# CONTENTS

## 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 instruments, repeaters must be used.

The communication parameters are :

Baud rate programmable
bit n. : 8
stop bit : 1
parity : programmable

**Data link level**

After each command, a response telegram must follow, unless the command was a broadcast one.
The data are transmitted in packets and are checked by a CRC word.

**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 in 2.5

## 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.

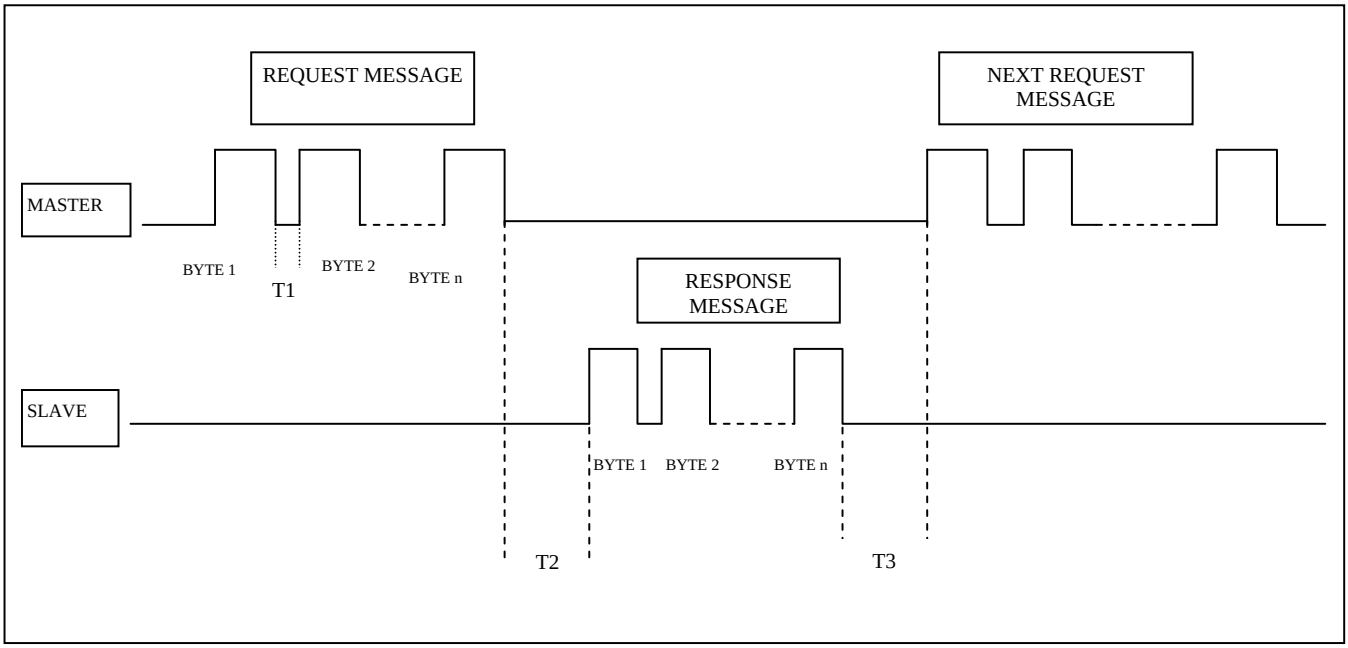
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*     ************************************************************
 *     Descrizione : calculates a data buffer CRC WORD
 *     Input       :       ptbuf = pointer to the first byte of the buffer
 *                  num   = number of bytes
 *     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.**<br>If this time exceeds the max. time allowed, the message is not considered by device. | Modbus standard | |
| T2 | **Slave response time**<br>Minimum and maximum response time of device to the Master request. | Min = 20 ms.<br>Max = 300ms. | |
| T3 | **Delay time**<br>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 100 BYTES.

