CONTENTS

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 Data format

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.

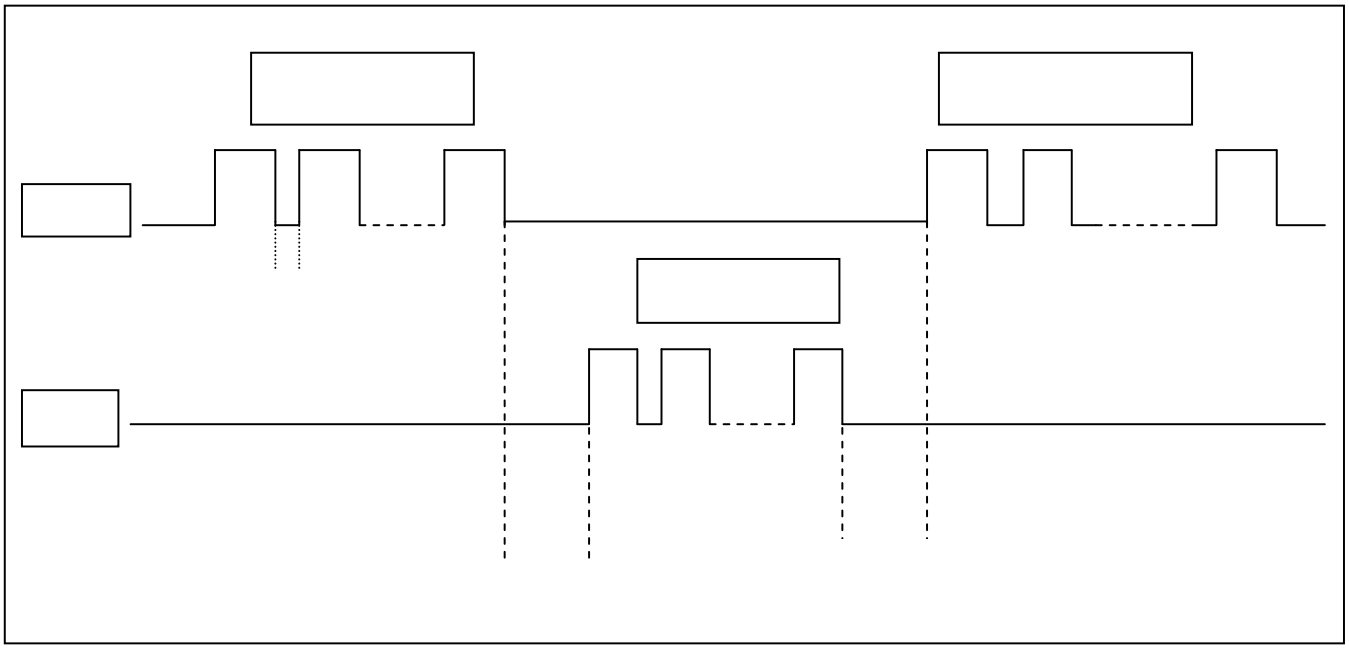
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*     ************************************************************
 *     Descrizione : calculates a data buffer CRC WORD
 *     Input       :       ptbuf = pointer to the first byte of the buffer
 *                  num   = number of bytes
 *     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	**Time between characters.** If this time exceeds the programmed timeout, the message is considered closed by the device	Min = 3 msec Max <= 99 msec
T2	**Slave response time** 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	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		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 ≤ 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
100000 ≤ KTA*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 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**	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	**U_WORD**	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	**U_WORD**	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	**U_WORD**	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
0x200c	**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
0x200d	**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 :

	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 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|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.