EM511 M-Bus

M-BUS COMMUNICATION PROTOCOL

Public version

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1. Introduction

The serial interface implemented in EM511_M1 models supports the M-Bus protocol. In this document only the information necessary to read Data Measurement from EM511 _M1 has been reported (not all the parts of the protocol have been implemented).

For more information about the M-Bus protocol, please refer to the web site *Home – M-Bus*.

2. M-Bus functions

The following list contains all the M-Bus functions available in EM511_M1 models:

- Single control character procedure SND_NKE,
- Data Transfer (Request/Respond Procedure REQ/RSP),
- Reset function,
- Switching Baud rate function,
- Changing Primary Address,
- Reset partial energy counters and meters,
- Changing the tariff,
- Primary Data Request (SND_UD).

2.1 Single control character procedure SND_NKE

This procedure is useful to start up the communication either after a communication's interruption or just at the beginning of it. The master sends a Request Frame to Slave which responds with a single character (E5h) if it is correctly addressed. Therefore, SND_NKE is an initialization procedure.

IMPORTANT: it is necessary to use the SND_NKE function to initialize the Slave's answer with the first frame.

Table - 2.1 - Request frame (from master to slave)

Description	Length	Value	Note
Start	1 byte	10h	-
Control	1 byte	40h	-
Physical Address (Slave)	1 byte	1 to FAh (1 to 250)	-
Check Sum	1 byte	-	Check Sum: is the arithmetical sum (without carry) of the Control Field and the Physical Address (Slave).
Stop	1 byte	16h	-

Table - 2.2 - Response frame in case of correct action (from master to slave)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

After the reception of a valid telegram, the Slave has to wait before answering (see also EN13757-3), as shown in the table below:

Table - 2.3 - Three Baud rates available

Baud rate	Min.	Max.
300 Baud	3.6 ms	1.15 s
2400 Baud	4.6 ms	187.5 ms
9600 Baud	1.2 ms	84.4 ms

Response frame in case of incorrect action (From Slave to Master)

When a fault has been detected as a result of the checks (Start/Parity/stop bits per character, Start/Check Sum/Stop Character per telegram format), the transmission shall not be accepted and the reply shall not be sent by the slave to master. The master must interpret the lack of a reply as a fault or wrong address.

2.2 **Request/Respond Procedure (REQ/RSP)**

This procedure is requested from Master to Slave and typically generates the complete data transfer from Slave to Master according to Class 2, EN13757-3. All data are transferred through M-Bus. The complete serial Slave Response take five Long Frames.

IMPORTANT: if the Slave has been previously programmed through a Primary Data Request (SND_UD) then the Request/Respond Procedure (REQ/RSP) returns only the selected data.

Table - 2.4 - Transmission order

Long Frame	Description
#1 (transmitted first)	Energies and Instantanoeus variables measurement
#2	DMD, Max DMD, Positive Partial and Tariff totalizers measurement
#3	Negative totalizers measurement

The DIF byte contains the coding for each transmitted parameter (16-bit integer, 32-bit integer or 64-bit integer). DIFE are used to manage subunit.

VIF/VIFE bytes contain the measurement unit and its multiplier. EM511_M1 uses two categories:

- Primary unit measurement
- Extended unit measurement

Each Data measurement available in EM511_M1 is packed with its DIF, DIFE, VIF, VIFE, Data field. This last contains the numerical representation of the measured value. DIFE are not present if the measurement subunit is 0. Transmission order is shown in Table 1. In the Data Field, the LSB is transmitted/received first.

