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1.0 ABSTRACT

Phisical level

The phisical 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 phisical 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

Three types of format are used for the data :

* BYTE
* WORD : two BYTES
* long : two WORDS

The base data format is the WORD.
If the required data is in a BYTE format, a WORD with the MSB (Most Significant Byte) set to 0 is anyway transmitted and this BYTE comes before the LSB (Least Significant Byte).
If the required data is in a long format, 2 WORDS are transmitted and the MSW comes before the LSW.

MSB	LSB	MSB	LSB
Most Significant WORD		Least Significant WORD	

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

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.

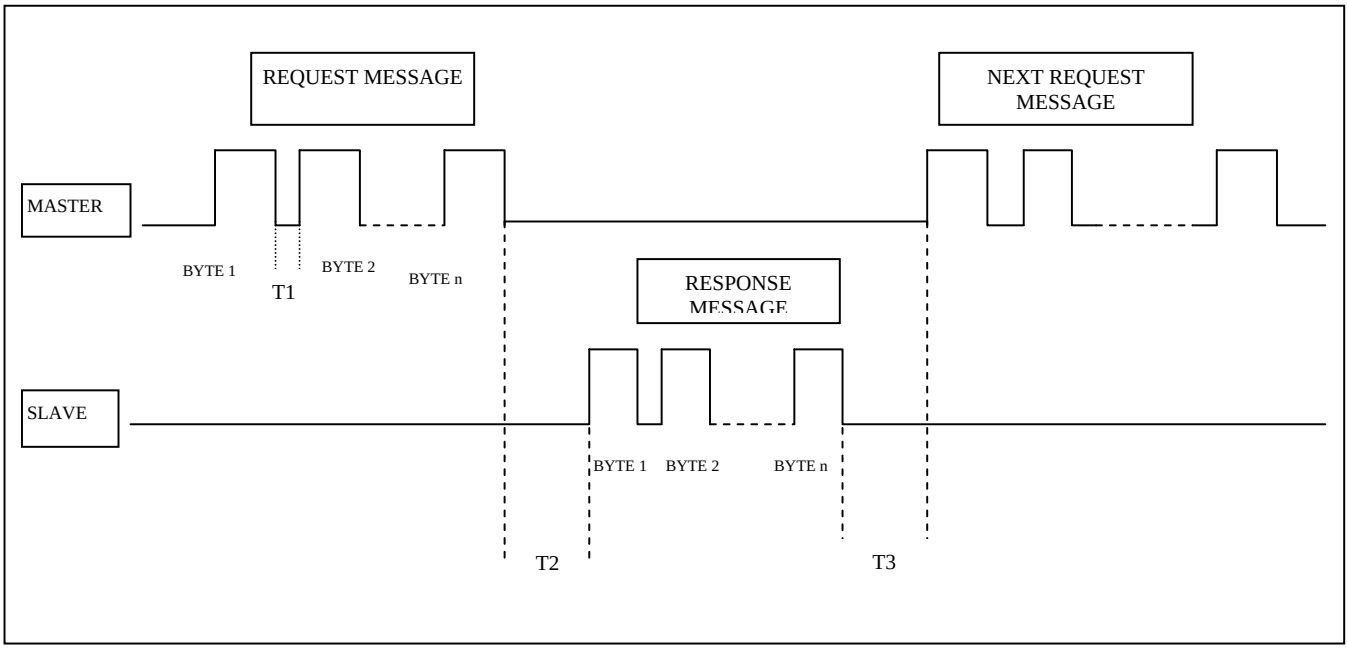
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*     ************************************************************
 *     Descrizione : calculates a data buffer CRC WORD
 *     Input       :       ptbuf = pointer to the first byte of the buffer
 *                  num   = number of bytes
 *     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	VALUES	
T1	**Time between characters.** If this time exceeds the max. time allowed, the message is not considered by device.	Modbus standard	
T2	**Slave response time** Minimum and maximum response time of device to the Master request.	Min = 20 ms. Max = 300ms.	
T3	***Delay time*** Time before a new message request from the Master	Min = 20 ms.	

