

Instruction manual: Modbus protocol for RS 485 connection



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## 1.0 Abstract

### Physical level

The physical 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 physical 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 Parameter 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 Abstract

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

\* U\_WORD : one WORD - unsigned

Example : 1000 = 0x 03 e8

MSB	LSB		
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 */

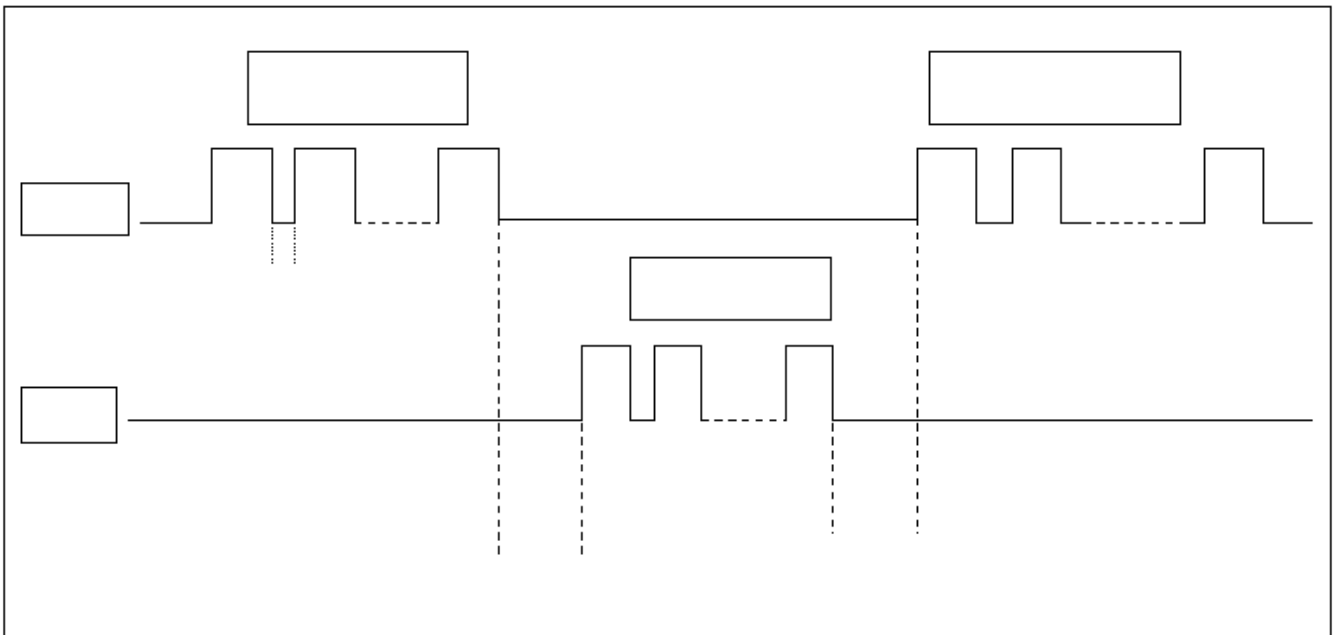
```

## 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



**Be careful :** among the setup parameters there is a timeout value that may be programmed. This is the inter-characters timeout and implicitly is the timeout to detect the end of a message. The value of 20 msec is suggested to keep compatibility with older IME devices. The minimum value is 3 msec.

TIME	DESCRIPTION	Min & Max VALUES
T1	<b>Time between characters.</b> If this time exceeds the programmed timeout, the message is considered closed by the device	Min = 3 msec Max <= 99 msec
T2	<b>Slave response time</b> Minimum and maximum response time of device to the Master request after a message has been detected valid	Max = 20 ms.
T3	Time before a new message request from the Master	Min = 1 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	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		WORDS number		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
0x102	U_WORD	Voltage transformer ratio (KTV)	1/100 (hundredths)
0x103	U_WORD	Future development	---
0x300	U_WORD	Device identifier	0x1013



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	(2)
0x1016	UD WORD	3-phase : reactive power	(2)
0x1018	UD WORD	3-phase : apparent power	(2)
0x101a	U WORD	3-phase : sign of active power	(4)
0x101b	U WORD	3-phase : sign of reactive power	(4)
0x101c	UD WORD	3-phase : positive active energy	(3)
0x101e	UD WORD	3-phase : positive reactive energy	(3)
0x1020	UD WORD	3-phase : negative active energy	(3)
0x1022	UD WORD	3-phase : negative reactive energy	(3)
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	(2)
0x1029	UD WORD	3-phase : peak maximum demand	(2)
0x102b	U WORD	Time counter for average power	minutes
0x102c	UD WORD	Phase 1 : active power	(2)
0x102e	UD WORD	Phase 2 : active power	(2)
0x1030	UD WORD	Phase 3 : active power	(2)
0x1032	U WORD	Phase 1 : sign of active power	(4)
0x1033	U WORD	Phase 2 : sign of active power	(4)
0x1034	U WORD	Phase 3 : sign of active power	(4)
0x1035	UD WORD	Phase 1 : reactive power	(2)
0x1037	UD WORD	Phase 2 : reactive power	(2)
0x1039	UD WORD	Phase 3 : reactive power	(2)
0x103b	U WORD	Phase 1 : sign of reactive power	(4)
0x103c	U WORD	Phase 2 : sign of reactive power	(4)
0x103d	U WORD	Phase 3 : sign of reactive power	(4)
0x103e	UD WORD	Phase 1 : apparent power	(2)
0x1040	UD WORD	Phase 2 : apparent power	(2)
0x1042	UD WORD	Phase 3 : apparent power	(2)
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	% (0..100.0)
0x104b	U WORD	Phase 2 : THD V2	% (0..100.0)



0x104c	U WORD	Phase 3 : THD V3	% (0..100.0)
0x104d	U WORD	Phase 1 : THD I1	% (0..100.0)
0x104e	U WORD	Phase 2 : THD I2	% (0..100.0)
0x104f	U WORD	Phase 3 : THD I3	% (0..100.0)
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
