EM24-IS
SFA and SFB versions

COMMUNICATION PROTOCOL

Revision 2.0

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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 EM24-DIN 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 EM24-DIN:

- 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 EM24-DIN 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 : 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 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 : 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.
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 : 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).
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 EM24-DIN 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

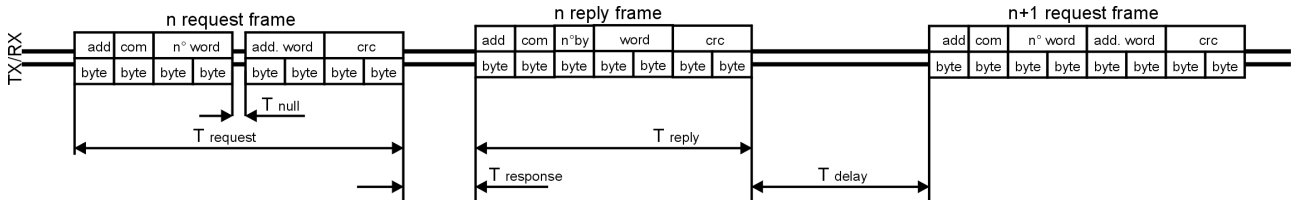


Fig. 1 : 2-wire timing diagram

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

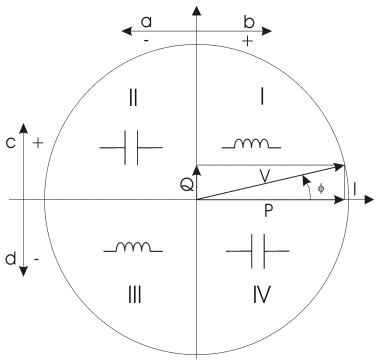
The variables are represented by integers or floating numbers, with 2's complement notation in case of "signed" format, using the following:

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 EM24-DIN

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

Table 2.1-1

	AV2 input option		AV5 input option	
	Max value	**Min value**	**Max value**	**Min value**
VL-N	280V	0	280V	0
VL-L	485V	0	485V	0
A	65A	0	11A	0
VT ratio			6000	1.0
CT ratio			60000	1.0

The overflow indication "EEEE" 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	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		INT32	**Reserved**
300021	0014h	2		INT32	
300023	0016h	2		INT32	
300025	0018h	2		INT32	**Reserved**
300027	001Ah	2		INT32	
300029	001Ch	2		INT32	
300031	001Eh	2		INT32	**Reserved**
300033	0020h	2		INT32	
300035	0022h	2		INT32	
300037	0024h	2	V L-N Σ	INT32	Value weight: Volt*10
300039	0026h	2	V L-L Σ	INT32	
300041	0028h	2		INT32	**Reserved**
300043	002Ah	2		INT32	**Reserved**
300045	002Ch	2		INT32	**Reserved**
300047	002Eh	2		INT32	**Reserved**
300049	0030h	2		INT32	**Reserved**
300051	0032h	1	PF L1	INT16	Negative values correspond to lead(C), positive value correspond to lag(L) Value weight: PF*1000
300052	0033h	1	PF L2	INT16	
300053	0034h	1	PF L3	INT16	
300054	0035h	1	PF Σ	INT16	
300055	0036h	1	Phase sequence	INT16	Value -1 correspond to L1-L3-L2 sequence, value 0 correspond to L1-L2-L3 sequence (this value is meaningful only in case of 3-phase systems)
300056	0037h	1	Hz	INT16	Value weight: Hz*10
300057	0038h	2		INT32	**Reserved**
300059	003Ah	2		INT32	**Reserved**
300061	003Ch	2		INT32	**Reserved**
300063	003Eh	2	kWh(+) TOT	INT32	Value weight: kWh*10
300065	0040h	2		INT32	**Reserved**
300067	0042h	2		INT32	**Reserved**
300069	0044h	2		INT32	**Reserved**
300071	0046h	2		INT32	**Reserved**
300073	0048h	2		INT32	**Reserved**
300075	004Ah	2		INT32	**Reserved**
300077	004Ch	2		INT32	**Reserved**
300079	004Eh	2		INT32	**Reserved**
300081	0050h	2		INT32	**Reserved**
300083	0052h	2		INT32	**Reserved**
300085	0054h	2		INT32	**Reserved**
300087	0056h	2		INT32	**Reserved**
300089	0058h	2		INT32	**Reserved**
300091	005Ah	2		INT32	**Reserved**
300093	005Ch	2		INT32	**Reserved**
300095	005Eh	2		INT32	**Reserved**
300097	0060h	2		INT32	**Reserved**
300099	0062h	2		INT32	**Reserved**
300101	0064h	2		INT32	
300103	0066h	2		INT32	

2.4 Digital input status

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
300769	0300h	1	Digital input status	UINT 16 bit=0 input close bit=1 input open	bit0=input status Ch1 bit1=input status Ch2 bit2=input status Ch3

2.5 Current tariff

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
300770	0301h	1		UINT 16	**Reserved, don't use**

2.6 Firmware version and revision 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
300771	0302h	1	Version and revision code	UINT 16	Data format: MSB: Bit 0..3 = Minor Bit 4..7 = Major (e.g. 01000011b / 43h / 67d = 4.3) LSB: Revision Example: 101E is 1.0.30
300772	0303h	1	RESERVED	UINT 16	**Reserved, don't use**

