UM2241
User manual

METERS AND MORE® compliant power line communication system-on-chip

Introduction

This user manual, which targets application developers, provides complete information on how to use the ST75MM in applications by describing the host interface, the available protocol services and the MIB accessible through the host interface. For ordering information, mechanical and electrical device characteristics, please refer to the ST75MM datasheet available at www.st.com.

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1 Host interface

1.1 Settings

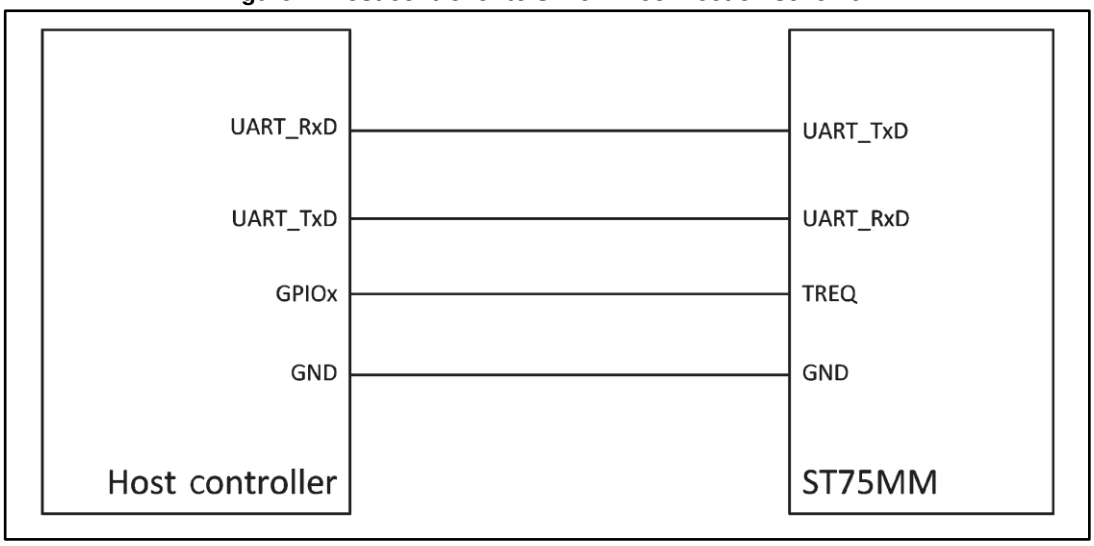
The host interface is used to interface the ST75MM to the host controller, it allows exchanging data, configuration and control messages.

The host interface can be managed by the host controller with a half-duplex asynchronous serial port (UART) plus an additional synchronization signal which will be referenced, in this document as **TREQ**.

The configuration at the host controller shall be the following one:

- 2-wire UART port set to (57600, 1, N, 1) no flow control
- Single wire push-pull output (TREQ line)

Figure 1: Host controller to ST75MM connection scheme



1.2 Operations

Being the communication link between the host controller and the ST75MM a half-duplex serial link, the communication paradigm is master/slave, where the ST75MM acts as the master of the communication.

When an event is triggered inside the ST75MM (incoming PLC frame, completion of requested activities or error/warning events), this is automatically and immediately sent to the host controller through the serial link. This means that the host controller should continuously monitor the UART port, decode the frames as they are detected and send an acknowledge message to the ST75MM.

When the host controller needs to send a command to the ST75MM (data request or MIB programming/reading) it shall drive low the TREQ signal (which indeed needs to remain high when idle) and wait for the ST75MM to send a special message, the so called "Status Message" (SM). As the SM holds information about the availability of the ST75MM to receive commands, it shall be detected by the host controller before sending the message request to the ST75MM. The ST75MM will respond immediately to the host controller with an acknowledge byte and, if the command requires a further communication (e.g., the result of the command) will be sent as an internally triggered event (see previous paragraph) once the operations inside the ST75MM are concluded.

Section 1.7: "Examples" contains some examples on how complex operations shall be managed between the host controller and the ST75MM.

1.3 Acknowledge

In order to improve the serial link robustness, every frame except the SM must be acknowledged by the receiver within a given period T_{ACK} (host interface timings are managed through a dedicated MIB object, see *Section 3.1: "MIB objects"* for reference), otherwise the sender will repeat once the same message waiting for a new acknowledge. If no acknowledge arrives after the second message is sent, the message is discarded by the sender and no further repetitions are sent. If the sender is the ST75MM, no further action is taken.

