COMMUNICATION MODBUS PROTOCOL

MGF37900-- Netzanalysator MF9, 96x96mm, mit RS 485 - Schnittstelle für ModBus RTU

Contents

1.0 ABSTRACT

Physical level

The electrical communication line complies with the EIA-RS485 standard in half-duplex modality.
In this case, as only two wires are used, only one instrument at a time can engage the line; this means that there must be a master which polls the slave instruments so the demand and the request are alternated.

On the same line only 32 instruments can be attached (master included). In order to increase the number of the slave instrument, the necessary repeaters must be used.

The communication parameters are :

Baud rate	: programmable (device dependant)
bit n.	8
stop bit	1
parity	: programmable (device dependant)

Data link level

The data are transmitted in a packet form (message) and are checked by a word (CRC).
See the description of the data packet in the next paragraphs for more details.

Application level

The communication protocol used is MODBUS / JBUS compatible.
Up to 255 different instruments can be managed by the protocol.
There are no limitations to the number of possible retries done by the master.
A delay between the response from the slave and the next command could be necessary and it is specified for each device (timing).

2.0 DATA MESSAGE DESCRIPTION

The generic data message is composed as following :

Device address	Functional code	Data	CRC word

Two answers are possible :

Answer containing data

Device address	Functional code	Data	CRC word

Error answer

Device address	Functional code + 0x80	Error code	CRC word

2.1 Parameters description

Device address : device identification number in the network.
It must be the same for the demand and the answer.
Format : 1 BYTE from 0 to 0xff
0 is for broadcast messages with no answer

Functional code : command code
Used functional code :
Format : 1 BYTE
0x03 : reading of consecutive words
0x10 : writing of consecutive words

Data : they can be
- the address of the required words (in the demand)
- the data (in the answer)

CRC word : it is the result of the calculation done on all the bytes in the message

2.2 Data format

The following types of format are used for the data values :

* U_WORD : one WORD - unsigned
* S_WORD : one WORD - signed
* UD_WORD : two WORDS - unsigned
* SD_WORD : two WORDS - signed

If the required data is in a DWORD format, 2 WORDS are transmitted and the MSW comes before the LSW (depending on the setting in the SCHRACK MF9: big endian / little endian / swap WORDS

MSB	LSB	MSB	LSB
Most Significant WORD		Least Significant WORD	

Example : 1000 = 0x 03 e8 or
0x 00 00 03 e8 (if UDWORD)

MSB	LSB	MSB	LSB
0x00	0x00	0x03	0xe8

2.3 Description of CRC calculation

The following is an example of the CRC calculation in C language.

