EM210

COMMUNICATION PROTOCOL
PFA and PFB Models

Version 4 Revision 3

October 30th, 2019

Index

1.1 Introduction

The RS485 serial interface supports the MODBUS/JBUS (RTU) protocol. In this document only the information necessary to read/write from/to EM210 has been reported (not all the parts of the protocol have been implemented).
For a complete description of the MODBUS protocol please refer to the "Modbus_Application_Protocol_V1_1a.pdf" document that is downloadable from the www.modbus.org web site.

1.2 MODBUS functions

These functions are available on EM210:

- Reading of n "Holding Registers" (code 03h)
- Reading of n "Input Register" (code 04h)
- Writing of one "Holding Registers" (code 06h)
- Diagnostic (code 08h with sub-function code 00h)
- Broadcast mode (writing instruction on address 00h)

IMPORTANT:

1) In this document the "Modbus address" field is indicated in two modes:
   1.1) "**Modicom address**": it is the "6-digit Modicom" representation with Modbus function code 04 (Read Input Registers). It is possible to read the same values with function code 03 (Read Holding Registers) replacing the first digit ("3") with the number "4".
   1.2) "**Physical address**": it is the "word address" value to be included in the communication frame.
2) The functions 03h and 04h have exactly the same effect and can be used indifferently.
3) The communication parameters are to be set according to the configuration of the instrument (refer to EM210 instruction manual)

Function 03h (Read Holding Registers)

This function is used to read the contents of a contiguous block of holding registers (word). The Request frame specifies the starting register address and the number of registers to be read. It is possible to read maximum 61 registers (words) with a single request, when not differently specified.
The register data in the response message are packed as two bytes per register (word), with the binary contents right justified within each byte. For each register, the first byte contains the high order bits (MSB) and the second contains the low order bits (LSB).

Request frame

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	03h	
Starting address	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
Quantity of registers (**N** word)	2 bytes	1 to 10h (1 to 11)	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (correct action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	03h	
Quantity of requested bytes	1 byte	**N** word * 2	
Register value	**N***2 bytes		Byte order: MSB, LSB
CRC	2 bytes		

Response frame (incorrect action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	Possible exception : 01h: illegal function 02h: illegal data address 03h: illegal data value 04h: slave device failure
Function code	1 byte	83h	
Exception code	1 byte	01h, 02h, 03h, 04h (see note)	
CRC	2 bytes		

Function 04h (Read Input Registers)

This function code is used to read the contents of a contiguous block of input registers (word). The Request frame specifies the starting register address and the number of registers to be read. It is possible to read maximum 61 register (word) with a single request, when not differently specified.
The register data in the response message are packed as two bytes per register (word), with the binary contents right justified within each byte. For each register, the first byte contains the high order bits (MSB) and the second contains the low order bits (LSB).

Request frame

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	04h	
Starting address	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
Quantity of registers (**N** word)	2 bytes	1 to 10h (1 to 11)	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (correct action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	04h	
Quantity of requested bytes	1 byte	**N** word * 2	
Register value	**N***2 bytes		Byte order: MSB, LSB
CRC	2 bytes		

Response frame (incorrect action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	Possible exception : 01h: illegal function 02h: illegal data address 03h: illegal data value 04h: slave device failure
Function code	1 byte	84h	
Exception code	1 byte	01h, 02h, 03h, 04h	
CRC	2 bytes		

Function 06h (Write Single Holding Register)

This function code is used to write a single holding register. The Request frame specifies the address of the register (word) to be written and its content.
The correct response is an echo of the request, returned after the register content has been written.

