MAR/MDA 144_

TECHNICAL DESCRIPTION, INSTRUCTION MANUAL,

AND COMMUNICATION PROTOCOL

MB OPT

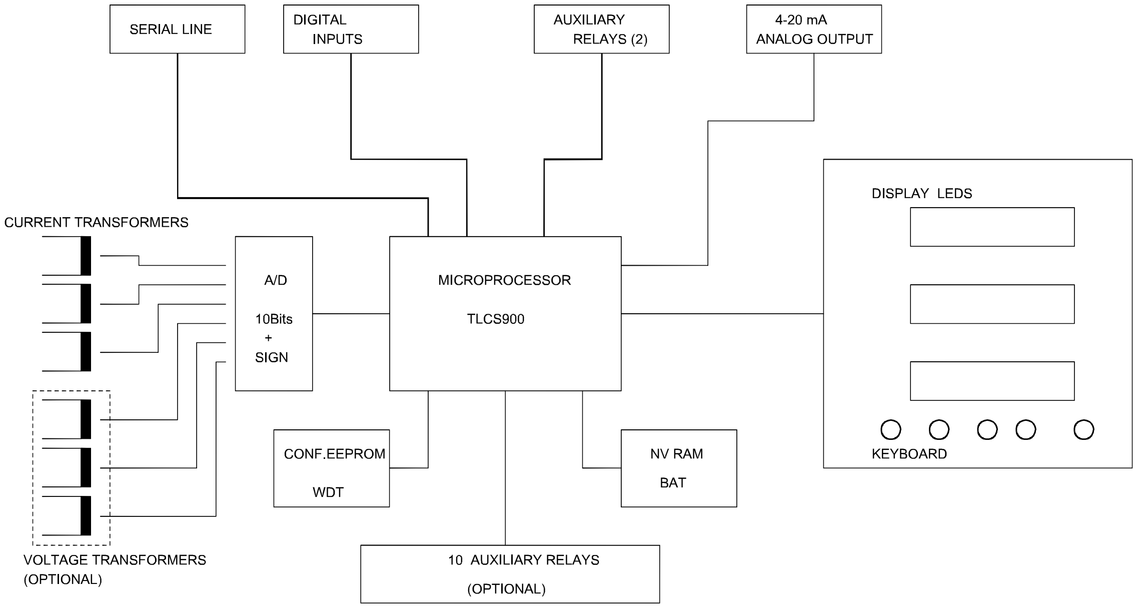
MARPRT3I.DOC

INDEX

1. – GENERAL DESCRIPTION.

The MAR144 models are multimeasurement meters able to give all the magnitudes for an electrical line, single or three phase, balanced or unbalanced. Microprocessor based, they are provided with a keyboard, a three line display, and a serial communication line to be connected to a PC or PLC. Flush mount type, 144x144 mm DIN, all the connections are made on the backside, by means of pluggable connectors.

A simplified block diagram is shown.



MAR 144. BLOCK DIAGRAM

1.1.-MEASURING PRINCIPLE.

The MAR models receive the three current and three voltage signals, and digitize them by means of a 10 bit plus sign A/D converter. The sampling is done synchronously with the input frequency, and 32 samples per period are taken for each signal. If the input frequency changes, the sampling rate is varied accordingly, maintaining the number of samples taken by period. Once the signals are acquired, the rest of the process is carried out in digital form, allowing to get a very high precision. However, although the sampling follows the input, the nominal frequency must be specified, to provide a better adaptive process, and to know the base point for frequency analog output.

The variables are calculated as follows:

$$Vi = sqr (\Sigma Vij^2 / 32)$$
$$Ii = sqr (\Sigma Iij^2 / 32)$$

$$Pi = \Sigma (Vij * Iij) / 32 \qquad Qi = \Sigma (Vi j\text{-}8 * Iij) / 32 \qquad Si = sqr (Pi^2 + Qi^2)$$
$$Pt = \Sigma (Pi) \qquad Qt = \Sigma (Qi) \qquad St = sqr (Pt^2 + Qt^2)$$

In the case of three system devices, the calculations are done for the three phase voltages and the three phase currents. The neutral current is measured adding the three line currents by HW, and taking the samples for this signal. In two systems devices, the calculations refer only to the input signals used. That is, only are done the multiplication V12 * I1, and V32* I3. These values added provide the total active power, but they do not have a meaning corresponding to any specific phase. They appear in the positions defined by P1 and P3, (or Q1 and Q3), and then P2 and Q2 do not appear. The voltage V31 is measured adding V12 and V23, and inverting the result. The same applies to current I2.

The reactive power is calculated multiplying the current samples by the voltage sampled delayed 90 degrees, equivalent to 8 sampling periods.

The energy is calculated from the active or reactive power values. As these are measured every period, this value is multiplied by the frequency to get the energy. This value is accumulated in a temporary register, and when the content exceeds the value programmed in the ENER parameter, a pulse is sent through the associated output relay, and a count is also added to the energy counter register.

Four energy counters are provided, allowing to measure:

Consumed active energy

Produced active energy

Consumed (inductive) reactive energy

Produced (capacitative) reactive energy

Each counter is four bytes long, in format “Long Integer”, and overflows at 1.000.000.000 count.

THD values are calculated by means of the DFT for each signal, evaluating the fundamental content, and calculating the rest as THD value. For instance, for Vi, the fundamental content is Vi1, and THD is

$$THD(Vi) = sqr (Vi^2 - Vi1^2)/ Vi1$$

2.- BLOCK DESCRIPTION.

2.1.- MICROPROCESSOR.

The microprocessor used is the TLCS900 from TOSHIBA. It is a 16 bit unit, working at 14,7456 MHz. Several peripheral circuits are included in the chip, as serial communication line, 16 and 8 bit timers, and watch-dog. A 32kBytes RAM is provided, as well as a 32K ROM.. The instruction set includes multiplication and division 16x16 and 32/16 bits, allowing a very fast operation in floating point calculations.

2.2.- DISPLAY AND KEYBOARD.

A three line led display is provided. In each line is possible to represent up to six different variables. The selection is done by means of one of the keys. Every time the associated key is pressed, the variable represented changes, until the next pressing. Each line is controlled by one key, allowing to select the variable represented in it.

2.3.- DIGITAL INPUTS.

Four digital inputs are provided in the device. They can be used to indicate the status of some event associated, for instance, the closing or aperture of a door, temperature alarm, etc. They are not visible in the display, but their status can be sent through the communication line. An internal power supply is provided, and therefore, free potential normally open contacts can be used.

2.4.- ANALOG OUTPUT 4/20 mA.

This option allows to send in analog form the values of the variables measured. Only the following variables can be sent, and only their positive values, that is, VFR, IFR, PTOTAL, VFS, IFS, QTOTAL, VFT, IFT, COS and FREQ.

The output range spans from 0 to 120% of the variable, except for cos and frequency. 4 mA output means 0%, and 20 mA, 120%. For COS, 4 mA means –0.5 (capacitative), and 20 mA +0.5 (inductive). For frequency, 12 mA means the nominal frequency programmed, 4 mA represents –10 %, and 20 mA represents + 10%. Maximum output load is 500 ohms.

Programming can be done both through keyboard and serial line.

2.5.- SERIAL LINE.

A serial communication line allows sending of all measurements to a PC or central unit. Two options are available, RS232 for point to point communications, and RS485 for multipoint. In both cases the line is isolated from the measuring circuit by means of optocouplers, and can be left floating or connected to earth without any restriction. The protocol used is JBUS, and the units behaves always as slaves. No spontaneous communications can occur.

2.6.- BASIC RELAYS.

Two relays can be provided with the following functions:

- Energy pulses output. Each closing pulse represents the energy defined by the ENER parameter.
- Alarm selection on maximum or minimum value of the displayed measurements.
- Uncommitted outputs, programmable from the central unit.

When programmed as alarms, the trigger point must be programmed in percentage of the nominal value. As no provision is done for sign, only the positive value is able to generate the alarm. For instance, for COS, only the inductive values can be used.

A fixed one second delay is permanently provided to avoid false triggerings.

2.7.- AUXILIARY RELAYS.

Ten more relays can be mounted as an option. Their function can be chosen as:

- Alarms on the display variables.
- SW driven outputs.

2.8.- AUXILIARY CIRCUITS.

The data to be saved in the case of supply failure are stored in a non volatile RAM, supplied by a battery (two months retention time), or a “supercap” capacitor (three days). This RAM includes also a real time clock, for applications depending on the hour. However, to avoid any possibility of loss of data, the configuration data are not stored in this RAM, but in an EEPROM which does not depend on any supply. An external WDT is also provided, in order to assure the microprocessor reset in case of extremely high disturbances.

3.- VARIANTS.

3.1.- Models.

Several models are available:

	CONN.	BASIC RELAYS	AUX. RELAYS	4-20 mA OUTPUT	DIG. INPUTS	CURR. TRANSF.	VOLT. TRANSF.	SERIAL LINE
MAR144B	3 PH	NO	NO	NO	NO	NO	NO	OPT
MAR144BA	3 PH	NO	NO	NO	NO	YES	NO	OPT
MAR144	1 PH	YES	OPT	OPT	YES	YES	OPT	OPT
MAR144-I	3PH BAL	YES	OPT	OPT	YES	YES	OPT	OPT
MAR144-2	3PH3W	YES	OPT	OPT	YES	YES	OPT	OPT
MAR144-3	3PH4W	YES	OPT	OPT	YES	YES	OPT	OPT

MAR144B and MAR144BA are basic units. They are not provided with any option but the serial communication line.

3.2.- Measuring values.

Standard values for voltage.
63,5V, 110V, 230V, 400V. 1 mA per phase.

Standard values for current
1A, 5A. 0,2 VA.

Standard values for power supply.
AC: 63,5V , 110V, 230V, 400V.
DC: 24V, 48V, 110V.

3.3.- Serial line options.

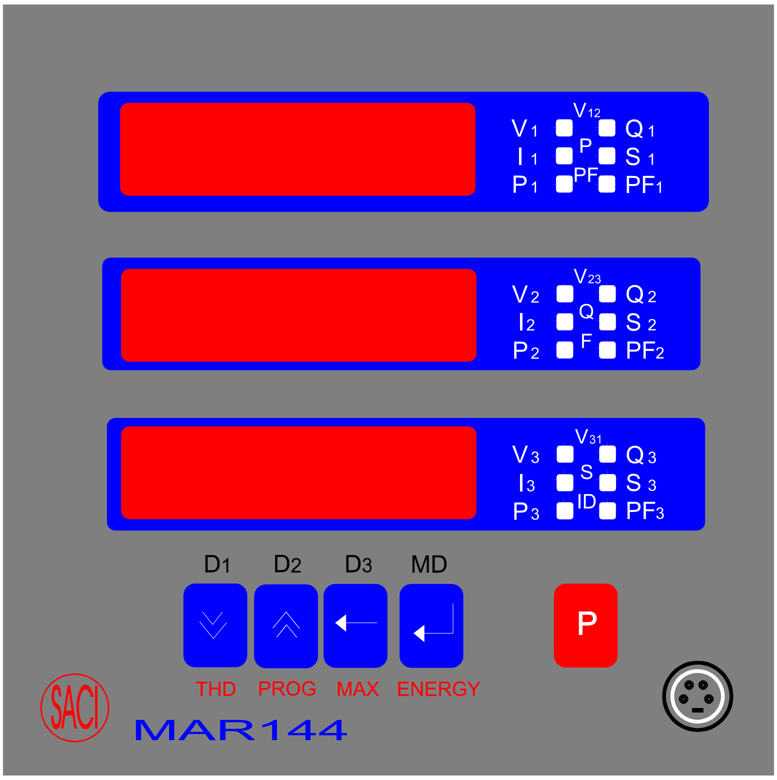
RS232, RS485.