Table - 2.5 - Request frame (from master to slave) - REQ_UD2 → RSP_UD

Description	Length	Value	Note
Start	1 byte	10h	-
Control	1 byte	01FV1011b	F = FCB-Bit V = FCV-Bit (set to one if the FCB/FCV protocol is active)
Physical Address (Slave)	1 byte	1 to FAh (1 to 250)	-
Check Sum	1 byte	-	Check Sum; is the arithmetical sum (without carry) of the Control Field and the Physical Address (Slave)
Stop	1 byte	16h	-

Table - 2.6 - Response frame in case of correct action (from master to slave)

Description	Length	Value	Note
Start	1 byte	68h	-
L Field	1 byte	-	L Field: is the bytes' number calculated starting from the Control Field up to the MDH Field (if the latter is present; otherwise up to the last byte of the Data User).
L Field	1 byte	-	See above.
Start	1 byte	68h	-
Control	1 byte	08h	-
Physical Address (Slave)	1 byte	1 to FAh (1 to 250)	-
CI	1 byte	72h	-
Ident. Nr.	4 Byte	-	-
Manufr.	2 Byte	1C36h	"GAV", ID Manuf. according to EN60870
Version	1 Byte	-	Read from EM511_M1
Medium	1 Byte	02h	02h = Electricity
Access No.	1 Byte	-	Incremented after each REQ_UD2 procedure
Status	1 Byte	-	See relevant paragraph
Signature	2 Byte	00h	It is always 00 for all
DIF	1 byte	-	Coding of the first transmitted value
DIFE	1 byte	-	Coding of sub-unit only (optional, max #4 DIFE)
VIF	1 byte	-	Unit and Multiplier of the first transmitted value
VIFE	1 byte	-	Unit and Multiplier of the first transmitted value (optional, max #4 VIFE)
Data	2, 4 or 8 byte	-	First transmitted value (single measure)
….	…	…	-
MDH	1 Byte	1Fh	In the last Long Frame of the slave the questioned byte is 0Fh. The latter (0Fh) indicates that the slave has been completely read.
Check Sum	1 byte	-	Check Sum: is the arithmetical sum (without carry) starting from Control Field to the MDH Field (if present, otherwise the last Data byte)
Stop	1 byte	16h	-

IMPORTANT: each transferred measurement requires: DIF, DIFE (optional), VIF, VIFE (optional) and Data (2, 4 or 8 Byte). See also Table 2.4.

The device supports the FCB/FCV-bit transfer protocol. This mechanism is activated if the FCV-bit is set to one in the Request Frame generated by the Master, otherwise the mechanism is ignored by the Slave. The FCB/FCV protocol allows a safer transfer from Slave to Master when the Slave response has more than one Long Frame. After a SND_NKE Procedure, the Master transmits in the REQ_UD2 → RSP_UD a Control Field with FCB-bit set to one (Control Field = 7Bh) and the Slave will reply with the first Long Frame. If this data is correctly received from the Master, the Master itself will send to the Slave a new Request Frame with the FCB-bit cleared (Control Field = 5Bh), hence the Slave will send the next Long Frame. On the contrary, if the Master did not correctly receive the first Long Frame from the Slave, it can send to the Slave the Control Field = 7Bh another time, in this way the Slave will repeat the First Long Frame. The same is valid for the Second Long Frame. The last Long Frame transmitted by the Slave does not have the MDH Field or has MDH field = 0Fh, this absence/value has to be interpreted by the Master as the receipt of the last Long Frame from the Slave. After a SND_NKE procedure, the slave is always set on the first frame, even if the last transmitted frame was not the last.

“Version” Field, which is directly read from the device, gives the instrument version:

Table - 2.7 - Version field

“Version” Field (decimal)	Device
224	EM511_M1 -DIN

The meter supports the “secondary address” addressing and its research through the wild card. The latter corresponds:

- to the nibble “Fh” and can substitute one BCD digit of the identification number ,
- to the byte “FFh” and can substitute a byte in Manufacturer field, Version field or Medium field,

so that, during the slave’s selection, it can be ignored. It is so possible to address groups of slaves whose secondary address (Identification number + Manufacturer field + Version field + Medium field) is the same except for the wild card. An appropriate algorithm allows the master to identify all slaves among those present in the network.
The sub unit function allows to mark electrical variables with the same engineering unit (for example: Wsys, WL1, WL2 and WL3 whose engineering unit is Watt). The meter supports the sub-unit.

2.3 Reset function

This function code is used by the Master and resets the Slave. After a Reset, the FCB/FCV-bit mechanism is re-initialized. Also, a Primary Data Request is automatically de-selected.