3.0 COMMANDS

Code 0x03 : reading of one or more consecutive WORDS

Command format :

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

Answer format (containing data) :

BYTE	BYTE	BYTE	MSB	LSB	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	MSB	LSB
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

Address	Byte n.	Description	Unit
0x301	Long	Phase 1 : phase voltage	mV
0x305	Long	Phase 2 : phase voltage	mV
0x309	Long	Phase 3 : phase voltage	mV
0x30d	Long	Phase 1 : current	mA
0x311	Long	Phase 2 : current	mA
0x315	Long	Phase 3 : current	mA
0x319	Long	3-phase : active power	(3)
0x31d	Long	3-phase : reactive power	(3)
0x321	Long	3-phase : apparent power	(3)
0x325	Long	3-phase : positive active energy	(4)
0x329	Long	Chained voltage : L1-L2	mV
0x32d	Long	Chained voltage : L2-L3	mV
0x331	Long	Chained voltage : L3-L1	mV
0x335	Long	3-phase : negative active energy	(4)
0x339	WORD	Frequency	Hz/10
0x33b	WORD	Operating timer counter	h
0x33d	WORD	3-phase : power factor	1/100 (7)
0x33f	BYTE	3-phase : sector of power factor (cap or ind)	1 : ind 2 : cap
0x340	BYTE	Voltages sequence diagnostic	1 : OK 2 : error
0x341	WORD	0	
0x343	Long	3-phase : positive reactive energy	(4)
0x347	BYTE	3-phase : sign of active power	(5)
0x348	Long	3-phase : negative reactive energy	(4)
0x34c	BYTE	3-phase : sign of reactive power	(5)
0x34d	BYTE	0	
0x34e	BYTE	0	
0x34f	BYTE	0	
0x350	Long	3-phase : average power	(3)
0x354	Long	3-phase : peak maximum demand	(3)
0x358	BYTE	Time counter for average power	minutes
0x359	Long	Neutral current	mA
0x35d	Long	Phase 1 : active power	(3)
0x361	Long	Phase 2 : active power	(3)
0x365	Long	Phase 3 : active power	(3)
0x369	BYTE	Phase 1 : sign of active power	(5)
0x36a	BYTE	Phase 2 : sign of active power	(5)
0x36b	BYTE	Phase 3 : sign of active power	(5)
0x36c	Long	Phase 1 : reactive power	(3)
0x370	Long	Phase 2 : reactive power	(3)
0x374	Long	Phase 3 : reactive power	(3)
0x378	BYTE	Phase 1 : sign of reactive power	(5)
0x379	BYTE	Phase 2 : sign of reactive power	(5)
0x37a	BYTE	Phase 3 : sign of reactive power	(5)
0x37b	Long	Phase 1 : apparent power	(3)
0x37f	Long	Phase 2 : apparent power	(3)
0x383	Long	Phase 3 : apparent power	(3)
0x387	WORD	Phase 1 : power factor	1/100 (7)
0x389	WORD	Phase 2 : power factor	1/100 (7)
0x38b	WORD	Phase 3 : power factor	1/100 (7)