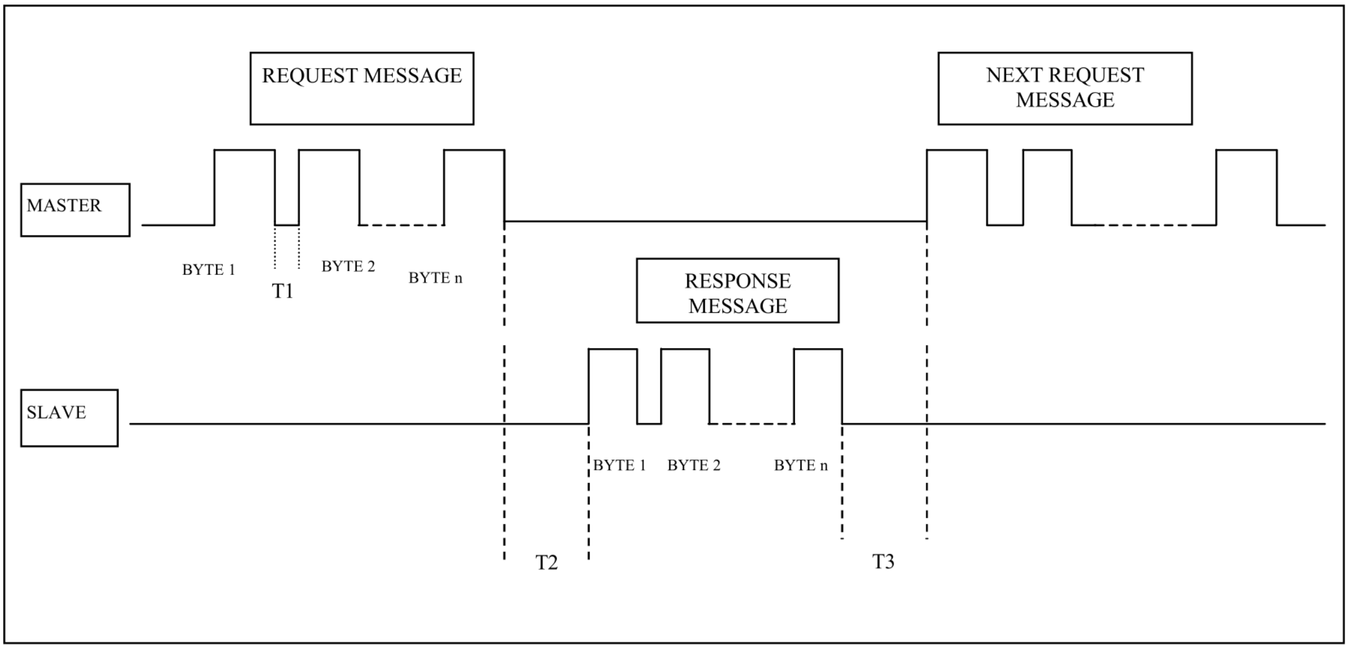
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*     ************************************************************************
 *     Descrizione : calculates a data buffer CRC WORD
 *     Input       :       ptbuf = pointer to the first byte of the buffer
 *                   num    = number of bytes
 *     Output      : //
 *     Return      :
**     ****************************************************************/
 {
  unsigned int crc16;
  unsigned int temp;
  unsigned char c, flag;

  crc16 = 0xffff;                              /* init the CRC WORD */
  for (num; num>0; num--) {
        temp = (unsigned int) *ptbuf;          /* temp has the first byte */
        temp &= 0x00ff;                        /* mask the MSB */
         crc16 = crc16 ^ temp;                 /* crc16 XOR with temp */
        for (c=0; c<8; c++) {
              flag = crc16 & 0x01;             /* LSBit di crc16 is mantained */
              crc16 = crc16 >> 1;              /* Lsbit di crc16 is lost */
              if (flag != 0)
                   crc16 = crc16 ^ 0x0a001;    /* crc16 XOR with 0x0a001 */
        }
        ptbuf++;                               /* pointer to the next byte */
  }

  crc16 = (crc16 >> 8) | (crc16 << 8);         /* LSB is exchanged with MSB */

  return (crc16);