| Address | Byte n. | Description | Unit | Soft. Vers. |
|---|---|---|---|---|
| 0x301 | Long | Phase 1 : phase voltage | mV | All |
| 0x305 | Long | Phase 2 : phase voltage | mV | All |
| 0x309 | Long | Phase 3 : phase voltage | mV | All |
| 0x30d | Long | Phase 1 : current | mA | All |
| 0x311 | Long | Phase 2 : current | mA | All |
| 0x315 | Long | Phase 3 : current | mA | All |
| 0x319 | Long | 3-phase : active power | (3) | All |
| 0x31d | Long | 3-phase : reactive power | (3) | All |
| 0x321 | Long | 3-phase : apparent power | (3) | All |
| 0x325 | Long | 3-phase : positive active energy | (4) | All |
| 0x329 | Long | Chained voltage : L1-L2 | mV | All |
| 0x32d | Long | Chained voltage : L2-L3 | mV | All |
| 0x331 | Long | Chained voltage : L3-L1 | mV | All |
| 0x335 | Long | 3-phase : partial positive active energy | (4) | >= 4.00 |
| 0x339 | WORD | Frequency | Hz/10 | All |
| 0x33b | WORD | 0 | - | |
| 0x33d | BYTE | 3-phase : power factor | 1/100 | All |
| 0x33f | BYTE | 3-phase : sector of power factor (cap or ind) | (1) | All |
| 0x340 | BYTE | 0 | - | |
| 0x341 | WORD | 0 | - | |
| 0x343 | Long | 3-phase : positive reactive energy | (4) | >= 4.00 |
| 0x347 | BYTE | 3-phase : sign of active power | (5) | All |
| 0x348 | Long | Time counter | sec. | All |
| 0x34c | BYTE | 3-phase : sign of reactive power | (5) | All |
| 0x34d | BYTE | 0 | | |
| 0x34e | BYTE | 0 | | |
| 0x34f | BYTE | 0 | | |
| 0x350 | Long | 3-phase : average power | (3) | All |
| 0x354 | Long | 3-phase : peak maximum demand | (3) | All |
| 0x358 | BYTE | Time counter for average power | minutes | All |
| 0x359 | Long | Neutro current | mA | All |
| 0x35d | Long | Phase 1 : active power | (3) | All |
| 0x361 | Long | Phase 2 : active power | (3) | All |
| 0x365 | Long | Phase 3 : active power | (3) | All |
| 0x369 | BYTE | Phase 1 : sign of active power | (5) | All |
| 0x36a | BYTE | Phase 2 : sign of active power | (5) | All |
| 0x36b | BYTE | Phase 3 : sign of active power | (5) | All |
| 0x36c | Long | Phase 1 : reactive power | (3) | >= 4.00 |
| 0x370 | Long | Phase 2 : reactive power | (3) | >= 4.00 |
| 0x374 | Long | Phase 3 : reactive power | (3) | >= 4.00 |
| 0x378 | BYTE | Phase 1 : sign of reactive power | (5) | >= 4.00 |
| 0x379 | BYTE | Phase 2 : sign of reactive power | (5) | >= 4.00 |
| 0x37a | BYTE | Phase 3 : sign of reactive power | (5) | >= 4.00 |
| 0x37b | Long | Phase 1 : average current | mA | >= 4.00 |
| 0x37f | Long | Phase 2 : average current | mA | >= 4.00 |
| 0x383 | Long | Phase 3 : average current | mA | >= 4.00 |
| 0x387 | Long | Phase 1 : current maximum demand | mA | >= 4.00 |
| 0x38b | Long | Phase 2 : current maximum demand | mA | >= 4.00 |
| 0x38f | Long | Phase 3 : current maximum demand | mA | >= 4.00 |

| | | | | |
|---|---|---|---|---|
| 0x100 | WORD | Current transformer ratio (KTA) | integer | All |
| 0x102 | WORD | Voltage transformer ratio (KTV) | 1/10 (tenths) | All |
| 0x300 | BYTE | Device identifier | 0xCE | All |

**A second address table is implemented in the software and the user may decide freely which use.**

| 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 : positive partial active energy | (4) |
| 0x1022 | Long | Time counter | sec. |
| 0x1024 | WORD | 3-phase : power factor | 1/100 |
| 0x1025 | WORD | 3-phase : sector of power factor (cap or ind) | (1) |
| 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 : average current | mA |
| 0x1040 | Long | Phase 2 : average current | mA |
| 0x1042 | Long | Phase 3 : average current | mA |
| 0x1044 | Long | Phase 1 : current maximum demand | mA |
| 0x1046 | Long | Phase 2 : current maximum demand | mA |
| 0x1048 | Long | Phase 3 : current maximum demand | mA |

| | | | |
|---|---|---|---|
| 0x1200 | WORD | Current transformer ratio (KTA) | integer |
| 0x1201 | WORD | Voltage transformer ratio (KTV) | 1/10 (tenths) |
| 0x1206 | WORD | Device identifier | 0xCE |

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

0 : PF = 0 or 1
1 : ind
2 : cap

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

W, var, VA / 100  if  KTA*KTI < 6000
W, var, VA        if  KTA*KTI >= 6000

(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 < 100000 | kWh(kvarh) * 10 | xxxxxx.yy M | xxxxxxyy |

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

0 : positive
1 : negative

**Example**

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

| BYTE | BYTE | MSB \| LSB | MSB \| LSB | MSB \| LSB |
|---|---|---|---|---|
| Device address<br>0x01 | F.code<br>0x03 | 1st WORD address<br>0x03 \| 0x25 | WORDS number<br>0x00 \| 0x04 | CRC16<br>0x55 \| 0x86 |

**Answer**

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

In the above case, the information is :

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

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