Table - 2.8 - Request frame (from master to slave)

Description	Length	Value	Note
Start	1 byte	68h	-
L	1 byte	03h	-
L	1 byte	03h	-
Start	1 byte	68h	-
Control	1 byte	53h or 73h	-
Physical Address (Slave)	1 byte	1 to FAh (1 to 250)	-
CI	1 byte	50h	Application Reset Code
Check Sum	1 byte	-	Check Sum: is the arithmetical sum (without carry) of Control Field, Physical Address (Slave) and CI-Field.
Stop	1 byte	16h	-

Table - 2.9 - Response frame (from master to slave)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.4 Switching Baud rate Function

The Master can set the Slave's Baud rate. 300, 2400 and 9600 BAUD are available (2400 is the default value). The Slave confirms the correctly received request by transmitting the E5h character with the old baud rate and uses the new baud rate from now on. It is necessary to wait at least 2 seconds after receiving the slave answer in order to EM511_M1 is able to use the new baud rate.

Table - 2.10 - Request frame (from master to slave)

Description	Length	Value	Note
Start	1 byte	68h	-
L	1 byte	03h	-
L	1 byte	03h	-
Start	1 byte	68h	-
Control	1 byte	53h or 73h	-
Physical Address (Slave)	1 byte	1 to FAh (1 to 250)	-
CI	1 byte	B8h/BBh/BDh	B8h = 300 BAUD, BBh = 2400 BAUD, BDh = 9600 BAUD
Check Sum	1 byte	-	Check Sum is the arithmetical sum (without carry) of Control Field, Physical Address (Slave) and CI-Field.
Stop	1 byte	16h	-

Table - 2.11 - Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.5 Changing Primary Address

The Master can set the primary address of the Slave. The Slave confirms the correctly received request by transmitting the E5h character and uses the new address from now on. It is necessary to wait at least 2 seconds after receiving the slave answer in order to EM511_M1 is able to use the new primary address.

Table - 2.12 - Request frame

Description	Length	Value	Note
Start	1 byte	68h	-
L	1 byte	06h	-
L	1 byte	06h	-
Start	1 byte	68h	-
Control	1 byte	53h or 73h	-
Physical Address (Slave)	1 byte	0 to FAh (0 to 250)	-
CI	1 byte	51h	-
DIF	1 byte	01h	-
VIF	1 byte	7Ah	-
New Physical Address (Slave)	1 byte	0 to FAh (0 to 250)	-
Check Sum	1 byte	-	Check Sum is the arithmetical sum (without carry) of Control Field, Physical Address (Slave) and CI-Field, DIF, VIF and New Physical Address (Slave)
Stop	1 byte	16h	-

Table - 2.13 - Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.6 Reset partial energy counters and meters

The Master can reset partial energy counters and meters of the Slave using a command with a Manufacturer-specific VIFE. The Slave confirms the correctly received request by transmitting the E5h character. This command resets:

- Partial kWh (+),
- Partial kWh (-),
- Partial kvarh (+),
- Partial kvarh (-),
- Partial kVAh,
- Partial run hour meter (+),
- Partial run hour meter (-);

Table - 2.14 - Request frame

Description	Length	Value	Note
Start	1 byte	68h	-
L	1 byte	07h	-
L	1 byte	07h	-
Start	1 byte	68h	-
Control	1 byte	53h or 73h	-
Physical Address (Slave)	1 byte	0 to FAh (0 to 250)	-
CI	1 byte	51h	-
DIF	1 byte	01h	-
VIF	1 byte	FFh	-
VIFE	1 byte	50h	Manufacturer specific VIFE
Coding of available reset	1 byte	01h	Coding of available reset: 01h: Partial energy counters and meters
Check Sum	1 byte	-	Check Sum is the arithmetical sum (without carry) of Control Field, Physical Address (Slave), CI-Field, DIF, VIF, VIFE and coding of available reset
Stop	1 byte	16h	-

Table - 2.15 - Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.7 Changing the tariff