} /* calc_crc  */
```

2.4 Error management

If the received message is incorrect (CRC16 is wrong) the polled slave doesn't answer.
If the message is correct but there are errors (wrong functional code or data) it can't be accepted, so the slave answers with an error message.

The error codes are defined in the following part of the document.

2.5 Timing



TIME	DESCRIPTION	Min & Max VALUES
T1	Time between characters. If this time exceeds the max. time allowed, the message is not considered by device.	Min = 3 msec Max = 99 msec
T2	Slave response time Minimum response delay to Master request.	Min = 10 ms
T3	Time before a new message request from the Master can be issued	Min = 1 ms

Be careful : among the setup parameters there is a timeout value that may be programmed
The value of 20 msec is suggested to keep compatibility with older IME devices.
The minimum value is 3 msec.

3.0 COMMANDS

Code 0x03 : reading of one or more consecutive WORDS

Command format :

BYTE	BYTE	MSB LSB	MSB LSB	
Device address	Funct. Code	First WORD address	WORDS number	CRC16

Answer format (containing data) :

BYTE	BYTE	BYTE	MSB LSB	MSB LSB	
Device address	Funct. Code	BYTES number	WORD 1	WORD N.	CRC16

The BYTES number must always match the WORDS number (in the demand) * 2.

Answer format (the demand was wrong) :

BYTE	BYTE	BYTE	
Device address	Funct. Code + 0x80	Error code	CRC16

Error codes :
* 0x01 : incorrect functional code
* 0x02 : wrong first WORD address
* 0x03 : incorrect data

Code 0x10 : writing of more consecutive WORDS

Command format :

BYTE	BYTE	MSB LSB	MSB LSB	BYTE	MSB LSB	MSB LSB	
Device address	Funct. Code	First WORD address	WORDS number	BYTE numbers	Word Value		CRC16

Answer format (containing data) :

BYTE	BYTE	MSB LSB	MSB LSB	
Device address	Funct. Code	First WORD address	WORD N.	CRC16

The BYTES number must always match the WORDS number (in the demand) * 2.

Answer format (the demand was wrong) :

BYTE	BYTE	BYTE	
Device address	Funct. Code + 0x80	Error code	CRC16

Error codes :
* 0x01 : incorrect functional code
* 0x02 : wrong first WORD address
* 0x03 : incorrect data

4.0 VARIABLES

Variables or groups of variables may be required up to 240 BYTES

0x100	U_WORD	Current transformer ratio (KTA)	No unit
0x300	U_WORD	Device identifier	0x1114

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Address	Format	Description	Unit
0x1000	UD_WORD	Phase 1 : phase voltage	mV
0x1002	UD_WORD	Phase 2 : phase voltage	mV
0x1004	UD_WORD	Phase 3 : phase voltage	mV
0x1006	UD_WORD	Phase 1 : current	mA
0x1008	UD_WORD	Phase 2 : current	mA
0x100a	UD_WORD	Phase 3 : current	mA
0x100c	UD_WORD	Neutral current	mA
0x100e	UD_WORD	Chained voltage : L1-L2	mV
0x1010	UD_WORD	Chained voltage : L2-L3	mV
0x1012	UD_WORD	Chained voltage : L3-L1	mV
0x1014	UD_WORD	3-phase : active power	(3)
0x1016	UD_WORD	3-phase : reactive power	(3)
0x1018	UD_WORD	3-phase : apparent power	(3)
0x101a	U_WORD	3-phase : sign of active power	(6)
0x101b	U_WORD	3-phase : sign of reactive power	(6)
