EM100 Series
and
ET100 Series

COMMUNICATION PROTOCOL

Version 2 Revision 6

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 EM/ET100 SERIES 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 latest revision of the "Modbus_Application_Protocol" document that is downloadable from the www.modbus.org web site.

1.2 MODBUS functions

These functions are available on EM/ET100 SERIES:

- 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 EM/ET100 SERIES 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 50 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 14h (1 to 20)	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		

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 50 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 14h (1 to 20)	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		

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 : 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		

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.
EM/ET100 SERIES 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		

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.

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). The termination resistance is included in EM111, EM112 and ET112 and can be inserted by connecting terminal T with terminal B. The network termination is necessary even in case of point-to-point connection and/or of short distances.
2. For connections longer than 1000m or if in the network there are more than 160 instruments (with 1/5 unit load as used in EM/ET100 SERIES interface), a signal repeater is necessary.
3. 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.
4. The GND is to be connected to ground only at the host side.
5. 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

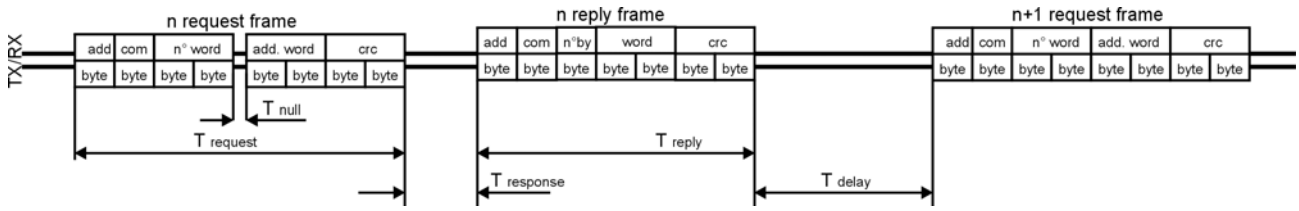


Fig. 1 : 2-wire timing diagram

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

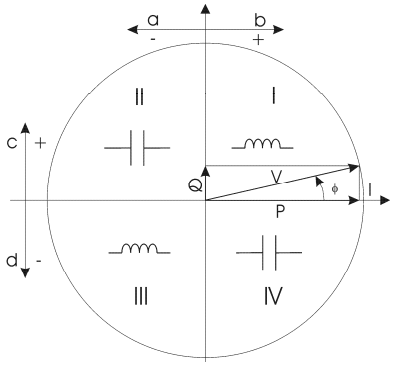
The variables are represented by integers or floating numbers, with 2's complement notation in case of "signed" format, using the following:

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.

2.2 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. 2 : Geometric Representation

According to the measurement mode (easy connection or bidirectional), the following sign convention is used in EM/ET100 SERIES.

- Easy connection mode
  - I always >0
  - P always >0
  - kWh always increasing (correspondent to Annex D option PFA)
  - **kvarh increases only when Q>0**
  - PF only with C and L (without sign) indication

- Bidirectional mode)
  - I < or >0 (with indication of "-" sign)
  - P < or >0 (with indication of "-" sign)
  - kWh+ increasing only when P > 0 (correspondent to Annex D option PFB)
  - kWh- increasing only when P < 0
  - kvarh+ increasing only when Q > 0
  - kvarh- increasing only when Q < 0
  - 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 **doesn't** increases	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 **doesn't** increases	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 in EM/ET100 SERIES

If the input is above the maximum value the display shows "EEE".

The overflow indication "EEE" is displayed when the MSB value of the relevant variable is 7FFFFFFFh (word order FFFF 7FFF).

2.4 Instantaneous variables and meters

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
300001	0000h	2	V L-N	INT32	Value weight: Volt*10
300003	0002h	2	A	INT32	Value weight: Ampere*1000
300005	0004h	2	W	INT32	Value weight: Watt*10
300007	0006h	2	VA	INT32	Value weight: VA*10
300009	0008h	2	Var	INT32	Value weight: var*10
300011	000Ah	2	Wdmd	INT32	Value weight: Watt*10
300013	000Ch	2	Wdmd peak	INT32	Value weight: Watt*10
300015	000Eh	1	PF	INT16	Value weight: PF*1000
300016	000Fh	1	Hz	INT16	Value weight: Hz*10
300017	0010h	2	kWh(+) TOT	INT32	Value weight: kWh*10
300019	0012h	2	kvarh(+) TOT	INT32	Value weight: kvarh*10
300021	0014h	2	kWh(+) PARTIAL	INT32	Value weight: kWh*10
300023	0016h	2	kvarh(+) PARTIAL	INT32	Value weight: kvarh*10
300025	0018h	2	kWh(+) tariff 1	INT32	Value weight: kWh*10
300027	001Ah	2	kWh(+) tariff 2	INT32	Value weight: kWh*10
300029	001Ch	2	kWh(+) tariff 3	INT32	Not available, value =0
300031	001Eh	2	kWh(+) tariff 4	INT32	Not available, value =0
300033	0020h	2	kWh(-) TOT	INT32	Value weight: kWh*10
300035	0022h	2	kvarh(-) TOT	INT32	Value weight: kvarh*10
300037	0024h	2	kWh(-) PARTIAL	INT32	Not available, value =0
300039	0026h	2	kvarh(-) PARTIAL	INT32	Not available, value =0
300041	0028h	2	kVAh TOT	INT32	Not available, value =0
300043	002Ah	2	kVAh PARTIAL	INT32	Not available, value =0
300045	002Ch	2	Hour counter meter	INT32	Value weight: hours*100, only ET series
300047	002Eh	2	n.a.	INT32	Not available, value =0
300049	0030h	2	n.a.	INT32	Not available, value =0
300051	0032h	2	THD(16h) A	INT32	Not available, value =0
300053	0034h	2	THD(16h) V	INT32	Not available, value =0