The acknowledge byte is only linked to the format of the frame, and shall never give feedback on the validity or execution of the command; it can have two values:

- 0x06 (ACK) which means that the received command is well formed
- 0x15 (NAK) which means that the received command has errors (length or CRC).

1.4 Command frame format

Commands are formatted as follows:

Table 1: Command frame format

Starting Byte	Field	Size	Value	Description
0	Frame start	1	0x02 / 0x03	Used to mark the start of a command. In order for the host controller to distinguish between a message and its repetition(1). The frame start has always the value 0x02, except for repeated messages, where a value of 0x03 is used. When the host controller receives a message starting with 0x03 it should verify if the same message has already been received, and, in this case, discards the latter one.
1	Length	1	Any	Number of payload bytes after the first one (always sent).
2	Command code	1	Any	Identifies the command to be executed.
3	Payload	1...256	Any	Contains the parameters associated with the command.
Length + 4	Checksum	2	Any	Sum of the Length, Command code and Payload fields. The sum is performed byte-wise, represented as 16-bit value and sent to the host controller MSB first.

Notes:

(1)This condition is generated when the modem doesn't receive the ACK message from the host controller within the proper T_{ACK} time.

1.5 Status message frame format (SM)

The SM is formatted as follows:

Table 2: Status message format

Starting Byte	Field	Size	Value	Description

Starting Byte	Field	Size	Value	Description
0	SM start	1	0x3F	Used to mark the start of the SM
1	Modem status	1	Any	Bit mask showing the status of the ST75MM modem
2	MIB status	2	Any	Bit mask showing which MIB objects have been reconfigured by the host controller

The following table shows the modem status field possible values.

Table 3: Modem status format

Bit	Sub-field	Values	Description
0	SET	0 1	The ST75MM modem has an internal configuration error. The ST75MM modem is configured and running properly.
1	TX	0 1	The ST75MM is not transmitting. The ST75MM is transmitting.
2	RX	0 1	The ST75MM is not in active reception state. The ST75MM is receiving a PLC frame.
3	PLC busy(1)	0 1	PHY layer is in idle state. PHY layer is busy or not yet configured.
4	OVC	0 1	No overcurrent events registered during the last transmission. At least one overcurrent event registered during the last transmission.
5	Reserved	-	-
6-7	Temperature	00(2) 01 10 11	ST75MM temperature is lower than 70 °C. ST75MM temperature is between 70 °C and 100 °C. ST75MM temperature is between 101 °C and 125 °C. ST75MM temperature is higher than 125 °C.

Notes:

(1)Before sending any command to the ST75MM the host controller should monitor this flag, proceeding only if the value is 0.

(2)Values are always given as [msb]...[lsb], so a value of “01” means bit_7 = 0 and bit_6 = 1.

The following table shows the correspondence between the MIB status field and the MIB configuration, if the MIB has been configured (or correctly reconfigured after a reset event) the corresponding bit is raised, otherwise is set to 0.

Table 4: MIB status format

Bit	Name	MIB index	Description
0	Reserved	-	-
1	Reserved	-	-
2	PHY configuration	2	Current PHY layer configuration
3	MAC configuration	3	Current MAC layer configuration
4	Reserved	-	-
5	Reserved	-	-

Bit	Name	MIB index	Description
6	Manufacturer data	6	Physical address (ACA) of the modem and serial number
7	Reserved	-	-
8	Reserved	-	-
9	Reserved	-	-
10	Reserved	-	-
11	Reserved	-	-
12	Reserved	-	-
13	Reserved	-	-
14	Reserved	-	-
15	Reserved	-	-

