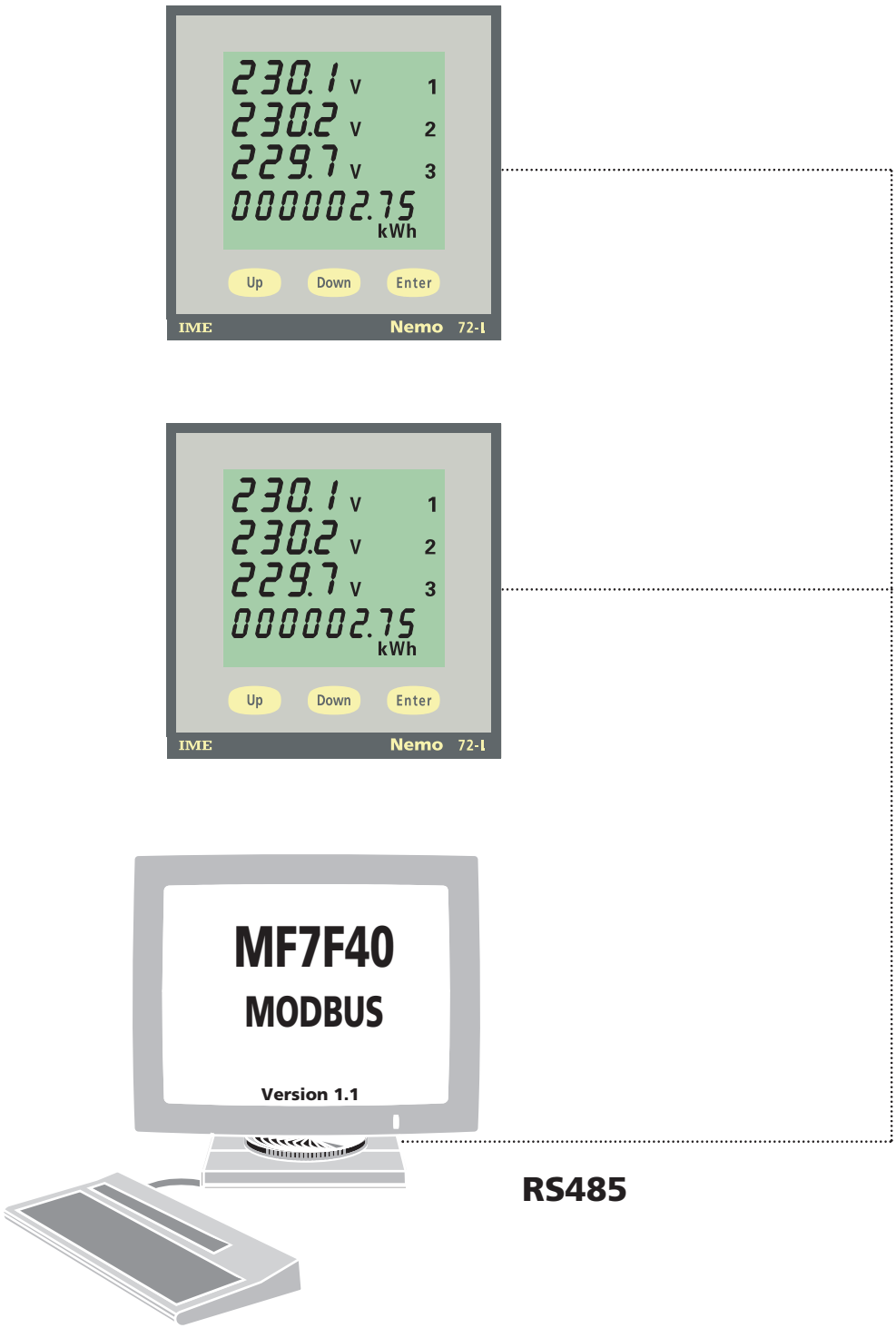
IME



Communication Protocol

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INDEX

1.0 INTRODUCTION

Logical level

The communication protocol used is MODBUS data format compliant.

The protocol is master-slave type.

Up to 255 different instruments can be managed by the protocol.

The data are transmitted in a packet form (message) and are checked by a word (CRC).

There are no limitations to the number of possible retries done by the master.

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 each slave instrument.
In this way the demand and the request are alternated.

On the same phisical line only 32 instruments can be attached (master included). In order to increase this number, repeaters must be used.