3.4.- Analog output.

One output, 4-20 mA. Max. Load 500 ohms. Max. Open circuit voltage, 15 V.

4.-KEYBOARD OPERATION.

The device is provided with five keys allowing to program, configure, and change the display. Each line has associated one of the keys marked D1, D2, and D3. Pressing one of them, the line changes to the next variable, signaled by the LED which is on.



4.1.- PROGRAMMING PROCESS.

To enter into the programming process, both keys “P” and “UP” must be pressed. In the upper line appears “PASS”, asking to the user for the password. This password must be written in the lower line, which appears as "----" , with the right digit flashing. This digit can be modified pressing “UP” or “DOWN”. Once reached the correct value, pressing “ROTATE”, the next digit flashes, indicating that can be modified. When all digits have been modified, and the password is correct, pushing “ENTER” allows to begin the programming procedure. If the password is not correct, appears “----“, to begin again the process.

The default value for the password is “0010”. In the case the password has been changed, and is unknown, is possible to get its value only by means of special commands through the serial communication.

When the device accepts the password, the measurement process is stopped, as it is awaiting new configuration parameters.

The different parameters to be changed appear in consecutive pages as shown following. The name appears in the upper line, and the value in the two lower ones. In the case of options, only those defined as active appear.

1.-Vpr. Nominal primary voltage. If there is no voltage transformer, it must be the voltage rated in the label.
2.- Ipr. Nominal primary current.
3.-ENER. Energy reference. (KWh per pulse).
4.- IDEN. Identity.
5.- TIME. Time.
6.- MODE. Basic relays function mode.
0000 : Energy pulse output Ep+ and Eq+.
0001 : Uncommited outputs, SW controlled.
0002 : Alarms.
7.- OUTP. Manual operation for output relays. (only if TIPO= 0001). Setting the digit on the right to 1, -(00X1) -, activates the relay 0, closing the contact 15. The next digit set, -(001X)-, activates the relay1, closing contact 14.

8.- AL00. Defines the variable for alarm0, as well as its level and working mode.
9.- AL01. As above for alarm1.

10.- AL02...AL0B. As above for alarm2 to alarm11 (*).

11.- 4-20. Defines the variable associated to the analog output 4..20 mA. (*).

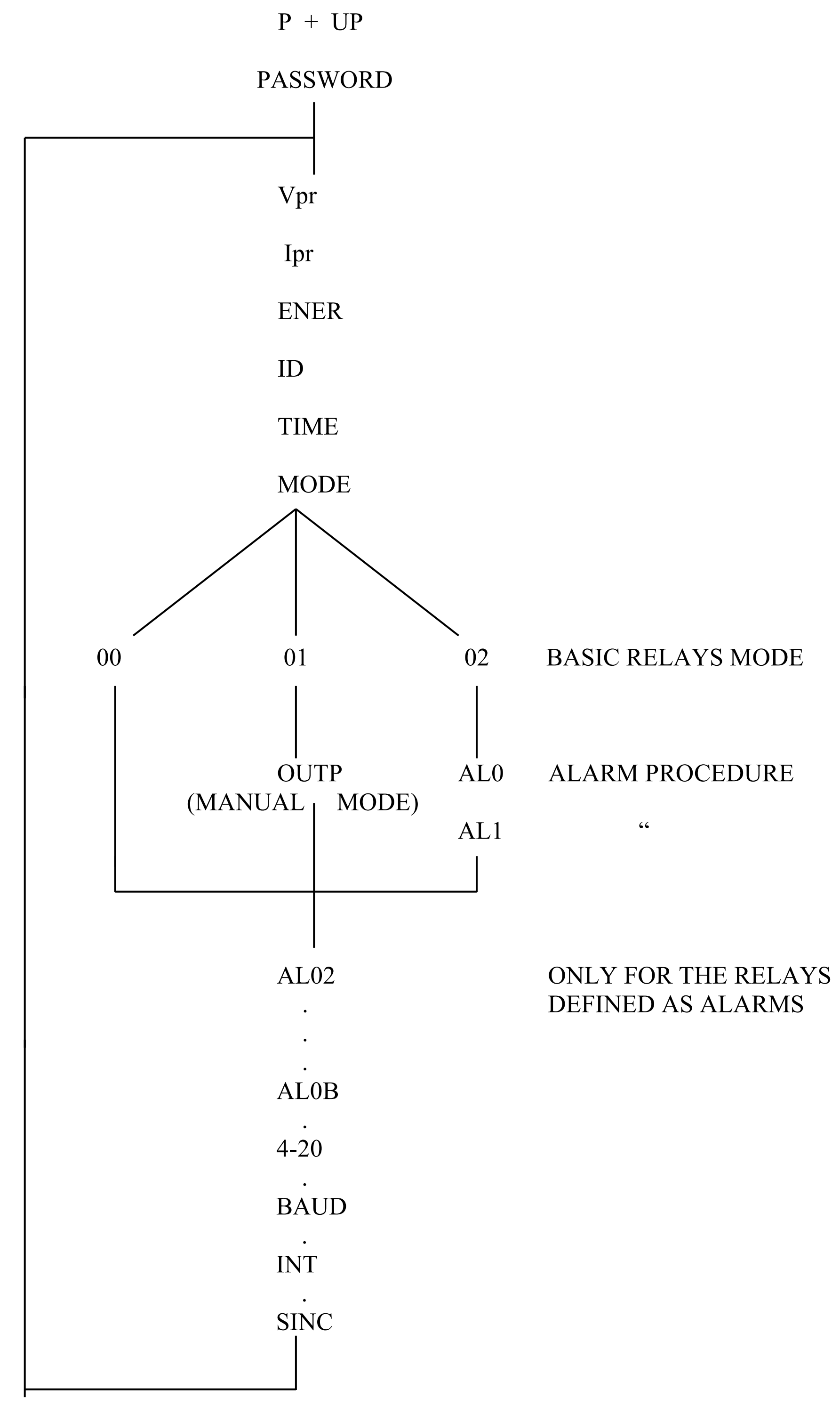
12.- bAUD. Defines the speed transmission for the serial line. The display shows the rate as
9600 Bps
0300 Bps
0600 Bps
1200 Bps
2400 Bps
4800 Bps
1920 (19200 Bps)
13.- Int. Defines the max.demand interval time: 15 or 30 minutes.

14.- Sinc. Define the synchronization , - Internal or external-, for the max.demand period.

15.- PASS. Appears the current password, and can be modified as will.

Pressing “ENTER” , several times, the cycle is repeated, to verify or change any parameter. If it is not needed to change any value, is enough to press “ENTER”. The current value is stored, and the following page appears.

A schematic flowchart is shown in the next page.



PROGRAMMING FLOWCHART

4.1.1.- NOMINAL VOLTAGE .

Once accepted the password, the upper line displays " U pr". The lower lines display the nominal voltage value, using both lines chained, with a decimal point before the last digit. In this way can be represented from 0.1 to 9,999,999.9 volts. This value must be the line to line voltage, and correspond to the primary nominal voltage in MT or HT lines. If there is no transformer, in low voltage installations, this value must coincide with the secondary voltage marked in the label.

To change the value, the keys "UP" and "DOWN" are used to increase or decrement the flashing digit, and when all digits have been modified, press "ENTER". If no change must be done, press "ENTER" to go to the following page.

4.1.2.- NOMINAL CURRENT.

Once the voltage value has been validated, the upper line displays "I pr", asking for the current value. This is the CT nominal primary current. It can be changed from 1 to 99 999 999 Amps. The way to modify it is the same as for the voltage.

4.1.3.- ENERGY REFERENCE.

The energy reference is the amount of energy, both active or reactive, used to produce a pulse through the output relays. It is also used to increment the value of the internal energy counters, and therefore, the value read in these counters must be multiplied by the ENER parameter. Any value between 1 Wh and 999.9 KWh can be programmed. It is advisable to select a decimal value, and related with the installation nominal power, in order not to move the counters very fast or very slowly.

Only the lower line is used to display the value, and is read always in KWh. The decimal point can be moved pressing P and "ROTATE" at the same time.

4.1.4.- IDENTIFICATION NUMBER..

This is the address number when the devices are connected in a communication network. As stated by the JBUS protocol, can take any value from 0 to 255, but 0, 199, and 205 must not be used, as they are reserved for special purposes.

4.1.6.- TIME.

The RTC included in the equipment can be modified also. Only is used the display lower line, and the format is Hh.Mm, in 24 hour , from 00.00 to 23.59.

4.1.7.- BASIC RELAYS.

Two basic relays are included as standard excepting in models B and BA. These two relays can have different functions as selected through the variable called "MODE". As this variable affects to both relays, the function is common for them.

MODE value	Function
0000:	- Pulse output for active and reactive energy.
0001:	- SW controlled outputs.
0002:	- Alarms on the variables displayed.

4.1.7.1.- MODE 0000. PULSE OUTPUTS.

In this mode, a pulse is produced when the energy consumed equals the energy reference value programmed in the REF_ENER variable. The RL1 output represents consumed active energy, and the RL0 corresponds to inductive reactive energy. The pulse width is nominally 80 ms.

4.1.7.2.- MODE 0001. SW CONTROLLED OUTPUTS.

In this mode is possible to change the status of each relay by means of SW commands sent through the serial communication line. To easy the installation, is possible also to set or reset any relay through the front keyboard, selecting during the programming procedure the message OUTP. When this message appears in the upper display, the lower line two right digits represent the relays status. As is usual, the digit flashing can be modified. If set to 1, the relay is closed, and is opened when set to 0. The RL0 is controlled by the right digit, and the RL1 by the next one. Pushing ENTER the relays status is accepted, and the display changes to the following page.

4.1.7.3.- MODE 0002. ALARM OUTPUTS.

Any relay can be assigned to any of the variables described below, in order to provide a maximum or minimum level alarm. In this way, the device can operate autonomously, giving a warning each time a defined level is surpassed. The alarm definition is carried out in the programming procedure. Page AL00 is selected for programming relay RL0, and page AL01 for relay RL01. If needed, both alarms can be activated by the same signal, for instance, one as maximum level and the other as minimum level detection. Once in the programming page, is possible:

- To select the variable assigned to the alarm.
- To select the mode.
- To fix the reference level.

The variable selected is marked by the display LED lit on flashing. To change, press UP or DOWN, and after, press ENTER. The variables to be selected are V12, I1, PTOTAL, V23, I2, QTOTAL, V31, I3, COS, Hz, and STOTAL.

The mode is represented by "++" for maximum, and by "----" for minimum. Also it can be changed by pressing UP or DOWN keys.