1.6 TREQ management

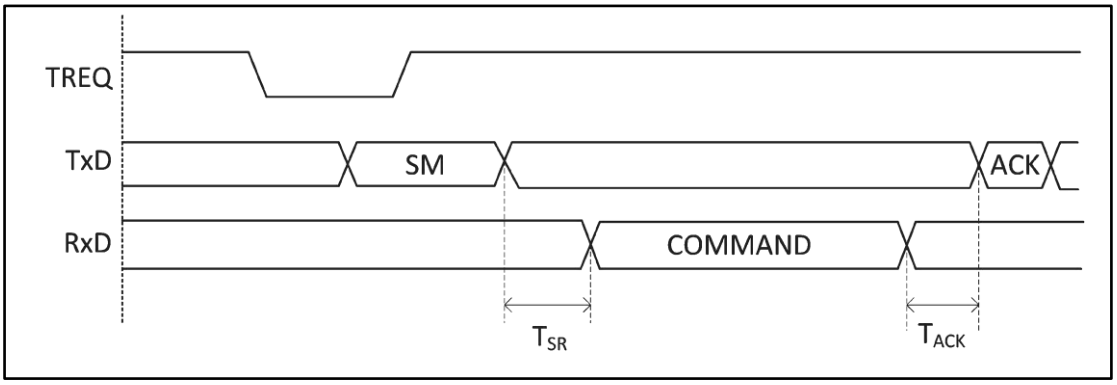
Here below a timing diagram of the priority negotiation of the serial link is depicted, first of all the host controller wanting to send a command to the ST75MM drives low the TREQ line, waiting for the SM frame before sending the message.

As soon as the SM frame starts, the host controller drives high the TREQ line and, when the SM is completely received, it verifies that PLC Busy flag is disabled.

If the PLC Busy flag of the SM is disabled the host controller sends the command to the ST75MM within T_{SR} time, and waits for a maximum of T_{ACK} time the acknowledge byte from the ST75MM.

If the acknowledge byte is not received within T_{ACK} time, the host controller can initiate a new transaction, sending the same command with 0x03 as start of the frame byte, this way, if the acknowledge byte has been lost in the serial link the ST75MM receives the command twice and can disregard the repetition.

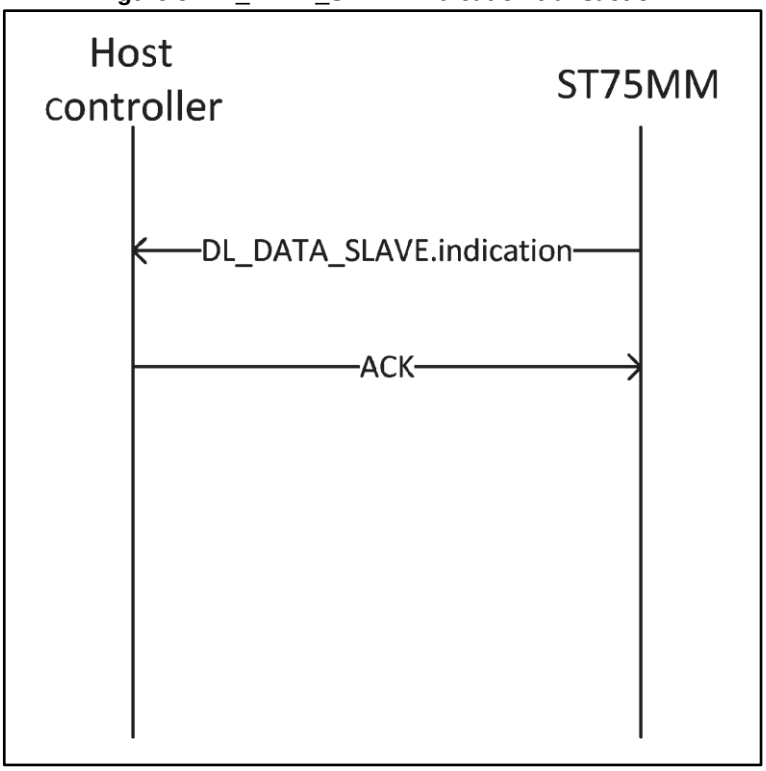
Figure 2: TREQ negotiation timing diagram



1.7 Examples

Here below an example of DL_DATA_SLAVE.indication coming from the ST75MM, in this case, as in MIB_Write.indication, being the message triggered by the ST75MM there is no negotiation with the host controller in the serial link.

Figure 3: DL_DATA_SLAVE.indication transaction



The same transaction, in case the acknowledge (the same applies in case the –indication is lost) is lost, is the one depicted in the next figure, where the second DL_DATA_SLAVE.indication message frame uses 0x03 as start of the frame byte instead 0x02 as the first one, to let the host controller check if the message has already been received or not.