The master can change the current slave tariff between available tariffs (t1, t2), provided that the digital input is not configured for tariff management. If the digital input is configured as such, the slave does not answer.
The device saves the last configured tariff to be restored after a power off.
The special frame for changing the tariff is the following:

Table - 2.16 - Request frame

Description	Length	Value	Note
Start	1 byte	68h	-
L	1 byte	07h	-
L	1 byte	07h	-
Start	1 byte	68h	-
Control	1 byte	53h or 73h	-
Physical Address (Slave)	1 byte	0 to FAh (0 to 250)	-
CI	1 byte	51h	-
DIF	1 byte	01h	-
VIF	1 byte	FFh	-
VIFE	1 byte	13h	Manufacturer specific VIFE
New tariff	1 byte	01h or 02h	New tariff value: 01h: Tariff 1 02h: Tariff 2
Check Sum	1 byte	-	Check Sum is the arithmetical sum (without carry) bytes between Control and New tariff (included)
Stop	1 byte	16h	-

Table - 2.17 - Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.8 Primary Data Request (SND_UD)

The Master unit can acquire only a partition of all data stored in the energy meter EM511_M1 and EM512, by specifying the desired VIF, VIFE in a Primary Data Request procedure. It is possible to program the Slave in order to obtain one or more measurement up to 20. The slave confirms the request with the E5h character. From now onwards, each REQ_UD2 → RSP_UD shall generate the transfer of the only selected data instead of all Data Slave. For example, with 08h, FDh, 48h, the Master programs the Slave to obtain only the Volt*10 Data. With 08h, FBh, 2Eh only the Hz*10 measurement will be obtained. With the string : 08h, FDh, 48h, 08h, FBh, 2Eh both Volt*10 and Hz*10 are programmed. Note that the Data response is generated only starting from the next REQ_UD2 → RSP_UD. The Slave Response could take more than a Long Frame, in this case the FCB/FCV-bit Protocol should be activated from the Master.

Table - 2.18 - Request frame (from Master to Slave)

Description	Length	Value	Note
Start	1 byte	68h	
L	1 byte	-	L Field is the number of byte calculated starting from the Control Field up to the last byte of the Data User.
L	1 byte	-	See above.
Start	1 byte	68h	-
C	1 byte	53h or 73h	-
Physical Address	1 byte	1 to FAh (1 to 250)	-
CI	1 byte	51h	-
Selector char	1 byte	08h	-
Requested VIF #1	1 byte	-	-
Requested VIFE #1 (if present)	1 byte	-	-
Requested VIFE #1 (if present)	1 byte	-	-
Requested VIFE #1 (if present)	1 byte	-	-
Selector char	1 byte	08h	-
Requested VIF #2	1 byte	-	-
Requested VIFE #2 (if present)	1 byte	-	-
Requested VIFE #2 (if present)	1 byte	-	-
Requested VIFE #2 (if present)	1 byte	-	-
…	…	…	…
Check Sum	1 byte	-	Check Sum is the arithmetical sum (without carry) starting from the Control Field until to the last requested VIF (or VIFE)
Stop	1 byte	16h	-

Table - 2.19 - Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	-

2.9 Special Addresses

Primary test address = Feh: is a test address, the slave always answers to the special address if no errors are present. The Slave answer contains its own Primary Address. The address FEh is normally used for point to point communication.

Primary broadcast address = FFh: is a broadcast address, the slave executes the request received from the Master without generating any response on the M-Bus. Used by master for SND_NKE and Reset function.

Primary address = FDh: it is used by the master when questioning slaves using the secondary address instead of the primary address.

Primary address = 0h: should only be used for new meters which haven't yet been configured. EM511_M1 manages this address as a valid address to help the commissioning of the network but it is recommended not to use it during the normal work of the meter. This is the reason why in all M-Bus functions except for the changing primary address request, the validity range of the primary address is [1 ; 250] and not [0 ; 250] even if primary address 0 works if it is the set primary address in the instrument. This address could be set during calibration of instrument as default setting and via a changing primary address request by M-Bus master. It is not possible setting this address using display programming mode.