0x101c	UD_WORD	3-phase : positive active energy	(4)
0x101e	UD_WORD	3-phase : positive reactive energy	(4)
0x1020	UD_WORD	3-phase :negative active energy	(4)
0x1022	UD_WORD	3-phase :negative reactive energy	(4)
0x1024	S_WORD	3-phase : power factor	1/100 signed
0x1025	U_WORD	3-phase : sector of power factor (cap or ind)	0 : PF = 1 1 : ind 2 : cap
0x1026	U_WORD	Frequency	Hz/10
0x1027	UD_WORD	3-phase : average power	(3)
0x1029	UD_WORD	3-phase : peak maximum demand	(3)
0x102b	U_WORD	Time counter for average power	minutes
0x102c	UD_WORD	Phase 1 : active power	(3)
0x102e	UD_WORD	Phase 2 : active power	(3)
0x1030	UD_WORD	Phase 3 : active power	(3)
0x1032	U_WORD	Phase 1 : sign of active power	(6)
0x1033	U_WORD	Phase 2 : sign of active power	(6)
0x1034	U_WORD	Phase 3 : sign of active power	(6)
0x1035	UD_WORD	Phase 1 : reactive power	(3)
0x1037	UD_WORD	Phase 2 : reactive power	(3)
0x1039	UD_WORD	Phase 3 : reactive power	(3)
0x103b	U_WORD	Phase 1 : sign of reactive power	(6)
0x103c	U_WORD	Phase 2 : sign of reactive power	(6)
0x103d	U_WORD	Phase 3 : sign of reactive power	(6)
0x103e	UD_WORD	Phase 1 : apparent power	(3)
0x1040	UD_WORD	Phase 2 : apparent power	(3)
0x1042	UD_WORD	Phase 3 : apparent power	(3)
0x1044	S_WORD	Phase 1 : power factor	1/100 signed
0x1045	S_WORD	Phase 2 : power factor	1/100 signed
0x1046	S_WORD	Phase 3 : power factor	1/100 signed
0x1047	U_WORD	Phase 1 : power factor sector	0 : PF = 1 1 : ind 2 : cap
0x1048	U_WORD	Phase 2 : power factor sector	0 : PF = 1 1 : ind 2 : cap
0x1049	U_WORD	Phase 3 : power factor sector	0 : PF = 1 1 : ind 2 : cap
0x104a	U_WORD	Phase 1 : THD V1	1/10 %
0x104b	U_WORD	Phase 2 : THD V2	1/10 %
0x104c	U_WORD	Phase 3 : THD V3	1/10 %
0x104d	U_WORD	Phase 1 : THD I1	1/10 %
0x104e	U_WORD	Phase 2 : THD I2	1/10 %
0x104f	U_WORD	Phase 3 : THD I3	1/10 %

0x1050	UD_WORD	Phase 1 : I1 average	mA
0x1052	UD_WORD	Phase 2 : I2 average	mA
0x1054	UD_WORD	Phase 3 : I3 average	mA
0x1056	UD_WORD	Phase 1 : I1 peak maximum	mA
0x1058	UD_WORD	Phase 2 : I2 peak maximum	mA
0x105a	UD_WORD	Phase 3 : I3 peak maximum	mA
0x105c	UD_WORD	(I1+I2+I3)/3	mA
0x105e	UD_WORD	Phase 1 : V1 min	mV
0x1060	UD_WORD	Phase 2 : V2 min	mV
0x1062	UD_WORD	Phase 3 : V3 min	mV
0x1064	UD_WORD	Phase 1 : V1 max	mV
0x1066	UD_WORD	Phase 2 : V2 max	mV
0x1068	UD_WORD	Phase 3 : V3 max	mV
0x106e	U_WORD	Run hour meter	Hour
0x106f	U_WORD	Not used	-
0x1070	UD_WORD	3-phase : active average power	(3)
0x1072	UD_WORD	3-phase : reactive average power	(3)
0x1074	UD_WORD	3-phase : apparent average power	(3)
0x1076	UD_WORD	3-phase : active PMD power	(3)
0x1078	UD_WORD	3-phase : reactive PMD power	(3)
0x107a	UD_WORD	3-phase : apparent PMD power	(3)

0x1200	U_WORD	Current transformer ratio (KTA)	No unit
0x1204	U_WORD	Device identifier	0x1114
0x1205	U_WORD	Voltages sequence diagnostic	1 : OK 2 : error

(**) for compliance with older products

0x1500	UD_WORD	Positive Active Energy – Low	Wh
0x1502	UD_WORD	Positive Active Energy – High	MWh
0x1504	UD_WORD	Positive Reactive Energy – Low	varh
0x1506	UD_WORD	Positive Reactive Energy – High	Mvarh