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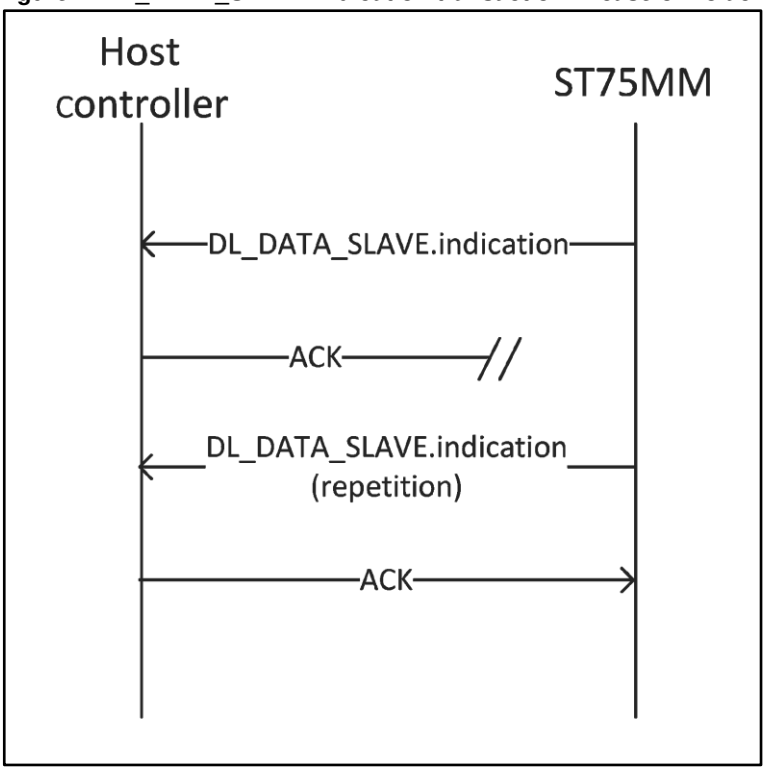
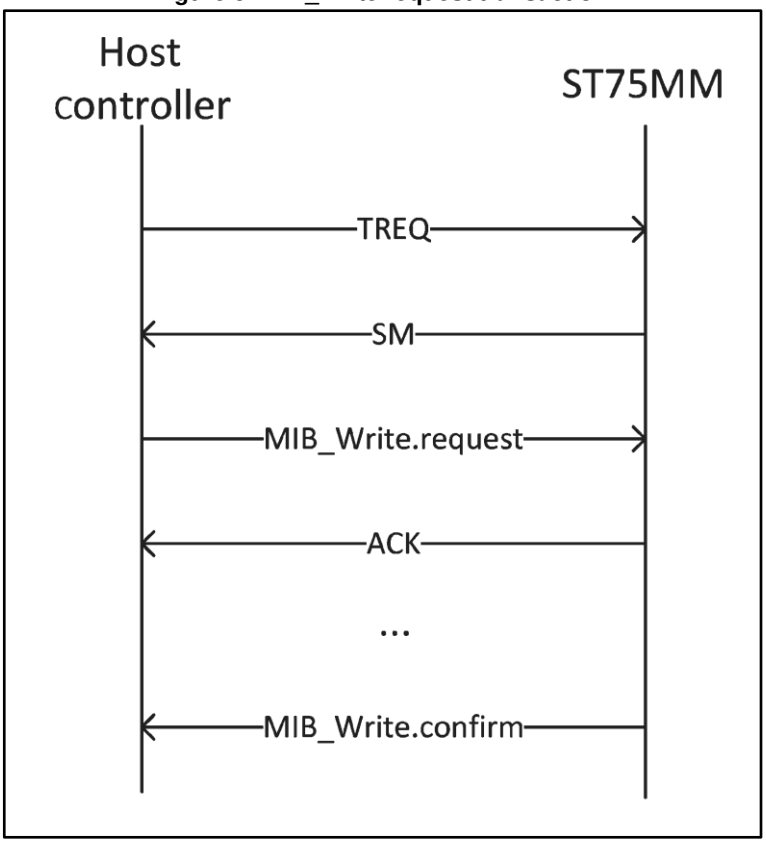
Figure 4: DL_DATA_SLAVE.indication transaction in case of no ack