Pressing again ENTER allows to fix the level. This value is always a percentage of the nominal value for the variable selected. For instance, if the voltage has been selected, the alarm level can be set to any value between the 0 and 120% of the nominal voltage previously programmed.

If maximum level alarm has been programmed, the relay closes when the value exceed the level stored. A fixed one second delay is added, in order to avoid repeated changes when the variable is close to the level. If minimum level detection has been chosen, the relay closes if the variable drops under the level marked.

4.1.8.- COMMUNICATION RATE.

Once programmed both alarms, the next page allows to program the communication speed. The message "bAUD" appears in the upper line, and a number in the lower one. Its meaning is as follows:

9600 Bps
300 Bps
600 Bps
1200 Bps
2400 Bps
4800 Bps
1920 Bps equals 19200 Bps

The change can be done by pressing UP, DOWN, and ENTER, and is effective only when there is no messages by the serial line.

4.1.9.- MAX.DEMAND INTERVAL.

The upper line shows “Int”, and the lower one the value in minutes. Pressing “UP” or “DOWN” changes between 15 and 30 minutes.

4.1.10.- SYNCHRONIZATION MODE.

The upper line shows “SINC”. The lower one, the “int” or “ext” mode. In external mode, the SYNC input is used to start the maximum demand calculation. If no signal is provided, an overflow can occur after 65536 accumulations.

4.1.11.- PASSWORD PROGRAMMING.

The last programming page allows to change the password. The upper line displays PASS, and the lower one the actual password. It can be modified using the UP and DOWN keys. Once programmed, press ENTER to validate it. If the password is not known, the device must be sent to our factory to set again the default password.

4.1.12.- PROGRAMMING ENDING.

When in programming, pressing ENTER validates the current value and goes to the following page. Once every parameter has been accepted, pressing P and DOWN at the same time, finishes the programming process, and the instrument begins the measuring process.

4.2.- DATA DISPLAY MODE.

4.2.1.- MODE 1.

Once the device is in measuring process, the data represented in every display line correspond to the LED which is on. Pressing D1, D2, or D3 changes the magnitude displayed.

Each value is represented in fixed point format, depending on the full scale programmed, according to the following table:

10 A, 10 kV, 10 kW, 10 MW, 10 GW	0,000	9,999
100 A, 100kV, 100 Kw, 100 MW	00,00	99,99
1000 A, 1000kV, 1000 kW, 1000 MW	000,0	999,9
10000 A	0000	9999

Please note that the value defining the point position is not the nominal full scale, but the 120% of this in the case of voltage and current, and the 150% in the case of power, allowing the nominal overload for them, without the need to change the point.

4.2.2.- MODE 2. MAX-MIN VALUES.

To get the max-min stored data, press “P”, and at the same time, “MAX”. The LED V1 will be lit on, and will appear the maximum and minimum values for this magnitude in the central and lower lines.

Pressing UP or DOWN changes the LED on, and the displayed magnitude.

Pressing “P” and UP, the max-min values are reset. It means that the current values are stored in the max-min registers, and the comparison process is started.

Pressing “P” and DOWN, the values are not changed, and the device returns to the normal display process.

4.2.3.- MODE 3. ENERGY COUNTERS.

Press “P” and “ENERGY”. The positive energy counter will be displayed. In the upper line appears “CON”, indicating consumed energy. The value is read using the two lower lines.

Pressing “UP” and “DOWN” changes to the other counters. To reset any of them press “P” and “UP”. To go back to the normal mode, press “P” and “DOWN”.

When displaying the energy counters, please note their content means number of pulses. Each pulse is equivalent to the REF_ENER value.

4.2.4.- MODE 4. MAX-DEMAND VALUES.

Press “MD”. The max demand values will be appearing beginning with the I1. The upper line displays the current value for the variable pointed by the LED lit on. Pressing “UP” or “DOWN” changes the variable selected. Pressing “P” and “UP” erases the values stored, and the calculation process begins again. Pressing “P” and “DOWN” the display returns to the normal mode.

4.2.5.- MODE 5. THD VALUES.

Press “P” and “THD”. The display will show in the upper line “THD”, in the central line the fundamental content, and in the lower line the percentage of total harmonic distorsion, for each of the variables pointed by the LED lit on. Pressing “UP” or “DOWN” changes the variable read. This mode is also used to show the neutral current, as the seventh variable, appearing in the upper line “In”, and its value in the lower line. Pressing “P” and “DOWN” puts the display again in normal mode.

5.- SERIAL LINE PROGRAMMING.

5.1.- MEMORY MAP.

The programming process from the PC is done by sending commands and data to the memory positions described. The data format is shown in 9.

The memory map is described below. In each table are specified the memory address, data format, description, and if the position is used in the different MAR models. The variables are grouped in the tables by their functionality. Those marked R are read only positions, W are write only positions, and RW can be both read and written. The address numbers are decimal values. Each number must be added to the base register to get the actual address position.

5.1.1.- Calibration variables.

ADD	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
400	VR100	LONG	AJUSTE HW VR	R	X	X	X	X	X	X
402	VS100	LONG	AJUSTE HW VS	R	X	X		X	X	X
404	VT100	LONG	AJUSTE HW VT	R	X	X		X	X	X
406	PR100	LONG	AJUSTE HW PR	R	X	X	X	X	X	X
408	PS100	LONG	AJUSTE HW PS	R	X	X			X	X
410	PT100	LONG	AJUSTE HW PT	R	X	X			X	X
412	QR100	LONG	AJUSTE HW QR	R	X	X	X	X	X	X
414	QS100	LONG	AJUSTE HW QS	R	X	X			X	X
416	QT100	LONG	AJUSTE HW QT	R	X	X			X	X
418	IR100	LONG	AJUSTE HW IR	R	X	X	X	X	X	X
420	IS100	LONG	AJUSTE HW IS	R	X	X			X	X
422	IT100	LONG	AJUSTE HW IT	R	X	X			X	X
424	PWMIN	BYTE	AJUSTE HW 4mA	R/W			X	X	X	X
425	PWMAX	BYTE	AJUSTE HW 20 Ma	R/W			X	X	X	X
454	CODE_ACC	BYTE	CALIBRATION CODE	W	X	X	X	X	X	X

These variables are only for calibration purposes. They must not be changed by the user. They define the gain and offset parameters for the different inputs.

5.1.2.- Configuration variables.

ADD (DEC)	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
0	BASE_REG	WORD	BASE ADDRESS	R/W	X	X	X	X	X	X
1	ESCALAV	IEEE	NOMINAL VOLTAGE	R/W	X	X	X	X	X	X
3	ESCV_BCD	LONG	NOM.VOLTAGE BCD	R	X	X	X	X	X	X
5	ESCALAI	IEEE	NOMINAL CURRENT	R/W	X	X	X	X	X	X
7	ESCI_BCD	LONG	NOM.CURRENT BCD	R	X	X	X	X	X	X
9	REF_ENER	IEEE	ENERGY REFERENCE	R/W			X	X	X	X
11	REF_BCD	LONG	ENERGY REF.BCD	R			X	X	X	X
13	ESCALAP	IEEE	NOMINAL POWER	R	X	X	X	X	X	X
200	SERNUM	STRING	SERIAL NUMBER	R	X	X	X	X	X	X
205	ID	WORD	NETWORK IDENTIFICATION	R/W	X	X	X	X	X	X
206	TYPE	STRING	SW VERSION&MODEL	R	X	X	X	X	X	X
211	PROT	WORD	JBUS/MODBUS PROTOCOL	R/W	X	X	X	X	X	X
212	VEL	WORD	COMM.SPEED SELECTION	R/W	X	X	X	X	X	X
215	MOD_INP	WORD	DIG.INPUT MODE	R/W			X	X	X	X
318	PASWORD	LONG	ACCESS CODE FOR KEYB.	R/W	X	X	X	X	X	X

These variables define the nominal values for voltage, current, power, and energy. Their format is IEEE, but some of them have a variable related in BCD format (read only).

In SERNUM is stored the serial number. Its format is STRING, ten bytes long, and it can not be written. Its value is "SACIXXXXXX", in which the digits marked X can have any value between 0 and FFH. (Normally are ASCII characters).

In ID is stored the address of the device when working in a network. It is a binary number, from 0 to 255. The values 0, 199, and 205 must not be used, as they have special meanings for the devices.

In TYPE is stored the model and SW version. It is a six characters string, and it can not be written.

PROT selects the transmission format for the IEEE and Long Integer data. “1” means JBUS, and “0” means MODBUS. See Annex 3.

VEL sets the communication line baud rate. It is coded in the same way as appears in the display:

0	9600 Bps
1	300 Bps
2	600 Bps
3	1200 Bps
4	2400 Bps
5	4800 Bps
6	19200 Bps

To change the speed, a message must be sent at the current baud rate, writing its value in the position 3587H. The device answers an acknowledge message at the same speed, and changes afterward to the new one.

MOD_INP stores the digital input working mode. These inputs are galvanically isolated from the rest of the circuit, and they have a separate power supply. A normally open free potential contact can be used in the input. They have two working modes:

1.- Digital inputs, ON-OFF.
2.- Pulse counters.

The programming can be done only through the serial line. Each input can work in any mode.

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	ENTR3	ENTR2	ENTR1	ENTR0

ENTRx = "0" means digital input.
ENTRx = "1" means counter input.

When configured as counter, a pulse is accepted if it is ON at least 30 ms, and OFF at least other 30 ms.

PASSWORD default value is 0010. Its format is LONG INTEGER, although, as the maximum number able to be represented in the display is 9999, the two MSB will be always zero.

5.1.3.- Digital inputs status.

ADDR	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
216	INP_STA	BYTE	DIGITAL INPUTS STATUS	R			X	X	X	X

The variable INP_STA represents the digital inputs status. Each bit set to "1" means open input. Each bit reset to "0", means closed input. Bit 7 represents the battery status. "1" means battery OK.

B7	B6	B5	B4	B3	B2	B1	B0
BAT	0	0	0	ENTR3	ENTR2	ENTR1	ENTR0

5.1.4.- Energy counters.

ADD (DEC)	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
302	TOT_ACT+	LONG	ACT. ENERGY CONSUMED	R/W			X	X	X	X
304	TOT_ACT-	LONG	ACT. ENERGY PRODUCED	R/W			X	X	X	X
306	TOT_REACT L	LONG	REACT. ENERGY (IND)	R/W			X	X	X	X
308	TOT_REACT C	LONG	REACT. ENERGY (CAP)	R/W			X	X	X	X

Each counter stores the total energy consumed or produced. Its format is LONG INTEGER, and they overload at 999.999.999. These register can be read and written, in order to be able to set them at any value, for instance to make them coincident with an electromechanical counter content.

5.1.5.- Pulse counters.

ADDR	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
310	CONT_IMP0	LONG	PULSE COUNTER 0	R/W			X	X	X	X
312	CONT_IMP1	LONG	PULSE COUNTER 1	R/W			X	X	X	X
314	CONT_IMP2	LONG	PULSE COUNTER 2	R/W			X	X	X	X
316	CONT_IMP3	LONG	PULSE COUNTER 3	R/W			X	X	X	X

Each digital input, when configured as counters, has a register in which the pulses are accumulated. Their format is LONG INTEGER, and they overload at 999.999.999.