2.7 Front selector status

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
300773	0304h	1	Front selector status	UINT 16	Value=3: keypad locked Value=2: keypad unlocked Value=1: keypad unlocked Value=0: keypad unlocked

2.8 Carlo Gavazzi Controls identification code

MODBUS: read only mode with functions code 03 and 04 limited to a word at a time **Table 2.8-1**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
300012	000Bh	1	Carlo Gavazzi Controls identification code	UINT 16	Value=1696: EM24DINAV23XISSFA Value=1697: EM24DINAV53XISSFA Value=1698: EM24DINAV23XISSFB Value=1699: EM24DINAV53XISSFB

2.9 Programming parameter tables

2.9.1 Password configuration menu

MODBUS: read and write mode **Table 2.9-1**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304353	1100h	1	PASSWORD	UINT 16	Minimum valid value: 0d Maximum valid value: 9999d If the value is outside the limits the instrument considers that the value is equal to 0.

2.9.2 "Application" menu

MODBUS: read only mode **Table 2.9-2**

Modicom	Physical	Length	VARIABLE	Data	Notes

address	address	(words)	ENG. UNIT	Format	
304354	1101h	1		UINT 16	**Reserved, don't use**

2.9.3 System configuration menu

MODBUS: read and write mode **Table 2.9-3**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304355	1102h	1	Measuring system	UINT 16	Value=0: "3Pn" Value=1: "3P1" Value=2: "2P" Value=3: "1P" Value=4: "3P"

Note: SFA and SFB models support only 3Pn system

2.9.4 DMD integration time menu

MODBUS: read and write mode **Table 2.9-4**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304356	1103h	1		UINT 16	**Reserved, don't use**

2.9.5 Selector menu

MODBUS: read and write mode **Table 2.9-5**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304357	1104h	1		UINT 16	**Reserved, don't use**
304358	1105h	1		UINT 16	
304359	1106h	1		UINT 16	
304360	1107h	1		UINT 16	

2.9.6 Filter configuration menu

MODBUS: read and write mode **Table 2.9-6**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304361	1108h	1	Filter span parameter	UINT 16	Value min = 0 Value max = 100
304362	1109h	1	Filter coefficient	UINT 16	Value min = 1 Value max = 32

2.9.7 Serial port configuration menu

MODBUS: read and write mode **Table 2.9-7**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304363	110Ah	1	RS485 instrument address	UINT 16	Value min = 1 Value max = 247
304364	110Bh	1	RS485 baud rate	UINT 16	Value=0: 4800 Value=1: 9600

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

2.9.8 User configuration menu

MODBUS: read and write mode **Table 2.9-9**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304365	110Ch	1		UINT 16	**Reserved, don't use**
304366	110Dh	1		UINT 16	
304367	110Eh	1		UINT 16	

2.9.9 Digital input configuration menu

MODBUS: read and write mode **Table 2.9-10**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304386	1121h	1		UINT 16	**Reserved, don't use**
304387	1122h	1		UINT 16	**Reserved, don't use**
304388	1123h	1		UINT 16	**Reserved, don't use**
304389	1124h	1		UINT 16	**Reserved, don't use**
304390	1125h	1		UINT 16	
304391	1126h	1		UINT 16	
304404	1133h	1		UINT 16	**Reserved, don't use**
304405	1134h	1		UINT 16	
304406	1135h	1		UINT 16	
304392	1127h	1		UINT 16	**Reserved, don't use**

2.9.10 PT and CT configuration menu

MODBUS: read only and write mode **Table 2.9-11**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304397	112Ch	2	Current transformer ratio	UINT 32	Value min = 10 (CT=1,0) Value max = 600000 (CT=60000.0)
304399	112Eh	2	Voltage transformer ratio	UINT 32	Value min = 10 (VT=1,0) Value max = 60000 (VT=6000.0)

2.9.11 Serial number

MODBUS: read only mode **Table 2.9-12**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
304865	1300h	1	Letter 1 (from SX) Letter 2 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304866	1301h	1	Letter 3 (from SX) Letter 4 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304867	1302h	1	Letter 5 (from SX) Letter 6 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304868	1303h	1	Letter 7 (from SX) Letter 8 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304869	1304h	1	Letter 9 (from SX) Letter 10 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304870	1305h	1	Letter 11 (from SX) Letter 12 (from SX)	UINT 16	MSB: ASCII code LSB: ASCII code
304871	1306h	1	Letter 13 (from SX)	UINT 16	MSB: ASCII code

2.9.12 Reset commands

MODBUS: write only mode **Table 2.9-13**

Modicom address	Physical address	Length (words)	VARIABLE ENG. UNIT	Data Format	Notes
312289	3000h	1		UINT 16	**Reserved, don't use**
312290	3001h	1		UINT 16	
312291	3002h	1		UINT 16	
312292	3003h	1		UINT 16	
312293	3004h	1		UINT 16	
312294	3005h	1		UINT 16	

3 REVISIONS

3.1 Revision 1.0

- First official release of the EM24 IS (SFA models) Serial communication protocol

3.2 Revision 2.0

- Added SFB models