Request frame

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	06h	
Starting address	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
Register value	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (correct action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	06h	
Starting address	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
Register value	2 bytes	0000h to FFFFh	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (incorrect action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	Possible exception : 01h: illegal function 02h: illegal data address 03h: illegal data value 04h: slave device failure
Function code	1 byte	86h	
Exception code	1 byte	01h, 02h, 03h, 04h	
CRC	2 bytes		

Function 08h (Diagnostic with sub-function code 00h)

MODBUS function 08h provides a series of tests to check the communication system between a client (Master) device and a server (Slave), or to check various internal error conditions in a server.
EM210 supports only 0000h sub-function code (Return Query Data). With this sub-function the data passed in the request data field is to be returned (looped back) in the response. The entire response message should be identical to the request.

Request frame

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	
Function code	1 byte	08h	
Sub-function	2 bytes	0000h	
Data (**N** word)	**N** *2 bytes	Data	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (correct action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7 (1 to 247)	
Function code	1 byte	08h	
Sub-function	2 bytes	0000h	
Data (**N** word)	**N** *2 bytes	Data	Byte order: MSB, LSB
CRC	2 bytes		

Response frame (incorrect action)

Description	Length	Value	Note
Physical address	1 byte	1 to F7h (1 to 247)	Possible exception : 01h: illegal function 02h: illegal data address 03h: illegal data value 04h: slave device failure
Function code	1 byte	88h	
Exception code	1 byte	01h, 02h, 03h, 04h	
CRC	2 bytes		

Broadcast mode

In broadcast mode the master can send a request (command) to all the slaves. No response is returned to broadcast requests sent by the master. It is possible to send the broadcast message only with function code 06h using address 00h.

1.3 Application notes

RS485 general considerations

1. To avoid errors due to the signal reflections or line coupling, it is necessary to terminate the bus at the beginning and at the end (inserting a 120 ohm 1/2W 5% resistor between line B and A in the last instrument and in the Host interface).
2. The network termination is necessary even in case of point-to-point connection and/or of short distances.
3. For connections longer than 1000m or if in the network there are more than 160 instruments (with 1/5 unit load as used in EM210 interface), a signal repeater is necessary.
4. For bus connection it is suggested to use an AWG24 balanced pair cable and to add a third wire for GND connection. Connect GND to the shield if a shielded cable is used.
5. The GND is to be connected to ground only at the host side.
6. If an instrument does not answer within the “max answering time”, it is necessary to repeat the query. If the instrument does not answer after 2 or 3 consecutive queries, it is to be considered as not connected, faulty or reached with a wrong address. The same consideration is valid in case of CRC errors or incomplete response frames.

MODBUS timing

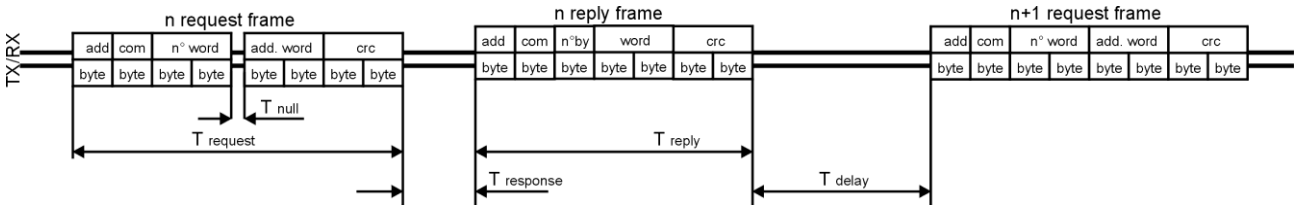


Fig. 1 : 2-wire timing diagram

Timing characteristics of reading function:	msec
T response: Max answering time	500ms
T response: Typical answering time	40ms
T delay: Minimum time before a new query	3.5char
T null: Max interruption time during the request frame	2.5char

2 TABLES

2.1 Data format representation in Carlo Gavazzi instruments

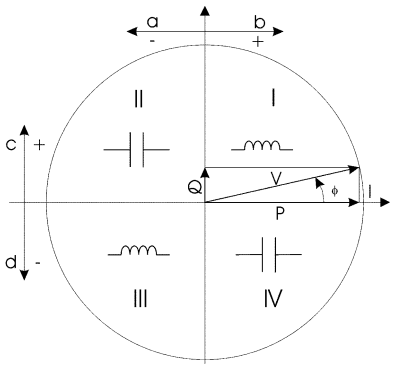
The variables are represented by integers or floating numbers, with 2's complement notation in case of "signed" format, using the following:

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	$-(1+[1-2^{-23}])x2^{127}$ .. 2^{128}

For all the formats the byte order (inside the single word) is MSB->LSB. In INT32, UINT32 and UINT64 formats, the word order is LSW-> MSW.