0x106a	UD WORD	3-phase : active partial energy	(3)
0x106c	UD WORD	3-phase : reactive partial energy	(3)
0x106e	U WORD	Run hour meter	Hour
0x106f	U WORD	RFU	(1)
0x1070	UD WORD	3-phase : active average power	(2)
0x1072	UD WORD	3-phase : reactive average power	(2)
0x1074	UD WORD	3-phase : apparent average power	(2)
0x1076	UD WORD	3-phase : active PMD power	(2)
0x1078	UD WORD	3-phase : reactive PMD power	(2)
0x107a	UD WORD	3-phase : apparent PMD power	(2)
0x107c	UD WORD	Run hour meter	minutes
0x107e	UD WORD	Distorting power	(2)

0x1200	U WORD	Current transformer ratio (KTA)	No unit
0x1201	U WORD	Voltage transformer ratio (KTV)	1/100 (hundredths)
0x1202	UD WORD	Future developments	---
0x1204	U WORD	Device identifier	0x1013
0x1205	U WORD	Future developments	---
0x1206	U WORD	Future developments	---

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	RFU	
0x1512	UD WORD	RFU	
0x1514	UD WORD	RFU	
0x1516	UD WORD	RFU	
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	W
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	Wrap round positive active energy	(5)
0x1541	U WORD	Wrap round positive reactive energy	(5)
0x1542	U WORD	Wrap round negative active energy	(5)
0x1543	U WORD	Wrap round negative reactive energy	(5)

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

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 %

(1) -----  
RFU : Reserved for future users

(2) -----  
W, var, VA / 100 if KTA\*KTV < 5000  
W, var, VA if KTA\*KTV >= 5000

(3) -----

Transformer ratio	Measurement unit	Display Format	Protocol Format
$1 \leq KTA \cdot KTV < 10$	Wh (varh) * 10	xxxxxx.yy k	xxxxxxxxyy
$10 \leq KTA \cdot KTV < 100$	Wh (varh) * 100	xxxxxxxx.y k	xxxxxxxxxy
$100 \leq KTA \cdot KTV < 1000$	kWh (kvarh)	xxxxxxxx k	xxxxxxxx
$1000 \leq KTA \cdot KTV < 10000$	kWh (kvarh) * 10	xxxxxx.yy M	xxxxxxxxyy
$10000 \leq KTA \cdot KTV < 100000$	kWh (kvarh) * 100	xxxxxxxx.y M	xxxxxxxxxy
$100000 \leq KTA \cdot KTV$	kWh (kvarh) * 100	xxxxxxxx M	xxxxxxxx

(4) -----  
0 : positive  
1 : negative

(5) -----  
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.

## 5.0 Setup parameters

NEMO D4e parameters may be read 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	Percentage of rated 3phase active power run hour meter	50..5000 means (0.5%..50.00%)
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	0:5min 1:8min 2:10min 3:15min 4:20min 5:30min 6:60min
0x200b	U_WORD	Insertion type	0:3n-3e 1: 3-3e 2: 3-2e 3:1n-1e
0x200c	U_WORD	Measure on line 3 of custom page	0:V1 1:V12 2:I1 3:In 4:P 5:Q 6:S 7:P1 8:Q1 9:S1 10:PF 3-phase

0x200d	<b>U_WORD</b>	Measure on line 2 of custom page	0:V2 1:V23 2:I2 3:P 4:Q 5:S 6:P2 7:Q2 8:S2 9:Freq 10:I1
0x200e	<b>U_WORD</b>	Measure on line 1 of custom page	0:V3 1:V31 2:I3 3:P 4:Q 5:S 6:P3 7:Q3 8:S3 9:P1 10:I1
0x200f	<b>U_WORD</b>	RFU	-

**Output option Setup 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	Pulse duration	0: 50msec 1: 100msec 2: 200msec 3: 300msec
0x220c	U_WORD	Pulse weight	0: 0.01 kWh 1: 0.10 kWh 2: 1.00 kWh 3:10.0 kWh 4: 0.10 MWh 5: 1.00 MWh 6:10.0 MWh
0x220d	U_WORD	Pulse on	0:Act Energy 1:Rea Energy
0x220e	U_WORD	RFU	
0x220f	U_WORD	RFU	
0x2210	U_WORD	RFU	
0x2211	U_WORD	RFU	
0x2212	U_WORD	RFU	
0x2213	U_WORD	RFU	
0x2213	U_WORD	RFU	
0x2214	U_WORD	RFU	-
0x2215	U_WORD	RFU	
0x2216	U_WORD	RFU	
0x2217	U_WORD	RFU	

**E.g. Request**

FF 03 22 00 00 18 5A 66

**Answer :**

