to stand-by after an interval defined by the value of register 441.

When the wakeup timeout defined by register 441 expires, if a radio frame reception is ongoing, the module does not enter stand-by mode but waits for the incoming frame to be received. Frame reception is considered to be initiated when the preamble has been received (refer to Sections 2.3.1 and 2.3.2 for more information on frame preamble). If a device expects to receive a frame within a defined time interval, the wakeup timeout of the module should be set to a value higher than the expected delay of the beginning of the frame, to take into account preamble transmission. The duration of frame preamble for a given mode can be calculated from the bit rate value (reported in Section 2.2) and the preamble length.

When timer is enabled, the stand-by consumption of the RF module is higher (refer to consumption data in refer to the user guides of the modules).

3.4.2. Wakeup of External User Equipment

There are 2 different ways to wake up the external user equipment:

- Through ‘STANDBY STATUS’ output signal (J2): this signal is set to logical ‘1’ while the module is operating and returns to ‘0’ during stand-by periods.
- Through serial character: when the module receives a valid RF frame, it can add a 0xFF character at the beginning of the serial frame to wake up the external user equipment. This type of functioning is so called “Wake on Radio”.

3.5. Advanced Features

3.5.1. Hardware Flow Control

In both configuration mode and data mode, flow control on the serial port is operated via the RTS pin, which is de-asserted (logic level 1) when the module is unable to receive bytes (e.g. when processing an AT command or a serial frame) and re-asserted (logic level 0) when new bytes can be received.

For ME70-169: when configuration register 432 is set to 1, the CTS pin is checked after a frame is received from radio and before sending it on the serial link. If CTS is de-asserted, only one frame is stored (the oldest one). CTS management does not apply to indications and during a Frequent Access Cycle.

3.5.2. Listen Before Talk

When bit 1 of configuration register 453 is set to 1, the Listen Before Talk (LBT) feature of the module is enabled. LBT operation allows decreasing the probability of collision between different modules trying to transmit radio frames at the same time. When this feature is enabled, the module listens to the wireless medium before transmitting a radio frame.

LBT threshold is configurable for ME50-169 and ME70-169 using configuration register 500, whereas ME50-868 has a fixed LBT threshold compliant with EN300-220-1.

Four LBT modes are available.

3.5.2.1. Basic LBT

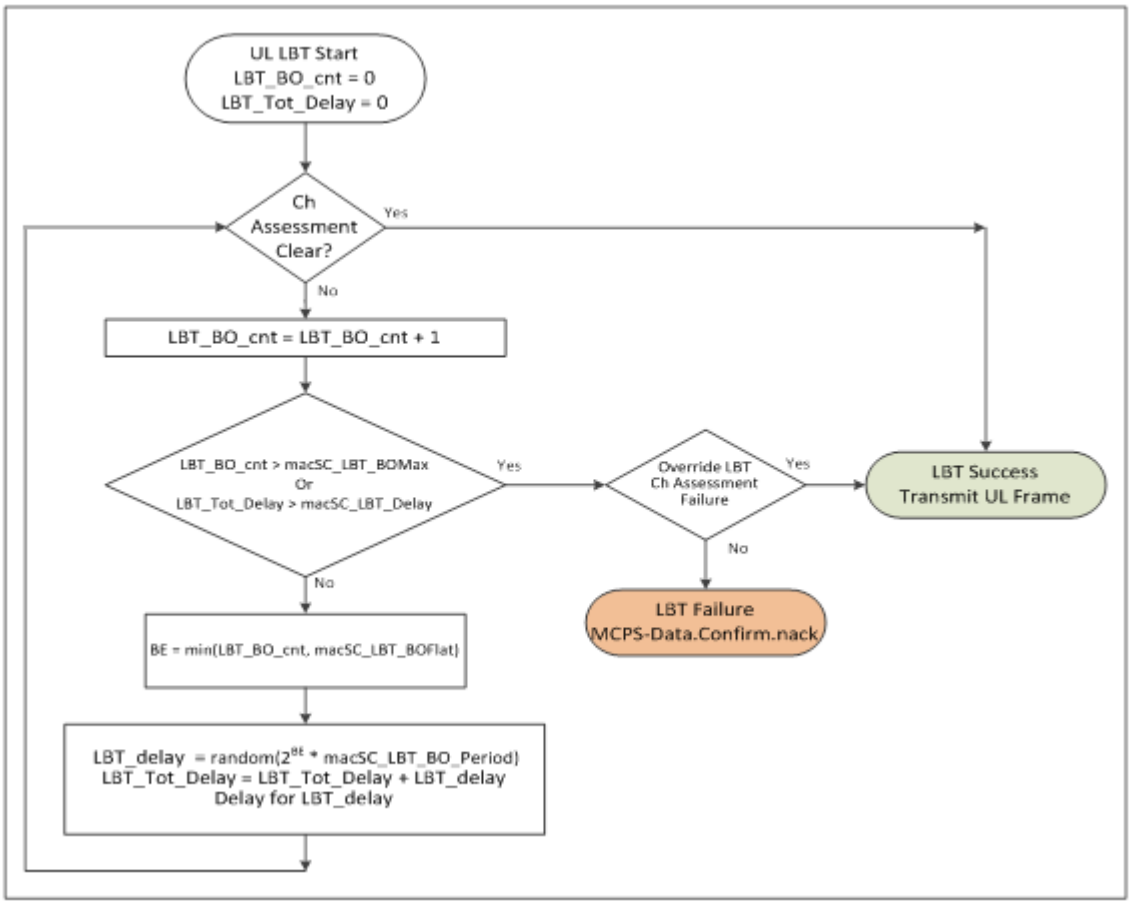
When bit 1 of configuration register 453 is set to 1 and bit 0 and 1 of configuration register 501 are set to 0, basic LBT is enabled.

The minimum listen time is 5 ms; if during this time no activity is detected on the radio link, frame transmission starts immediately, otherwise the module waits until the link becomes free and then listens again for another 5 ms interval, after which an additional listen interval of random duration between 0 and 5 ms is added before frame transmission finally starts. If the radio link becomes busy during the listen time, the module waits for the channel to become free and then restarts the listen procedure.

3.5.2.2. ALOHA LBT (ME70-169)

When bit 1 of configuration register 453 is set to 1 and bit 0 and 1 of configuration register 501 are set to 1 and 0 respectively, ALOHA LBT is enabled. ALOHA LBT parameters can be set using configuration registers 502-506.

The single channel ALOHA LBT access uses an exponentially increasing random time backoff with a limited allowed time delay. If the channel is clear then the module transmits the frame, else if the channel is not clear the module performs a random backoff in time and then re-assesses the channel. The random backoff is exponentially increasing. The module shall attempt this for a number of LBT tries or for an overall delay time limit. If the number of tries is exceeded or the delay time limit is exceeded then the module determines if it is allowed to transmit the frame or not in a LBT override (bit 2 of configuration register 501).

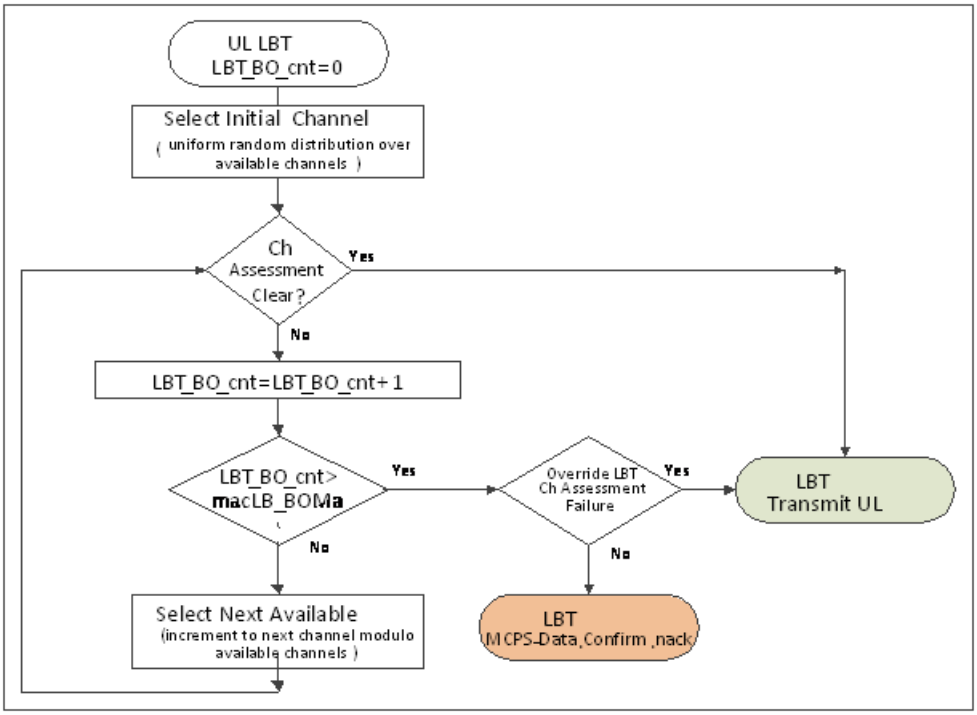


3.5.2.3. AFA LBT (ME70-169)

When bit 1 of configuration register 453 is set to 1 and bit 0 and 1 of configuration register 501 are set to 0 and 1 respectively, AFA LBT is enabled. AFA LBT requires that Channel Plan (configuration register 423) be different from 0 (see Section 3.5.12). If Channel Plan is 0, bit 1 of configuration register 501 is ignored and basic LBT will be used. AFA LBT parameter (multichannel LBT BO max) can be set using configuration register 508.

AFA is defined as the capability of an equipment to dynamically change channel within its available frequencies for proper operation. The algorithm described includes the use of Adaptive Frequency Agility, AFA, which changes channels between LBT attempts. The list of the available channels is defined by register 423 (Channel Plan, refer to Sections 4.5.12).