0x1508	UD_WORD	Negative Active Energy – Low	Wh
0x150A	UD_WORD	Negative Active Energy – High	MWh
0x150C	UD_WORD	Negative Reactive Energy – Low	varh
0x150E	UD_WORD	Negative Reactive Energy – High	Mvarh
0x1510	UD_WORD	Partial Active Energy – Low	Wh
0x1512	UD_WORD	Partial Active Energy – High	MWh
0x1514	UD_WORD	Partial Reactive Energy – Low	varh
0x1516	UD_WORD	Partial Reactive Energy – High	Mvarh
0x1518	SD_WORD	Signed 3-ph Active Power	W
0x151A	SD_WORD	Signed 3-ph Reactive Power	var
0x151C	SD_WORD	Signed Phase1 Active Power	W
0x151E	SD_WORD	Signed Phase2 Active Power	W
0x1520	SD_WORD	Signed Phase3 Active Power	W
0x1522	SD_WORD	Signed Phase1 Reactive Power	var
0x1524	SD_WORD	Signed Phase2 Reactive Power	var
0x1526	SD_WORD	Signed Phase3 Reactive Power	var
0x1528	SD_WORD	Signed 3-ph Power Factor	1/1000
0x152A	SD_WORD	Signed Phase1 Power Factor	1/1000
0x152C	SD_WORD	Signed Phase2 Power Factor	1/1000
0x152E	SD_WORD	Signed Phase3 Power Factor	1/1000

0x1530	UD_WORD	Apparent power	VA
0x1532	UD_WORD	3-phase : active average power	W
0x1534	UD_WORD	3-phase : reactive average power	Var
0x1536	UD_WORD	3-phase : apparent average power	VA
0x1538	UD_WORD	3-phase : active PMD power	W
0x153a	UD_WORD	3-phase : reactive PMD power	Var
0x153c	UD_WORD	3-phase : apparent PMD power	VA
0x1540	U_WORD	Active positive energy wrap around	(*)
0x1541	U_WORD	Reactive positive energy wrap around	(*)
0x1542	U_WORD	Active negative energy wrap around	(*)
0x1543	U_WORD	Reactive negative energy wrap around	(*)

(*) wrap around means : when the main register of the energy value increases over 100 000 000 , the register is then reset to 0 and the wrap around value is incremented by 1

0x1700	UD_WORD	Positive Active Energy - Low	Wh
0x1702	UD_WORD	Positive Active Energy – High	MWh
0x1704	UD_WORD	Positive Reactive Energy - Low	varh
0x1706	UD_WORD	Positive Reactive Energy – High	Mvarh
0x1708	UD_WORD	Negative Active Energy - Low	Wh
0x170A	UD_WORD	Negative Active Energy – High	MWh
0x170C	UD_WORD	Negative Reactive Energy - Low	varh
0x170E	UD_WORD	Negative Reactive Energy – High	Mvarh
0x1710	UD_WORD	Partial+ Active Energy - Low	Wh
0x1712	UD_WORD	Partial+ Active Energy - High	MWh
0x1714	UD_WORD	Partial+ Reactive Energy - Low	varh
0x1716	UD_WORD	Partial+ Reactive Energy - High	Mvarh
0x1718	UD_WORD	Partial- Active Energy - Low	Wh
0x171a	UD_WORD	Partial- Active Energy - High	MWh
0x171c	UD_WORD	Partial- Reactive Energy – Low	varh
0x171e	UD_WORD	Partial- Reactive Energy - High	Mvarh
0x1720	SD_WORD	Signed 3-ph active power	W
0x1722	SD_WORD	Signed 3-ph reactive power	var
0x1724	SD_WORD	Signed phase1 active power	W
0x1726	SD_WORD	Signed phase2 active power	W
0x1728	SD_WORD	Signed phase3 active power	W
0x172A	SD_WORD	Signed phase1 reactive power	var
0x172C	SD_WORD	Signed phase2 reactive power	var
0x172E	SD_WORD	Signed phase3 reactive power	var
0x1730	SD_WORD	Signed 3-ph Power Factor	1/100
0x1732	SD_WORD	Signed phase1 Power Factor	1/100
0x1734	SD_WORD	Signed phase2 Power Factor	1/100