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. 2 : Geometric Representation

2.2 Maximum and minimum electrical values in EM210

The maximum electrical input values are reported in electrical data sheet. The overflow indication "EEE" is displayed when the MSB value of the relevant variable is 7FFFh.

2.3 Instantaneous variables and meters (grouped by variable type)

MODBUS: read only mode with functions code 03 and 04 Table 2.3-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
300001	0000h	2	V L1-N	INT32	Value weight: Volt*10
300003	0002h	2	V L2-N	INT32	
300005	0004h	2	V L3-N	INT32	
300007	0006h	2	V L1-L2	INT32	
300009	0008h	2	V L2-L3	INT32	
300011	000Ah	2	V L3-L1	INT32	
300013	000Ch	2	A L1	INT32	Value weight: Ampere*1000
300015	000Eh	2	A L2	INT32	
300017	0010h	2	A L3	INT32	
300019	0012h	2	W L1	INT32	Value weight: Watt*10
300021	0014h	2	W L2	INT32	
300023	0016h	2	W L3	INT32	
300025	0018h	2	VA L1	INT32	Value weight: VA*10
300027	001Ah	2	VA L2	INT32	
300029	001Ch	2	VA L3	INT32	
300031	001Eh	2	VAR L1	INT32	Value weight: Var*10
300033	0020h	2	VAR L2	INT32	
300035	0022h	2	VAR L3	INT32	
300037	0024h	2	V L-N $\sum$	INT32	Value weight: Volt*10
300039	0026h	2	V L-L $\sum$	INT32	
300041	0028h	2	W $\sum$	INT32	Value weight: Watt*10
300043	002Ah	2	VA $\sum$	INT32	Value weight: VA*10
300045	002Ch	2	VAR $\sum$	INT32	Value weight: Var*10
300047	002Eh	1	PF L1	INT16	Negative values correspond to exported active power, positive values correspond to imported active power Value weight: PF*1000
300048	002Fh	1	PF L2	INT16	
300049	0030h	1	PF L3	INT16	
300050	0031h	1	PF $\sum$	INT16	
300051	0032h	1	Phase sequence	INT16	The value 1 corresponds to L1-L3-L2 sequence, the value 0 corresponds to L1-L2-L3 sequence. The phase sequence value is meaningful only in a 3-phase system
300052	0033h	1	Hz	INT16	Value weight: Hz
300053	0034h	2	kWh(+) TOT	INT32	Value weight: kWh*10
300055	0036h	2	kvarh(+) TOT	INT32	Value weight: kvarh*10
300079	004Eh	2	kWh(-) TOT		Value weight: kWh*10

Important note:

The product (CT ratio)x(VT ratio) shall be automatically limited to prevent overflow of kW indication on the meter

The product (CT ratio)x(VT ratio) shall be automatically limited in MID versions to prevent the rollover of the kWh meter before 4000 h, as stated in MID regulation.