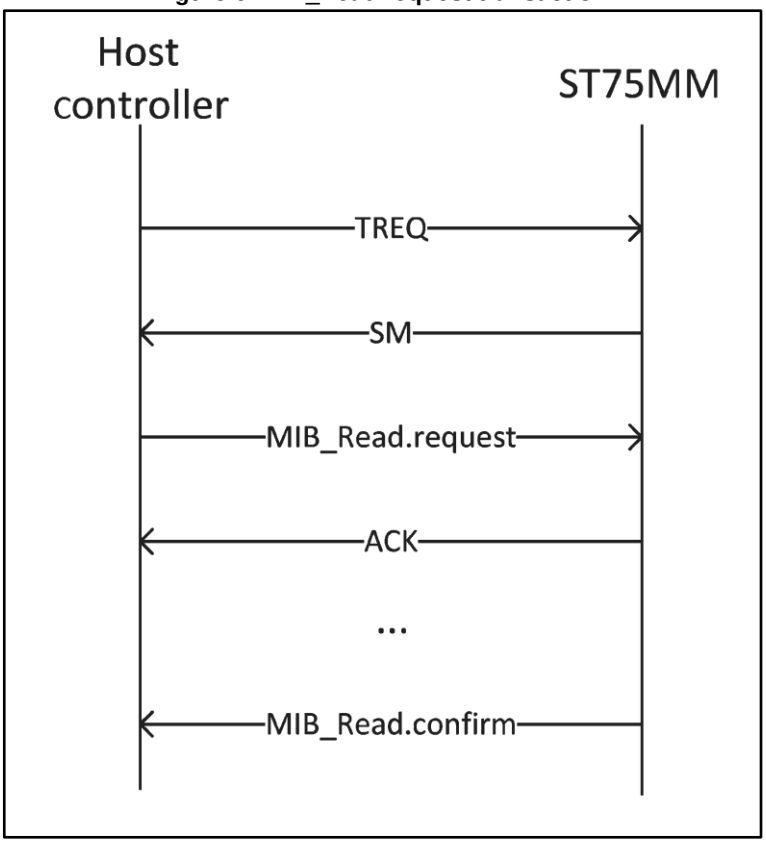
This is an example of the MIB_Write request coming from the host controller, as the initiator is the host controller, the session is started with the negotiation with the ST75MM to gain priority on the serial link

Figure 5: MIB_Write.request transaction



The MIB_Read request coming from the host controller follows the same mechanism as the MIB_Write.

Figure 6: MIB_Read.request transaction



2 Host interface commands

2.1 Commands

The following table is a summary of the available commands, each command will be better specified later on.

Table 5: Available commands

Command	.request	.confirm (positive)	.indication	.confirm (negative)	Description
MIB_Write	0x08	0x09	0x0A	0x0B	Modifies the value of a specific MIB object (.request) or notifies about an internally triggered modification (.indication).
MIB_Read	0x0C	0x0D	-	0x0F	Reads the current value of a specific MIB object.
DL_DATA_SLAVE	-	-	0x26	-	Notifies about data packet received over the power line.
HI_Ping	0x2C	0x2D	-	-	Host interface loop, used to monitor the healthy state of the serial link and modem.
HI_Error	-	-	-	0x36	Notifies about the reception of an unknown command.
BIO_Reset	0x3C	0x3D	0x3E	0x3F	Triggers a SW reset (.request) or notifies about an internally triggered reset event (.indication).

2.2 Error codes

Table 6: List of error codes

Value	Error	Description
0x02	WPL	Wrong argument or parameter length
0x03	WPV	Wrong argument or parameter value
0x04	BUSY	Subsystem which is supposed to perform the operation is busy
0x06	NOT_PRESENT	Subsystem which is supposed to perform the operation is either not present or not connected
0x07	DISABLED	Subsystem which is supposed to perform the operation is disabled
0x08	TIMEOUT	The operation has not been performed in the proper time
0xFF	ERROR	Generic error

2.3 MIB_Write

This command is initiated by the host controller to request a modification on a specific MIB object, the MIB object index and the expected new value are embedded in the payload of the .request message, while the .confirm messages carry the information about the success of the operation. The indication message is issued by the ST75MM modem when some specific MIB objects change their values due to the internal state and events or following a request coming from the PLC.