2.10 Status byte

Status byte is a byte of flags used by slave in REQ/RSP procedure and defined in EN13757-3:2013:

Table - 2.20 - Coding of the status field

Bit	Meaning with bit set	Description	Significance with bit set
0,1	See Table - 2.17	See Table - 2.17	See Table - 2.17
2	Power low	Warning - The bit “power low” 1s set only to signal interruption of external power supply or the end of battery life.	Power ok
3	Permanent error	Failure - The bit "permanent error" is set only if the meter signals a fatal device error (which requires a service action). Errar can be rese! only by a service action.	No permanent error
4	Temporary error	Warning - The bit "temporary error" is set only if the meter signals a slight error condition (which not immediately requires a service action). This error condition may later disappear.	No temporary error
5	Specific to manufacturer	-	Specific to manufacturer
6	Specific to manufacturer	-	Specific to manufacturer
7	Specific to manufacturer	-	Specific to manufacturer

Table - 2.21 - Coding of the status field

Bit	Significance with bit set	Description
0 0	No error	-
0 1	Application busy	-
1 0	Any application error	Shall be used lo communicate a failure during the interpretation or the execution of a received command, e.g. if a not decrypt able message was received.
1 1	Abnormal condition / alarm	Shall be used if a correct working application detects an abnormal behaviour like a permanent flow or water by a water meter.

Table - 2.22 - EM511 managed bit

Bit	Allowed values	Note
0, 1	0 0: no error 1 1: abnormal condition	-
6	0: digital input set to 0 (Open) 1: digital input set to 1 (Closed)	-
7	0: virtual alarm set to 0 (no alarm) 1: virtual alarm set to 1 (alarm triggered)	-

Abnormal condition happens when an overflow condition occurs to at least one of the following variables:

- Voltage,
- Current,
- System frequency.

3. Data format representation In Carlo Gavazzi instruments

3.1 Data format representation In Carlo Gavazzi instruments

The variables are represented by integers or floating numbers, with 2's complement notation in case of "signed" format, using the following:

Table 3.1 - Data format

Format	IEC data type	Description	Bits	Range
INT16	INT	Integer	16	-32768 .. 32767
UINT16	UINT	Unsigned integer	16	0 .. 65535
INT32	DINT	Double integer	32	-2^{31} .. 2^{31}
UINT32	UDINT	Unsigned double int	32	0 .. 2^{32-1}
UINT64	ULINT	Unsigned long integer	64	0 .. 2^{64-1}
IEEE754 SP		Single-precision floating-point	32	$-(1+[1-2^{-23}])x2^{127}$ .. 2^{128}

For all the formats the M-Bus byte order always is LSB->MSB (the LSB is transmitted/received first), as described in EN 60870-5-4 standard.

IEEE754 SP data format is not managed by EM511_M1.

3.2 Available part number (M-Bus models)

Table 3.2 - Data format

Part Number	Family	Sub Family	FW	Note
EM511DINAV81XM1X	EM511-AV8	X	1.0.0	EM511 – 240 VLL / 45 A - M1 Module - standard
EM511DINAV81XM1PFA	EM511-AV8	PFA	1.0.0	EM511 – 230 VLL / 45 A - M1 Module - MID PFA
EM511DINAV81XM1PFB	EM511-AV8	PFB	1.0.0	EM511 – 230 VLL / 45 A - M1 Module - MID PFB

4. TABLES

4.1 Instantaneous variables and meters

IMPORTANT: colours highlight the type of M-Bus code:

= Primary M-Bus Codes
= Extension of Primary M-Bus Codes

Table 4.1 - Frame #1 (transmitted first)

