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1.0 ABSTRACT

Physical level

The electrical 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 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

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

* U_WORD : one WORD - unsigned
* S_WORD : one WORD - signed
* UD_WORD : two WORDS - unsigned
* SD_WORD : two WORDS - signed

If the required data is in a D_WORD 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 UD_WORD)

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.

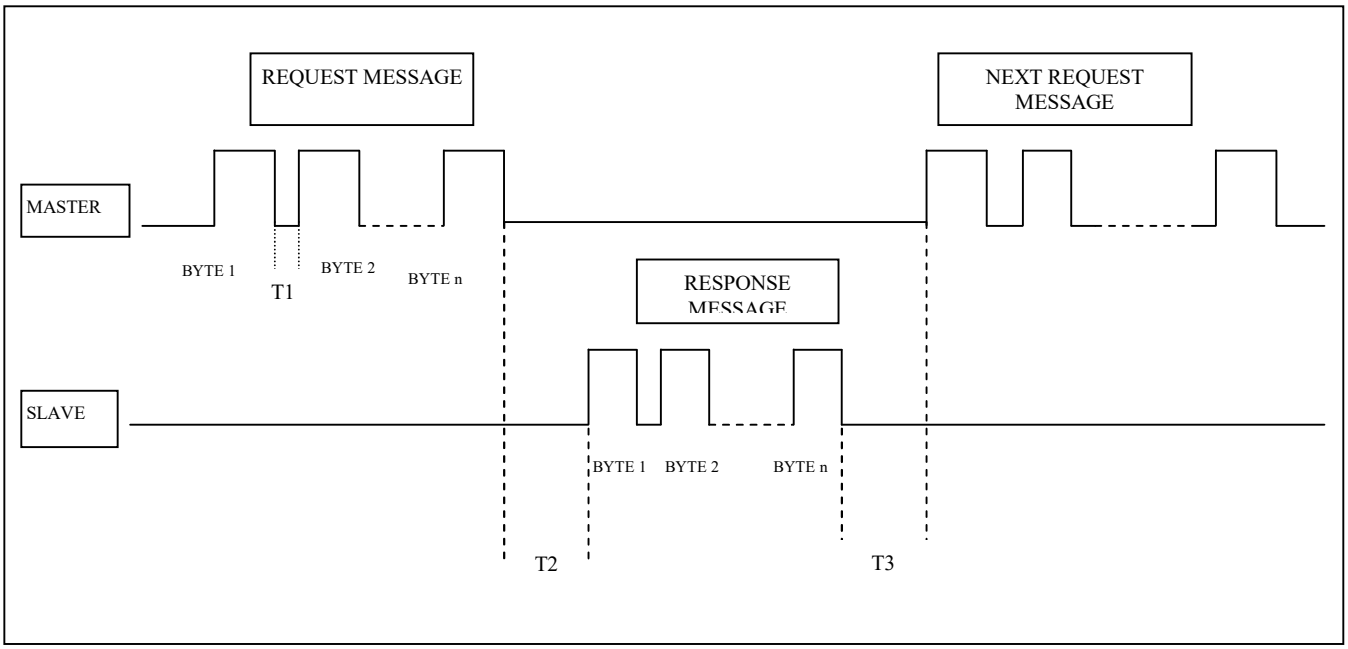
```
unsigned int calc_crc (char *ptbuf, unsigned int num)
/*     ************************************************************
 *     Descrizione : calculates a data buffer CRC WORD
 *     Input       :       ptbuf = pointer to the first byte of the buffer
 *                  num    = number of bytes
 *     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	Min & Max VALUES
T1	**Time between characters.** If this time exceeds the max. time allowed, the message is not considered by device.	Typ. = 20 ms
T2	**Slave response time** Minimum response delay to Master request.	Min = 10 ms
T3	Time before a new message request from the Master can be issued	Min = 1 ms

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	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

4.0 VARIABLES

Variables or groups of variables may be required up to 100 BYTES.

Address	Byte n.	Description	Unit
0x301	UD_WORD	Phase 1 : phase voltage	mV
0x305	UD_WORD	Phase 2 : phase voltage	mV
0x309	UD_WORD	Phase 3 : phase voltage	mV
0x30d	UD_WORD	Phase 1 : current	mA
0x311	UD_WORD	Phase 2 : current	mA
0x315	UD_WORD	Phase 3 : current	mA
0x319	UD_WORD	3-phase : active power	(3)
0x31d	UD_WORD	3-phase : reactive power	(3)
0x321	UD_WORD	3-phase : apparent power	(3)
0x325	UD_WORD	3-phase : indirect positive active energy	(4)
0x329	UD_WORD	Chained voltage : L1-L2	mV
0x32d	UD_WORD	Chained voltage : L2-L3	mV
0x331	UD_WORD	Chained voltage : L3-L1	mV
0x335	UD_WORD	3-phase : direct positive active energy	(4)
0x339	U_WORD	Frequency	Hz/10
0x33b	U_WORD	0	-
0x33d	BYTE	3-phase : power factor	1/100
0x33f	BYTE	3-phase : sector of power factor (cap or ind)	(1)
0x340	BYTE	Reserved	-
0x341	U_WORD	CRC of the software	-
0x343	UD_WORD	3-phase : direct positive reactive energy	(4)
0x347	BYTE	3-phase : sign of active power	(5)
0x348	UD_WORD	Operating time counter	sec.
0x34c	BYTE	3-phase : sign of reactive power	(5)
0x34d	BYTE	Reserved	-
0x34e	BYTE	0	
0x34f	BYTE	0	
0x350	UD_WORD	3-phase : average power	(3)
0x354	UD_WORD	3-phase : peak maximum demand	(3)
0x358	BYTE	Time counter for average power	minutes
0x359	UD_WORD	Neutral current	mA
0x35d	UD_WORD	Phase 1 : active power	(3)