2.3.1 MIB_Write request

Issued by: host controller

Command code: 0x08

Payload size: variable

Payload content:

- MIB object index (1 byte)
- MIB content (variable)

2.3.2 MIB_Write positive confirm

Issued by: ST75MM

Command code: 0x09

Payload size: 1 byte

Payload content:

- MIB object index (1 byte)

2.3.3 MIB_Write negative confirm

Issued by: ST75MM

Command code: 0x0B

Payload size: 1 byte

Payload content:

- Error code (1 byte)

2.3.4 MIB_Write indication

Issued by: ST75MM

Command code: 0x0A

Payload size: variable

Payload content:

- MIB object index (1 byte)
- MIB value (variable)

2.4 MIB_Read

This command is initiated by the host controller to request the current value of a specific MIB object, the MIB object index is specified in the payload of the .request message, while the .confirm messages hold the MIB object index and its current value.

2.4.1 MIB_Read request

Issued by: host controller

Command code: 0x0C

Payload size: 1 byte

Payload content:

- MIB object index (1 byte)

2.4.2 MIB_Read positive confirm

Issued by: ST75MM

Command code: 0x0D

Payload size: variable

Payload content:

- MIB current value (variable)

2.4.3 MIB_Read negative confirm

Issued by: ST75MM

Command code: 0x0F

Payload size: 1 byte

Payload content:

- Error code (1 byte)

2.5 BIO_Reset

These commands are exchanged when the host controller needs to force a SW reset to the ST75MM modem (request), at the power-on, after a hardware reset or when the ST75MM modem reaches an instability state and internally triggers a SW reset (indication).

2.5.1 BIO_Reset request

Issued by: host controller

Command code: 0x3C

Payload size: 1 byte

Payload content:

- Reserved (1 byte) – set to 0

2.5.2 BIO_Reset positive confirm

Issued by: ST75MM

Command code: 0x3D

Payload size: 1 byte

Payload content:

- Reserved (1 byte)

2.5.3 BIO_Reset negative confirm

Issued by: ST75MM

Command code: 0x3F

Payload size: 1 byte

Payload content:

- Error code (1 byte)

2.5.4 BIO_Reset indication

Issued by: ST75MM

Command code: 0x3E

Payload size: 1 byte

Payload content:

- Reset cause (1 byte)

Table 7: Reset cause byte format

Bit	Field	Value	Description
0-6	Reset cause	0 1 2 3 4 5 6 7 8 - 127	Power-on or HW reset Watchdog SW reset BIO_Reset request PHY error (diagnostic) Timer or zero crossing (diagnostic) Inconsistent state (diagnostic) PHY layer error (diagnostic) Reserved
7	Reconfiguration status	0 1	One or more reconfigurable MIB objects have not been properly reconfigured after reset. All the reconfigurable MIB objects have been correctly reconfigured after reset.

2.6 DL_DATA_SLAVE

The DL_DATA_SLAVE commands provide data communication as a slave node (e.g. the meter in meter to concentrator communication or the customer device in meter to home communication).

2.6.1 DL_DATA_SLAVE indication

Issued by: ST75MM

Command code: 0x26

Payload size: variable

Payload content:

- Protocol type (1 byte)
- Request ID (1 byte)

- Applicative payload (variable)

Only commands having the protocol type equal to 0 shall be processed, if a command with a different protocol type is received it shall be discarded and no action performed.

2.7 HI_Ping

HI_Ping commands can be used to periodically test the serial link between the host controller and the ST75MM modem, and the healthy state of the modem itself. If the HI_Ping fails (once or several times) a hardware reset shall be issued to restore the ST75MM functionalities.

2.7.1 HI_PING request

Issued by: host controller

Command code: 0x2C

Payload size: variable

Payload content:

- Test sequence (variable)

The test sequence can be any possible sequence and length (between 1 and 256).

2.7.2 HI_PING positive confirm

Issued by: ST75MM

Command code: 0x2D

Payload size: variable

Payload content:

- Test sequence (variable)

The test sequence is the same received within the request command.

2.8 HI_Error

This command is issued by the ST75MM when a well formed command frame is received but the command code has not been recognized.

2.8.1 HI_ERROR indication

Issued by: ST75MM

Command code: 0x36

Payload size: 1 byte

Payload content:

- Command code received (1 byte)

3 Management information base (MIB)

3.1 MIB objects

The following table shows the MIB objects present in the ST75MM modem, reserved MIB objects should not be modified and notifications involving those MIB objects can be ignored.