The initial channel selected is from a uniform random distribution of the available channels (defined by Channel Plan). The channel assessment is performed. If the channel is clear then the LBT is successful and the frame is transmitted, else if the channel assessment is not clear then the LBT backoff count is incremented by one (1) and resaved. If the LBT backoff count is greater than the maximum allowed LBT backoff then the module determines if it is allowed to transmit the frame or not in a LBT override (bit 2 of configuration register 501).



3.5.2.4. Single Channel LBT Reattempt (ME70-169)

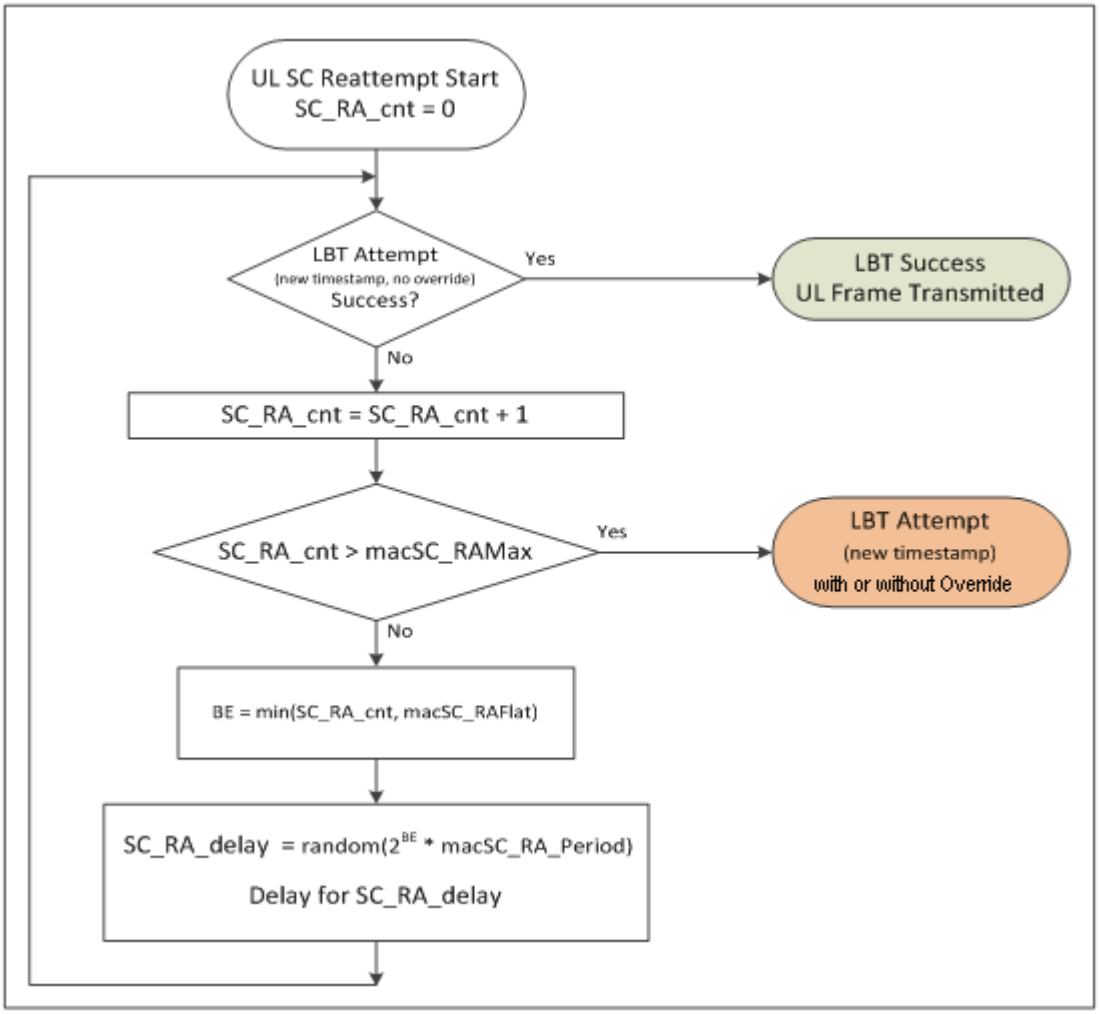
When ALOHA LBT is enabled and there is a failure of a single channel access, it is possible to perform a reattempt process. Single channel LBT reattempt is enabled when:

- bit 1 of configuration register 453 is set to 1
- bit 0 of configuration register 501 is set to 1
- bit 1 of configuration register 501 is set to 0
- bit 3 of configuration register 501 is set to 1

Single channel LBT reattempt parameters can be set using configuration registers 520-522.

ALOHA algorithm without override is performed for each attempt. If the number of reattempt is exceeded then the module determines if it is allowed to transmit the frame or not in a LBT override (bit 2 of configuration register 501).

When indications are enabled, it is possible to send different frames for each attempt, setting to 1 the bit 4 of configuration register 501 (see Section 3.5.13).



3.5.3. Date and Time

The module is able to keep track of current date and time, with a supported calendar covering the years from 2005 to 2099. The internal clock runs also with low power mode enabled. The current date and time can be set and retrieved in configuration mode with the ATDT command (see Section 3.1 for details on command syntax). The module clock is also updated when a clock synchronization frame is stored for automatic transmission (refer to Section 3.5.9).

3.5.4. Frame Format B

When operating in Mode C or Mode N, the modules are able to send and receive Wireless M-Bus frames coded with format B (refer to Section 2.3.2 for format details). Frames with either format A or B can be received by the modules without any specific configuration; to send frames with a specific format, bit 2 of configuration register 453 is used: when this bit is set to 1, frame transmission is done using format B, otherwise the default format A is used. In

ME50-868, bit 2 of register 453 can be set to 1 only when the module is configured to operate in Mode C.

3.5.5. Registered Meters

A module can register up to 32 or 64 meters, to be used for filtering received M-Bus frames, encrypting radio communication, or generating automatic messages. Data for registered meters is stored in EEPROM memory, which is accessed through configuration registers 460, 461-468 and 470-485. ME50-868 and ME50-169 modules have a limit of 32 registered meters, while **ME70-169 can register up to 64 meters.**

To add, edit or delete an entry in the list of registered meters, the manufacturer ID and address of the meter must be inserted in registers 461 to 468, the encryption key (if used) must be inserted in registers 470 to 485, and the appropriate flags must be set in register 460. When bit 0 of register 460 is set to 1, if no meter corresponding to the contents of registers 461 to 468 is present in the list, a new entry is added with the option flags specified in register 460; if the meter is already present, no entry is added, but the option flags of the existing entry are updated. When bit 0 of register 460 is set to 0, the registered meter corresponding to the contents of registers 461 to 468, if present in the list, is unregistered. An error response is returned by the module when trying to add a new entry if the list is full. Register 460 is write-only, and an error response is returned when trying to read the register value. After exiting configuration mode, contents of registers 461 to 468 and 470 to 485 are not guaranteed to remain the same when re-entering configuration mode, thus the user should always set the register contents (at least manufacturer ID and address, if no encryption is needed) before setting a value in register 460. Issuing the ATR or ATM command clears the list of registered meters. Refer to Sections 3.5.8, 3.5.9 and 3.5.10 for details on how to use registered meters and their option flags.

3.5.6. Frame Filtering

An optional filter on received M-Bus frames can be activated, which allows transmitting to the serial port only frames whose meter manufacturer ID and address match one or more specific values. If an Application Layer Address is present in a received frame, the meter manufacturer ID and address are taken from those fields, otherwise the Link Layer Address is used to identify the meter; refer to Section 2.3 for details on the address formats. Frame filtering is enabled by setting bit 0 of register 452 to 1. The addresses used to filter incoming frames differ depending on whether the module is configured as ‘meter’ or ‘other’ device.

Meter devices use the manufacturer ID and address defined by the content of registers 411 to 418 to filter incoming frames; this applies to unicast frames. In order to enable also the reception of multicast and broadcast frames to a meter, respectively bit 1and bit 2 of register 452 must be set to 1 (only for ME70-169).

Multicast frames use a soft address in place of meter address. This soft address, that defines a group of meters, is assigned to module using the content of registers 510 to 517.

Broadcast frames are distinguished by:

- C-field with PRM bit set to 1 and function code set to 3 (refer to Section 2.3.3 for a description of C-field format)
- CI-field set to 0x5A, 0x61 or 0x65 (data frames with short transport layer, no destination address)

Concentrators can use the frame filtering feature of the module by registering the meters from which they want to receive data, i.e. putting their manufacturer ID and address in the list of registered meters. When registering a given meter (or changing the options of a registered meter), bit 1 in the value of register 460 must be set to 1 in order to enable sending to the serial port M-Bus frames received from that meter.

A Wireless M-Bus application can define an installation mode in which a meter looks for a concentrator to bind to. Frames sent by meters in installation mode use typically a C-field with function code set to 6 (refer to Section 2.3.3 for a description of C-field format). In order to be able to receive frames from meters in installation mode, when the module is configured to act as concentrator, filtering does not apply to received frames in which the C-field has the PRM bit set to 1 and the function code set to 6: these frames are sent to the serial port regardless of the frame filtering option.

These are the possible configurations of register 452:

- Concentrator - Bit 0 set to 0: concentrator sends on the serial link to the host all the received radio frames; no filtering is performed.
- Concentrator - Bit 0 set to 1: concentrator sends on the serial link to the host the unicast frames coming only from its registered meters and all the installation radio frames.
- Meter - Bit 0 set to 0: meter sends on the serial link to the host all the received radio frames; no filtering is performed.
- Meter - Bit 0 set to 1, bits 1 and 2 set to 0: meter sends on the serial link to the host only the unicast radio frames addressed to it.
- Meter - Bits 0 and 1set to 1, bit 2 set to 0: meter sends on the serial link to the host the the unicast radio frames addressed to it and also the multicast radio frames with its destination soft address.
- Meter - Bits 0 and 2 set to 1, bit 1 set to 0: meter sends on the serial link to the host the unicast radio frames addressed to it and also the broadcast radio frames.
- Meter - Bit 0, 1 and 2 set to 1: meter sends on the serial link to the host the unicast radio frames addressed to it, the multicast radio frames with its destination soft address and the broadcast radio frames.

