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# EM111-EM112

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## M-BUS COMMUNICATION PROTOCOL

Revision 4.2

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## 1.1 Introduction

The serial interface implemented in EM111 and EM112 models supports the M-Bus protocol. In this document only the information necessary to read Data Measurement from EM111 and EM112 has been reported (not all the parts of the protocol have been implemented).

## 1.2 M-BUS functions

The below reported functions are available on EM111 and EM112:

- Single control character procedure SND\_NKE
- Data Transfer (Request/Respond Procedure REQ/RSP)
- Reset function
- Switching Baudrate function
- Changing Primary Address
- Primary Data Request (SND\_UD)

### 1.2.1 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.

It is necessary to use the SND\_NKE function to initialize the Slave's answer with the first frame.

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 F7h (1 to 247)	
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	

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

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 (three Slave BAUDRATEs are available).

BAUD RATE	Min.	Max.
300 BAUD	36,6 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.

### 1.2.2 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 four Long Frames. 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.

Long Frame	EM111 and EM112
#1 (transmitted first)	Energy Measurement – Instantaneous variables
#2	Partial and Tariff meters

The DIF byte contains the coding for each transmitted parameter (32-bit integer or 16-bit integer). VIF/VIFE bytes contain the measurement unit and its multiplier. There are three categories:

- Primary unit measurement
- Extended unit measurement
- User's measurement

Each Data measurement available in EM111 and EM112 is packed with its DIF, VIF, VIFE, Data field, this last contains the numerical representation of the measured value. VIFE is not present in case of Primary unit measurement. Transmission order is shown in Table 1. In the Data Field, the LSB is transmitted/received first.

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 F7h (1 to 247)	
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	

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

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 F7h (1 to 247)	
CI	1 byte	72h	
Ident. Nr.	4 Byte		
Manufr.	2 Byte	1C36h	"GAV", ID Manuf. according to EN60870
Version	1 Byte		Read from EM111 and EM112
Medium	1 Byte	02h	02h = Electricity
Access No.	1 Byte		Incremented after each REQ_UD2 procedure
Status	1 Byte		
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 (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)
Data	2 or 4 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	

NOTE: each transferred measurement requires: DIF, DIFE (optional), VIF, VIFE (optional) and Data (2 or 4 Byte).

See also Table 1



The device supports the **FCB/FCV-bit transfer protocol**. This mechanism is activated if the FCB-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, this absence 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:

“Version” Field (decimal)	Device
196	EM111 -DIN
197	EM112-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 secondary address so that, during the slave’s selection, it can be ignored. It is so possible to address groups of slaves whose secondary address 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 W, which engineering unit is Watt). The meter supports the sub-unit, give a look at Table 2.

### 1.2.3 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.

#### Request frame

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 F7h (1 to 247)	
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	

#### Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	

### 1.2.4 Switching Baudrate Function

The Master can set the Slave’s Baud rate to a different value from 300 BAUD, 2400 and 9600 BAUDs are available (2400 is the default value). The Slave confirms the correctly received request by transmitting the E5h character and the old baudrate and uses the new baudrate from now on.

### Request frame

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 F7h (1 to 247)	
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	

### Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	

### 1.2.5 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.

#### 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	1 to F7h (1 to 247)	
CI	1 byte	51h	
DIF	1 byte	01h	
VIF	1 byte	7Ah	
New Physical Address (Slave)	1 byte	1 to F7h (0 to 247)	
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	

### Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	

### 1.2.6 Primary Data Request (SND\_UD)

The Master unit can acquire only a partition of all data stored in the energy meter EM111 and EM112, 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, FFh, 03h only the Hz\*10 measurement will be obtained. With the string : 08h, FDh, 48h, 08h, FFh, 03h 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.

