EATON

Powering Business Worldwide

EM21

COMMUNICATION PROTOCOL

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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 EM21 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 EM21:
- 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 EM21 instruction manual)

1.2.1 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 11 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 :
Function code	1 byte	83h	01h: illegal function
Exception code	1 byte	01h, 02h, 03h, 04h (see note)	02h: illegal data address
CRC	2 bytes		03h: illegal data value
			04h: slave device failure

1.2.2   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 11 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 :
Function code	1 byte	84h	01h: illegal function
Exception code	1 byte	01h, 02h, 03h, 04h	02h: illegal data address
CRC	2 bytes		03h: illegal data value
			04h: slave device failure

1.2.3   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 :
Function code	1 byte	86h	01h: illegal function
Exception code	1 byte	01h, 02h, 03h, 04h	02h: illegal data address
CRC	2 bytes		03h: illegal data value
			04h: slave device failure

1.2.4 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.
EM24-DIN 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 :
Function code	1 byte	88h	01h: illegal function
Exception code	1 byte	01h, 02h, 03h, 04h	02h: illegal data address
CRC	2 bytes		03h: illegal data value
			04h: slave device failure

1.2.5 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.

Energy management

1.3 Application notes

1.3.1 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 EM21 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.

1.3.2 MODBUS timing
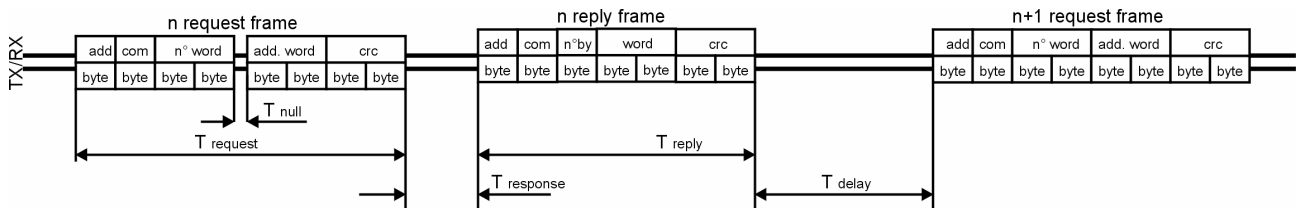
Fig. 1 : 2-wire timing diagram

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.

2.1.1 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:
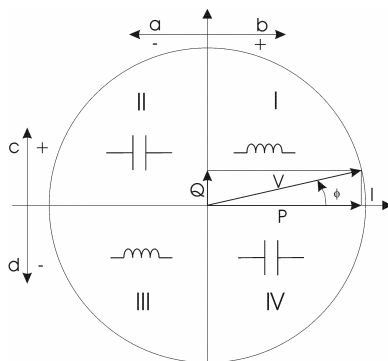
a = Exported active power
b = Imported active power
c = Imported reactive power
d = Exported reactive power

Fig. 2 : Geometric Representation

2.2 Maximum and minimum electrical values in EM21

The maximum electrical input values are reported in the following table. If the input is above the maximum value the display shows "----".

Table 2.1-1

	AV5 input option		AV6 input option	
	Max value	Min value	Max value	Min value
VL-N	485V	0	150V	0
VL-L	840V	0	260V	0
A	6,5A	0	6,5A	0
VT	6000	1.0	6000	1.0
CT	60000	1.0	60000	1.0

The overflow indication "----" is displayed when the MSB value of the relevant variable is 7FFFh.