Length (byte)	VARIABLE ENG. UNIT	Data Format	Notes	#SUB UNIT	VIF byte	VIFE #1 byte	VIFE #2 byte
4	KWh (+) TOT	INT32	Engineering unit: Wh	0	0x03	-	
4	Kvarh (+) TOT	INT32	Engineering unit: kVarh*0,001	0	0xFB	0x82	0x73
4	W	INT32	Engineering unit: Watt*10	0	0x2A	-	
4	VAR	INT32	Engineering unit: kVar*0.0001	0	0xFB	0x97	0x72
4	VA	INT32	Engineering unit: kVA*0.0001	0	0xFB	0xB7	0x72
4	A L	INT32	Engineering unit: Ampere *0.001	0	0xFD	0x59	-
4	V L-N	INT32	Engineering unit: Volt *0.1	0	0xFD	0x48	-
2	PF	INT16	Negative values correspond to exported active power Positive values correspond to imported active power Engineering unit: PF*0.001	0	0xFD	0xBA	0x73
2	Hz	INT16	Engineering unit: Hz*0.1	0	0xFB	0x2E	-

Table 4.2 - Frame #2

Length (byte)	VARIABLE ENG. UNIT	Data Format	Notes	#SUB UNIT	VIF byte	VIFE #1 byte	VIFE #2 byte
4	DMD W	INT32	Engineering unit: Watt*10	1	0x2A	-	-
4	DMD W max	INT32	Engineering unit: Watt*10	2	0x2A	-	-
4	KWh (+) PAR	INT32	Engineering unit: Wh	1	0x03	-	-
4	KWh (+) tariff 1	INT32	Engineering unit: Wh	3	0x03	-	-
4	KWh (+) tariff 2	INT32	Engineering unit: Wh	4	0x03	-	-

Table 4.3 - Frame #3

Length (byte)	VARIABLE ENG. UNIT	Data Format	Notes	#SUB UNIT	VIF byte	VIFE #1 byte	VIFE #2 byte
4	KWh (-) TOT	INT32	Engineering unit: Wh	2	0x03	-	-
4	Kvarh (-) TOT	INT32	Engineering unit: kVarh*0,1	2	0xFB	0x82	0x73
4	Hour meter +	INT32	Engineering unit: Hour*0.01	0	0xA6	0x74	-
4	Hour meter -	INT32	Engineering unit: Hour*0.01	1	0xA6	0x74	-
4	Lifetime	INT32	Engineering unit: Hour*0.01	2	0xA6	0x74	-
4	DMD VA	INT32	Engineering unit: kVA*0.0001	1	0xFB	0xB7	0x72
4	DMD VA max	INT32	Engineering unit: kVA*0.0001	2	0xFB	0xB7	0x72
4	DMD A max	INT32	Engineering unit: Ampere*0.001	2	0xFD	0x59	-

4.2 M-Bus Measurement Unit Coding (VIF/VIFE).

Table 4.4 - Unit coding

Engineering Unit	VIF	VIFE #1	VIFE #2	Notes
Watt*0.1	00101010b = 2Ah	-	-	PRIMARY MBUS CODES
Wh	00000011b = 03h	-	-	
Wh*100	00000101b = 05h	-	-	
Hour*0.01 (operating time)	10100110b = A6h	01110100b = 74h	-	
Volt*0.1	11111101b = FDh	01001000b = 48h	-	EXTENSION OF PRIMARY MBUS CODES
Ampere * 0.001	11111101b = FDh	01011001b = 59h	-	
PF*0.001 (dimensionless)	11111101b = FDh	10111010b = BAh	01110011b = 73h	
THD*0.01 (dimensionless)	11111101b = FDh	10111010b = BAh	01110100b = 74h	
Hz * 0.1	11111011b = FBh	00101110b = 2Eh	-	
Kvarh * 0.001	11111011b = FBh	10000010b = 82h	01110011b = 73h	
Kvar * 0.0001	11111011b = FBh	10010111b = 97h	01110010b = 72h	
kVA * 0.0001	11111011b = FBh	10110111b = B7h	01110010b = 72h	

4.3 Manufacturer-specific VIFE

Note: these VIFEs are introduced by the standard VIF FFh

Table 4.5 - VIF and VIFE coding

Description	VIF (standard)	VIFE (Manufacturer-specific)
Reset counters and meters	11111111b = FFh	01010000b = 50h
Change tariff	11111111b = FFh	00010011b = 13h

5. Revisions

Revisions	Date	Authors	Note
Rev. 1.0	16/07/2025	-	Reorganization of the document layout. No content has been changed.