## 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 F7h (1 to 247)	
CI	1 byte	51h	
Selector char	1 byte	08h	
Requested VIF #1	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		
...	...	...	...
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	

## Response frame (correct action)

Description	Length	Value	Note
Confirm Character	1 byte	E5h	

### 1.2.7 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

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

## 2 TABLES

### 2.1 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:

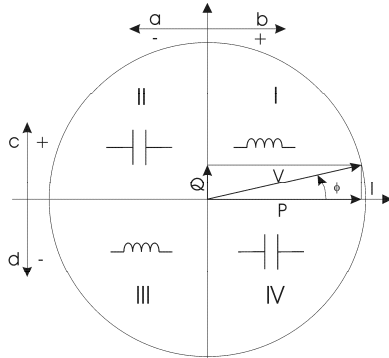
Format	IEC data type	Description	Bits	Range
INT16	INT	Integer	16	-32768 .. 32767
UINT16	UINT	Unsigned integer	16	0 .. 65535
INT32	DINT	Double integer	32	$-2^{31} .. 2^{31}$
UINT32	UDINT	Unsigned double int	32	$0 .. 2^{32}-1$
UINT64	ULINT	Unsigned long integer	64	$0 .. 2^{64}-1$
IEEE754 SP		Single-precision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

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.



2.2 Geometric representation

According to the signs of the power factor, the active power P and the reactive power Q, it is possible to obtain a geometric representation of the power vector, as indicated in the drawing below, according to EN 60253-23:



- a = Exported active power
- b = Imported active power
- c = Imported reactive power
- d = Exported reactive power

Fig. 1 : Geometric Representation

According to the measurement mode (easy connection or bidirectional), the following sign convention is used in EM100 SERIES.

- Easy connection mode
  - o I always >0
  - o P always >0
  - o kWh always increasing (correspondent to Annex D option PFB)
  - o **kvarh increases only when Q>0**
  - o PF only with C and L (without sign) indication
- Bidirectional mode
  - o I < or >0 (with indication of “-“ sign)
  - o P < or >0 (with indication of “-“ sign)
  - o kWh+ increasing only when P > 0 (correspondent to Annex D option PFA)
  - o kWh- increasing only when P < 0
  - o kvarh+ increasing only when Q > 0
  - o kvarh- increasing only when Q < 0
  - o PF with ±C or ±L indication

Application	Real measurement	Displayed values	Displayed energies	Notes
Easy connection mode	Quadrant I	A, W, var, L PF	kWh increases, kvarh increases	Measurement A or PFA models
	Quadrant II	A, W, -var, C PF	kWh increases, kvarh <b>does not</b> increase	Measurement A or PFA models
	Quadrant III	A, W, var, L PF	kWh increases, kvarh increases	Measurement A or PFA models
	Quadrant IV	A, W, -var, C PF	kWh increases, kvarh <b>does not</b> increase	Measurement A or PFA models
Bidirectional mode	Quadrant I	A, W, var, +L PF	kWh+ increases, kvarh+ increases	Measurement B or PFB models
	Quadrant II	-A, -W, +var, -C PF	kWh- increases, kvarh+ increases	Measurement B or PFB models
	Quadrant III	-A, -W, -var, -L PF	kWh- increases, kvarh- increases	Measurement B or PFB models
	Quadrant IV	A, W, -var, +C PF	kWh+ increases, kvarh- increases	Measurement B or PFB models



### 2.3 Maximum and minimum electrical values

The maximum electrical input values are reported in the following table. If the input is above the maximum value the display shows “EEE”.

Table 2.3-1 – EM111 and EM112 (MID and non MID versions)

	AV7 input		AV8 input		AV0 input		AV1 input	
	Max value	Min value	Max value	Min value	Max value	Min value	Max value	Min value
VL-N	156V	0	299V	0	299V	0	156V	0
A	54A	0	54A	0	120A	0	120A	0

The overflow indication “EEE” is displayed when the MSB value of the relevant variable is 7FFFh.  
The overflow indication “-EEE” is displayed when the MSB value of the relevant variable is 8000h.