3.5.7. Encryption

The module can encrypt and decrypt Wireless M-Bus frames to provide secure communication between nodes. Both DES and AES-128 encryption algorithms as defined in EN 13757-3:2012 are supported, as well as AES-128 with Counter Mode as defined in EN 13757-4:2013.

In order to use encrypted communication, frames sent by the user application must contain either an extended link layer containing the Session Number field with a valid encryption method (refer to Section 2.3.4), or a data header as defined in Section 2.3.5. Depending on the contents of the frame, the module encrypts or decrypts it with the appropriate method.

The encryption methods defined in EN 13757-3 are identified by codes 2, 3, 4 and 5. Method 3 needs the current date to initialize the CBC algorithm, therefore in order to communicate with this encryption method a meter must have the same date as set in the concentrator. Beside the methods defined in EN 13757-3, the module supports method 15 defined in the Dutch Smart Meter Requirements. Refer to Section 2.3.5 for more details on the different encryption methods.

Concentrator devices can send encrypted frames to (and receive encrypted frames from) any of the registered meters; to enable encryption for communication with a given meter, manufacturer ID, address and key (DES or AES-128) of the meter must be inserted in the relevant registers and bit 2 must be set to 1 in the option register 460. A meter device must insert its own manufacturer ID, address and key in an entry of the registered meter list and set bit 2 of register 460. The manufacturer ID and address of the meter in a given frame are taken from the Link Layer Address if the CI-field of the frame does not indicate a long data header, otherwise they are taken from the Application Layer Address.

Once all the relevant configuration registers for encryption have been set, when a frame with an extended link layer or a data header specifying one of the supported encryption methods is received from the serial port, the module encrypts the frame using the key corresponding to the meter manufacturer ID and address and the given encryption method. If method 15 is used, the user application must insert a frame counter and its header at the end of the serial frame, as described in Section 2.3.5. If the encryption methods is incompatible with the CI-field, or if method 15 is specified but the frame counter and its header are not present at the end of the data field, the frame is discarded. If the encryption method is not supported (or is 0, which means no encryption), the frame is sent unencrypted. Before encrypting a frame, if CBC is used (as defined in EN 13757-3) filler bytes with value 0x2F are added at the end of the Data-field, if necessary, to make the length of the encrypted payload a multiple of the block size (8 bytes for DES and 16 bytes for AES-128); if filler bytes cannot be added because the maximum frame length has been reached, the frame is discarded. If encryption method 15 is used, when filler bytes are added to the frame to be encrypted, the frame counter and its header are moved accordingly so that they are placed after the encrypted data. The number of encrypted blocks contained in the configuration word provided by the user is ignored, and the value corresponding to the length of the encrypted content is inserted in the configuration word before sending the frame (sent frames cannot be partially encrypted).

When receiving from the radio interface an encrypted Wireless M-Bus frame, if the meter address corresponds to a registered meter with encryption enabled, the module decrypts the frame before sending it to the serial port, provided the frame contains a valid extended link layer or data header and a supported encryption method code. Received frames that cannot

be decrypted because of invalid contents (such as Data-field length incompatible with configuration word, or encryption method incompatible with data header) are discarded, and frames with unsupported encryption methods are sent unaltered to the serial port. Decryption of partially encrypted frames is supported. The module does not modify the SN field or the configuration word of a received M-Bus frame after decryption, so that user applications are able to verify which encryption method has been used and how many blocks of the frame have been sent encrypted.

3.5.8. Remote AT Commands

The module is able to accept and execute AT commands sent over the radio link as Wireless M-Bus frames; this feature is particularly useful to update the firmware of the module from a remote host. For ME70-169 and ME50-868, remote AT commands can be enabled using the configuration register 405. For ME50-169 this feature is always enabled.

A Wireless M-Bus frame containing an AT command for a given module must have the C-Field set to 0x4B and the CI-Field set to 0xA0 (this is the first value in the range reserved for manufacturer-specific applications according to EN 13757-4); the first 8 bytes of the Data-Field must contain the manufacturer Id and address of the module to which the command is directed, corresponding to the contents of configuration registers 411 to 418 of the receiving module. After the module identification, the Data-Field must contain the AT command with the format described in Section 3.1, without the trailing <CR> character. Upon receiving a remote AT command, the module, instead of sending the received frame to the serial port, executes the command and replies with a Wireless M-Bus frame containing the response to the command. The response frame has the C-Field set to 0x08 and the CI-Field set to 0xA0; the first part of the Data-Field contains the manufacturer Id and address of the module which sent the command frame, while the rest of the Data-Field contains the response with the format described in Section 3.1, without the trailing <CR> character.

If the module receives a remote AT command including a <CR> character, this character and all subsequent bytes in the command string are ignored.

The '+++' escape sequence and the ATT command cannot be sent remotely, and an ERROR response is sent by the module if these command strings are received. Since registers 461 to 468 and 470 to 485 are not guaranteed to keep their content when the module is in operating mode, it is not recommended to use remote AT commands to update the list of registered meters of a given module.

In order to avoid conflict with the execution of remote AT commands, external applications should not use the CI-Field value 0xA0 for other purposes than sending AT commands.

3.5.9. Automatic frame transmission

In typical installations, meter devices are battery-powered, thus energy saving mechanisms must be implemented in order to optimize battery consumption. The standard approach prescribed in the EN 13757-4 specification for battery-operated meters is to enable the radio receiver for a small amount of time after every frame transmission, and then disable radio reception until the next frame transmission. If the meter receives a frame during the short interval in which reception is activated, it enters the so-called Frequent Access Cycle (FAC), during which it sends a frame every few seconds and then listens for a frame from the

concentrator; the FAC allows the concentrator to communicate with meters with a short latency. The FAC ends when either a specific frame (SND-NKE) is sent by the concentrator, or the meter does not receive frames for a specified amount of time.

In order for a frame to be received by a meter operating with the above logic, the concentrator must transmit the frame within a short time interval after the meter transmission. This constraint is particularly severe in mode T, in which frame transmission by the concentrator must start within 3 milliseconds after reception of the frame from the meter; since each frame received and transmitted by the module must pass through the serial port in order to interact with the user application, standard module operation might not be able to satisfy the timing requirements of EN 13757-4. For this reason, a feature has been introduced which allows a module configured as concentrator to automatically send frames to meters, based on specific rules as described in the rest of this section.

When bit 3 of configuration register 453 is set to 1, a frame received on the serial port by a module configured as concentrator is not sent immediately to the radio interface, but is stored in the module memory to be sent when specific conditions are met, as described later in this section. This stored frame can either refer to a specific destination meter, or be a generic frame, based on the meter address; as always, the meter address is taken from the Application Layer Address if the stored frame has a CI-field indicating the presence of a long data header, otherwise it is taken from the Link Layer Address. The stored frame is a generic frame when its meter address has a special value in which all bytes are set to 0xFF; generic frames are used to let the module generate automatically the meter destination address based on frames received from the radio interface. If multi-frame operation is enabled (bit 5 of configuration register 453), it is possible to store in the module multiple frames, specifying the location of each frame with the command byte (described next); otherwise, only one frame can be stored in the module at a given time, and the serial frame does not include the command byte.

If multi-frame operation is enabled, the module internal memory dedicated to automatic frame transmission is composed of 4 contiguous buffers of 256 bytes each, and each buffer is divided in 4 slots of 64 bytes each. The user application assigns a given frame to a specific slot via an additional field of the serial frame, called command byte, whose format is described below.

Reserved	**CMD**		**BufNo**			**SlotNo**	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

- **BufNo** is the buffer number, with allowed values from 0 to 3
- **SlotNo** is the slot number inside a given buffer, with allowed values from 0 to 3
- **CMD** is the command field; the allowed values of this field are the following:
    - 0: clear the memory, i.e. delete all stored frames
    - 2: clear the buffer specified by **BufNo**, i.e. delete all stored frames in that buffer
    - 3: insert a frame in the slot **SlotNo** inside the buffer specified by **BufNo**

The reserved bit of the command byte must be set to 0. In order to insert a frame in a slot inside a specific buffer, the command byte is sent with **CMD** set to 3 and **BufNo** and **SlotNo** set to the desired values; after the command byte follows the frame with the usual format

determined by the Serial Rx Format options (configuration register 401). If the wakeup character is enabled in the options, the command byte must be sent after the wakeup character. If the frame length (including all the frame contents from L-field to Data-field, but excluding the CRC-fields) exceeds the slot size (64 bytes), the frame occupies also the next slots (up to 4 slots can be occupied by a single frame); for example, if a 150-byte frame is assigned to slot number 3 of buffer 0, it occupies 3 consecutive slots: slot 3 of buffer 0 and slot 0 and slot 1 of buffer 1. Any existing frames in the assigned slots will be overwritten by the new frame. If a frame cannot be inserted in a series of consecutive slots, it is discarded by the module; for example, it is not possible to insert a 100-byte frame in slot 3 of buffer 3, because the frame occupies two slots and there is no next slot after the assigned slot 3 of buffer 3. With the command byte it is possible to delete the stored frames, clearing either a single buffer, or the entire memory area; if one of the delete commands is used, the command byte is not followed by frame data.

