CONTENTS

1.0 INTRODUCTION

Data link level

The communication protocol used is MODBUS / JBUS compatible.
Up to 255 different instruments can be managed by the protocol.
Data are transmitted in messages and are checked by mean of a CRC16 WORD
There are no limitations to the number of possible retries done by the master.

Physical level

The physical communication line respects 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 polling the slave instruments and waiting for the answers.

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 :

speed : programmable
19200, 9600, 4800 Baud
bit n. : 8
stop bit : 1
parity : programmable

2.0 DATA MESSAGE DESCRIPTION

The generic data message is composed as following :

Instrument address	Functional code	Data	CRC word

Two answers are possible :

Answer containing data

Instrument address	Functional code	Data	CRC word

Error answer

Instrument address	Functional code + 0x80	Error code	CRC word

2.1 Data field description

Instrument address : instrument 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 (not used)

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 and the number of the required words (in the demand)
- the data (in the answer)

CRC word : it is the result of the calculation made 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

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* BYTE
* WORD : two BYTES
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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

All data are positive and the sign indications are readable in other variables.

2.3 Description of CRC calculation

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

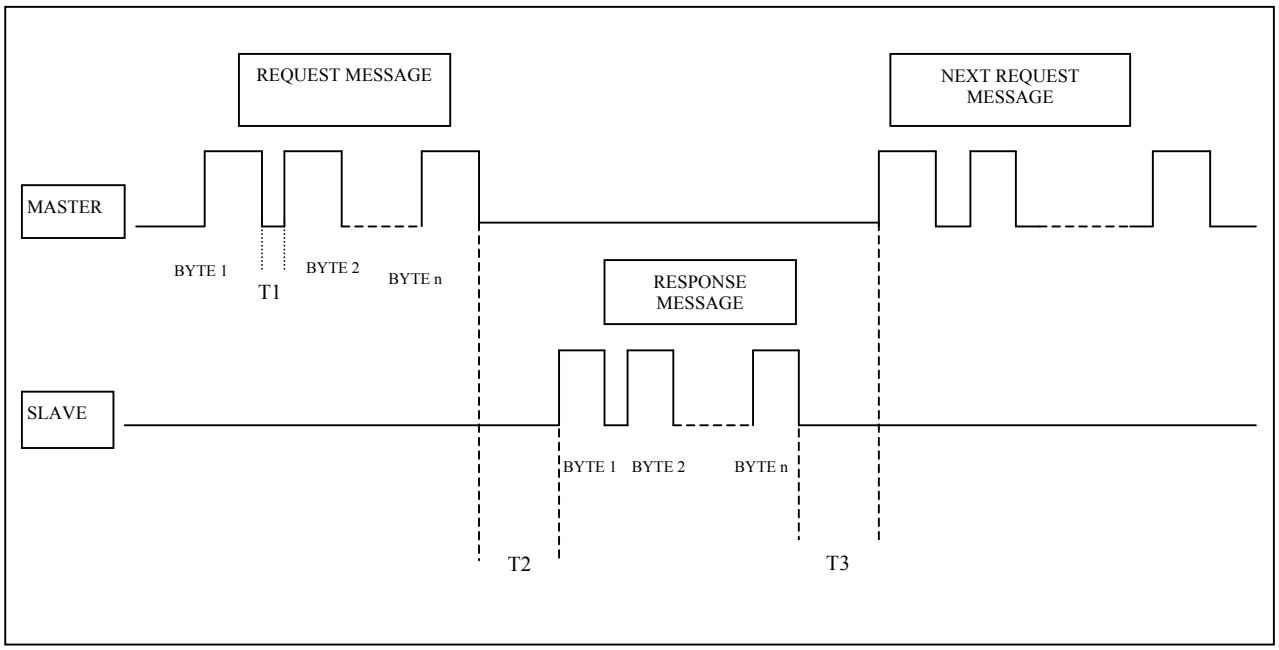
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*    ****************************************************************
 *    Descrizione : calculates a data buffer CRC WORD
 *    Input       : ptbuf = pointer to the first byte of the buffer
 *                  num   = number of bytes
 *    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 kept */
              crc16 = crc16 >> 1;              /* LSBit di crc16 is lost */
              if (flag != 0)
                   crc16 = crc16 ^ 0x0a001;    /* crc16 XOR with 0x0a001 */
        }
        ptbuf++;                               /* points 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) so it can't be accepted, the slave answers with an error message.