Take in account that a repeater counts as 1 and so decreases by 1 the number of the other instruments.

The communication parameters are :

speed : programmable
4800, 9600, 19.200 Baud/s

bit n. : 8

stop bit : 1

parity : none

Modbus Address : 1 - 255

2.0 DATA PACKET DESCRIPTION

The generic request data message is composed in the following way:

Instrument address	Functional code	Data	CRC word

Two answers are possible:

Answer with data

Instrument address	Functional code	Data	CRC word

Error answer

Instrument address	Functional code + 0x80	Error code	CRC word

2.1 PARAMETERS DESCRIPTION

Instrument address : instrument identification number in the network
It must be the same for the demand and the answer.
Format : 1 BYTE from 1 to 0xff

Functional code : command code
Used functional code :
Format : 1 BYTE
0x03 : reading 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 performed on all bytes in the message from the address to the last byte in the data field.

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.

In a WORD the Most Significant Byte is transmitted first.

If the required data is in a long format, 2 WORDS are transmitted and the Most Significant Word comes before the Least Significant Word.

MSB	LSB	MSB	LSB
Most Significant WORD		Lest Significant WORD	

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

WORD

MSB	LSB
0x03	0xe8

Long

MSB	BYTE2	BYTE3	LSB
0x00	0x00	0x03	0xe8

2.3 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      : CRC 16
 **      ************************************************************/
{
    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) and so it can't be accepted, the slave answers with an error message.

The error codes are defined in the next chapter of the document.

2.5 TIMING

The message is considered finished after a timeout specified by the Modbus standard.

In other words, if a new character is not received in the timeout period, the message is considered complete.

The response time required by the device is not a constant but depends on the internal operation performed at the moment of the communication demand; anyway it is lower than 100 msec.

After a response, a new command may be issued without any delay time.

This may be not true if devices other than MF7F, are connected on the same line.

3.0 COMMANDS

Code 0x03 : reading of one or more consective WORDS

Command format:

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

Answer format (with data) :

BYTE	BYTE	BYTE	MSB	LSB	MSB	LSB	MSB	LSB
Instrument address	Funct. Code	BYTES number	WORD 1.....		WORDS 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
Instrument Address	Funct. Code +0x80	Error code	CRC 16

Error codes:

* 0x01 : incorrect functional code
* 0x02 : wrong first WORD address
* 0x03 : incorrect data

Example :

Demand of 4 WORDS (8 BYTES) starting from the address 0x301 :

BYTE	BYTE	MSB	LSB	MSB	LSB	MSB	LSB
Instrum. Address	Code	1st WORD address		WORDS number		CRC 16	
0x01	0x03	0x03	0x01	0x00	0x04	0x15	0x8d

Answer

Variables : 0x0301 : 0x00 00 d8 85

BYTE	BYTE	BYTE	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
0x01	0x03	BYTES N. 0x08	WORD 1		WORD 2		WORD 3		WORD 4		CRC16	
			0x00	0x00	0xd8	0x85	0x00	0x00	0x86	0x9f	0x68	0xd9

4.0 VARIABLES

4.1 DATA ADDRESSES

Variables may be required, up to 100 BYTES.

Many variables with consecutive addresses can be required at one time.

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	(*)
0x31d	Long	3-phase : reactive power	(*)
0x321	Long	3-phase : apparent power	(*)
0x325	Long	3-phase : positive active energy	(***)
0x329	Long	Chained voltage : L1 - L2	mV
0X32d	Long	Chained voltage : L2 - L3	mV
0x331	Long	Chained voltage : L3 - L1	mV
0x335	Long	0	
0x339	WORD	Frequency	Hz/10
0x33b	WORD	0	
0x33d	WORD	3-phase : power factor	1/100
0x33f	BYTE	3-phase : sector power factor (cap or ind)	1 : ind 2 : cap
0x340	BYTE	0	
0x341	WORD	0	
0x343	Long	3-phase : positive reactive energy	(***)
0x347	BYTE	3-phase : sign of active power	(**)
0x348	Long	Operating time counter (works on V1 presence)	seconds
0x34c	BYTE	3-phase : sign of reactive power	(**)
0x34d	BYTE	0	
0x34e	BYTE	0	
0x34f	BYTE	0	
0x350	Long	3-phase : average power	(*)
0x354	Long	3-phase : peak maximum demand	(*)
0x358	BYTE	Time counter for average power	minutes
0x359	Long	Neutral current	mA