When multi-frame operation is enabled, if bit 6 of configuration register 453 is set a serial acknowledge message is sent by module after each command received from the serial port. The acknowledge message contains the result of command execution and its format is explained below:

Reserved			**Ack/Nack**			**Type**		**Command Byte**
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Bits 7 … 0

The first byte is a header with the following bit fields:

- **Type**: identifies the message type. A value of 0b00 indicates a Wireless M-Bus frame: in this case the message is not the reply to a command, does not contain the command byte and is followed by the serial frame formatted according to the settings of configuration register 402; if the wakeup character is enabled, it is sent before the header byte. A value of 0b01 in the **Type** field indicates an acknowledgement (positive or negative) to a received command: in this case the **Ack/Nack** field contains the result of command execution. Other values for the **Type** field are reserved.
- **Ack/Nack**: when the **Type** field has the value 0b01, the **Ack/Nack** field contains the result of command execution; defined values are:
    - 0b000: command executed successfully
    - 0b001: command not recognized
    - 0b010: invalid buffer number
    - 0b011: the frame cannot be stored because its length is incompatible with the buffer and slot number
    - 0b100: the stored frame cannot be encrypted because it contains invalid data; refer to Section 3.5.7 for details on frame encryption
- **Reserved**: reserved for future use, currently set to 0

The second byte of the acknowledge message is a copy of the command byte received by the module and allows to associate a command with its corresponding acknowledge.

Standard Wireless M-Bus frames sent by a meter should contain information on whether the meter is able to receive a response frame from the concentrator. If the meter uses the extended link layer, this information is carried in the B-field of the CC field (refer to Section 2.3.4), which is set to 1 to indicate that the meter supports bi-directional communication. If no extended link layer is present and a standard data header (Section 2.3.5) is used instead, and the configuration word indicates an encryption method with one of the values 0, 4, 5, 6 and 15, the most significant bit of the second byte of the configuration word indicates whether the meter is able to receive frames: if this bit is set to 1, it means that the meter can receive frames. When a module configured as concentrator receives a frame indicating that the sending meter can receive a response, the module can automatically send a frame to the meter based on the following rules:

- If the received frame has a C-field with the PRM bit set to 1 and a function code set to 6 (installation request), and the sending meter is a registered meter in the concentrator module with bit 3 (automatic CNF-IR) of the option flags set to 1, the concentrator automatically sends a response frame with the C-field set to 6 and a long data header containing the meter address. This frame exchange is typically used at installation time when the meter searches for a concentrator to bind to; the response from the concentrator indicates that the concentrator accepts the installation request from the meter.
- If the received frame has a C-field with the PRM bit set to 1 and a function code set to 8, and the sending meter is a registered meter in the concentrator module with bit 4 (automatic ACK) of the option flags set to 1, the concentrator automatically sends a response frame with the C-field set to 0 and a long data header containing the meter address. This frame exchange is typically used when the meter has data to transmit and wants the concentrator to request this data; the concentrator response activates the Frequent Access Cycle.
- If the module in the concentrator has one or more stored frames with the meter address either corresponding to the address of the sending meter, or with all bytes set to 0xFF (generic frame), the concentrator sends automatically the first (starting from slot number 0 in buffer number 0) of these stored frames, after replacing the 0xFF bytes of the meter address with the address of the sending meter if the frame is a generic frame.

In the above rules, if the CI-field of the frame sent by the meter indicates the presence of a long data header the meter address is taken from the Application Layer Address, otherwise the meter address is taken from the Link Layer Address.

If multi-frame operation is not enabled, a stored frame is kept in the module internal memory (and possibly sent multiple times) until it is overwritten by another frame.

If multi-frame operation is enabled, a stored frame is not deleted from the internal memory after being transmitted, but the module waits to receive from the meter a response frame (with the **PRM** bit of the C-field set to 0) with the same access number as the stored frame: when this frame is received, the stored frame transmitted previously is deleted from the module, and the next frame (if any) stored for the meter is automatically transmitted. The access number is taken from the Extended Link Layer (refer to Section 2.3.4) if present, otherwise it is taken from the Data Header (described in Section 2.3.5); if no access number field is present in a stored frame, the frame is deleted immediately after transmission. Also, the stored frame is deleted immediately if it has a C-field with the **PRM** bit set to 1 and the function field set to 0x00, because this type of frame (called SND-NKE) is used by the concentrator to end the

Frequent Access Cycle of a meter and there is no corresponding response frame from the meter. The same mechanism applies to generic frames, i.e. frames whose meter address has all bytes set to 0xFF: after transmitting a generic frame, the frame is kept in the module memory (unless it is a SND-NKE or does not have an access number) until a response frame with the same access number is received from any meter.

The automatic frame transmission mechanism allows to store in the module frames that will be sent at a later time, typically when the destination meter wakes up. If a stored frame contains a clock synchronization command, the date and time information in the frame might be outdated when the frame is sent by the module. For this reason, the module is able to update automatically the date and time information in clock synchronization frames before sending them to the destination meters. When the automatic frame transmission is enabled, if a frame with a CI-field set to 0x6C (clock synchronization frame containing a date and time setting) is stored in the module, the module parses the frame contents and, if valid, uses the date and time information in the frame to synchronize its own clock; before transmitting the stored frame, the module changes the date and time settings of the frame with an up-to-date timestamp taken from its own clock. Refer to the European standard EN 13747-3 for information on the format to be used for clock synchronization frames.

When a stored frame is automatically sent by the concentrator, it is encrypted as described in Section 3.5.8 if the destination meter is a registered meter with encryption enabled. In case of a generic frame, the encryption must be carried out after determining the address of the sending meter; since AES-128 encryption is a computationally intensive process, if more than four 16-byte blocks have to be encrypted in a generic frame, the module is unable to satisfy the timing requirement of Mode T. For this reason, if frames with more than 4 encrypted blocks have to be automatically transmitted in Mode T, it is recommended to use stored frames with a specific meter address, because in this case frame encryption can be performed as soon as the frame is received from the serial port. The same limitation applies when the extended link layer is used with AES-128 Counter Mode encryption, because the encryption algorithm needs a frame number which is known only after the concentrator receives the frame from the meter.

3.5.10. Synchronized frame transmission

Bit 4 of configuration register 453 allows controlling the timing of frames sent by the concentrator. If this bit is cleared, every frame to be sent to the radio interface is sent as soon as the module is ready to send it, after the internal processing done by the firmware (such as encryption and CRC calculation). If this bit is set to 1, the module sends frames after a specific delay from the last received frame; this feature is useful to ensure that the concentrator response to a frame sent by a meter satisfies the requirements on minimum response delay prescribed by EN 13757-4.

The minimum response delay values used by the module for the different modes are taken from the EN 13757-4 specification and are listed below:

- Mode S: 3 ms
- Mode T: 2 ms
- Mode R2: 10 ms

- Mode C: the delay value depends on the contents of the frame received from the meter: if the frame contains an extended link layer, the D-field of the CC byte (refer to Section 2.3.4) indicates whether a fast (90 ms) or slow (1000 ms) response delay should be used; if no extended link layer is present, by default a fast response delay is used.
- Mode N: the delay value depends on the contents of the frame received from the meter: if the frame contains an extended link layer, the D-field of the CC byte (refer to Section 2.3.4) indicates whether a fast or slow response delay should be used; if no extended link layer is present, the default response delay is used.
    - ME50-169: 100 ms for the fast response delay; 1100 ms for the slow response delay. The default response delay (fast or slow) can be chosen using the bit 1 in the configuration register 530.
    - ME70-169: the delay value depends on the contents of the registers 531 (fast response) and 535 (slow response). The default response delay (fast or slow) can be chosen using the bit 1 in the configuration register 530.

Synchronized frame transmission can be used together with the automatic frame transmission mechanism described in the previous section; in this case, automatic frames are sent by the concentrator after the minimum response delay defined for the different modes.

For ME70-169 and ME50-868, bit 7 of configuration register 453 allows controlling when the frames received from radio are sent on the serial link if automatic and synchronized frames are enabled; if bit 7 is set to 1, when any frame is received from radio, it is immediately sent on the serial link; if bit 7 is set to 0, the frame received from radio is sent on the serial link only after the transmission of the automatic frame (ME50-169 always has this last behaviour).

If synchronized transmission is used without automatic transmission, when a frame is received from the serial port the module checks if the minimum delay value has passed since the last received frame, and if necessary the module waits for this delay to pass before transmitting the frame.

3.5.11. Repeater operation

The Open Metering System Specification defines the functionality of repeater devices, used to extend the communication range between meters and concentrators. These devices are unidirectional repeaters, which receive frames sent by meters and forward them toward the concentrator; the use of such repeaters is limited to modes S and T.

ME50-868 modules can provide autonomous repeater functionality according to the OMS specification. This feature is enabled when configuration register 454 is set to 1 and register 400 is set to either 3 (for Mode S) or 7 (for Mode T). When repeater operation is enabled, the module can work autonomously (i.e. without an external host connected to the serial port).

A module functioning as repeater does not send or receive frames through the serial port; any character received from the serial port is discarded by the module, except the '+' character which is used to enter configuration mode. As soon as three '+' characters are received, the module sends the "OK\r" response, deactivates repeater operation and enters configuration mode (refer to Section 3.1).

A Wireless M-Bus frame received by a repeater is forwarded only if its C-field is either 0x44 or 0x46; also, the received frame must have a data header as described in Section 2.3.5, its configuration word must indicate an encryption method with one of the values 0, 5 and 6, and the two least significant bits of the first byte of its configuration word must be zero. When the above conditions (dictated by the OMS specification) are met, the repeater stores the received frame and forwards it automatically after a random delay between 5 and 25 seconds; the repeated frame is identical to the original frame, with the exception that the least significant bit of the first byte of the configuration word is set to 1.

If a received frame has the C-field set to 0x46 (typically used during the installation process), the repeater stores an additional frame to be sent (with a random delay of at least 2 seconds) after repeating the received frame. This additional frame has the M-field and A-field set to the manufacturer ID and address of the repeater, the C-field set to 0x40 and a long data header with the Application Layer Address of the sending meter and a status byte containing the RSSI of the received frame coded as described in EN 13757-3; if the RSSI of the received frame is greater than -6 dBm, the status byte is set to 63, otherwise it contains a value expressed by the following formula: (RSSI + 130 dBm) / 2. This additional frame is typically used by an optional installation service tool to verify that the repeater is in communication range with a given meter.