0x1736	SD_WORD	Signed phase3 Power Factor	1/100

0x7500	U_WORD	THD I1	1/10 %
0x7501	U_WORD	THD I2	1/10 %
0x7502	U_WORD	THD I3	1/10 %
0x7503	U_WORD	THD V1 (V12)	1/10 %
0x7504	U_WORD	THD V2 (V23)	1/10 %
0x7505	U_WORD	THD V3 (V31)	1/10 %

(3) ---

W, var, VA / 100 if KTA*KTV < 5000
W, var, VA if KTA*KTV >= 5000

(4) ---

Transformer ratio	Measurement unit	Display Format	Protocol Format
1 □ KTA*KTV < 10	Wh(varh) * 10	xxxxxx.yy k	xxxxxxyy
10 □ KTA*KTV < 100	Wh(varh) * 100	xxxxxxx.y k	xxxxxxxy
100 □ KTA*KTV < 1000	kWh(kvarh)	xxxxxxxx k	xxxxxxxx
1000 □ KTA*KTV < 10000	kWh(kvarh) * 10	xxxxxx.yy M	xxxxxxyy
10000 □ KTA*KTV < 100000	kWh(kvarh) * 100	xxxxxxx.y M	xxxxxxxy

(6) ---

0 : positive
1 : negative

5.0 SETUP PARAMETERS

SCHRACK MF9 parameters may be red and written accordingly to the procedure described in the following. The variable table to read and write the parameters are located at the same address.
It is allowed to write the setup parameters addressed at 0x2000 and 0x2200 only by a single telegram for each group.

Standard Setup parameters (read and write) →Length : 16 BYTES

0x2000	U_WORD	RFU	
0x2001	U_WORD	RFU	
0x2002	U_WORD	RFU	
0x2003	U_WORD	RFU	
0x2004	U_WORD	RFU	
0x2005	U_WORD	Run hour meter active on	0:V1 1:P
0x2006	U_WORD	RFU	
0x2007	U_WORD	RFU	
0x2008	U_WORD	RFU	
0x2009	U_WORD	RFU	
0x200a	U_WORD	Power Averaging time	0: 5 min 1: 8 min 2: 10 min 3: 15 min 4: 20 min 5: 30 min 6: 60 min
0x200b	U_WORD	Insertion type	0: 3n-3e 3: 1n-1e
0x200c	U_WORD	Measure on line 3 of custom page	0: V phase 3 1: V31 2: I phase 3 3: P 3-phase 4: Q 3-phase 5: S 3-phase 6: P phase 3 7: Q phase 3 8: S phase 3 9: P phase 1 10: I phase 1
0x200d	U_WORD	Measure on line 2 of custom page	0: V phase 2 1: V23 2: I phase 2 3: P 3-phase 4: Q 3-phase 5: S 3-phase 6: P phase 2 7: Q phase 2 8: S phase 2 9: Frequency 10: I phase 1

0x200e	U_WORD	Measure on line 1 of custom page	0: V phase 1 1: V12 2: I phase 1 3: I Neutral 4: 3-phase 5: Q 3-phase 6: S 3-phase 7: P phase 1 8: Q phase 1 9: S phase 1 10:PF 3-phase
0x200f	U_WORD	RFU	

E.g. Request

FF 03 20 00 00 10 5A 18

Answer :

	0x2000	0x2001	0x2002	0x2003	0x2004	0x2005	0x2006	0x2007	0x2008
FF 03 20	W0	W1	W2	W3	W4	W5	W6	W7	W8
	0x2009	0x200a	0x200b	0x200c	0x200d	0x200e	0x200f		
	W9	W10	W11	W12	W13	W14	W15	CRC WORD	

FF 03 20 | 00 00 | 00 05 | 00 00 | 00 03 | 00 0A | 00 00 | 00 00 | 00 00 | 00 01 |
| 00 01 | 00 00 | 00 00 | 00 03 | 00 02 | 00 01 | 00 00 | BC B2

W0, W1, W2, W3, W4, W6, W15 are not used.

Ouptut options parameters (read and write)

Length : 24 BYTES

0x2200	U_WORD	RFU	
0x2201	U_WORD	RFU	
0x2202	U_WORD	RFU	
0x2203	U_WORD	RFU	
0x2204	U_WORD	RFU	
0x2205	U_WORD	RFU	
0x2206	U_WORD	RFU	
0x2207	U_WORD	RFU	
0x2208	U_WORD	RFU	
0x2209	U_WORD	RFU	
0x220a	U_WORD	RFU	
0x220b	U_WORD	RFU	
0x220c	U_WORD	RFU	
0x220d	U_WORD	RFU	
0x220e	U_WORD	RFU	
0x220f	U_WORD	RFU	
0x2210	U_WORD	RFU	
0x2211	U_WORD	RFU	
0x2212	U_WORD	RFU	
0x2213	U_WORD	RFU	
0x2214	U_WORD	RFU	
0x2215	U_WORD	Pulse duration	0: 50 ms 1: 100 ms 2: 200 ms 3: 300 ms 4: 400 ms 5: 500 ms