5.1.6.- Measured variables.

ADDR	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2

120	V1	IEEE	VOLTAGE V1	R	X	X	X	X	X	
122	V2	IEEE	VOLTAGE V2	R	X	X		X	X	
124	V3	IEEE	VOLTAGE V3	R	X	X		X	X	
126	V12	IEEE	VOLTAGE L12	R	X	X		X	X	X
128	V23	IEEE	VOLTAGE L23	R	X	X		X	X	X
130	V31	IEEE	VOLTAGE L31	R	X	X		X	X	X
132	PFR	IEEE	ACT POWER R/L1	R	X	X	X	X	X	X
134	PFS	IEEE	ACT POWER S/L2	R	X	X		X	X	
136	PFT	IEEE	ACT POWER T /L3	R	X	X		X	X	X
138	QFR	IEEE	REACT. POWER R/L1	R	X	X	X	X	X	X
140	QFS	IEEE	REACT. POWER S/L2	R	X	X		X	X	
142	QFT	IEEE	REACT. POWER T/L3	R	X	X		X	X	X
144	IFR	IEEE	CURRENT R/L1	R	X	X	X	X	X	X
146	IFS	IEEE	CURRENT S/L2	R	X	X		X	X	X
148	IFT	IEEE	CURRENT T/L3	R	X	X		X	X	X
150	SFR	IEEE	APAR. POWER R/L1	R	X	X	X	X	X	
152	SFS	IEEE	APAR. POWER S/L2	R	X	X		X	X	
154	SFT	IEEE	APAR. POWER T/L3	R	X	X		X	X	
156	COSR	IEEE	COS FI R/L1	R	X	X	X	X	X	
158	COSS	IEEE	COS FI S/L2	R	X	X		X	X	
160	COST	IEEE	COS FI T/L3	R	X	X		X	X	
162	PRST	IEEE	TOTAL ACT.POWER	R	X	X	X	X	X	X
164	QRST	IEEE	TOTAL REACT.POWER	R	X	X	X	X	X	X
166	SRST	IEEE	TOTAL AP. POWER	R	X	X	X	X	X	X
168	COSENO	IEEE	TOTAL COS FI	R	X	X	X	X	X	X
170	FREC_RED	IEEE	FREQUENCY	R	X	X	X	X	X	X
172	IN	IEEE	NEUTRAL CURRENT	R		X			X	
217	TIME	BCD	REAL TIME CLOCK	R/W			X	X	X	X

TIME represents the time as it is stored in the RTC. Its format is WORD, and it is BCD coded as follows.

MSB:

B7	B6	B5	B4	B3	B2	B1	B0
H7	H6	H5	H4	H3	H2	H1	H0

-- ---------------------------------------

HOUR MSB (BCD) HOUR LSB (BCD)

LSB:

B7	B6	B5	B4	B3	B2	B1	B0
MIN7	MIN6	MIN5	MIN4	MIN3	MIN2	MIN1	MIN0

--- --------------------------------------

MINUTE MSB (BCD) MINUTE LSB (BCD)

5.1.7.- Relay control.

ADDR	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
209	MOD_OUT	WORD	BASIC RELAYS CONFIG.	R/W			X	X	X	X
210	DIG_OUT	BYTE	CONTROL RL0 & RL1	R/W			X	X	X	X
213	ALARMA0	WORD	AL0 VAR & MODE	R/W			X	X	X	X
214	ALARMA1	WORD	AL1 VAR & MODE	R/W			X	X	X	X
15	VALOR_AL0	IEEE	AL0 LEVEL	R/W			X	X	X	X
17	VALOR_AL1	IEEE	AL1 LEVEL	R/W			X	X	X	X
218	CONF_OPC	WORD	OPTIONS DEFINITION	R/W			X	X	X	X
220	CONF_REL	WORD	AUX. REL.CONFIG.	R/W			X	X	X	X
221	ALARMA2	WORD	AL2 VAR & MODE	R/W			X	X	X	X
222	ALARMA3	WORD	AL3 VAR & MODE	R/W			X	X	X	X

223	ALARMA4	WORD	AL4 VAR & MODE	R/W			X	X	X	X
224	ALARMA5	WORD	AL5 VAR & MODE	R/W			X	X	X	X
225	ALARMA6	WORD	AL6 VAR & MODE	R/W			X	X	X	X
226	ALARMA7	WORD	AL7 VAR & MODE	R/W			X	X	X	X
227	ALARMA8	WORD	AL8 VAR & MODE	R/W			X	X	X	X
228	ALARMA9	WORD	AL9 VAR & MODE	R/W			X	X	X	X
229	ALARMAA	WORD	ALA VAR & MODE	R/W			X	X	X	X
230	ALARMAB	WORD	AL1BVAR & MODE	R/W			X	X	X	X
231	VALOR_AL2	IEEE	AL2 LEVEL	R/W			X	X	X	X
233	VALOR_AL3	IEEE	AL3 LEVEL	R/W			X	X	X	X
235	VALOR_AL4	IEEE	AL4 LEVEL	R/W			X	X	X	X
237	VALOR_AL5	IEEE	AL5 LEVEL	R/W			X	X	X	X
239	VALOR_AL6	IEEE	AL6 LEVEL	R/W			X	X	X	X
241	VALOR_AL7	IEEE	AL7 LEVEL	R/W			X	X	X	X
243	VALOR_AL8	IEEE	AL8 LEVEL	R/W			X	X	X	X
245	VALOR_AL9	IEEE	AL9 LEVEL	R/W			X	X	X	X
247	VALOR_ALA	IEEE	ALA LEVEL	R/W			X	X	X	X
249	VALOR_ALB	IEEE	ALB LEVEL	R/W			X	X	X	X
251	OUT_REL	WORD	OPTIONAL REL.CONTROL	R/W			X	X	X	X

These variables control the working mode for both the basic relays and for the auxiliary relays.

MOD_OUT defines the working mode for the two basic relays.

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	0	X	X

XX: 00 Energy pulse outputs.
01 SW programmed outputs.
02 Alarms.

DIG_OUT is a byte controlling the basic relays status

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	0	RL1	RL0

Writing a "1" in a bit closes the relay.

CONF_OPC defines the active options installed.

B7	B6	B5	B42	B3	B2	B1	B0
0	0	0	0	0	0	4-20	REL10

A bit set to "1" means the option is active. When a 4-20 mA option is installed, writing a 0 in the B1,sets the output to 4mA.

CONF_REL sets the working mode for the auxiliary relays. These relays can be programmed in a similar way as the basic relays:

- SW controlled outputs.
- Alarms.

B15	B14	B13	B12	B11	B10	B9	B8
0	0	0	0	0	0	REL11	REL10

B7	B6	B5	B4	B3	B2	B1	B0

REL9	REL8	REL7	REL6	REL5	REL4	REL3	REL2

Each bit reset to “0” means digital output. Set to “1” means alarm mode. Each relay can have its own working mode.

ALARMAX stores the actuation mode for each relay, when configured as alarm:

B15	B14	B13	B12	B11	B10	B9	B8
MODE	ACTIV	0	0	0	STOT	FREC	COS

B7	B6	B5	B4	B3	B2	B1	B0
I3	V31	QTOT	I2	V23	PTOT	I1	V12

MODE: “1” means maximum level alarm.“0”, means minimum level alarm.
ACTIV: “1” means the alarm has been triggered. This bit does not have any memory. It will be ON when the alarm condition occurs. In the moment this condition disappears, the bit is reset.
Each of the rest of the bits indicates which magnitude is associated to the relay alarm. Only one bit can be set.

VALOR_ALX contains the value for alarm trigger, expressed as percentage of the nominal value of the magnitude. Its format is IEEE, and can have a value between 0 and 120. No sign is allowed.

OUT_REL controls the auxiliary relay status when the mode is SW controlled outputs. Setting each bit to 1 closes the relay, resetting it to 0 open the relay.

B15	B14	B13	B12	B11	B10	B9	B8
0	0	0	0	0	0	REL11	REL10

B7	B6	B5	B4	B3	B2	B1	B0
REL9	REL8	REL7	REL6	REL5	REL4	REL3	REL2

5.1.8.- 4-20 mA output.

DIR	VAR	TIPO	DESCRIPCION	MOD	B	BA	144	144-I	144-3	144-2
218	CONF_OPC	BYTE	OPTIONS DEFINITION	R/W			X	X	X	X
219	CONF_420	WORD	OUTPUT VARIABLE	R/W			X	X	X	X

CONF_420 defines the magnitude associated to the analog output. Its meaning is similar to the ALARMAX word.

B15	B14	B13	B12	B11	B10	B9	B8
0	0	0	0	0	STOT	FREC	COS

B7	B6	B5	B4	B3	B2	B1	B0
I3	V3	QTOT	I2	V2	PTOT	I1	V1

5.1.9.- Maximum-minimum values.

ADDR	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
19	VF1_MAX	IEEE	MAX. V1	R	X	X	X	X	X	
21	VF2_MAX	IEEE	MAX. V2	R	X	X		X	X	
23	VF3_MAX	IEEE	MAX. V3	R	X	X		X	X	
25	VF12_MAX	IEEE	MAX. V12	R	X	X		X	X	X
27	VF23_MAX	IEEE	MAX. V23	R	X	X		X	X	X
29	VF31_MAX	IEEE	MAX. V32	R	X	X		X	X	X
31	IFR_MAX	IEEE	MAX. IF1	R	X	X	X	X	X	X
33	IFS_MAX	IEEE	MAX. IF2	R	X	X		X	X	X
35	IFT_MAX	IEEE	MAX. IF3	R	X	X		X	X	X
37	PFR_MAX	IEEE	MAX. ACT.POWER L1	R	X	X	X	X	X	
39	PFS_MAX	IEEE	MAX. ACT.POWER L2	R	X	X		X	X	
41	PFT_MAX	IEEE	MAX. ACT.POWER L3	R	X	X		X	X	
43	PRST_MAX	IEEE	MAX. ACT. POWER	R	X	X	X	X	X	X
45	QRST_MAX	IEEE	MAX. REACT. POWER	R	X	X	X	X	X	X
47	SRST_MAX	IEEE	MAX: APP: POWER	R	X	X	X	X	X	X
49	COS_MAX	IEEE	MAX. TOTAL COS FI	R	X	X	X	X	X	X
51	FREC_MAX	IEEE	VALOR MAX. FREC.	R	X	X	X	X	X	X
53	VF1_MIN	IEEE	MIN. VF1	R	X	X	X	X	X	
55	VF2_MIN	IEEE	MIN. VF2	R	X	X		X	X	
57	VF3_MIN	IEEE	MIN. VF3	R	X	X		X	X	
59	VF12_MIN	IEEE	MIN. VF12	R	X	X		X	X	X
61	VF23_MIN	IEEE	MIN. VF23	R	X	X		X	X	
63	VF31_MIN	IEEE	MIN. VF32	R	X	X		X	X	X
65	IFR_MIN	IEEE	MIN. IF1	R	X	X	X	X	X	X
67	IFS_MIN	IEEE	MIN. IF2	R	X	X		X	X	X
69	IFT_MIN	IEEE	MIN. IF3	R	X	X		X	X	X
71	PFR_MIN	IEEE	MIN. ACT.POWER L1	R	X	X	X	X	X	
73	PFS_MIN	IEEE	MIN. ACT.POWER L2	R	X	X		X	X	
75	PFT_MIN	IEEE	MIN. ACT.POWER L3	R	X	X		X	X	
77	PRST_MIN	IEEE	MIN. ACT.POWER	R	X	X	X	X		X
79	QRST_MIN	IEEE	MIN. REACT. POWER	R	X	X	X	X		X
81	SSRT_MIN	IEEE	MIN_APP.POWER	R	X	X	X	X	X	X
83	COS_MIN	IEEE	MIN. TOTAL COS FI	R	X	X	X	X	X	X
85	FREC_MIN	IEEE	MIN. FREQ.	R	X	X	X	X		X
600	SW_RST	WORD	RESET AND START	W	X	X	X	X	X	X
601	SYNC_MAXM	WORD	MAX-MIN RESET/START	W	X	X	X	X	X	X
602	SW_SYNC	WORD	SYNC. FOR MAX.DEMAND	W	X	X	X	X	X	X

Each variable stores the max or min value for each magnitude, from the last reset.