The module is able to store internally up to 16 frames (whose Data-field has a maximum length of 63 bytes) to be transmitted when the random delay expires; for frames with a Data-field bigger than 63 bytes, the maximum number of storable frames decreases proportionally. When a frame cannot be stored due to unavailable memory resources, the frame is discarded.

As prescribed in the OMS specification, a module operating as repeater sends periodically (every 240 minutes) a management frame containing its status.

When repeater operation is enabled, the configuration settings in register 440 are ignored and module does not enter stand-by mode.

3.5.12. Multichannel mode (ME70-169)

Multichannel mode can be set using configuration register 423. This register defines the list of the available channels (Channel Plan).

Multichannel is required for AFA LBT; but if a different LBT method is enabled (basic or ALOHA), multichannel allows to choose a random channel from a list of the available channels before performing the single channel LBT method (basic or ALOHA) on that chosen channel. It is also possible to use multichannel with no LBT: in this case module chooses a random channel before transmitting any frame.

When Channel Plan is different from 0, these rules apply:

a) After power-up, if module is able to receive frames on the radio link (N2-meter or other), it listens to the channel indicated by register 420, ready to receive radio frames.

b) Before transmitting any radio frame:

- If LBT is disabled, module chooses a random channel from the Channel Plan, and then frame is sent on the air on that channel.

- If basic or ALOHA LBT is enabled, random channel is chosen from the Channel Plan, and then LBT is performed; if LBT returns OK, frame is sent on the air on the chosen channel. N1-meter will enable its radio receiver only to perform LBT.
- If LBT reattempt is enabled, random channel is chosen from the Channel Plan before the first attempt; all the attempts are performed using the same channel. N1-meter will enable its radio receiver only to perform LBT.
- If AFA LBT is enabled, channel is chosen using the algorithm described in Section 3.5.2.3. N1-meter will enable its radio receiver only to perform LBT.

c) After transmission, if module is able to receive frames on the radio link (N2-meter or other), it listens to the channel on which it has transmitted the last frame, ready to receive radio frames.

d) Current channel can be read from register 424.

If indications are disabled, channel selection and LBT in the rule b) are performed for each frame transmission. If indications are enabled, it is possible to specify when module has to choose a random channel and perform LBT (see Section 3.5.13).

When multichannel is enabled, channel selection is always performed in transmission. In reception channel is always fixed and no channel hopping mechanism is implemented by the firmware, so the external host is in charge to manage multichannel frame reception.

Example:

- Indications are disabled
- Channel Plan is set to 0xF1.
- The available channels are:
  - 1a@4800bps
  - 3a@4800bps
  - 3b@4800bps
  - 2a@4800bps
  - 2b@4800bps
- If AFA LBT is not enabled, before transmitting any radio frame, module chooses a random channel from these 5 channels. If basic, ALOAH LBT or LBT reattempt is enabled; LBT is performed on the chosen channel.
- If AFA LBT is enabled, module chooses a random channel from these 5 channels (for example 3b@4800bps) and listens to it. If this channel is busy, module chooses the next channel (in this case 2a@4800) and so on. In this case, channels will be chosen in this order:
  - 3b@4800bps (first channel randomically chosen)
  - 2a@4800bps
  - 2b@4800bps
  - 1a@4800bps

- 3a@4800bps

3.5.13. Indications (ME70-169)

When configuration register 490 is set to 0, indications are disabled and in operative mode each frame arriving on the serial link is sent on the radio link, and each valid Wireless M-Bus frame received on the radio link is sent on the serial link.

When configuration register 490 is set to 1, indications are enabled and in operative mode it is possible to send/receive indications and frames together on the serial link. In this case serial frame has an additional header to distinguish MBUS frames from indications.

- **MBUS frame**

Header	MBUS frame
1 byte	*this is the serial frame as defined when indications are disabled*

  - **Header** is always **0x00** when serial frames are sent on the serial link by the RF module (in the direction from the RF module to the user host).
  - **Header** in serial frames arriving on the serial link of the RF module (in the direction from the user host to the RF module) can have the following values:
    - **0x00 - Channel selection and assessment are not performed**: frame will be sent on the channel on which it has transmitted the last frame, without using any LBT method (register 501 and bit 1 of register 453 are ignored).
    - **0x01 - Channel selection and assessment are performed**: before transmitting any radio frame, depending on the configuration for multichannel (register 423) and LBT (register 501 and bit 1 of register 453), module selects a random channel and/or performs LBT. If the user host sends a MBUS frame with Header equal to 0x01, an indication with Indication Type 0x0000, 0x0001, 0x0002 or 0x0003 will be sent to the user host just after the frame is sent to RF.
    - **0x02 – Channel assessment is performed, new frame for a new LBT reattempt**: when bit 4 of register 501 is set to 1 (see Section 3.5.2.4), a new frame can be sent between an LBT attempt and the next one. This frame can be sent after the indication 0x0004. The first attempt is performed using the header 0x01, the following ones using 0x02.

- **Indications**

Header	Length	Reserved	Indication Type	Optional
1 byte	1 byte	1 byte	2 bytes	From 0 to 16 bytes

  - **Header** is always **0xFF**.
  - **Length** is the length indication: this field includes the length of Reserved, Indication Type and Optional. For incoming indications (the indications sent by

user), this field is present only if Length field is activated in Serial Rx Format (bit 0 set to 1 in register 401). For outcoming indications (the indications sent to user), this field is present only if Length field is activated in Serial Tx Format (bit 0 set to 1 in register 402). When Length field is not activated, module uses the time-out on the serial link (register 431).

- **Reserved** is always **0xFF**.
- **Indication Type** can have the following values:
  - **0x0000 - LBT OK**: this outcoming indication is sent when channel assessment is performed and LBT returns OK (channel free: frame can be sent) or LBT is disabled. This indication is sent just after the frame is sent to RF.
  - **0x0001 - LBT override**: this outcoming indication is sent when channel assessment is performed, LBT returns FAIL but override option is enabled. This indication is sent just after the frame is sent to RF.
  - **0x0002 - LBT error**: this outcoming indication is sent when channel assessment is performed, LBT returns FAIL and override option is disabled. This indication is sent just after LBT returns. If LBT reattempt is enabled, this indication is sent if the last attempt returns FAIL and override is disabled.
  - **0x0003 – LBT reattempt: error in the current attempt**: this outcoming indication is sent when channel assessment is performed with LBT reattempt, and the current attempt returns FAIL. This indication is sent just after LBT returns.
  - **0x0004 - LBT reattempt: new attempt can be performed; waiting for a new frame**: this outcoming indication is sent when bit 4 of register 501 is set to 1. Module waits for a new frame for the next attempt.
  - **0x0005 - LBT reattempt: error; algorithm has been stopped**: this outcoming indication is sent when module exits from LBT reattempt. Examples:
    - bit 4 of register 501 is set to 0: a new serial frame is sent during the algorithm;
    - bit 4 of register 501 is set to 1: a new serial frame is sent before the indication 0x0004 has been received.
  - **0x0006 – synchronized frame:** this outcoming indication is sent when bit 4 of register 453 is set to 1. Module has waited for tROmin to send automatically the frame.
  - **0x0007 – not synchronized frame:** this outcoming indication is sent when bit 4 of register 453 is set to 1. Module has received a serial frame after tROmax, so this frame is immediately sent on the air.
  - **0x0010 - Standby**: this outcoming indication is sent just before the module goes in standby mode. This indication is not sent during the LBT reattempt algorithm and during FAC.

- **0x0020 - FAC: frame sent by the meter**: this outcoming indication is sent just after the frame (a valid frame has been previously stored in the meter) is sent to RF. Refer to Section 3.5.14 for more details.
- **0x0021 - FAC: automatic ACC-NR sent by the meter**: this outcoming indication is sent just after the automatic ACC-NR (there is no valid frame stored in the meter) is sent to RF. Refer to Section 3.5.14 for more details.
- **0x0022 - FAC: frame stored in the meter**: this outcoming indication is sent just after a valid frame is stored in the meter. Refer to Section 3.5.14 for more details.
- **0x0023 - FAC: no frame received from the other**: this outcoming indication is sent just after tROmax if no frame has been received from other. Refer to Section 3.5.14 for more details.
- **0x0024 - FAC timeout**: this outcoming indication is sent when the FAC timeout is reached. Refer to Section 3.5.14 for more details.
- **0x0025 - FAC end**: this outcoming indication is sent when a SND-NKE frame has been received. Refer to Section 3.5.14 for more details.
- **0x0026 - FAC error**: this outcoming indication is sent when module exits from FAC because of an error. Refer to Section 3.5.14 for more details.

- **Optional** is a variable-length field**:**
  - If Indication Type is 0x0000, 0x0001, 0x0002 or 0x0004, Optional is one byte long indicating the last chosen channel. If multichannel is disabled, this field indicates the only one available channel.
  - If Indication Type is 0x0003, Optional is three bytes long: the first byte indicates the channel used during the LBT reattempt; the last two bytes indicate the SC_RA_Delay in seconds (rounded down to the nearest whole second).
  - If Indication Type is 0x0005, 0x0010, 0x0020, 0x0021, 0x0022, 0x0023, 0x0024, 0x0025 or 0x0026, Optional is not sent.

If automatic frame transmission is enabled, indications can be used in order to know when an automatic frame is sent to RF.