ADDRESS	BYTE N°.	DESCRIPTION	UNIT
0x35d	Long	Phase 1 : active power	(*)
0x361	Long	Phase 2 : active power	(*)
0x365	Long	Phase 3 : active power	(*)
0x369	BYTE	Phase 1 : sign of active power	(**)
0x36a	BYTE	Phase 2 : sign of active power	(**)
0x36b	BYTE	Phase 3 : sign of active power	(**)
0x36c	Long	Phase 1 : reactive power	(*)
0x370	Long	Phase 2 : reactive power	(*)
0x374	Long	Phase 3 : reactive power	(*)
0x378	BYTE	Phase 1 : sign of reactive power	(**)
0x379	BYTE	Phase 2 : sign of reactive power	(**)
0x37a	BYTE	Phase 3 : sign of reactive power	(**)
0x396	BYTE	Phase 1 : THD current	%
0x398	BYTE	Phase 2 : THD current	%
0x39a	BYTE	Phase 3 : THD current	%
0x39c	Long	Phase 1 : averange current demand	mA
0x3a0	Long	Phase 2 : averange current demand	mA
0x3a4	Long	Phase 3 : averange current demand	mA
0x3a8	Long	Phase 1 : peak current demand	mA
0x3ac	Long	Phase 2 : peak current demand	mA
0x3b0	Long	Phase 3 : peak current demand	mA
0x100	WORD	Current transformer ratio (KTA)	
0X102	WORD	Voltage transformer ratio (KTV)	1/10
0X300	BYTE	Device identifier : 0xD0	

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	(*)
0x1016	Long	3-phase : reactive power	(*)
0x1018	Long	3-phase : apparent power	(*)
0x101a	WORD	3-phase : sign of active power	(**)
0x101b	WORD	3-phase : sign of reactive power	(**)
0x101c	Long	3-phase : positive active energy	(***)
0x101e	Long	3-phase : positive reactive energy	(***)
0x1020	Long	0	
0x1022	Long	Operating time counter (works on V1 presence)	seconds
0x1024	WORD	3-phase : power factor	1/100
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	(*)
0x1029	Long	3-phase : peak maximum demand	(*)
0x102b	WORD	Time counter for average power	minutes
0x102c	Long	Phase 1 : active power	(*)
0x102e	Long	Phase 2 : active power	(*)
0x1030	Long	Phase 3 : active power	(*)
0x1032	WORD	Phase 1 : sign of active power	(**)
0x1033	WORD	Phase 2 : sign of active power	(**)
0x1034	WORD	Phase 3 : sign of active power	(**)
0x1035	Long	Phase 1 : reactive power	(*)
0x1037	Long	Phase 2 : reactive power	(*)
0x1039	Long	Phase 3 : reactive power	(*)
0x103b	WORD	Phase 1 : sign of reactive power	(**)
0x103c	WORD	Phase 2 : sign of reactive power	(**)
0x103d	WORD	Phase 3 : sign of reactive power	(**)

ADDRESS	BYTE N°.	DESCRIPTION	UNIT
0x104d	BYTE	Phase 1 : THD current	%
0x104e	BYTE	Phase 2 : THD current	%
0x104f	BYTE	Phase 3 : THD current	%
0x1050	Long	Phase 1 : averange current demand	mA
0x1052	Long	Phase 2 : averange current demand	mA
0x1054	Long	Phase 3 : averange current demand	mA
0x1056	Long	Phase 1 : peak current demand	mA
0x1058	Long	Phase 2 : peak current demand	mA
0x105a	Long	Phase 3 : peak current demand	mA
0x1200	WORD	Current transformer ratio (KTA)	
0X1201	WORD	Voltage transformer ratio (KTV)	1/10
0X1206	WORD	Device identifier : 0xD0	

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

(*) W, var, VA / 100 if KTA * KTV < 6000

W, var, VA if KTA * KTV >= 6000

(**) 0 : POSITIVE

1 : NEGATIVE

(***)

TRANSFORMER RATIO				MEASUREMENT UNIT
1	KTA*KTV	<	10	Wh (varh) * 10
10	KTA*KTV	<	100	Wh (varh) * 100
100	KTA*KTV	<	1000	kWh (kvarh)
1000	KTA*KTV	<	100000	kWh (kvarh) * 10

4.2 VARIABLE DESCRIPTIONS

Phase voltage

This is the phase to neutral voltage.