0x38d	BYTE	Phase 1 : power factor sector	1 : ind 2 : cap
0x38e	BYTE	Phase 2 : power factor sector	1 : ind 2 : cap
0x38f	BYTE	Phase 3 : power factor sector	1 : ind 2 : cap
0x390	WORD	Phase 1 : THD V1	%
0x392	WORD	Phase 2 : THD V2	%
0x394	WORD	Phase 3 : THD V3	%
0x396	WORD	Phase 1 : THD I1	%
0x398	WORD	Phase 2 : THD I2	%
0x39a	WORD	Phase 3 : THD I3	%
0x39c	Long	Phase 1 : I1 average	mA
0x3a0	Long	Phase 2 : I2 average	mA
0x3a4	Long	Phase 3 : I3 average	mA
0x3a8	Long	Phase 1 : I1 peak maximum	mA
0x3ac	Long	Phase 2 : I2 peak maximum	mA
0x3b0	Long	Phase 3 : I3 peak maximum	mA
0x3b4	Long	(I1+I2+I3)/3	mA
0x3b8	Long	Phase 1 : V1 min	mV
0x3bc	Long	Phase 2 : V2 min	mV
0x3c0	Long	Phase 3 : V3 min	mV
0x3c4	Long	Phase 1 : V1 max	mV
0x3c8	Long	Phase 2 : V2 max	mV
0x3cc	Long	Phase 3 : V3 max	mV
0x3d0	Long	3-phase : active partial energy	(4)
0x3d4	Long	3-phase : reactive partial energy	(4)
0x3d8	Long	3-phase : active average power	(3)
0x3dc	Long	3-phase : reactive average power	(3)
0x3e0	Long	3-phase : apparent average power	(3)
0x3e4	Long	3-phase : active PMD power	(3)
0x3e8	Long	3-phase : reactive PMD power	(3)
0x3ec	Long	3-phase : apparent PMD power	(3)

0x100	WORD	Current transformer ratio (KTA)	integer
0x102	WORD	Voltage transformer ratio (KTV)	1/10 (tenths)
0x104	Long	Device configuration	(1)
0x300	BYTE	Device identifier	0x11

A second address table is implemented in the software and the user may decide to use one or both freely.

Address	Byte n.	Description	Unit
0x1000	Long	Phase 1 : phase voltage	mV
0x1002	Long	Phase 2 : phase voltage	mV
0x1004	Long	Phase 3 : phase voltage	mV
0x1006	Long	Phase 1 : current	mA
0x1008	Long	Phase 2 : current	mA
0x100a	Long	Phase 3 : current	mA
0x100c	Long	Neutral current	mA
0x100e	Long	Chained voltage : L1-L2	mV
0x1010	Long	Chained voltage : L2-L3	mV
0x1012	Long	Chained voltage : L3-L1	mV
0x1014	Long	3-phase : active power	(3)
0x1016	Long	3-phase : reactive power	(3)
0x1018	Long	3-phase : apparent power	(3)
0x101a	WORD	3-phase : sign of active power	(5)
0x101b	WORD	3-phase : sign of reactive power	(5)
0x101c	Long	3-phase : positive active energy	(4)
0x101e	Long	3-phase : positive reactive energy	(4)
0x1020	Long	3-phase : negative active energy	(4)
0x1022	Long	3-phase : negative reactive energy	(4)
0x1024	WORD	3-phase : power factor	1/100 (7)
0x1025	WORD	3-phase : sector of power factor (cap or ind)	1 : ind 2 : cap
0x1026	WORD	Frequency	Hz/10
0x1027	Long	3-phase : average power	(3)
0x1029	Long	3-phase : peak maximum demand	(3)
0x102b	WORD	Time counter for average power	minutes
0x102c	Long	Phase 1 : active power	(3)
0x102e	Long	Phase 2 : active power	(3)
0x1030	Long	Phase 3 : active power	(3)
0x1032	WORD	Phase 1 : sign of active power	(5)
0x1033	WORD	Phase 2 : sign of active power	(5)
0x1034	WORD	Phase 3 : sign of active power	(5)
0x1035	Long	Phase 1 : reactive power	(3)
0x1037	Long	Phase 2 : reactive power	(3)
0x1039	Long	Phase 3 : reactive power	(3)
0x103b	WORD	Phase 1 : sign of reactive power	(5)
0x103c	WORD	Phase 2 : sign of reactive power	(5)
0x103d	WORD	Phase 3 : sign of reactive power	(5)
0x103e	Long	Phase 1 : apparent power	(3)
0x1040	Long	Phase 2 : apparent power	(3)
0x1042	Long	Phase 3 : apparent power	(3)
0x1044	WORD	Phase 1 : power factor	1/100 (7)
0x1045	WORD	Phase 2 : power factor	1/100 (7)
0x1046	WORD	Phase 3 : power factor	1/100 (7)
0x1047	WORD	Phase 1 : power factor sector	1 : ind 2 : cap
0x1048	WORD	Phase 2 : power factor sector	1 : ind 2 : cap
0x1049	WORD	Phase 3 : power factor sector	1 : ind 2 : cap
0x104a	WORD	Phase 1 : THD V1	%
0x104b	WORD	Phase 2 : THD V2	%
0x104c	WORD	Phase 3 : THD V3	%
0x104d	WORD	Phase 1 : THD I1	%
0x104e	WORD	Phase 2 : THD I2	%
0x104f	WORD	Phase 3 : THD I3	%
0x1050	Long	Phase 1 : I1 average	mA
0x1052	Long	Phase 2 : I2 average	mA
0x1054	Long	Phase 3 : I3 average	mA