Examples - MBUS serial frames sent from user to RF module:

S401 = 31, S440 = 3 or 7 and S490 = 1

Serial frame must have this format:

Wakeup	**Header**	Length	C	M	A	CI	Data

S401 = 30, S440 = 3 or 7 and S490 = 1

Serial frame must have this format:

Wakeup	**Header**	C	M	A	CI	Data

S401 = 17, S440 = 3 or 7 and S490 = 1

Serial frame must have this format:

Wakeup	**Header**	Length	CI	Data

S401 = 31, S440 = 1 or 5 and S490 = 1

Serial frame must have this format:

Header	Length	C	M	A	CI	Data

Examples - MBUS serial frames sent from RF module to user:

S402 = 127 and S490 = 1

Serial frame will have this format:

Wakeup	**Header**	Length	C	M	A	CI	Data	LQI

S402 = 126 and S490 = 1

Serial frame will have this format:

Wakeup	**Header**	C	M	A	CI	Data	LQI

S402 = 209 and S490 = 1

Serial frame will have this format:

Wakeup	**Header**	Length	CI	Data	RSSI

S402 = 31 and S490 = 1

Serial frame will have this format:

Header	Length	C	M	A	CI	Data

Examples - MBUS indications sent to user:

S402 = 209 and S490 = 1

Serial frame will have this format:

Wakeup	**Header**	**Length**	**Reserved**	**Indication Type**	**Optional**

S402 = 31 and S490 = 1

Serial frame will have this format:

Header	**Length**	**Reserved**	**Indication Type**	**Optional**

S402 = 30 and S490 = 1

Serial frame will have this format:

Header	**Reserved**	**Indication Type**	**Optional**

Examples - Indications:

S401 = 30, S402 = 209, S440 = 1 or 5, S453 = 2, S490 = 1 and S501=1

Serial frame sent to user will have this format:

Wakeup	**Header1**	Length	CI	Data	RSSI

with **Header = 0x00**

Serial frame sent by user will have this format:

Header2	C	M	A	CI	Data

If **Header2 = 0x00**, no indication will be sent to user and the frame will be immediately sent via Radio.

If **Header2 = 0x01**, this indication will be sent to user just after the MBUS frame is sent to RF:

Header3	Reserved	Indication Type	Optional

With **Header3 = 0xFF, Reserved = 0xFF, Indication Type = 0x0000 or 0x0001**(in this case it depends on ALOHA LBT result). **Optional** indicates the channel on which LBT has been performed.

S401 = 30, S402 = 209, S440 = 1 or 5, S453 = 2, S490 = 1 and S501=25

First LBT attempt: serial frame sent by user will have this format with **Header = 0x01**:

Header	C	M	A	CI	Data

This indication will be sent to user just after the MBUS frame is sent to RF:

Header2	Reserved	Indication Type	Optional

With **Header2 = 0xFF, Reserved = 0xFF**

Indication Type can be:

- **0x0000** if LBT returns OK. **Optional** indicates the channel on which LBT has been performed.
- **0x0003** if LBT returns FAIL. A new attempt will be performed. **Optional** indicates the channel on which LBT has been performed and the SC_RA_Delay.
    - In this case, after SC_RA_Delay, this indication will be sent to user:

Header3	Reserved	Indication Type2	Optional2

With **Header3 = 0xFF, Reserved = 0xFF** and **Indication Type2 = 0x0004**. **Optional2** indicated the radio channel.

Now new frame can be sent: serial frame sent by user will have this format with **Header4 = 0x02**:

Header4	C	M	A	CI	Data

LBT reattempt algorithm will go on until LBT returns OK or maximum number of LBT attempt is reached.

3.5.14. Frequent Access Cycle (ME70-169)

Bit 0 of configuration register 530 allows enabling support for the Frequent Access Cycle on meter side. Indications are required for this functionality.

If the meter transmits a frame containing an Extended Link Layer, if the D-field is set to 1, module will use the fast response delay (registers 531 and 533); else if the D-field is set to 0, the slow response delay (registers 535 and 537) will be used.

If the meter transmits a frame not containing an Extended Link Layer, if the bit 1 of register 530 is set to 1, module will use the fast response delay (registers 531 and 533); otherwise the slow response delay (registers 535 and 537) will be used.

The response delay tRO is calculated from end of the last bit transmitted by meter to expected start of the preamble of the frame received from other. Meter can receive frames between tROmin and tROmax after each its transmission.

The reference time point for the transmission delay txD and for the FAC timeout is the end of preamble (end of sync sequence) of the meter transmission. Meter can send frames every txD seconds.

When Frequent Access Cycle is enabled, these rules apply:

1) The first frame in a FAC session is always sent by meter performing the channel assessment. When a frame with Header = 0x01 is received from serial port, meter performs the channel assessment to send the first unsolicited frame to other. Indication with the channel assessment result is sent to host. If the frame cannot be sent, FAC will be not started.
2) If the first unsolicited frame is sent, meter waits for tROmin.
3) After the first unsolicited frame, between tROmin and tROmax, meter listens to the radio for an incoming frame from other. Only one frame can be received in this window. If no frame is received from other, meter exits from FAC.
4) If other sends a command frame after the meter unsolicited frame, FAC will be started. The frame received from other will be sent to user with Header = 0x00.
5) Host can send serial frames (with Header = 0x00) to meter after tROmax and before txD. These frames will be stored if they have the same access number of the last frame received from other. When a frame is stored, an indication with IndicationType = 0x0022 will be sent to user.
6) When txD is reached, if there is a valid frame stored in the meter, it will be sent to other and an indication with IndicationType = 0x0020 will be sent to user; otherwise if there is no stored frame, an automatic ACC-NR frame is sent to other and an indication with IndicationType = 0x0021 will be sent to user.
7) Between tROmin and tROmax, meter listens to the radio for an incoming frame from other. Only one frame can be received in this window. If no frame is received from other, an indication with IndicationType = 0x0023 will be sent to user at tROmax and meter will repeat the last frame when txD will be reached.
8) FAC terminates if meter receives a SND-NKE frame. In this case an indication with IndicationType = 0x0025 will be sent to user.
9) FAC lasts until the FAC timeout after the last successful reception of a command or a request from other. If timeout is reached, an indication with IndicationType = 0x0024 will be sent to user.
10) If host sends serial frames before tROmax, FAC exits and an indication with IndicationType = 0x0026 will be sent to user.

3.5.14.1. FAC example 1: Other without automatic frames

Meter configuration – list of the registers with values different from default:

400=16; 401=18; 402=30; 420=4; 453=2; 490=1; 501=1; 530=1

Other configuration – list of the registers with values different from default:

400=17; 401=18; 402=30; 416=19; 418=8; 420=4; 453=16

Meter with ALOHA LBT, FAC and indications.
Other with synchronized frames.
In this example data fields after the transport layer are meaningless.

1. Host on the meter-side sends:
   0x01 0x44 0x7d 0x91 0x00 0x00 0x80 0x31 0x32 0x33 0x34 0x35
   Channel assessment con ALOHA LBT (header = 0x01), C-field = 0x44 (SND-NR),
   CI-field = 0x7d (short transport layer), ACC = 0x91, STS = 0x00,
   CW = 0x00 0x80 (bidirectional without encryption),
   DataField = 0x31 0x32 0x33 0x34 0x35

2. As soon as the meter sends successfully the frame, host on the meter-side receives the indication:
   0xff 0xff 0x00 0x00 0x04
   Frame successfully sent on the channel 4

3. Host on the other-side receives the frame:
   0x44 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x7d 0x91 0x00 0x00 0x80 0x31 0x32 0x33 0x34 0x35
   C-field = 0x44, Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07, CI-field = 0x7d,
   ACC = 0x91, STS = 0x00, CW = 0x00, DataField = 0x31 0x32 0x33 0x34 0x35

4. Host on the other-side wants to start a FAC; it sends before tROmin (in this case 1100 msec) the frame:
   0x43 0x60 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x01 0x00 0x00 0x80 0x35 0x36 0x37 0x38 0x39
   C-field = 0x43 (SND-UD2), CI-field = 0x60 (long transport layer),
   MeterAddress = 0x78 0x56 0x34 0x12, Meter M-Field = 0xae 0x0c,
   MeterVersion = 0x01, MeterDeviceType = 0x07, ACC = 0x01, STS = 0x00,
   CW = 0x00 0x80 (bidirectional without encryption),
   DataField = 0x35 0x36 0x37 0x38 0x39

5. This frame is automatically sent from other at time tROmin.

6. Host on the meter-side receives:
   0x00 0x43 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08 0x60 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x01 0x00 0x00 0x80 0x35 0x36 0x37 0x38 0x39
   Received frame (header = 0x00),
   Address = 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08, CI-field = 0x60,
   MeterAddress = 0x78 0x56 0x34 0x12, Meter M-Field = 0xae 0x0c,

MeterVersion = 0x01, MeterDeviceType = 0x07, ACC = 0x01, STS = 0x00,
CW = 0x00 0x80, DataField = 0x35 0x36 0x37 0x38 0x39

7. FAC starts, but host on the meter-side does not have any ready frame.

8. Host on the meter-side receives periodically these two indications:
   0xff 0xff 0x21 0x00 (automatic ACC-NR at txD)
   0xff 0xff 0x23 0x00 (no frame received from other after tROmax)

9. Other periodically receives ACC-NR at txD:
   0x47 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x8a 0x01 0x00 0x00 0x80
   C-field = 0x47 (ACC-NR), Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07,
   CI-field = 0x8a (short transport without data),
   ACC = 0x01 (ACC of the last request from other), STS = 0x00,
   CW = 0x00 0x80 (bidirectional without encryption)

10. When the response is ready, host on the meter-side sends between tROmax and txD the frame:
    0x00 0x08 0x7d 0x01 0x00 0x00 0x80 0x41 0x42 0x43 0x44 0x45
    No channel assessment (header = 0x00), C-field = 0x08 (RSP-UD),
    CI-field = 0x7d (short transport layer),
    ACC = 0x01 (ACC of the last request from other), STS = 0x00,
    CW = 0x00 0x80 (bidirectional without encryption),
    DataField = 0x41 0x42 0x43 0x44 0x45