MODBUS: read only mode with functions code 03 and 04 Table 2.4-2

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
System variables					
300257	0100h	2	A	INT32	Value weight: Ampere*1000
300259	0102h	2	V L-N	INT32	Value weight: Volt*10
300261	0104h	2	n.a.	INT32	Not available, value =0
300263	0106h	2	W	INT32	Value weight: Watt*10
300265	0108h	2	VAΣ	INT32	Value weight: VA*10
300267	010Ah	2	VAR Σ	INT32	Value weight: var*10
300269	010Ch	2	PF Σ	INT32	(*) Value weight: PF*1000
300271	010Eh	2	n.a.	INT32	Not available, value =0
300273	0110h	2	Hz	INT32	Value weight: Hz*10
Total energies and dmd power					
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
300281	0118h	2	kvarh(-) TOT	INT32	Value weight: kvarh*10
300283	011Ah	2	kWdmd	INT32	Value weight: Watt*10
300285	011Ch	2	kWdmd peak	INT32	Value weight: Watt*10
300287 to 300327	011Eh to 0146h		n.a.	INT32	Not available, value =0
Other energies					
300329	0148h	2	kWh(+) PARTIAL	INT32	Value weight: kWh*10
300331	014Ah	2	kvarh(+) PARTIAL	INT32	Value weight: kvarh*10
300333	014Ch	2	n.a.	INT32	Not available, value =0
300335	014Eh	2	n.a.	INT32	Not available, value =0
300337	0150h	2	n.a.	INT32	Not available, value =0
300339	0152h	2	kWh(+) tariff 1	INT32	Value weight: kWh*10
300341	0154h	2	kWh(+) tariff 2	INT32	Value weight: kWh*10
300343	0156h	2	kWh(+) tariff 3	INT32	Not available, value =0
300345	0158h	2	kWh(+) tariff 4	INT32	Not available, value =0
300347	015Ah	2	kWh(-) PARTIAL	INT32	Not available, value =0
300349	015Ch	2	kvarh(-) PARTIAL	INT32	Not available, value =0
300351	015Eh	2	kVAh TOT	INT32	Not available, value =0
300353	0160h	2	kVAh PARTIAL	INT32	Not available, value =0
300365	016Ch	2	n.a.	INT32	Not available, value =0
300367	016Eh	2	n.a.	INT32	Not available, value =0
300369	0170h	2	n.a.	INT32	Not available, value =0
300371	0172h	2	kWh(+) tariff 5	INT32	Not available, value =0
300373	0174h	2	kWh(+) tariff 6	INT32	Not available, value =0
300375	0176h	2	kWh(+) tariff 7	INT32	Not available, value =0
300377	0178h	2	kWh(+) tariff 8	INT32	Not available, value =0
300379	017Ah	2	n.a.	INT32	Not available, value =0
300381	017Ch	2	n.a.	INT32	Not available, value =0
300383	017Eh	2	n.a.	INT32	Not available, value =0
Other variables					
300385	**0180h**	**2**	THD(16h) A	INT32	Not available, value =0
300387	**0182h**	**2**	THD(16h) V	INT32	Not available, value =0
300389	**0184h**	**2**	n.a.	INT32	Not available, value =0

(*): Negative values correspond to exported active power, positive values correspond to imported active power.

Note Table 2.4-1 and 2.4-2 are equivalent and includes a copy of the same variable values.

Programming parameter note: reading values in addresses not specified in the below tables returns an illegal data address exception.

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
300771	0302h	1	Version code	UINT 16	Value=0: Version “A”, =1: Version “B”, etc.
300772	0303h	1	Revision code	UINT 16	Value=0: Revision “0” etc.

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	See table 2.6-2

.