2.3   Instantaneous variables and meters

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	
300003	0002h	2	V L2-N	INT32	
300005	0004h	2	V L3-N	INT32	
300007	0006h	2	V L1-L2	INT32	Value weight: Volt*10
300009	0008h	2	V L2-L3	INT32	
300011	000Ah	2	V L3-L1	INT32	
300013	000Ch	2	A L1	INT32	
300015	000Eh	2	A L2	INT32	Value weight: Ampere*1000
300017	0010h	2	A L3	INT32	
300019	0012h	2	W L1	INT32	
300021	0014h	2	W L2	INT32	Value weight: Watt*10
300023	0016h	2	W L3	INT32	
300025	0018h	2	VA L1	INT32	
300027	001Ah	2	VA L2	INT32	Value weight: VA*10
300029	001Ch	2	VA L3	INT32	
300031	001Eh	2	VAR L1	INT32	
300033	0020h	2	VAR L2	INT32	Value weight: var*10
300035	0022h	2	VAR L3	INT32	
300037	0024h	2	V L-N Σ	INT32	Value weight: Volt*10
300039	0026h	2	V L-L Σ	INT32	
300041	0028h	2	W Σ	INT32	Value weight: Watt*10
300043	002Ah	2	VA Σ	INT32	Value weight: VA*10
300045	002Ch	2	VAR Σ	INT32	Value weight: var*10
300047	002Eh	1	PF L1	INT16	Negative values correspond to
300048	002Fh	1	PF L2	INT16	lead(C), positive value correspond
300049	0030h	1	PF L3	INT16	to lag(L)
300050	0031h	1	PF Σ	INT16	Value weight: PF*1000
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*10
300053	0034h	2	KWh(+) TOT	INT32	Value weight: kWh*10
300055	0036h	2	Kvarh(+) TOT	INT32	Value weight: kvarh*10

2.4   Firmware version and revision code

MODBUS: read only mode with functions code 03 and 04 limited to a word at a time   Table 2.4-1

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
300771	0302h	1	Version code	UINT 16	Value=0: Version "A"
300772	0303h	1	Revision code	UINT 16	Value=0: Revision "0"

2.5   Programming lock status

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
300773	0304h	1	Programming lock (trimmer position in the rear of the display)	UINT 16	Value=1: programming locked Value=0: programming unlocked

2.6 Carlo Gavazzi Controls identification code

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
300012	000Bh	1	Carlo Gavazzi Controls identification code	UINT 16	Value=57: EM21 AV5 input model Value=58: EM21 AV6 input model

.

2.7 Programming parameter tables

2.7.1 Password configuration menu

MODBUS: read and write mode   Table 2.7-1

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

2.7.2 "Application" menu

MODBUS: read and write mode   Table 2.7-2

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304098	1001h	1	Type of application	UINT 16	Value=0: "A" application Value=1: "B" application Value=2: "C" application

2.7.3 System configuration menu

MODBUS: read and write mode   Table 2.7-3

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304099	1002h	1	Measuring system	UINT 16	Value=0: "3Pn" Value=1: "3P1" Value=2: "2P" Value=3: "1P" Value=4: "3P"

2.7.4 PT and CT configuration menu

MODBUS: read and write mode   Table 2.7-4

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 = 600000 (CT=60000.0)
304102	1005h	2	Voltage transformer ratio	UINT 32	Value min = 10 (VT=1,0) Value max = 60000 (VT=6000.0)

2.7.5 Pulse output configuration menu

MODBUS: read read and write mode

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304104	1007h	1	Kwh per pulse	UINT 16	Value min = 1 (0,01Kwh) Value max = 999 (9,99KWh)

2.7.6 Serial port configuration menu

MODBUS: read and write mode   Table 2.7-5

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304105	1008h	1	RS485 instrument address	UINT 16	Value min = 1 Value max = 247

Note: The number of stop bits is fixed to "1" and the parity control is fixed to "none".

2.7.7 Reset commands

MODBUS: write only mode   Table 2.7-12

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
312289	3000h	1	Reset of all meters (KwhTOT and KvarhTOT)	UINT 16	Value=1: Command is executed All other values produce no effects

2.7.8 Note

A default value is not automatically assignes to the parameters when an out-of-range or invalid value is written.
If an invalid value is assigned to any parameter, the unit could not work properly.

3   REVISIONS

This is the first release of the EM21 communication protocol