SYNC_MAXM allows the starting of the max-.min process. When a “0” is written in it, the max and min values are overwritten with the current values, and starts the comparison process, in which each new value is compared with the previous one, and if greater, it is stored in the maximum register, or if smaller, in the minimum register.

5.1.10.- Max. demand variables.

Values

ADD	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
560	MAX_ACT_P	IEEE	PRESENT PERIOD VALUE	R	X	X	X	X	X	X
562	MAX_ACT_Q	IEEE	PRESENT PERIOD VALUE	R	X	X	X	X	X	X
564	MAX_ACT_S	IEEE	PRESENT PERIOD VALUE	R	X	X	X	X	X	X
566	MAX_ACT_IR	IEEE	PRESENT PERIOD VALUE	R	X	X	X	X	X	X
568	MAX_ACT_IS	IEEE	PRESENT PERIOD VALUE	R	X	X			X	X
570	MAX_ACT_IT	IEEE	PRESENT PERIOD VALUE	R	X	X			X	X
572	MAX_PUNT_P	IEEE	MAX PEAK VALUE	R	X	X	X	X	X	X
574	MAX_PUNT_Q	IEEE	MAX PEAK VALUE	R	X	X	X	X	X	X
576	MAX_PUNT_S	IEEE	MAX PEAK VALUE	R	X	X	X	X	X	X
578	MAX_PUNT_IR	IEEE	MAX PEAK VALUE	R	X	X	X	X	X	X
580	MAX_PUNT_IS	IEEE	MAX PEAK VALUE	R	X	X			X	X
582	MAX_PUNT_IT	IEEE	MAX PEAK VALUE	R	X	X			X	X
584	MAX_ANT_P	IEEE	PAST PERIODVALUE	R			X	X	X	X
586	MAX_ANT_Q	IEEE	PAST PERIODVALUE	R			X	X	X	X
588	MAX_ANT_S	IEEE	PAST PERIODVALUE	R			X	X	X	X
590	MAX_ANT_IR	IEEE	PAST PERIODVALUE	R			X	X	X	X
592	MAX_ANT_IS	IEEE	PAST PERIODVALUE	R					X	X
594	MAX_ANT_IT	IEEE	PAST PERIODVALUE	R	X	X			X	X

Time stamps

ADD	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
254	H_PUNT_P	WORD	PEAK TIME FOR P	R	X	X	X	X	X	X
255	H_PUNT_Q	WORD	PEAK TIME FOR Q	R	X	X	X	X	X	X
256	H_PUNT_S	WORD	PEAK TIME FOR S	R	X	X	X	X	X	X
257	H_PUNT_IR	WORD	PEAK TIME FOR IR	R	X	X	X	X	X	X
258	H_PUNT_IS	WORD	PEAK TIME FOR IS	R	X	X			X	
259	H_PUNT_IT	WORD	PEAK TIME FOR IT	R	X	X			X	X
260	INTERVAL	WORD	MDEMAND PERIOD	R	X	X	X	X	X	X
2356	SYNC_MD	WORD	START COMMAND	R	X	X	X	X	X	X

The format is the same as the TIME variable, as explained in 5.1.6.

5.1.11.- THD variables.

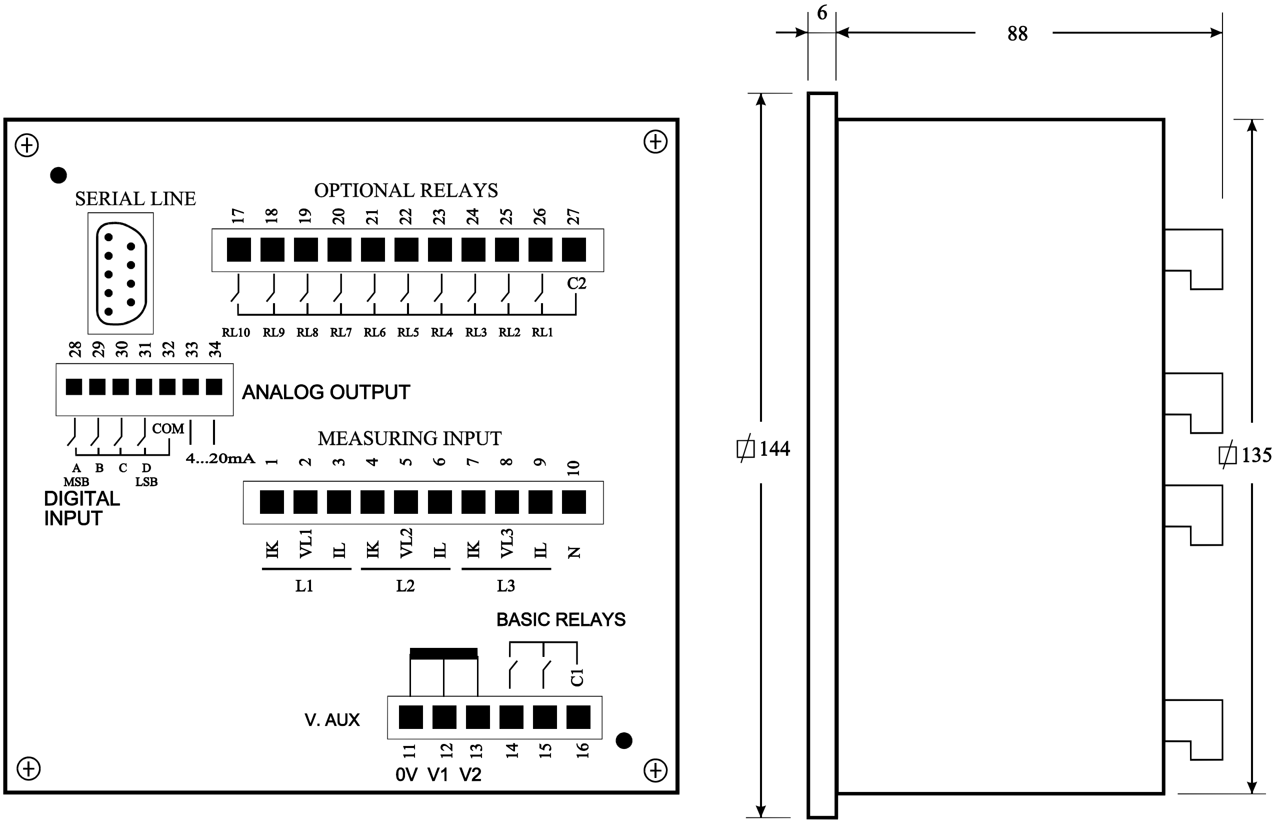
ADD	VAR	TYPE	DESCRIPTION	MOD	B	BA	144	144-I	144-3	144-2
500	VR_REAL	IEEE	ACTUAL VR VALUE	R	X	X	X	X	X	X
502	VS_REAL	IEEE	ACTUAL VS VALUE	R	X	X			X	X
504	VT_REAL	IEEE	ACTUAL VT VALUE	R	X	X			X	X
506	IR_REAL	IEEE	ACTUAL IR VALUE	R	X	X	X	X	X	X
508	IS_REAL	IEEE	ACTUAL IS VALUE	R	X	X			X	X
510	IT_REAL	IEEE	ACTUAL IT VALUE	R	X	X			X	X
512	VR_XTR	IEEE	FUNDAMENTAL VR VALUE	R	X	X	X	X	X	X
514	VS_XTR	IEEE	FUNDAMENTAL VS VALUE	R	X	X	X	X	X	X
516	VT_XTR	IEEE	FUNDAMENTAL VT VALUE	R	X	X	X	X	X	X
518	IR_XTR	IEEE	FUNDAMENTAL IR VALUE	R	X	X	X	X	X	X
520	IS_XTR	IEEE	FUNDAMENTAL IS VALUE	R	X	X			X	X
522	IT_XTR	IEEE	FUNDAMENTAL IT VALUE	R	X	X			X	X
524	VR_THD	IEEE	ABSOLUTE THD VALUE	R			X	X	X	X
526	VS_THD	IEEE	ABSOLUTE THD VALUE	R			X	X	X	X
528	VT_THD	IEEE	ABSOLUTE THD VALUE	R			X	X	X	X
530	IR_THD	IEEE	ABSOLUTE THD VALUE	R			X	X	X	X
532	IS_THD	IEEE	ABSOLUTE THD VALUE	R					X	X
534	IT_THD	IEEE	ABSOLUTE THD VALUE	R	X	X			X	X
536	THD_VR	IEEE	RELATIVE THD VALUE (%)	R						
538	THD_VS	IEEE	RELATIVE THD VALUE (%)	R						
540	THD_VT	IEEE	RELATIVE THD VALUE (%)	R						
542	THD_IR	IEEE	RELATIVE THD VALUE (%)	R						
544	THD_IS	IEEE	RELATIVE THD VALUE (%)	R						
546	THD_IT	IEEE	RELATIVE THD VALUE (%)	R						

Actual Vx/Ix value means the RMS measure. It is the same as Ix in table 5.1.6.
Fundamental Vx/Ix value is the first harmonic content, in absolute value, volts or amps.
Absolute THD value is the harmonics distortion in absolute value, volts or amps.
Relative THD value is expressed in percentage relative to the fundamental.

6.- MOUNTING.

6.1.- Dimensions.

Dimensions and generic connections are shown in the figure.



M144CON2I.CDR

6.2.- Electrical connections.

Connections are done by pluggable connectors. The connector corresponding to the auxiliary relays is only mounted if it has been ordered, as this option is not possible to be installed afterwards. The other connectors are always mounted, although the related option would not be asked for.

6.2.1.- Serial line.

Two types of serial line can be ordered: RS232, and RS485. They are accesible through a DB9 connector in the backside. Optionally, a mini-DIN connector can be mounted in the front. The pinning is as follows.