```

FF 03 30  0x2200  0x2201  0x2202  0x2203  0x2204  0x2205  0x2206  0x2207  0x2208
           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 01 | 00 02 | 6D C1

```

W0 .. W9 / W20 are not used.



## Procedure to write

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

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

## Reset of NEMO parameters

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

it is mandatory to send the following commands :

Address 0x2700 : write WORD with value = 0x 5AA5 ( Master Unlock Key )

Address 0x2800 : write WORD with value = 0x YYYY ( any value )

This command will reset the NEMO 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 = 0x 5AA5 ( Master Unlock Key )

Address 0x2600 : write WORD with value = 0x YYYY ( any value )

**Write address table**

Address	Format	Description	Value
0x100	U_WORD	Current transformer ratio	1 - 9999
0x2000	16 U_WORD	Standard setup parameters	(10)
0x2200	24 U_WORD	Option setup parameters	(10)
0x2400	U_WORD	Reset Hour Meter, Maximum Powers, Maximum Voltages, Maximum Currents, Minimum Voltages	(6)
0x2600	U_WORD	Saving in EEPROM parameters changed by Remote commands	(7)
0x2700	U_WORD	Enable Remote Writing Operation	(8)
0x2800	U_WORD	Load previous setup parameters stored in EEPROM	(9)

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

```
0|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 .. b15 = 0
```

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

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

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

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