11. This frame is stored with this indication:
    0xff 0xff 0x22 0x00

12. At time txD the meter automatically sends the response frame to RF and this indication to its host:
    0xff 0xff 0x20 0x00

13. Other receives the response frame:
    0x08 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x7d 0x01 0x00 0x00 0x80 0x41 0x42 0x43 0x44 0x45
    C-field = 0x08, Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07, CI-field = 0x7d,
    ACC = 0x01, STS = 0x00, CW = 0x00 0x80

14. If other does not reply, meter will continue to send the last RSP-UD frame to RF at time txD and these indicatons to its host:
    0xff 0xff 0x20 0x00 (send last RSP-UD at txD)
    0xff 0xff 0x23 0x00 (no frame received from other after tROmax)

15. Other wants to end FAC; its host sends before tROmin:
    0x40 0x80 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x02 0x00 0x00 0x80
    C-field = 0x40 (SND-NKE), CI-field = 0x80 (long transport layer with no data),
    MeterAddress = 0x78 0x56 0x34 0x12, Meter M-Field = 0xae 0x0c,
    MeterVersion = 0x01, MeterDeviceType = 0x07, ACC = 0x02, STS = 0x00,
    CW = 0x00 0x80 (bidirectional without encryption)

16. Host on the meter-side receives:
    0x00 0x40 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08 0x80 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x02 0x00 0x00 0x80
    and this indication:
    0xff 0xff 0x25 0x00 (FAC end)

3.5.14.2. FAC example 2: Other with automatic frames

Meter configuration – list of the registers with values different from default:

400=16; 401=18; 402=30; 420=4; 453=2; 490=1; 501=1; 530=1

Other configuration – list of the registers with values different from default:

400=17; 401=18; 402=30; 416=19; 418=8: 420=4; 453=248; 490=1

Meter with ALOHA LBT, FAC and indications.
Other with indications and multiframe, automatic and synchronized frames.
In this example data fields after the transport layer are meaningless.

Before the beginning of each FAC, other stores two frames without sending them to radio: SND-UD2 and SND-NKE.

1. Host on the other-side sends:
   0x60 0x43 0x60 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0x01 0x00 0x00 0x80 0x35 0x36 0x37 0x38 0x39
   Store new frame at slot 0 = 0x60,
   C-field = 0x43 (SND-UD2), CI-field = 0x60 (long transport layer),
   0xFF address = 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0xff,
   ACC = 0x01, STS = 0x00,
   CW = 0x00 0x80 (bidirectional without encryption),
   DataField = 0x35 0x36 0x37 0x38 0x39

2. Host on the other-side receives this ACK:
   0x01 0x60 (stored frame at slot 0)

3. Host on the other-side sends:
   0x61 0x40 0x80 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0x02 0x00 0x00 0x80
   Store new frame at slot 1 = 0x61,
   C-field = 0x40 (SND-NKE), CI-field = 0x80 (long transport layer with no data),
   0xFF address = 0xff 0xff 0xff 0xff 0xff 0xff 0xff 0xff,
   ACC = 0x02, STS = 0x00,
   CW = 0x00 0x80 (bidirectional without encryption)

4. Host on the other-side receives this ACK:
   0x01 0x61 (stored frame at slot 1)

5. Host on the meter-side sends:
   0x01 0x44 0x7d 0x91 0x00 0x00 0x80 0x31 0x32 0x33 0x34 0x35
   Channel assessment con ALOHA LBT (header = 0x01), C-field = 0x44 (SND-NR),
   CI-field = 0x7d (short transport layer), ACC = 0x91, STS = 0x00,

CW = 0x00 0x80 (bidirectional without encryption),
DataField = 0x31 0x32 0x33 0x34 0x35

6. As soon as the meter sends successfully the frame, host on the meter-side receives the indication:
   0xff 0xff 0x00 0x00 0x04
   Frame successfully sent on the channel 4

7. Host on the other-side receives the frame:
   0x00 0x44 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x7d 0x91 0x00 0x00 0x80 0x31 0x32 0x33 0x34 0x35
   Received frame (multiframe) = 0x00,
   C-field = 0x44, Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07, CI-field = 0x7d,
   ACC = 0x91, STS = 0x00, CW = 0x00, DataField = 0x31 0x32 0x33 0x34 0x35

8. Other automatically sends the first stored frame at time tROmin, replacing the 0xFF address with the meter one; it sends to its host this indication:
   0xff 0xff 0x06 0x00
   Synchronized frame successfully sent

9. Host on the meter-side receives:
   0x00 0x43 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08 0x60 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x01 0x00 0x00 0x80 0x35 0x36 0x37 0x38 0x39
   Received frame (header = 0x00),
   Address = 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08, CI-field = 0x60,
   MeterAddress = 0x78 0x56 0x34 0x12, Meter M-Field = 0xae 0x0c,
   MeterVersion = 0x01, MeterDeviceType = 0x07, ACC = 0x01, STS = 0x00,
   CW = 0x00 0x80, DataField = 0x35 0x36 0x37 0x38 0x39

10. FAC starts, but host on the meter-side does not have any ready frame.

11. Host on the meter-side receives periodically this indication at txD:
    0xff 0xff 0x21 0x00 (automatic ACC-NR)

12. Host on the meter-side receives periodically this frame at tROmin:
    0x00 0x43 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08 0x60 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x01 0x00 0x00 0x80 0x35 0x36 0x37 0x38 0x39

13. Other periodically receives ACC-NR at txD:
    0x00 0x47 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x8a 0x01 0x00 0x00 0x80
    Received frame (multiframe) = 0x00,
    C-field = 0x47 (ACC-NR), Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07,
    CI-field = 0x8a (short transport without data),
    ACC = 0x01 (ACC of the last request from other), STS = 0x00,
    CW = 0x00 0x80 (bidirectional without encryption)

14. Other automatically repeats the first stored frame at tROmin, replacing the 0xFF address with the meter one, until it receives a frame from meter with PRM=0 and same ACC. Every transmission is signaled with this indication:

0xff 0xff 0x06 0x00
Synchronized frame successfully sent

15. When the response is ready, host on the meter-side sends between tROmax and txD the frame:
0x00 0x08 0x7d 0x01 0x00 0x00 0x80 0x41 0x42 0x43 0x44 0x45
No channel assessment (header = 0x00), C-field = 0x08 (RSP-UD),
CI-field = 0x7d (short transport layer),
ACC = 0x01 (ACC of the last request from other), STS = 0x00,
CW = 0x00 0x80 (bidirectional without encryption),
DataField = 0x41 0x42 0x43 0x44 0x45

16. This frame is stored with this indication:
0xff 0xff 0x22 0x00

17. At time txD the meter automatically sends the response frame to RF and this indication to its host:
0xff 0xff 0x20 0x00

18. Other receives the response frame:
0x00 0x08 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07 0x7d 0x01 0x00 0x00 0x80 0x41 0x42 0x43 0x44 0x45
Received frame (multiframe) = 0x00,
C-field = 0x08, Address = 0xae 0x0c 0x78 0x56 0x34 0x12 0x01 0x07, CI-field = 0x7d,
ACC = 0x01, STS = 0x00, CW = 0x00 0x80

19. Other automatically replies; it deletes the first stored frame (other received a frame with PRM=0 and same ACC) and sends the second stored frame at time tROmin, replacing the 0xFF address with the meter one; it sends to its host this indication:
0xff 0xff 0x06 0x00
Synchronized frame successfully sent

20. Host on the meter-side receives:
0x00 0x40 0xae 0x0c 0x78 0x56 0x34 0x13 0x01 0x08 0x80 0x78 0x56 0x34 0x12 0xae 0x0c 0x01 0x07 0x02 0x00 0x00 0x80
and this indication:
0xff 0xff 0x25 0x00 (FAC end)

4. Power Consumption

Please refer to the user guides of the modules for power consumption values.