	Name	DB9	mini-DI N
RS232:	GND	5	4
	TD	2	2
	RD	3	1

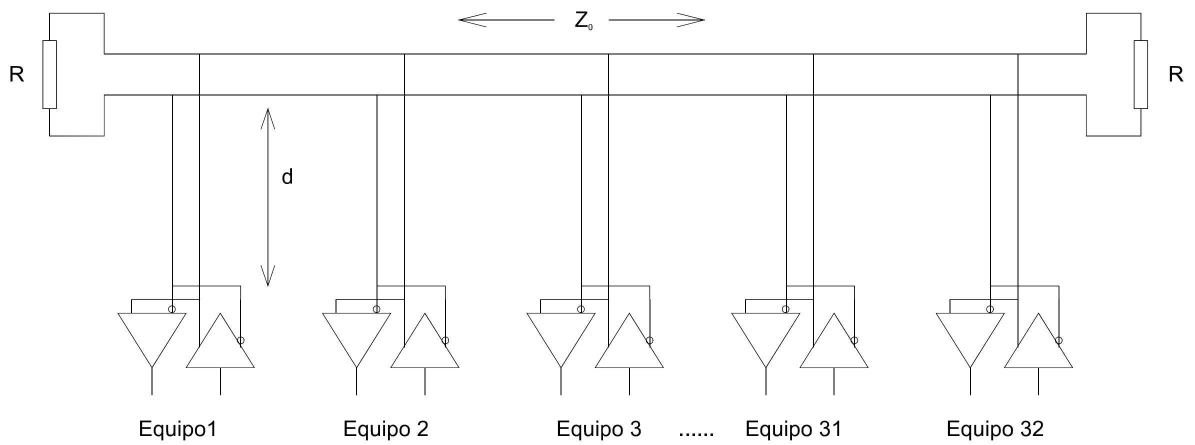
	Name	DB9	mini_DIN
RS485:	GND	4	2
	L+	9	1
	L-	5	4
	LA+	8	
	LA-	7	

RS232 pins are named as the computer to be connected. TD means data transmitted by the computer, and received by the MAR144.

RS485 connections are named L+ and L-. They must be connected to homologous terminals in the network, that is, the same wire goes to all terminals marked L+, and the other wire goes to all terminals marked L-.

If four wires connection is required, the terminals marked LA+ and LA- must be used. If the RS232 to RS485 IFRA's are used, the terminals with the same name will be connected together. If the device is going to be connected to an existing network, L+ and L- are the transmission line, and LA+ and LA- the reception line.

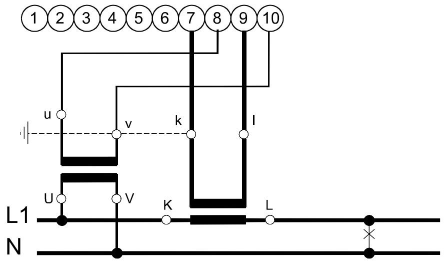
The following schematic diagram shows the typical connection for two wires.



If the transmission line length is longer than a few hundred meters, termination resistors are required, nominally 120 ohms.

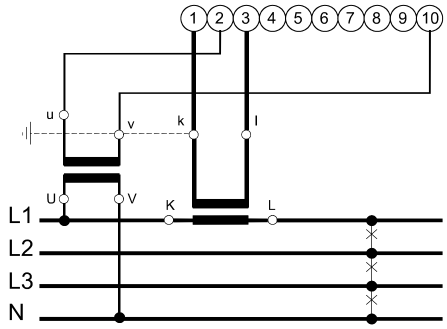
6.2.2.- Electrical network connections.

The device is wired in the standard way as a wattmeter, single phase, two systems, or three systems, depending on the type of electrical supply to be connected.



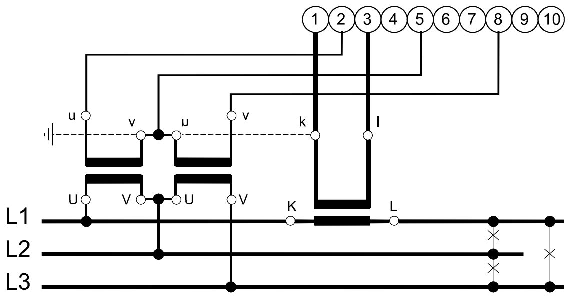
SINGLE PHASE

MAR144



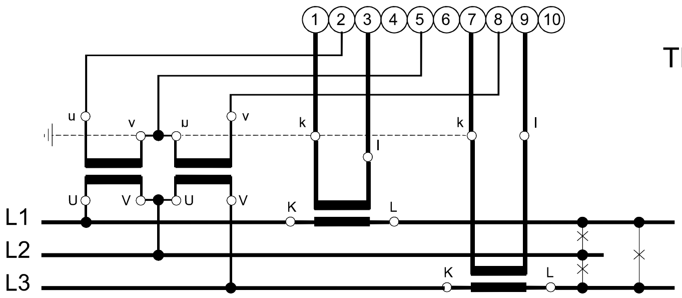
THREE PHASE, BALANCED
(A)

MAR144 I



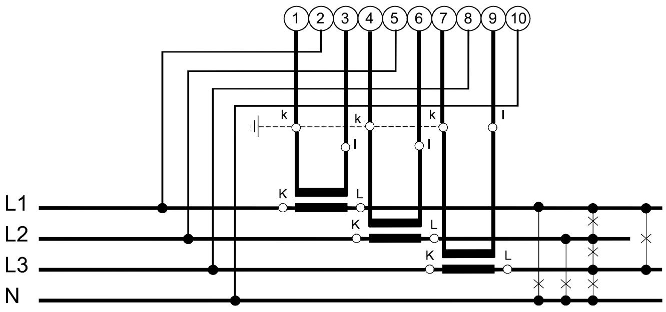
THREE PHASE, BALANCED
(B)

MAR 144 I



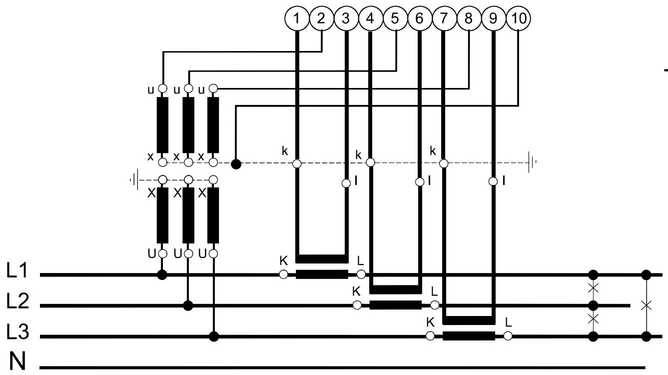
THREE PHASE, UNBALANCED
THREE WIRES
(TWO SYSTEMS)

MAR 144-2, MAR144-2M



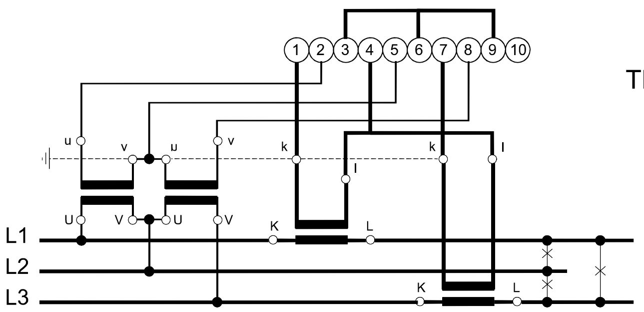
THREE PHASE, UNBALANCED
FOUR WIRES
(THREE SYSTEMS)

MAR 144-3, MAR 144-3M



THREE PHASE, UNBALANCED
THREE OR FOUR WIRES
(STAR CONNECTION)

MAR 144-3, MAR 144-3M
MAR 144B, MAR144BA



THREE PHASE, UNBALANCED
THREE WIRES

MAR 144-3, MAR144-3M
MAR144BA

esqmar3.cdr

6.2.3.- Power supply.

A separate connection is provided for the power supply. In this way, a different supply can be used, allowing to maintain the unit working, - for instance to be able to communicate-, without measuring voltage. The AC supply consists of a multi secondary transformer, rectifiers, filters, etc. This transformer is designed for one voltage input, allowing a ±20% operating range.

NOTE: The input transformer will be changed to a double tap input transformer, allowing the device to be connected to two different voltages. In this way, the same device can be supplied for instance from phase to neutral or phase to phase voltage, without any change.

6.2.4.- Digital inputs.

As the digital inputs are provided with a separate power supply and optocouplers, normally open free potential contacts can be used to activate them. The only precaution is to recall there is a common point between them. Nominal voltage is 12 V, and an internal 2K resistor is included in the circuit. If any kind of semiconductor switch is used, recall that the common point between the inputs is the positive terminal.

6.2.5.- Relay outputs.

The output relays have also a common point. No protection device is included, and then the manufacturer's characteristics must be carefully respected, and some kind of external sectioning device must be provided. The relays used are the model NY from FUJITSU/TAKAMISAWA, able to switch 70 VA/250 V AC, or 3 A on resistive load.

6.2.6.- Analog output.

The analog output is always 4 to 20 mA. It does not requires any external power supply. Maximum open circuit voltage is 15 V. Maximum load resistance is 500 ohms.

NOTE. The models not equipped with current transformers have shunts in the current inputs. These shunts have a common connection point, coincident with the neutral wire if existing. Therefore, they must be connected with the following restrictions:

- As no isolation is provided between current and voltage terminals, the CT wires can be live, for instance, if one of the voltage terminals is disconnected. Special care must be taken as the secondary wires must not be manipulated unless the device is totally disconnected from the electrical supply, marking this fact accordingly.
- In the case the equipment is connected to CT's in series with other meters, as amperemeters, wattmeters, etc., this device must be the last one in the chain, close to the currents return point.
- Connections using current sum or differences must be avoided. These type of connections are only allowed in transformer isolated units.

7.- COMUNICATION PROTOCOL.

The MAR devices transducers are equipped with a serial line in order to be able to communicate all the measured variables to any device with serial input capability. There are two different versions, one as RS232 standard, and the other as RS485. The first one can be used when the connection is point to point, and the second in multidrop connections. In this case, up to 32 devices, - as the standard specifies-, can be connected to the same communication line, to a maximum length of 1200 meters, allowing gathering data coming from any measurement unit.

Both versions are isolated from the rest of circuitry by means of optical couplers. This avoids problems in earth connection, breaking any grounding loops, and allows to connect the cable screen to earth in the best point of the installation.

Although the signal levels are different, the protocol used in both is the same, and complies with the JBUS/MODBUS protocol. This is a master-slave protocol, very common in PLC's. The communication is always started by the master, and no spontaneous messages are allowed.

Each transaction consists of one request frame, generated by the master, and one reply frame, generated by the slave. In the case the master sends a writing command, the slave sends an acknowledge message. Only two commands are used for the exchange, the Write multiple word command (type 16H), and the Read multiple word command (type 04H). The standard transmission rate is 9600 Bps, 8 bits, no parity, and one stop bit. The addressing map is relocatable, as every address is formed adding the number shown in the memory map to the content of the BASE_REG. This register can be written or read at physical position zero, or at [BASE_REG] + 0.

In some cases, certain PLC's are not able to address some positions in the map, and they are constrained to some addresses defined specifically for each command. Until now, the MAR144 accepts command 04H, - READING INPUT REGISTERS-, and command 10H, - PRESET MULTIPLE REGISTERS-, as reading and writing commands. The new units accept also 03H, - READ HOLDING REGISTERS- , and 06H, - PRESET SINGLE REGISTER- , for the same purpose.