Format : long

Engineering unit : mV

Example : 100V => 100.000mV => 00 01 86 A0

Demand of 2 WORDS (4 BYTES) starting from 0x301 :

BYTE	BYTE	MSB	LSB	MSB	LSB	MSB	LSB
Instrument Address 0x01	F. code 0x03	1st WORD address		WORDS number		CRC 16	
		0x03	0x01	0x00	0x02	0x95	0x8f

Answer

Variable at 0x301 : 0x00 01 86 a0

BYTE	BYTE	BYTE	MSB	LSB	MSB	LSB	MSB	LSB
0x01	0x03	BYTES number 0x04	WORD 1		WORDS 2		CRC 16	
			0x00	0x01	0x86	0xa0	0xc9	0xeb

Chained voltages

This is the phase to phase voltages.

Format : long

Engineering unit : mV

Phase currents

Format : long

Engineering unit : mA

Example : 5.4A => 5400 mA => 00 00 15 18

Active powers

Phase and 3-phase active powers.

Format : long

Engineering unit : *see data address table page 12

Reactive powers

Phase and 3-phase reactive powers.

Format : long

Engineering unit : *see data address table page 12

Apparent power

3-phase apparent power.

Format : long

Engineering unit : *see data address table page 12

Positive active / reactive energies

These are the energies actually consumed by the user.

Format : long

Engineering unit : ***see data address table page 12

Frequency

Format : WORD

Engineering unit : tenth of Hz

Example : 50 Hz => 500 => 0x01 f4

Signs of phase and 3-phase active powers

Format : BYTE

Engineering unit : //

Values : 0x01 => negative

0x00 => positive

Sign of phase and 3-phase reactive powers

Format : BYTE

Engineering unit : //

Values : 0x01 => negative

0x00 => positive

Power factor (3-phase)

Format : WORD

Engineering unit : //

Values : the measure *100

Example : 0.98 => 98 => 0x00 62

Sector of power factor (3-phase)

Format : BYTE

Engineering unit : //

Values : 0x00 => PF is 1 o 0

0x01 => PF is inductive

0x02 => PF is capacitive

Neutral current

The neutral current is the real time sum of the 3 currents.

Format : long

Engineering unit : mA

Example : 50mA => 0x00 00 00 32

Time counter

Device working time (V1 > 30V)

Format: long

Engineering unit : seconds

Example : 3700 sec => 0x00 00 0E 74

Average power

Average power

This is the power calculated with the fixed average algorithm. It is updated at every expiration of the average period.

Format : long

Engineering unit : it depends on the type of the selected power. *see data address table page 12

Peak maximum demand

This is the power obtained as the maximum of the average powers and it is updated at every expiration of the average period.

Format : long

Engineering unit : it depends on the type of the selected power. *see data address table page 12

Average counter

Counter of the minutes elapsed from the beginning of the average period.

Example : Average period of 15 → counter goes from 0 to 14

Format : WORD

Current THD

These values are the Total Harmonics Distortions of the currents.

Format : BYTE

Engineering unit : % (two digits)

Example: 7 = 7%

Average demand current

These are the values of the average currents demand calculated using the fixed window algorithm.

The values are obtained as a sum all the current values in the period and then divided by the number of them.

The values are updated at every expiration of the average time which is set by the user.

Format : Long

Engineering unit : mA

Example: 5.4A => 5400mA => 00 00 15 18

Peak demand current

These are the values of the maximum of the average currents demand.

Every time a maximum is found, the peak value is updated and this happens only one time at the expiration of the average period.

Format : Long

Engineering unit : mA

Identification data

Current transformer ratio (KTA)

The current transformer ratio is the ratio between the rated primary value and the rated secondary value.

For example, if a CT primary/secondary ratio is 100/5, the value to be set is 20 and this is also the value given in the data packet.

Format : WORD

Engineering unit : //

Voltage transformer ratio (KTV)

The voltage transformer ratio is the ratio between the rated primary value and the rated secondary value.

For example, if a VT primary/secondary is 380/100, the value to be set is 3.8

For the TVs, the first decimal of the ratio is mantained and so the value given in the data packet is multiplied by 10, in this case 38.

Format : WORD

Engineering unit : //

Device identifier

0XD0