0x1056	Long	Phase 1 : I1 peak maximum	mA
0x1058	Long	Phase 2 : I2 peak maximum	mA
0x105a	Long	Phase 3 : I3 peak maximum	mA
0x105c	Long	(I1+I2+I3)/3	mA
0x105e	Long	Phase 1 : V1 min	mV
0x1060	Long	Phase 2 : V2 min	mV
0x1062	Long	Phase 3 : V3 min	mV
0x1064	Long	Phase 1 : V1 max	mV
0x1066	Long	Phase 2 : V2 max	mV
0x1068	Long	Phase 3 : V3 max	mV
0x106a	Long	3-phase : active partial energy	(4)
0x106c	Long	3-phase : reactive partial energy	(4)
0x106e	WORD	Operating timer counter	h
0x106f	WORD	0	
0x1070	Long	3-phase : active average power	(3)
0x1072	Long	3-phase : reactive average power	(3)
0x1074	Long	3-phase : apparent average power	(3)
0x1076	Long	3-phase : active PMD power	(3)
0x1078	Long	3-phase : reactive PMD power	(3)
0x107a	Long	3-phase : apparent PMD power	(3)

0x1200	WORD	Current transformer ratio (KTA)	integer
0x1201	WORD	Voltage transformer ratio (KTV)	1/10 (tenths)
0x1202	Long	Device configuration	(1)
0x1204	WORD	Device identifier	0x11
0x1205	WORD	Voltages sequence diagnostic	1 : OK 2 : error

0x2000	16 WORD	Standard setup parameters	(6)
0x2100	24 WORD	Not used SLOT 1	
0x2200	24 WORD	Not used SLOT 2	
0x2300	24 WORD	Programming parameters of Pulse out on SLOT 3	(6)

(1) ----------

Variable			
MSB (BYTE 3)	BYTE 2	BYTE 1	LSB (BYTE 0)
PULSES OUT	xxx	xxx	Slot 0

Type of slot 0:
'A' : RS485

(2) ----------

Not used

(3) ----------

W, var, VA / 100 if KTA*KTI < 5000
W, var, VA if KTA*KTI >= 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	**kWh(kvarh) * 100**	xxxxxxx.y M	xxxxxxxy

(5) ----------

0 : positive
1 : negative

(6) ----------

Standard Programming Parameters and **Pulse Output** : 16 WORD received or sent.

x|w14|w13|w12|x|x|x|W8|W7|W6|W5|W4|W3|W2|W1|x

W1 : custom page – line 1

 0 => V phase 1
 1 => V12
 2 => I phase 1
 3 => I Neutral
 4 => P 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

W2 : custom page – line 2

 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

W3 : custom page – line 3

 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

W4 : wiring

 0 => 3N3E
 1 => 3-3E
 2 => 3-2E
 3 => 1N1E
 4 => 3N1E
 5 => 3-1E

W5 : average maximum demand calculation

 0 => 5 minutes
 1 => 8 minutes
 2 => 10 minutes
 3 => 15 minutes
 4 => 20 minutes
 5 => 30 minutes
 6 => 60 minutes

W6 : contrast display

 0 => level 0
 1 => level 1
 2 => level 2
 3 => level 3

W7 : backlight intensity

 0 =>   0%
 1 =>   50%
 2 => 100%

W8 : rated current

 0 =>   5A
 1 =>   1A

W12 : Energy Type   (**Pulse Output**)