By means of SW commands can be done the following operations:

1.- General programming and configuration.
2.- Identity change.
3.- Reading of every magnitude measured.
4.- Energy counters reset (or load at any value).
5.- Time adjustment.
6.- Nominal values change (FS voltage, current, energy).
7.- Baud rate change.
8.- Password setting.

7.1. – FRAME DESCRIPTION.

7.1.1. - DATA POLLING.

Each frame consists of:

- Identity number	one byte
- Command code	03H or 04H
- Data address	two bytes: H, L
- Number of words to be read	two bytes: H, L
- CRC	two bytes: L, H

7.1.2. – WRITING COMMAND.

Each frame consists of:

- Identity number	one byte
- Command code	06H or 10H
- Data address	two bytes: H, L
- Number of words to be written	10H:two bytes: H, L. (06H:none)
- Number of bytes to be written	one byte
- Variable value	10H:four bytes. (06H:only one)
- .	.
- .	.
- .	.
- Variable value	four bytes
- CRC	two bytes: L, H

(It is assumed an IEEE data type transfer. For byte or character type, the variable length is not the same).

7.1..3. – ANSWER FRAME

Each frame consists of:

- Identity	one byte
- Command code (the same as received)	04H
- Number of bytes sent	one byte
- Variable value	four bytes
- .	.
- .	.
- .	.
- Variable value	four bytes
- CRC	two bytes: L, H

7.1.4. – ACKNOWLEDGE FRAME.

It consists of:

- Identity	one byte
- Command code (the same as received)	10H
- Data address (the same as received)	two bytes: H, L
- Number of words written (the same as received)	two bytes: H, L
- CRC	two bytes: L, H

7.2.- COMMANDS.

7.2..1. – READING COMMANDS.

Any reading command consists of

ID---Command type---Address---Number of words---CRCL---CRCH

ID is the identity number. Command type is always 04H. Address corresponds to the first data position in the memory map. Number of words is one word long that is, two bytes. If only one byte is needed, also the number of words written is 1. Every data is accessible by a specific command to its respective address. However, the habitual reading values can be accessed by means of block commands, with the following limitations:

The values read must be all IEEE variables.

The total reading must not exceed 12 variables.

CRC is the result of the algorithm as explained in Annex 1.

The answer to a read command is

ID - Command type - Number of bytes - Data - CRCL - CRCH

ID is the identity number. Command is the same received. Number of bytes expresses the number of data not including ID, Command, No. of bytes, nor CRC. Data is the information asked for.

7.2..2. – WRITING COMMANDS.

The writing commands consists of

ID---Command type---Address---Number of words---Number of bytes---CRCL---CRCH

ID is the identity number. Command type is always 10H. Number of words is two byte long. First is sent the high byte, then the low byte. Number of bytes is one byte long.

No block commands are allowed. Each variable must be written by special command.

The writing commands must receive an acknowledgement answer, with the following format:

ID - Command type – Address - Number of words - CRCL - CRCH

7.2.3.- DATA FORMATS.

The following data formats are used in the data transmission from the MAR144.

ASCII: As characters, for serial number, etc. They are sent in the order specified.

BYTE: Eight bits. For status or control parameters.

WORD: Two bytes. They are sent as MSB-LSB.

LONG: Four bytes. They are sent as MSB-___-___-LSB.

IEEE: Four bytes. They are sent as S+EXP-Mh-Mm-ML. (See annex).

7..3.- EXAMPLES.

The following examples are given as a guide, to help in implementing the protocol.

Several programs are available to provide the user an easy way to communicate with the devices.

IDENTITY READING

0C7H 04H 04H 0B5H 00H 01H 30H 07AH
0C7H 04H 02H 00H 01H 0F0H 0E1H

SERIAL NUMBER READING

0C7H 04H 04H 0B0H 00H 05H 21H 0B8H
0C7H 04H 0AH 53H 41H 43H 49H 30H 30H 35H 31H 32H 41H 44H 0E1H

IDENTITY WRITING

01H 10H 04H 0B5H 00H 01H 02H 00H 02H 78H 34H
01H 10H 04H 0B5H 00H 01H 11H 2FH

TIME READING

0C7H 04H 04H 0C1H 00H 01H 70H 60H
0C7H 04H 02H 17H 34H 3FH 06H

TIME: 17 h 34 m.

TIME WRITING

0C7H 10H 04H 0C1H 00H 01H 02H 14H 39H 47H 0F6H
0C7H 10H 04H 0C1H 00H 01H 40H 63H

Sets the time to 14: 39

DIGITAL INPUTS STATUS

0C7H 04H 04H 0C0H 00H 01H 21H 0A0H
0C7H 04H 02H 00H 0FH 71H 25H

```
                ------
BYTE  READ :
      0     0     0     0     1     1     1     1
      |                       |     |     |     |
      |  INPUTS:              |     |     |     A  OPEN
      |                       |     |     B  OPEN
      |                       |     C  OPEN
      |                       D  OPEN
      |
      |______________   0= Battery NOT OK
```

CONT_IMP0 READING

CONT_IMPx contain the total pulses received by the digital inputs when configured as counters. Their format is LONG INTEGER.

0C7H	04H	05H	1EH	00H	02H	00H	67H	
0C7H	04H	04H	00H	01H	3FH	02H	9CH	79H

The answer tells the content of CONT_IMP0 is 00013F02H (81.666 in decimal).

OUTPUT RELAYS MODE READING

01H	04H	04H	04H	0B9H	00H	01H	0E1H	1FH
01H	04H	02H	00H	01H	78H	0F0H		

MODE_OUT=01 means digital output mode.

NOMINAL VOLTAGE WRITING

01H	10H	03H	0E9H	00H	02H	04H	43H	0C8H	00H	00H	0BDH	07H
01H	10H	03H	0E9H	00H	02H	90H	78H					

Nom. Voltage= 400 V

ACTIVE ENERGY COUNTER WRITING

ID 10H 32H 54H 00H 02H 04H 00H 00H 01H 00H CRCL CRCH
ID 10H 32H 54H 00H 02H CRCL CRCH

The value 100H (256 dec) is stored in TOT_ACT+.

ENERGY COUNTERS READING

0C7H	04H	05H	16H	00H	08H	01H	0A2H
0C7H	04H	10H	00H 00H 00H 03CH			00H 00H 00H 00H	00H 00H 00H 00H
			------- Ep+ --------			-------- Ep- -------	-------- Eq+ ------
			00H 00H 00H 01H			70H	49H
			-------- Eq- -------				

BLOCK READING

0C7H	04H	04H	66H	00H	18H	00H	49H

0C7H	04H	30H	43H 0C7H 0FFH 00H	43H 0C8H 2CH 00H	43H 0C8H 2CH 00H
			--------V12 ----------	-------- V23 --------	-------- V31 --------
		44H 90H 7AH 00H	44H 90H 2DH 00H	44H 90H 0D0H 00H	
		-------- P1 ---------	--------- P2 -------	--------- P3 --------	
		0C2H 5DH 7BH 00H	0C1H 2DH 76H 00H	0C1H 1AH 0BAH 00H	
		-------- Q1 --------	--------- Q2 -------	--------- Q3 --------	
		40H 0A0H 29H 00H	40H 9FH 0FFH 00H	40H 0A0H 3DH 00H	
		-------- I1 --------	--------- I2 --------	-------- I3 ---------	
				CRCL CRCH	

V12= 400.0	V23= 400.3	V31= 400.3
P1= 1156	P2= 1153	P3= 1159
Q1= -55	Q2= -11	Q3= -10
I1= 5005	I2= 5000	I3= 5007

BLOCK READING

0C7H	04H	8AH	00H	0AH	41H	0B1H

0C7H	04H	14H	45H 58H 0DEH 00H	0C2H 96H 5FH 00H	45H 58H 0F2H 00H
			-------- P --------	-------- Q -------	------- S --------
			0BFH 7FH 0E8H 00H	42H 47H 0E5H 00H	0EFH 0C6H
			------- COS -----	------- FREQ -----	

P= 3470 Q=-75 S=3471
COS=-1.000 FREQ=49.97

ALARM0 MODE READING

0C7H	04H	04H	0BDH	00H	01H	0B1H	0B8H
0C7H	04H	02H	80H	04H	51H	22H	

The answer indicates that the ALARM0 is associated to the PTOTAL, the working mode is maximum level, and the alarm is not triggered.

8. – INSULATION PERFORMANCE.

8.1. – Definitions as per EN61010.

Protection class:	II.	
Overvoltage category:	III.	
Nominal values	Voltage inputs:	500 V (350V to earth).
	Current inputs:	300V.
	Analog outputs:	50V.
	Serial output:	50V.
	Digital outputs:	500V.

8.2. - High voltage tests (kV).

8.2.1.- No voltage transformers option.

	Current inp.	Voltage inp.	Vaux.	Serial out	An. output	Dig.output
Current inp.	-	3.7	3.7	3.7	3.7	3.7
Voltage inp.		-	3.7	2.5	2.5	2.5
Vaux.			-	3.7	3.7	3.7
Serial out				-	2	3.7
An. output					-	2

8.2.2.- Voltage transformers option.

	Current inp.	Voltage inp.	Vaux.	Serial out	An. output	Dig.output
Current inp.	-	3.7	3.7	3.7	3.7	3.7
Voltage inp.		-	3.7	3.7	3.7	3.7
Vaux.			-	3.7	3.7	3.7
Serial out				-	2	3.7
An. output					-	3.7

9. – OPERATIONAL CHARACTERISTICS.

9.1. – STANDARDS APPLICABLE.

The MAR144 have been manufactured as per one or more of the points from the following standards:

IEC 68	Environmental tests.	EN60068
IEC 255-4	Insulation tests.	
IEC 688	Measuring transducers.	EN60688
IEC 801	High frequency disturbances.	
IEC 1000	EMC.	EN61000
IEC 1010	Safety requirements.	EN61010
IEC 1036	Electronic meters.	EN61036
DIN 43864	Interface requirements.	
EN 50081	EMC. Emission.	
EN 50082	EMC. Immunity.	
EN 60529	Protection requirements	
UL 94	Flammability.	

9.2. – REFERENCE CONDITIONS.

Unless otherwise specified, the working, use, operation, and calibration are as per standard EN 60688/IEC 688. The usage group is defined as group III, that is, for ambient operation from –5 and 55ºC. For error definition, the following reference conditions are applicable:

Temperature	23ºC ±1
Aux. Voltage supply	Un ±10%.
Voltage input	60-120% Un.
Current input	0-120% In.
Frequency	50 (60) Hz.
Power factor	1 (0 for reactive power).
Waveform	Sinusoid.
Output characteristic	Nominal.
Output load	½ nominal.

Under these conditions, the maximum errors are specified as follows.

Magnitude	Range	Max. Error
Auxiliary supply	90-110 %	
Input voltage	60-120%	.2%Reading +.2%Range
Input current	4-120%	.2%Reading +.2% Range
Active power	0-150%	.2%Reading +.2% Range
Reactive /apparent power	0-150%	.5%Reading +.5% Range
Power factor	-.5/+.5	.5%Reading +.5% Range
Frequency	45-65	.25% Nominal Frequency
Active energy	10-150%	1% Reading
Reactive energy	10-150%	2% Reading

9.4. – WORKING CONDITIONS.