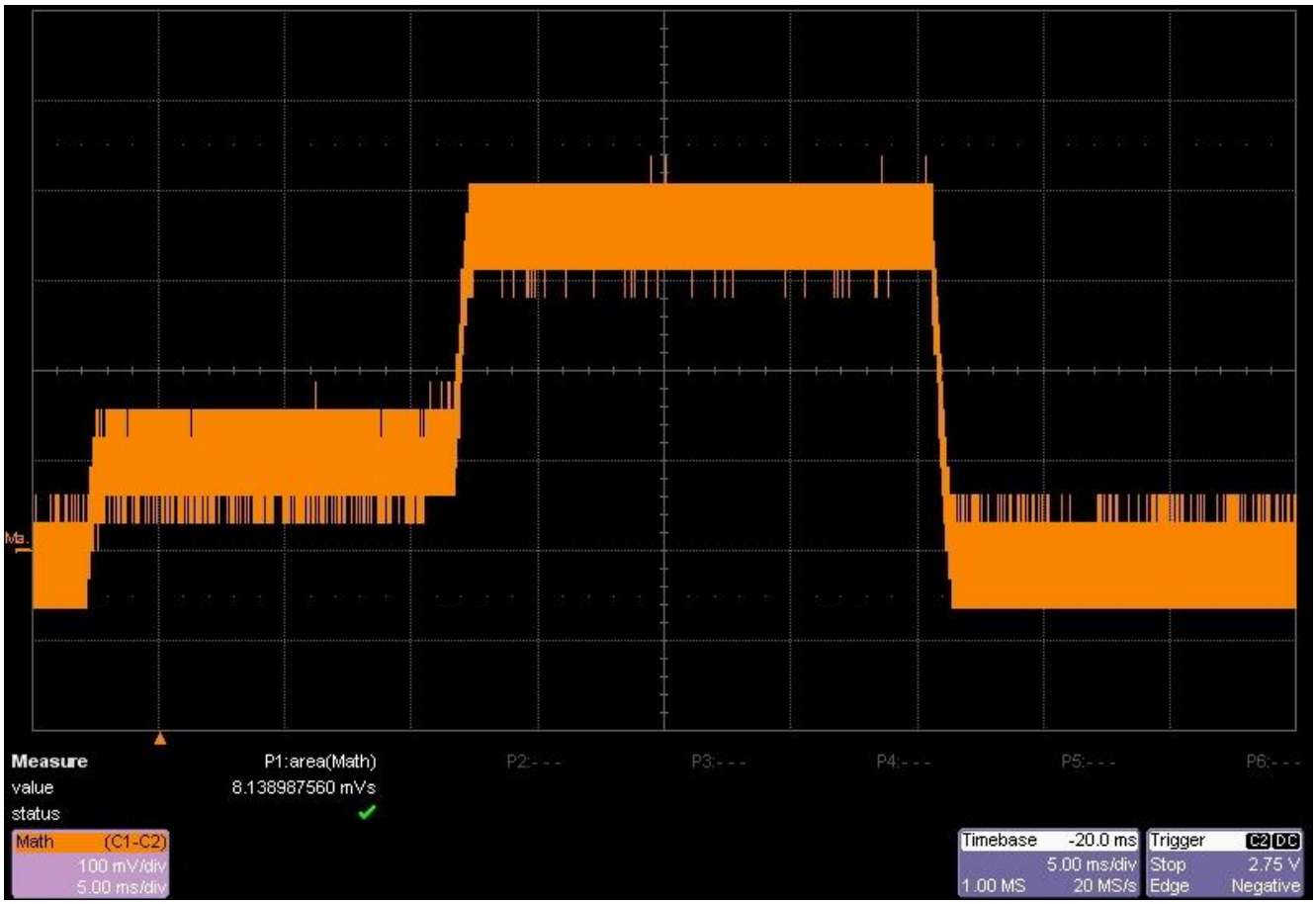
The remainder of this chapter reports a few examples showing ME50-868 power consumption values in typical operating conditions.

4.1. S1 Mode

The following example is using Mode S1 (stationary) of Wireless M-Bus. The stand-by mode is activated, with serial wake-up, and the wakeup timeout value (register 441) is set to zero.

Let us suppose that user equipment wakes-up the module to send a 30 bytes frame with serial data rate at 19200 bps.

Here is a picture of current consumption during a transmission cycle. The power supply voltage is 3 V and the output power is 25 mW. Each such transmission cycle spends typically 814 µAs.



Here is a table of average consumption versus the period of transmission cycles.

Sleep Time	Equivalent Consumption (µA)
1 second	815.4
10 seconds	82.8
1 minute	15
1 hour	1.6
1 day	1.4

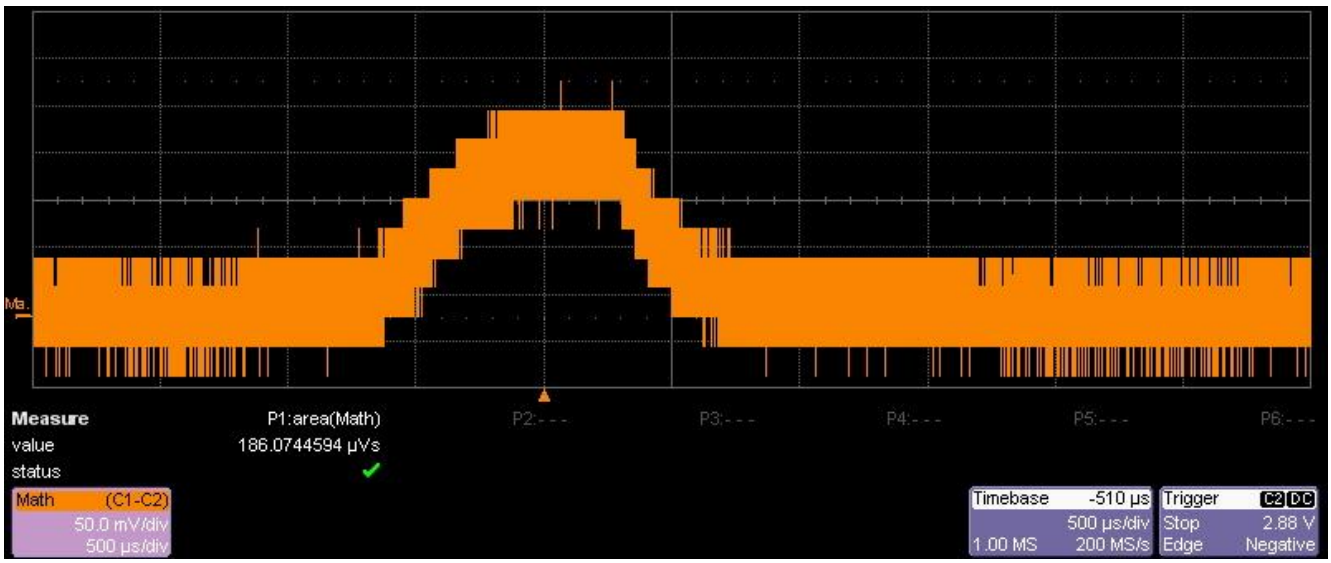
4.2. R2 Mode

The following example is using the R2 mode (frequent receive) of Wireless M-Bus. The stand-by mode is activated, with cyclic wake-up.

With this functioning mode, the meter module wakes up periodically to listen to the radio channel during a very short time. If some activity is detected, the module stays awake to receive the frame, else returns quickly in stand-by mode.

Assuming that the concentrator is rarely present and considering that this band is clear (duty cycle < 1% as requested by ETSI rules in EN 300 220-2), the main current consumption is due to wake up cycles without detection of energy.

Here is a picture of a typical current consumption pattern during a wake-up cycle. The power supply voltage is 3 V. In this case, Wakeup Time Out register 441 has no influence since no event is detected.



Here is a table of average consumption versus wake-up period (register 442) when no exchanges are done and no radio perturbation occurs.

Sleep Time	Equivalent Consumption (µA)
1 second	20.5
5 seconds	5.6
10 seconds	3.8
20 seconds	2.8
30 seconds	2.5
1 minute	2.3
2 minutes	2.1

5. Acronyms and Abbreviations

ACP	Adjacent Channel Power
AES	Advanced Encryption Standard
AFA	Adaptive Frequency Agility
ALA	Application Layer Address
BCD	Binary Coded Decimal
BER	Bit Error Rate
CBC	Cipher Block Chaining
CER	Character Error Rate
dBm	Power level in decibel milliwatt (10 log (P/1mW))
DES	Data Encryption Standard
EMC	Electro Magnetic Compatibility
EEPROM	Electrically Erasable Programmable Read-Only Memory
ETR	ETSI Technical Report
ETSI	European Telecommunications Standards Institute
FAC	Frequent Access Cycle
FSK	Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical
kbps	kilobits per second
kcps	kilochips per second
LBT	Listen Before Talk
LLA	Link Layer Address
LNA	Low Noise Amplifier
LQI	Link Quality Indication
M-Bus	Meter Bus
MHz	Mega Hertz
OMS	Open Metering System
PLL	Phase Lock Loop
NRZ	Non Return to Zero
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RSSI	Received Signal Strength Indicator
Rx	Reception
SRD	Short Range Device
Tx	Transmission
SMD	Surface Mounted Device
VCO	Voltage Controlled Oscillator
VCTCXO	Voltage Controlled and Temperature Compensated Crystal Oscillator
VHF	Very High Frequency

6. Document History

Revision	Date	Changes
0	2011-09-08	• First issue
1	2011-09-29	• Added ME50-169 product
2	2012-01-24	• Changed doc. name to be coherent with other W-Mbus User guides • Updated ME50-169 Hardware Characteristics
3	2012-04-03	• Updated firmware version
4	2012-11-09	• Removed duty cycle management • Changed automatic frame transmission • Changed firmware version to GC.U03.01.01 • Added ME70-169 • Added serial acknowledge option • Enhanced support of Extended Link Layer
5	2012-12-19	• Changed ME50-169 firmware version to GI.U03.01.02
6	2013-03-29	• Changed ME70-169 firmware version to GL.U03.01.02
7	2013-05-15	• Section 2.3.2: added missing CRC-field • Changed ME50-868 firmware version to GC.U03.01.02 • Changed ME50-169 firmware version to GI.U03.01.03 • Changed ME70-169 firmware version to GL.U03.01.03
8	2014-02-05	• Added new channels as required by TS 11291-4 • Added multichannel mode • Added advanced LBT • Added indications • Added multicast/broadcast • Added FAC • Added ATT0/1/2/3 • Added register S403 • Changed doc. name and updated the version of EN 13757-4 (2013)
9	2014-04-01	• Added reference in to1vv0301021 • Aligned Consumption, PER values with XE50-868 /ME70 HW user guides)
10	2014-07-02	• Changed ME50-868 firmware version to GC.U03.01.03 • Changed ME50-169 firmware version to

		GI.U03.01.04 • Changed ME70-169 firmware version to GL.U03.01.05 • Added ATM command • ME50-169 supports ATT0/1/2/3 commands, new channels as required by TS 11291-4 and configurable LBT threshold • Added simultaneous Mode T1/C1-other
11	2014-11-07	• Added CTS management • Added 12, 15, 18 dBm for ME70-169 • Added ATS404, ATS425, ATS426 • Removed chapter 3 • Removed power consumption table
12	2015-03-05	• Changed firmware version • Changed section 3.5.10 – mode N
13	2015-03-13	• Changed firmware version • Added register ATS427
14	2016-01-11	• Changed firmware version • Added ATS405, ATS428 and ATS429 • Added configurable preamble length for Mode N • Mode N supports dynamic tRO according to the D-field in the CC-field • Added indications 0x0006 and 0x0007 • Added FAC examples