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

2.5 Timing



Values :

T1 (time between characters) = 25 msec (max)
T2 (slave response time) = 100 msec (max)
T3 (delay time) = 25 msec (min)

3.0 COMMANDS

Code 0x03 : reading of one or more consecutive WORDS

Command format :

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

Answer format (containing data) :

BYTE	BYTE	BYTE	MSB LSB	MSB LSB	MSB LSB
Instrument 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 (wrong request) :

BYTE	BYTE	BYTE	MSB LSB
Instrument 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
Instr. 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
Instrument Address	Funct. Code	BYTES number	First WORD address	00 00	CRC16

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

Answer format (wrong request) :

BYTE	BYTE	BYTE	MSB LSB
Instrument Address	Funct. Code + 0x80	Error code	CRC16

Error codes :
* 0x01 : wrong functional code
* 0x02 : wrong first WORD address
* 0x03 : wrong 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)	All
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)	All
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)	All
0x370	Long	Phase 2 : reactive power	(3)	All
0x374	Long	Phase 3 : reactive power	(3)	All
0x378	BYTE	Phase 1 : sign of reactive power	(5)	All
0x379	BYTE	Phase 2 : sign of reactive power	(5)	All
0x37a	BYTE	Phase 3 : sign of reactive power	(5)	All
0x37b	Long	Phase 1 : average current	mA	All
0x37f	Long	Phase 2 : average current	mA	All
0x383	Long	Phase 3 : average current	mA	All
0x387	Long	Phase 1 : current maximum demand	mA	All
0x38b	Long	Phase 2 : current maximum demand	mA	All
0x38f	Long	Phase 3 : current maximum demand	mA	All
0x393	WORD	Phase 1 : THD voltage	% (3..99)	>= 4.06
0x395	WORD	Phase 2 : THD voltage	% (3..99)	>= 4.06
0x397	WORD	Phase 3 : THD voltage	% (3..99)	>= 4.06
0x399	WORD	Phase 1 : THD current	% (3..99)	>= 4.06
0x39a	WORD	Phase 2 : THD current	% (3..99)	>= 4.06
0x39c	WORD	Phase 3 : THD current	% (3..99)	>= 4.06

0x0c8	BYTE	Reset (R/W) - bit to bit defined	(6)	All
0x100	WORD	Current transformer ratio (KTA)	integer	All
0x102	WORD	Voltage transformer ratio (KTV)	1/10 (tenths)	All
0x300	BYTE	Device identifier	0xce	All

The following second address table is available at any time.

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	
0x104a	WORD	Phase 1 : THD voltage	% (3..99)	>= 4.06
0x104b	WORD	Phase 2 : THD voltage	% (3..99)	>= 4.06
0x104c	WORD	Phase 3 : THD voltage	% (3..99)	>= 4.06
0x104d	WORD	Phase 1 : THD current	% (3..99)	>= 4.06
0x104e	WORD	Phase 2 : THD current	% (3..99)	>= 4.06
0x104f	WORD	Phase 3 : THD current	% (3..99)	>= 4.06

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) ----------

The value is transmitted exactly as it is visualized without any indication of the decimal point.

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

0 : positive
1 : negative

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

R/W property

0x01 : partial active energy reset
0x08 : operating time counter reset
0x10 : peak maximum demand reset
0x20 : peak maximum current demands reset (all phases)

Example 1

Reading of 4 WORDS (8 BYTES – 2 variables) starting from the address 0x100c :

Request :

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

In the above case, the information is :

WORD 1 ,WORD 2 : Total indirect active energy 0x0000648C = 25740
WORD 3 ,WORD 4 : Total direct reactive energy 0x00003554 = 13652

Example 2

Writing of 1 WORD at address 0xc8 (reset of partial active energy) :

Command :

BYTE	BYTE	MSB | LSB	MSB | LSB		MSB | LSB	MSB | LSB
Device address 0x01	F. code 0x10	1st WORD address 0x00 | 0xc8	WORDS number 0x00 | 0x01	BYTEs number 0x02	WORD 0x00 | 0x10	CRC16 0x72 | 0xE4