Table 8: MIB objects list

Index[(1)]	Name	Size	Rights[(2)]	Description
1	MAC data	12	RW	Statistical information related to MAC layer
2	PHY configuration	6	RWCS	PHY layer configuration
3	MAC configuration	2	RWCS	MAC layer configuration
6	Manufacturer data	22	RWCS	Node identification parameters
14	HI timings	3	RW	Host interface (UART) timings
18	ZC alarm	1	RWI	No zero crossing detected on mains alarm
23	PHY custom frequency	17	RWC	Custom frequency setting
24	PHY statistics	9	RW	PHY layer statistics

Notes:

(1)Objects not listed here with index in the range (0, 34) are reserved objects, the host controller should avoid to change their values and disregard any MIB_Write indication related to them.

(2)R = read, W = write, C = self-reconfigured at startup, S = affect MIB state in SM, I = can generate spontaneous MIB_Write.indication

Table 9: MAC data MIB object (1)

Byte	Field	Bit	Sub-field	Description and values
0-1	RX stats	-	Refused UW	Counter of incoming packets rejected as MAC was busy
2-3		-	Bad CRC	Counter of incoming packets discarded for wrong CRC
4-5		-	Rx packet	Counter of packets received by MAC
6-7	TX stats	-	Refused packets	Not relevant
8-9		-	Requested packets	Not relevant
10-11		-	Timeouts	Not relevant

Table 10: PHY configuration MIB object (2)

Byte	Field	Bit	Sub-field	Description and values
0	General settings	0	Current control	0: current control disabled 1: current control enabled

Byte	Field	Bit	Sub-field	Description and values
		1	Zero crossing	0: next transmitted frame will start immediately 1: next transmitted frame will start at the next zero crossing event
		2	RX channel	0: single channel operations 1: dual channel operations
		3	TX channel	0: transmit on high channel 1: transmit on low channel
		4-5	Frequency pair	0, 1, 2: reserved 3: custom frequency (see MIB 23 for channel frequencies)
		6	BU enable	0: band in use, detector not enabled 1: band in use, detector enabled
		7	CSMA enable	0: CSMA not enabled 1: CSMA enabled
1		0-4	TX gain	Gain, in dB, applied in transmission
		5-7	TX modulation	Modulation used in transmission: 0 to 3: reserved 4: BPSK coded 5: QPSK coded 6 to 7: reserved
2		0-1	PSK preamble	0:16 bits preamble 1: 24 bits preamble 2: 32 bits preamble 3: 40 bits preamble
		2	RX low channel	Receiving mode for lower channel 0: FSK modulation 1: any PSK modulation
		3	RX high channel	Receiving mode for higher channel 0: FSK modulation 1: any PSK modulation
		4-7	Reserved	-
3-5	Reserved	-	Reserved	-

Table 11: MAC configuration MIB object (3)

Byte	Field	Bit	Sub-field	Description and values
0	RX mode	-	-	0: RX disable 1: RX normal 2 to 255: reserved
1	TX mode	-	-	0: TX disable 1: TX normal 2 to 255: reserved

Table 12: Manufacturer data MIB object (6)

Byte	Field	Bit	Sub-field	Description and values
0-15	Device ID	-	-	Device identification string
16-21	ACA	-	-	Physical address of the node (ACA)

Table 13: Host interface timings MIB object (14)

Byte	Field	Bit	Sub-field	Description and values
0	TSR	-	-	Maximum time (ms) between the SM reception and the start of the request from the host controller
1	TACK	-	-	Maximum time (ms) between the end of the command frame and the start of transmission of the acknowledge byte
2	TIC	-	-	Maximum time (ms) between two characters before an end of the command frame is detected

Table 14: ZC alarm MIB object (18)

Byte	Field	Bit	Sub-field	Description and values
0	ZC Alarm	-	-	0: ZC events on the mains are regular 1: ZC detection on mains failed at least once since the last reset of the attribute

Table 15: PHY custom frequencies MIB object (23)

Byte	Field	Bit	Sub-field	Description and values
0-5	TX frequency	-	-	Set to {0x08, 0x7A, 0xE1, 0x07, 0x0A, 0x3D} for 132.5 kHz / 110 kHz frequency pair
6-11	RX frequencies	-	-	Set to { 0x07, 0xC2, 0x8F, 0x09, 0x5C, 0x29} for 132.5 kHz / 110 kHz frequency pair
12-16	Reserved	-	-	Always set to { 0x00, 0x00, 0x00, 0x00, 0x00 }

Table 16: PHY statistics MIB object (24)