0x2216	U_WORD	Pulse weight	0: 0.01 k 1: 0.1 k 2: 1.0 k 3: 10.0 k 4: 100,0 k 5: 1,0 M 6: 10,0 M
0x2217	U_WORD	Positive Energy type used for the pulse output	0: active 1: reactive

E.g. Request
FF 03 22 00 00 18 5A 66

Answer :

	0x2200	0x2201	0x2202	0x2203	0x2204	0x2205	0x2206	0x2207	0x2208
FF 03 30	W0	W1	W2	W3	W4	W5	W6	W7	W8
	0x2209	0x220a	0x220b	0x220c	0x220d	0x220e	0x220f	0x2210	0x2211
	W9	W10	W11	W12	W13	W14	W15	W16	W17
	0x2212	0x2213	0x2214	0x2215	0x2216	0x2217			
	W18	W19	W20	W21	W22	W23	CRC WORD		

FF 03 30 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 |
00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 | 00 00 |
00 00 | 00 00 | 00 00 | 00 00 | 00 02 | 00 01 | 6D C1

W0 .. W20 are not used.

Procedure to write

SCHRACK MF9 parameters may be written accordingly to the procedure described in the following. Master

Unlock Key Writing

Every write operation must be preceded by a "Master Unlock Key" command.

Address 0x2700 : write word with value = 0x5AA5 (Master Unlock Key)

Reset of SCHRACK MF9

Any writing operation of any parameter will have effect only in the volatile memory (RAM).
After any writing operation of parameters described in the following of the document, if necessary to go back to the default then it is mandatory to send the following commands :

Address 0x2700 : write word with value = 0x5AA5 (Master Unlock Key)
Address 0x2800 : write word with value = 0xYYYY (any value)

This command will reset the SCHRACK MF9 and in this way all changes will be lost so returning to the previous conditions.

EEPROM savings

If it is necessary to save the new parameters in EEPROM it is mandatory to send these following messages :

Address 0x2700 : write WORD with value = 0x5AA5 (Master Unlock Key)
Address 0x2600 : write WORD with value = 0xYYYY (any value)

Write address table

Address	Format	Description	Value
0x100	U_WORD	Write Current transformer ratio	1 - 9999
0x2000	16 U_WORD	Write Standard setup parameters	(16)
0x2200	24 U_WORD	Write Programming parameters of pulse output (slot 2)	(16)
0x2400	U_WORD	Reset Hour Meter, Maximum Powers, Maximum Voltages, Maximum Currents, Minimum Voltages	(12)
0x2600	U_WORD	Saving in EEPROM parameters changed by Remote commands	(13)
0x2700	U_WORD	Enable Remote Writing Operation	(14)
0x2800	U_WORD	Load previous setup parameters stored in EEPROM	(15)

(12) To reset desired measurements write the following word (in binary) :

0|0|0|0|0|0|0|0|b8|b7|b6|b5|b4|b3|b2|b1|b0

b0 = 1 => Reset Hour Meter
b1 = 1 => Reset Peak Maximum Demand
b2 = 1 => Reset Maximum Voltage values
b3 = 1 => Reset Maximum Current values
b4 = 1 => Reset Minimum Voltage values

b9 .. b15 = 0

(13) Write any value to save the new parameters changed by Remote commands

(14) To do any remote programming write operation, it's mandatory to write a safety key = 0x5AA5.

(15) Write any value to abort any remote programming write operation and reload the previous values.

(16) The parameters are read and written with the same sequence.