2.4 Instantaneous variables and meters (grouped by phase)

MODBUS: read only mode with functions code 03 and 04 Table 2.4-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
System variables					
300257	0100h	2	n.a.	INT32	Not available, value =0
300259	0102h	2	V L-N ∑	INT32	Value weight: Volt*10
300261	0104h	2	V L-L ∑	INT32	Value weight: Volt*10
300263	0106h	2	W ∑	INT32	Value weight: Watt*10
300265	0108h	2	VA ∑	INT32	Value weight: VA*10
300267	010Ah	2	VAR ∑	INT32	Value weight: var*10
300269	010Ch	2	PF ∑	INT32	(*) Value weight: PF*1000
300271	010Eh	2	Phase sequence	INT32	The value –1 corresponds to L1-L3-L2 sequence, the value 0 corresponds to L1-L2-L3 sequence. The phase sequence value is meaningful only in a 3-phase system
300273	0110h	2	Hz	INT32	Value weight: Hz
Total energies					
300275	0112h	2	kWh(+) TOT	INT32	Value weight: kWh*10
300277	0114h	2	kVarh(+) TOT	INT32	Value weight: kvarh*10
300279	0116h	2	kWh(-) TOT	INT32	Value weight: kWh*10
Phase 1 variables					
300287	011Eh	2	V L1-L2	INT32	Value weight: Volt*10
300289	0120h	2	V L1-N	INT32	Value weight: Volt*10
300291	0122h	2	A L1	INT32	Value weight: Ampere*1000
300293	0124h	2	W L1	INT32	Value weight: Watt*10
300295	0126h	2	VA L1	INT32	Value weight: VA*10
300297	0128h	2	VAR L1	INT32	Value weight: var*10
300299	012Ah	2	PF L1	INT32	(*) Value weight: PF*1000
Phase 2 variables					
300301	012Ch	2	V L2-L3	INT32	Value weight: Volt*10
300303	012Eh	2	V L2-N	INT32	Value weight: Volt*10
300305	0130h	2	A L2	INT32	Value weight: Ampere*1000
300307	0132h	2	W L2	INT32	Value weight: Watt*10
300309	0134h	2	VA L2	INT32	Value weight: VA*10
300311	0136h	2	VAR L2	INT32	Value weight: var*10
300313	0138h	2	PF L2	INT32	(*) Value weight: PF*1000
Phase 3 variables					
300315	013Ah	2	V L3-L1	INT32	Value weight: Volt*10
300317	013Ch	2	V L3-N	INT32	Value weight: Volt*10
300319	013Eh	2	A L3	INT32	Value weight: Ampere*1000
300321	0140h	2	W L3	INT32	Value weight: Watt*10
300323	0142h	2	VA L3	INT32	Value weight: VA*10
300325	0144h	2	VAR L3	INT32	Value weight: var*10
300327	0146h	2	PF L3	INT32	(*) Value weight: PF*1000

Notes : Negative values correspond to exported active power, positive values correspond to imported active power.

2.5 Firmware version and revision code

MODBUS: read only mode with functions code 03 and 04 limited to a word at a time Table 2.5-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
00769	0300h	1	Firmware version code (reserved)	UINT 16	Value=0: Version A Value=1: Version B
00770	0301h	1	Firmware revision code (reserved)	UINT 16	Value=0: Revision 0 Value=5: Revision 5
300771	0302h	1	Display version code	UINT 16	Value=0: Version A Value=2: Version C
300772	0303h	1	Display revision code	UINT 16	Value=5: Revision 5 Value=0: Revision 0

2.6 Programming lock status

MODBUS: read only mode with functions code 03 and 04 limited to a word at a time Table 2.6-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
300773	0304h	1	Programming lock (trimmer position in the rear of the display)	UINT 16	Value=1: programming locked Value=0: programming unlocked

2.7 Carlo Gavazzi Controls identification code

MODBUS: read only mode with functions code 03 and 04 limited to a word at a time Table 2.7-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
300012	000Bh	1	Carlo Gavazzi Controls identification code	UINT 16	Value=210: EM210

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2.8 Programming parameter tables

The values are update immediately.