Byte	Field	Bit	Sub-field	Description and values
1-2	PHY statistics	-	Received frames	Counter of received frames
3-4		-	Transmitted frames	Counter of transmitter frames
5-6		-	Refused frames	Counter of frames requested but not transmitted due to errors in the request or the overtemperature state of the modem
7		-	Skipped frames	Counter of frames requested but not transmitted due to busy channel conditions

Byte	Field	Bit	Sub-field	Description and values
8		-	Discarded frames	Counter of frames discarded from the MAC layer due to busy upper layers condition
9		-	Overcurrent events	Number of overcurrent events in the last transmitted frame

4 Configuring the ST75MM

Only the four MIB objects detailed below need to be programmed/monitored to ensure correct operation as receiver-only in the CENELEC 132.5 kHz band.

4.1 PHY configuration (MIB index 2)

In order to configure the ST75MM modem to work as a single channel receiver in the CENELEC 132.5 kHz band the MIB object 2 shall be programmed with the following string:

{0x31, 0x95, 0x0A, 0x3B, 0x58, 0x9B}

Corresponding to the following configuration (selected values are in **bold**).

Table 17: PHY configuration values for CENELEC 132.5 kHz operations

Byte	Field	Bit	Sub-field	Description and values
0	General settings	0	Current control	0: current control disabled **1: current control enabled**
		1	Zero crossing	**0: next transmitted frame will start immediately** 1: next transmitted frame will start at the next zero crossing event
		2	RX channel	**0: single channel operations (only high channel)** 1: dual channel operations
		3	TX channel	**0: transmit on high channel** 1: transmit on low channel
		4-5	Frequency pair	0, 1, 2: reserved **3: custom frequency (see MIB 23 for channel frequencies)**
		6	BU enable	**0: band in use detector not enabled** 1: band in use detector enabled
		7	CSMA enable	**0: CSMA not enabled** 1: CSMA enabled
1		0-4	TX gain	Gain, in dB, applied in transmission, default is 21 dB (TX gain = 21)
		5-7	TX modulation	Modulation used in transmission: 0 to 3: reserved **4: BPSK coded** 5: QPSK coded 6 to 7: reserved
2		0-1	PSK preamble	0:16 bits preamble 1: 24 bits preamble **2: 32 bits preamble** 3: 40 bits preamble
		2	RX low channel	Receiving mode for lower channel **0: FSK modulation** 1: any PSK modulation

Byte	Field	Bit	Sub-field	Description and values
		3	RX high channel	Receiving mode for higher channel 0: FSK modulation **1: any PSK modulation**
		4-7	Reserved	-
3-5	Reserved	-	Reserved	{0x3B, 0x58, 0x9B}

4.2 MAC configuration (MIB index 3)

In order to configure the ST75MM modem to work in the normal MAC mode the MIB object 3 shall be programmed with the following string:

{0x01, 0x00}

Corresponding to the following configuration (selected values are in **bold**).

Table 18: MAC configuration values for CENELEC 132.5 kHz operations

Byte	Field	Bit	Sub-field	Description and values
0	RX mode	-	-	0: RX disable **1: RX normal** 2 to 255: reserved
1	TX mode	-	-	**0: TX disable** 1: TX normal 2 to 255: reserved

4.3 Manufacturer data (MIB index 6)

The modem identifier and the modem address selection are outside the scope of this document, anyhow, as soon as the manufacturer, or the network administrator, or any competent authority, have assigned those values, the host controller shall program it inside the modem by writing the MIB object 6. Until this operation the modem will be capable only of receiving broadcast frames, as no default valid address has been programmed into the ST75MM.

In case no device ID is available, a dummy value could be used, as the only parameter which influences the communication is ACA.

4.4 Custom frequencies (MIB index 23)

In order to configure the ST75MM modem to work as a single channel receiver in the CENELEC 132.5 kHz band the MIB object 2 shall be programmed with the following string:

{0x08, 0x7A, 0xE1, 0x07, 0x0A, 0x3D,

0x07, 0xC2, 0x8F, 0x09, 0x5C, 0x29,

0x00, 0x00, 0x00, 0x00, 0x00}

Which sets as a channel pair the couple (132.5 kHz, 110 kHz), as in single channel operations the ST75MM modem only operates in the high frequency channel.

5 Revision history

Table 19: Document revision history

Date	Revision	Changes
09-Aug-2017	1	Initial release.

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