## 2.4 Instantaneous variables and meters

Table 1 - EM111 and EM112-DIN

Length (byte)	VARIABLE ENG. UNIT	Data Format	Notes	#SUB UNIT	VIF byte	VIFE byte
<b>FRAME #1 (transmitted first)</b>						
4	KWh (+) TOT	INT32	Engineering unit: Wh*100	0	1	-
4	Kvarh (+) TOT	INT32	Engineering unit: kVarh*0,1	0	1	2
4	W	INT32	Engineering unit: Watt*0.1	0	1	-
4	VAR	INT32	Engineering unit: kVar*0.0001	0	1	2
4	VA	INT32	Engineering unit: kVA*0.0001	0	1	2
4	A L	INT32	Engineering unit: Ampere *0.001	0	1	1
4	V L-N	INT32	Engineering unit: Volt *0.1	0	1	1
2	PF	INT16	Negative values correspond to exported active power, positive values correspond to imported active power. Engineering unit: PF*0.001	0	1	2
2	Hz	INT16	Engineering unit: Hz*0.1	0	1	1
<b>FRAME #2</b>						
4	DMD W	INT32	Engineering unit: Watt*0.1	1	1	-
4	DMD W max	INT32	Engineering unit: Watt*0.1	2	1	-
4	KWh (+) PAR	INT32	Engineering unit: Wh*100	1	1	-
4	Kvarh (+) PAR	INT32	Engineering unit: kVarh*0,1	1	1	2
4	KWh (+) tariff 1	INT32	Engineering unit: Wh*100	3	1	-
4	KWh (+) tariff 2	INT32	Engineering unit: Wh*100	4	1	-
4	KWh (+) tariff 3 (n.a. in EM111-112)	INT32	Engineering unit: Wh*100	5	1	-
4	KWh (+) tariff 4 (n.a. in EM111-112)	INT32	Engineering unit: Wh*100	6	1	-
<b>FRAME #3</b>						
4	KWh (-) TOT	INT32	Engineering unit: Wh*100	2	1	-
4	Kvarh (-) TOT	INT32	Engineering unit: kVarh*0,1	2	1	2
4	Hour (n.a. in EM111-112)	INT32	Engineering unit: Hour*0.01	0	1	1
4	DMD VA (n.a. in EM111-112)	INT32	Engineering unit: kVA*0.0001	1	1	2
4	DMD VA max (n.a. in EM111-112)	INT32	Engineering unit: kVA*0.0001	2	1	2
4	DMD A max (n.a. in EM111-112)	INT32	Engineering unit: Ampere*0.001	2	1	1

Table 2 –EM111 and EM112 M-Bus Measurement Unit Coding (VIF/VIFE).

Measurement Unit	VIF	VIFE #1	VIFE #2	
Watt*0.1	00101010b = 2Ah	-	-	<b>PRIMARY M-BUS CODES</b>
Wh*100	00000101b = 05h	-	-	
Hour*0.01 (operating time)	10100110b = A6h	01110100b = 74h	-	
Volt*0.1	11111101b = FDh	01001000b = 48h	-	<b>EXTENSION OF PRIMARY M-BUS CODES</b>
Ampere * 0.001	11111101b = FDh	01011001b = 59h	-	
PF*0.001 (dimensionless)	11111101b = FDh	10111010b = BAh	01110011b = 73h	
Hz * 0.1	11111011b = FBh	00101110b = 2Eh	-	
Kvarh * 0.1	11111011b = FBh	10000010b = 82h	01110101b = 75h	
Kvar * 0.0001	11111011b = FBh	10010111b = 97h	01110010b = 72h	
kVA * 0.0001	11111011b = FBh	10110111b = B7h	01110010b = 72h	

Colors:



= Primary M-Bus Codes



= Extension of Primary M-Bus Codes



= Manufacturer-Specific



### **3 REVISIONS**

- From rev. 4.0 to 4.1:
  - updating of the electrical limits in “2.3 Maximum and minimum electrical values”
- From rev. 4.1 to 4.2:
  - correction of the normative related to the “dedicated application layer”.