Table 2.6-2

Complete item number	CG identification code
EM110-DIN AV8 1 x S1 X	110
EM110-DIN AV8 1 x S1 PF B	110
EM110-DIN AV7 1 x S1 X	100
EM110-DIN AV7 1 x S1 PF B	100
EM111-DIN AV8 1 x S1 X ENGINEERING SAMPLE (with MSW-LSW word order)	111
EM111-DIN AV8 1 x S1 X	103
EM111-DIN AV8 1 x S1 PF B	103
EM111-DIN AV7 1 x S1 X	101
EM111-DIN AV7 1 x S1 PF B	101
EM112-DIN AV0 1 x S1 X ENGINEERING SAMPLE (with MSW-LSW word order)	112
EM112-DIN AV0 1 x S1 X	104
EM112-DIN AV0 1 x S1 PF B	104
EM112-DIN AV1 1 x S1 X	102
EM112-DIN AV1 1 x S1 PF B	102
ET112-DIN AV0 1 x S1 X	120
ET112-DIN AV1 1 x S1 X	121

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 (EM only)	UINT 16	Minimum valid value: 0d Maximum valid value: 9999d In ET always 0.

2.7.2 System configuration menu

MODBUS: read and write mode

Table 2.7-2

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304099	1002h	1	Measuring system	UINT 16	Value=0: “1P” (1-phase)

2.7.3 Dmd and pulse outs configuration menu

MODBUS: read and write mode

Table 2c

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
	1010h	2	Integration time for dmd power calculation	UINT 32	Value min = 1 Value max = 30
	1012h	2	Ton (Ton time for pulse output square wave)	UINT 32	Value min = 0 (30ms) Value max = 1 (100 ms)
	1020h	2	kWh per pulse relevant to digital out 1 (if existing)	UINT 32	
	1022h	2	kWh per pulse relevant to digital out 2 (if existing)	UINT 32	

2.7.4 Other functions configuration menu

MODBUS: read and write mode

Table 2.7

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304353	1100h	1	Display mode (only EM112)	UINT 16	Value min = 0 (Full, default) Value max = 1 (Easy) Any other value = Full
304354	1101h	1	Tariff management enabling	UINT 16	Value min = 0 (OFF) Value max = 1 (ON) Any other value = OFF
304355	1102h	1	Home page selection (only EM112)	UINT 16	Value min = 0 (page 0, default) Value max = 17 (page 17) Restrictions in case of display mode = Easy Any other value = page 0 **Except for EM112, always =0**
304356	1103h	1	Measurement mode selection	UINT 16	Value min = 0 (A) Value max = 1 (B) Any other value = A

2.7.5 Active tariff selection (not available in EM111-112)

MODBUS: read and write mode

Table 2.7-2c

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304608	1200h	1	Tariff mode selection (tariff management via digital input or serial comm.)	UINT 16	Value min = 0 (via digital inputs) Value max = 1 (via serial comm.) Any other value = via digital in.
304609	1201h	1	Tariff number selection via serial comm.	UINT 16	Value min = 1 (tariff 1) Value max = 2 (tariff 2) Any other value = tariff 1 If 1200h = 0 (tariff via digital input), this parameter is “read only” mode

2.7.6 Serial port configuration menu

MODBUS: read and write mode

Table 2.7-3

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
308193	2000h	1	RS485 instrument address	UINT 16	Value min = 1 (default) Value max = 247
308194	2001h	1	RS485 baud rate	UINT 16	Value 1 = 9.6 kbps (default) Value 2 = 19.2 kbps Value 3 = 38.4 kbps Value 4 = 57.6 kbps Value 5 = 115.2 kbps Any other value = 9.6 kbps
308195	2002h	1	RS485 parity	UINT 16	Value 1= no parity (default) Value 2 = even parity Any other value = no parity
308196	2003h	1	Stop bit	UINT 16	Value 1= 1 (default) Value 2 =2 (only if parity is even) Any other value = 1
308197	2004h	1	Max number of words readable with a single Modbus request	UINT 16	Value = 50 (words)

Note: The number of stop bits is fixed to “1” if parity is EVEN.

2.7.7 Reset commands

MODBUS: read and write mode

Table 2.7-12

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
316385	4000h	1	Reset of all partial and tariff meters, kWdmd and kWdmdm peak.	UINT 16	Value=0: reset done Value=1: execute the command All other values produce no effects
316386	4001h	1	Reset of total energy meters (only for non-MID versions, X option)	UINT 16	Value=0: reset done Value=1: execute the command All other values produce no effects
316387	4002h	1	Reset of hour counter (ET112 only)	UINT 16	Value=0: reset done Value=1: execute the command All other values produce no effects

2.7.8 Serial number

MODBUS: read only mode

Table 2.7-13

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

2.7.9 Note

The default value shall be automatically assigned to the parameters when an out-of-range or invalid value is written.