The following conditions are applicable for the normal operation of the devices.

Temperature	-5 to 55ºC
Aux. Voltage supply	Un ±20%.
Voltage input	0-120% Un.
Current input	0-120% In.
Frequency	50 (60) Hz.
Power factor	-.2- 1- +.2
Waveform	THD less than 10% (active). THD less than 1% (reactive).
Output characteristic	50 to 100% nominal.
Output load	0 to nominal.

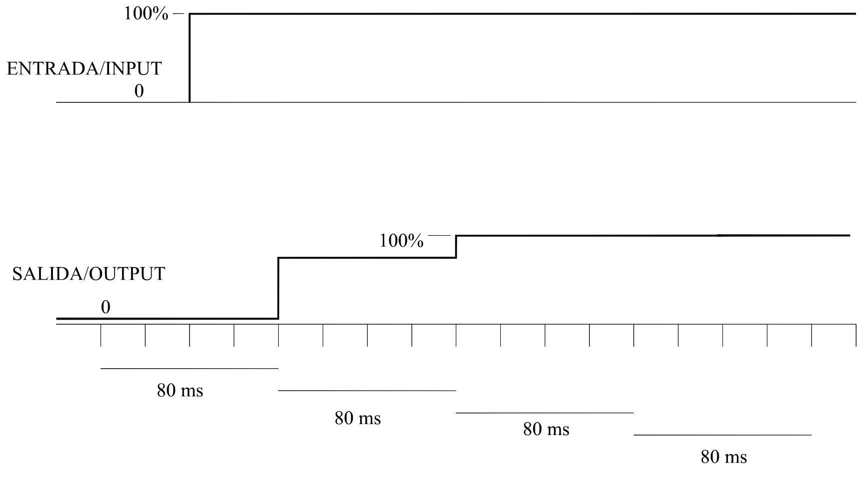
9.5. – OVERLOADS.

Duration	Continuously	10 sec	3 sec	1 sec
Current input	2 In	-	20 In	40 In
Voltage input	1.2 Un	2 Un	-	-

9.6. – RESPONSE TIME.

The response time for an input change from 0 to 100% is <160ms for an output change from 0 to 99%. This fact is due to the averaging process for each signal done through four periods. This is an absolute maximum figure, as is shown in the drawing. From a statistical point of view, the response time would be 120 ms, corresponding to 4 x 20 ms plus half this time, totaling 120 ms.

The display refresh rate is once per second.



ANNEX 1. CRC ALGORITHM TYPE "CRC16".

1. - GENERATOR POLYNOMIAL.

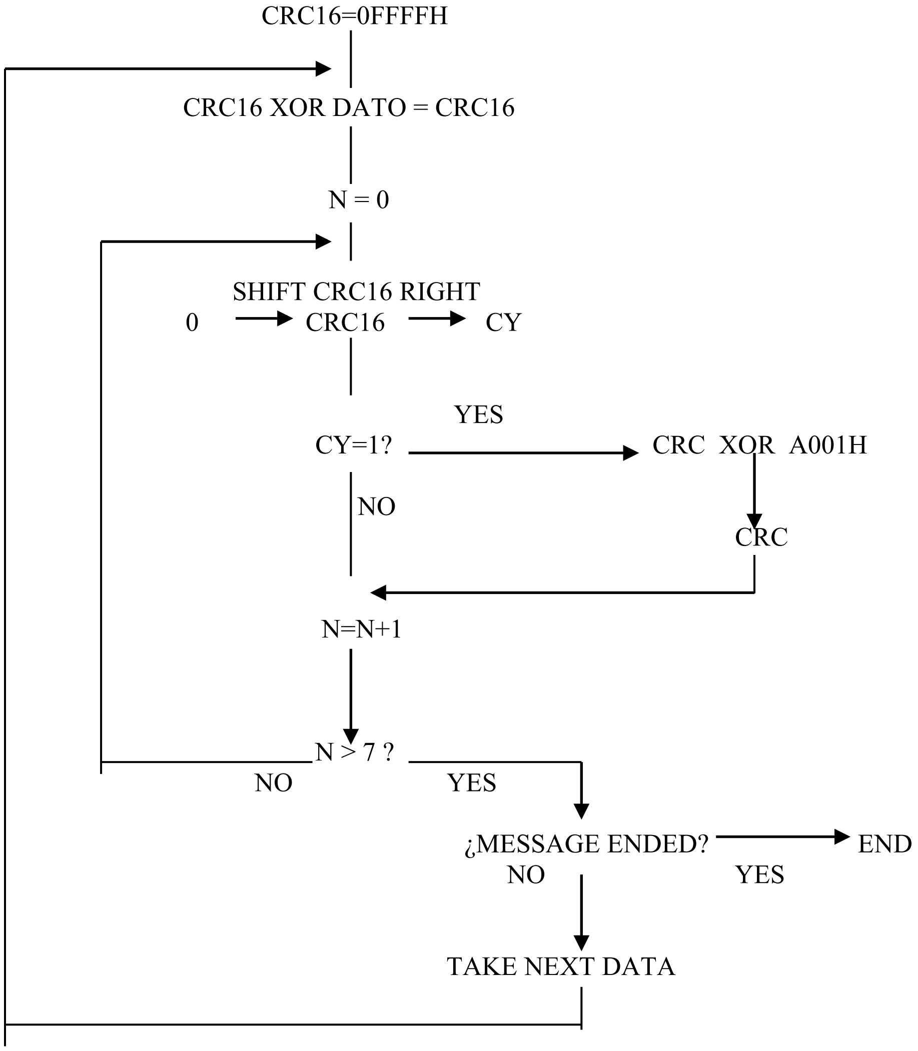
Polynomial used:

$X^{16} + X^{15} + X^{2} + 1 = 18005H$

To get the CRC, this polynomial must be inverted, omitting the least significative bit.

CRC16 POLYNOMIAL: 1 1000 0000 0000 0101 = 18005H
WORKING POLYNOMIAL : 1010 0000 0000 0001 = A001H.

2. - ALGORITMH.



"DATA" is the byte received/or to be transmitted.
"CRC16" is a 16 bits word. The result is left in CRC16. If the received CRC characters are included in the algorithm, the final result will be zero.

ANNEX 2. IEEE NOTATION USED. (IEEE 754).

Notation IEEE754 is followed in floating point numbers. As extremely high precision is not required, the mantissa least significative byte is always zero. This could produce some disagreements between for instance, the value written and read for a high number, as 220,000 V, which can be read as 219,987.

BYTE1	BYTE2	BYTE3	BYTE4
SIGN+ EXPONENT	MANTISSA HIGH	MANTISSA MEDIUM	MANTISSA LOW

SIGN: sign of the number.

0H means a positive number.

1H means a negative number.

MANTISSA: FRACTION 0, XXX XXXX XXXX XXXX XXXX XXXX

(first X: M1 … last X: M23)

EXPONENT: Number exponent, with offset 127.

0: 127. (7FH)

1: 128. (80H)

-1: 126. (7EH)

To find the value:

$$\text{VALUE: } (-1)^{S} * 2^{EXP-127} * (1+\text{FRACTION})$$

$$\text{FRACTION: } \sum_{i=1}^{i=23} 2^{-i} * M(i)$$

THE BYTE CONFIGURATION IS AS FOLLOW:

BYTE1:

7	6	5	4	3	2	1	0
SIGN	-------		EXPONENT		----------		
	E7	E6	E5	E4	E3	E2	E1

BYTE2:

7	6	5	4	3	2	1	0
EXP	---------		MANTISSA HIGH		--------		
E0	M1	M2	M3	M4	M5	M6	M7

BYTE3:

7	6	5	4	3	2	1	0
--------------		MANTISSA MIDDLE		-------			
M8	M9	M10	M11	M12	M13	M14	M15

BYTE4: (Always null).

7	6	5	4	3	2	1	0
--------------		MANTISSA LOW			--------		
M16	M17	M18	M19	M20	M21	M22	M23

ANNEX 3. IEEE FLOATING POINT DATA TRANSMISSION FORMAT.

IEEE data are sent in the following order:

1. SIGN + EXPONENT BYTE
2. HIGH MANTISSA
3. MEDIUM MANTISSA
4. LOW MANTISSA (ALWAYS ZERO)

This mode of transmission is referred in our documents as JBUS mode.

In certain applications, data is required in the following order:

1. MEDIUM MANTISSA
2. LOW MANTISSA (ALWAYS ZERO)
3. SIGN + EXPONENT BYTE
4. HIGH MANTISSA

This mode of transmission is referred in our documents as MODBUS mode.

Both formats are supported in the MAR144 protocol. The standard way is the JBUS mode.

To select the protocol type the one byte variable, named PROT, must be used.

00H select the mode to JBUS.
01H selects the mode to MODBUS

These two different modes apply also to the way in which the Long Integer Data are sent. In the JBUS mode, data are sent as MSB..msb ..LSB...lsb bytes. In MODBUS mode they are swapped , and sent as LSB...lsb...MSB....msb.

ANNEX 4. CRC CALCULATION ROUTINES.

BASIC:

```
function crc16 (txt, lon) AS INTEGER
        DIM flag AS LONG
        DIM crc AS LONG
        DIM car AS INTEGER
        DIM bit AS INTEGER
        CRC= &HFFFF&
        FOR car =1 TO LON
        crc = crc XOR ASC(MID$ ( txt, car, 1))
        FOR bit = 0 TO 7
                flag = crc AND 1&
                crc = crc\ 2&
                IF flag = 1 THEN
                        crc= crc XOR &HA001&
                END IF
        NEXT bit
        NEXT car
        crc16 = INT (crc AND &HFFFF&)
END FUNCTION
```

C:

```
        Void Saci_CalculoCRC ( unsigned char *Mensaje, int NumeroDeElementos)
{
        long flag, crcx;
        int car,bit;
        unsigned char v1,v2;
        crcx= 0xffff;
        for (car=0; car < NumeroDeElementos; car++)
        {
                crcx = crcx ^ Mensaje[car];
                for (bit=0; bit <8; bit++)
                {
                        flag= crcx & 1
                        crcx = crcx >>1 ;
                        if ( flag== 1 ) { crcx = crcx ^ 0xa001; }
                }
        }
        crcx= crcx & 0xffff;
        v1 = ( unsigned char)  abs (crcx / 256 );
        v2 = ( unsigned char ) crcx – (v1*256);
        Mensaje [NumeroDeElementos] = v2;
        Mensaje [NumeroDeElementos+1] = v1;
```

To check the message, calculate the CRC, including the CRC bytes received. If the result is zero, the message has been correctly received.

EU Regulation 2023/1542 concerning batteries and waste batteries requires that, from 18 February 2027, all products placed on the market incorporating portable batteries shall ensure that those batteries are readily removable and replaceable by the end-user at any time during the lifetime of the product. This requirement does not apply to this equipment (MAR144) as it falls within the exceptions set out in Article 11(3) of Regulation (EU) 2023/1542, as clarified in Commission Notice C/2025/214, since it is a product whose main function is to collect and supply data and the purpose of the battery is to maintain the integrity of that data.