Password configuration menu

MODBUS: read and write mode Table 2.8-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304097	1000h	1	PASSWORD	UINT 16	Minimum valid value: 0d Maximum valid value: 999d Default: 0d

System configuration menu

MODBUS: read and write mode Table 2.8-2

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304099	1002h	1	Measuring system	UINT 16	Value=0: 3Pn Default: 3Pn

PT and CT configuration menu

MODBUS: read and write mode Table 2.8-3

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304100	1003h	2	Current transformer ratio	UINT 32	Value min = 10 (CT=1.0) Value max = 9990 (CT=999.0) Default = 10 (CT=1.0)
304102	1005h	2	Voltage transformer ratio	UINT 32	Value min = 10 (VT=1.0) Value max = 9990 (VT=999.0) Default = 10 (VT=1.0)

Note: the voltage transformer ratio in AV5 PFA and PFB models is fixed to 1.0.

Pulse output duration (T_{ON})

MODBUS: read and write mode Table 2.8-4

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304129	1012h	1	Pulse output duration (T_{ON})	UINT 16	Value=0: 30ms Value=1: 100ms Default=0: 30ms

Pulse output configuration menu

MODBUS: read and write mode Table 2.8-5

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304866	1020h	1	kWh per pulse	UINT 16	Value min = 1 (0.01kWh) Value max = 999 (9.99kWh) Default = 1 (0.01kWh)

Application menu

MODBUS: read and write mode

Table 2.8-6

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304865	1300h	1	Type of application	UINT 16	Value=0: A application Value=1: B application Value=2: C application (default model PFA) Value=3: D application (default model PFB) Value=4: E application Value=5: F application

Note:

- PFA models support applications “A”, “B”, “C” and “F” only;
- PFB models support application “D” and “E” only.

Serial port configuration menu

MODBUS: read and write mode

Table 2.8-7

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
308193	2000h	1	RS485 instrument address	UINT 16	Value min = 1 Value max = 247
308194	2001h	1	RS485 baud rate	UINT 16	Value 0 = 9.6 kbps (default) Value 1 = 19.2 kbps Value 2 = 38.4 kbps Value 3 = 57.6 kbps Value 4 = 115.2 kbps Any other value = 9.6 kbps
308195	2002h	1	RS485 parity	UINT 16	Value 0 = no parity (default) Value 1 = even parity Any other value = no parity
308196	2003h	1	RS485 Stop bit	UINT 16	Value 0 = 1 stop bit (default) Value 1 = 2 stop bit Any other value = 1 stop bit

NOTE: The values are update in real time

Serial number

MODBUS: read only mode

Table 2.8-8

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
320481	5000h	1	Letter 1 (from SX) Letter 2 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320482	5001h	1	Letter 3 (from SX) Letter 4 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320483	5002h	1	Letter 5 (from SX) Letter 6 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320484	5003h	1	Letter 7 (from SX) Letter 8 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320485	5004h	1	Letter 9 (from SX) Letter 10 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320486	5005h	1	Letter 11 (from SX) Letter 12 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
320487	5006h	1	Letter 13 (from SX)	UINT 16	MSB: ASCII code

Production year

MODBUS: read only mode

Table 2.8-9

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
320488	5007h	1	Instrument production year	UINT 16	

Secondary address

MODBUS: read only mode

Table 2.8-10

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
320737	5100h	2	Instrument secondary address	UINT 32	**5100h:LSW** **5101h:MSW**

Note.

A default value is automatically assigned to the parameters when an out-of-range or invalid value is written.
The default value is the minimum valid value.
Reading with functions code 03 and 04 of more words are limited by the range in each table.

3 Revisions

Version 3 Revision 1:

Changed par. Maximum and minimum electrical values in EM210

Version 3 Revision 2:

Changed par. Function 08h (Diagnostic with sub-function code 00h) (EM210 synchronized)

Version 4 Revision 0:

Deleted reset counter by MID version. Changed revision.

Version 4 Revision 1:

Add note in 2.8 section.

Version 4 Revision 2:

Delete note in 2.4 section. Update table 2.8-2. Update table 2.8-6. Delete Reset commands table 2.8-8.

Version 4 Revision 3:

Frequency weight correction (address 0110hex), from Hz*10 to Hz.