  0   =>   Energy Type ACTIVE
  1   =>   Energy Type REACTIVE

W13 : Pulse Weight   (**Pulse Output**)

  0   =>   Pulse Weight 0.01 K
  1   =>   Pulse Weight 0.1 K
  2   =>   Pulse Weight 1.0 K
  3   =>   Pulse Weight 10.0 K
  4   =>   Pulse Weight 0.1 M
  5   =>   Pulse Weight 1.0 M
  6   =>   Pulse Weight 10.0 M

W14 : Pulse Duration (**Pulse Output**)

  0   =>   Pulse Duration 50 ms
  1   =>   Pulse Duration 100 ms
  2   =>   Pulse Duration 200 ms
  3   =>   Pulse Duration 300 ms

NOTES : x means that this word value is without meaning.

(7) ----------

  Value signed

Reading Example

Demand of 4 WORDS (8 BYTES – 2 variables) starting from the address 0x0325 :

BYTE	BYTE	MSB | LSB	MSB | LSB	MSB | LSB
Device address 0x01	F.code 0x03	1st WORD address 0x10 | 0x1C	WORDS number 0x00 | 0x04	CRC16 0x81 | 0x0F

Answer

BYTE	BYTE	BYTE	MSB | LSB	MSB | LSB	MSB | LSB	MSB | LSB	MSB | LSB
0x01	0x03	BYTES number 0x08	WORD 1 0x00 | 0x00	WORD 2 0x64 | 0x8c	WORD 3 0x00 | 0x00	WORD 4 0x35 | 0x54	CRC16 0x9a | 0x83

In the above case, the information is :

WORD 1 ,WORD 2 : Positive active energy 0x0000648C = 25740

WORD 3 ,WORD 4 : Positive reactive energy 0x00003554 = 13652

5.0 REMOTE RESETS AND PROGRAMMING

Data are written at the same way as they are read. The WORD sequence is the same.

In writing the messages sequence is :

1) write word 0x5AA5 to address 0x2700
2) write the number of necessary WORDS at the address where the standard parameters or the module variables are mapped

Note that parameters will be changed **only** in volatile memory.

If it is necessary to go back to the old parameters saved in EEPROM, it is mandatory to send also these following messages :

1) write word 0x5AA5 to address 0x2700
2) write word 0xYYYY to address 0x2800 (Y = any value)

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

1) write word 0x5AA5 to address 0x2700
2) write word 0xYYYY to address 0x2600 (Y = any value)

WRITE ADDRESS TABLE

Address	Byte n.	Description	Value
0x100	WORD	Write Current transform ratio	1-9999
0x102	WORD	Write Voltage transform ratio	1–10.0 (8)
0x2000	16 WORD	Write Standard setup parameters	(6)
0x2100	24 WORD	Not used SLOT 1	
0x2200	24 WORD	Not used SLOT 2	
0x2300	24 WORD	Write Programming parameters of Module on SLOT 3	(6)
0x2400	WORD	Reset Hour Meter, Maximum Powers, Maximum Voltages, Maximum Currents, Minimum Voltages, Active Partial Energy, Reactive Partial Energy	(9)
0x2600	WORD	Saving in EEPROM parameters changed by Remote commands	(10)
0x2700	WORD	Enable Remote Writing Operation	(11)
0x2800	WORD	Load previous setup parameters stored in EEPROM	(12)

(8)This value is in V/10
For instance, write 50 to have KTV = 5.0

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

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

b0 = 1 => Reset Hour Meter
b1 = 1 => Reset Maximum Powers
b2 = 1 => Reset Maximum Voltages
b3 = 1 => Reset Maximum Currents
b4 = 1 => Reset Minimum Voltages
b5 = 1 => Reset Active Partial Energy
b6 = 1 => Reset Reactive Partial Energy

b7 .. b15 = 0

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

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

(12)Write any value to abort any remote programming write operation and go back to previous values.