0x361	UD_WORD	Phase 2 : active power	(3)
0x365	UD_WORD	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	UD_WORD	Phase 1 : reactive power	(3)
0x370	UD_WORD	Phase 2 : reactive power	(3)
0x374	UD_WORD	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)

0x0c8	BYTE	Reset - bit to bit defined	(6)
0x100	U_WORD	Current transformer ratio (KTA)	integer
0x102	U_WORD	Voltage transformer ratio (KTV)	*10 always
0x300	BYTE	Device identifier	0x11

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

Address	Length	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	(3)
0x1016	UD_WORD	3-phase : reactive power	(3)
0x1018	UD_WORD	3-phase : apparent power	(3)
0x101a	U_WORD	3-phase : sign of active power	(5)
0x101b	U_WORD	3-phase : sign of reactive power	(5)
0x101c	UD_WORD	3-phase : indirect positive active energy	(4) (*)
0x101e	UD_WORD	3-phase : direct positive reactive energy	(4)
0x1020	UD_WORD	3-phase : direct positive active energy	(4)
0x1022	UD_WORD	Operating time counter	sec.
0x1024	U_WORD	3-phase : power factor	1/100
0x1025	U_WORD	3-phase : sector of power factor (cap or ind)	(1)
0x1026	U_WORD	Frequency	Hz/10
0x1027	UD_WORD	3-phase : average power	(3)
0x1029	UD_WORD	3-phase : peak maximum demand	(3)
0x102b	U_WORD	Time counter for average power	minutes
0x102c	UD_WORD	Phase 1 : active power	(3)
0x102e	UD_WORD	Phase 2 : active power	(3)
0x1030	UD_WORD	Phase 3 : active power	(3)
0x1032	U_WORD	Phase 1 : sign of active power	(5)
0x1033	U_WORD	Phase 2 : sign of active power	(5)
0x1034	U_WORD	Phase 3 : sign of active power	(5)
0x1035	UD_WORD	Phase 1 : reactive power	(3)
0x1037	UD_WORD	Phase 2 : reactive power	(3)
0x1039	UD_WORD	Phase 3 : reactive power	(3)
0x103b	U_WORD	Phase 1 : sign of reactive power	(5)
0x103c	U_WORD	Phase 2 : sign of reactive power	(5)
0x103d	U_WORD	Phase 3 : sign of reactive power	(5)

0x1200	U_WORD	Current transformer ratio (KTA)	integer
0x1201	U_WORD	Voltage transformer ratio (KTV)	*10 always
0x1206	U_WORD	Device identifier	0x11

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

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

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

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

(4) ----------

For indirect positive active energy :

Format : xxxxxx.yy kWh always

(*) Indirect energy = metrological energy at terminal side without taking in account the transformer ratios.

Otherwise:

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 < 1000000	kWh(kvarh) * 1000	xxxxxxxx M	xxxxxxxx

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

0 : positive
1 : negative

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

0x08 : operating time counter reset
0x010 : peak maximum demand reset