GB - User's manual

CHAUVIN ARNOUX ENERGY

ULYS FLEX Modbus

Ed2111

Measure up

WARRANTY, RESPONSIBILITY AND INTELLECTUAL PROPERTY

WARRANTY
Unless expressly stipulated, the warranty runs for twelve months after the date of supply of the monitor (extract from our General Conditions of Sale, available on request).

INTELLECTUAL PROPERTY RIGHTS
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First edition, May 2018.

REGISTERED TRADEMARKS
ULYS FLEX MODBUS is a trademark registered by CA ENERGY.

EQUIPMENT END-OF-LIFE
The products which we sell do not fall within the scope of Decree No. 2005-829 relating to the construction of electrical and electronic equipment and the disposal of waste arising from this equipment.
In accordance with Article L541-2 of the Environmental Code, it is the responsibility of the holder of the waste to dispose of it, or to make sure it is disposed of, appropriately.

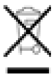
MANUAL
Use & Programming

INDEX • Use&Programming

1. INTRODUCTION

You have just purchased an ULYS FLEX MODBUS. Thank you for your choice. To get the best from your device:

- **Read** this user's manual before installing and using the device.
- **Follow** the precautions for use stated in this document.

Symbol	Meaning
	HAZARD WARNING! The operator must consult this manual whenever this danger symbol is encountered.
	This symbol indicates compliance with European directives, including LVD and EMC.
	This symbol means that in the European Union, the product is subject to separate collection in accordance with WEEE 2002/96/EC: this material should not be treated as household waste.
	Information.

- Make sure the device is intact and undamaged upon receipt. In the event of any problems, please contact the after-sales department for any repairs or replacements.
- The device described in this manual is intended to be used by trained staff only.
- Any maintenance operations must be carried out by qualified and authorized personnel only.
- For correct and safe use and for all maintenance operations, it is essential that staff follow standard safety procedures.
- This device is intended to be used in Category III installation and pollution degree 2 conditions in accordance with standard IEC 61010-1.
- Before installation, check that the supply voltage matches that of the mains supply network.

1.1 SAFETY PRECAUTIONS

Safety precautions
Before any intervention, check that the device is unplugged from all power sources.

Precautions against electrical noise
Although the ULYS FLEX MODBUS is protected from electrical and electromagnetically induced interference, keep away from the immediate vicinity of equipment generating significant electrical noise (high-power switches, busbars, etc.). The quality of data communication on the data bus depends heavily on taking such precautions.

Precautions in the event of deterioration
When safe operation is no longer possible, the instrument must be switched off and isolated. This applies when:

- the device is visibly damaged during operation (whether the device still operates or not),
- the device does not work after prolonged storage in poor conditions,
- the device no longer works following severe damage during transport.

Cleaning instructions
When the device is disconnected from the mains, clean the outer surface using only a dry cloth. Do not use abrasives or solvents. Prevent the connector terminals getting wet.

2. GRAPHIC SYMBOLS

In this manual, some instructions are highlighted with graphic symbols to alert the reader to possible danger. These symbols are:

DANGER! This symbol warns of the presence of dangerous voltage (even for short moments) on the indicated points.

WARNING! This symbol alerts you to the possibility of a serious incident or damage to the unit if proper precautions are not taken.

NOTE. This symbol indicates the presence of important information that should be read carefully.

3. PRELIMINARY VERIFICATION

NOTE. At the opening of the box, check that the instrument has not been damaged during transport. If the instrument appears to be damaged, contact the technical after-sales service.

The box contains:

- the instrument
- the quick guide
- no. 3 Rogowski coils

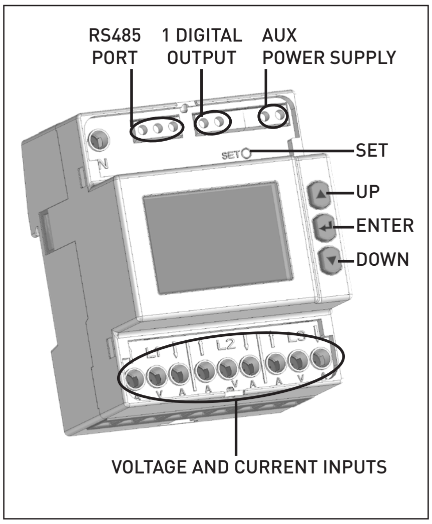
4. GENERAL DESCRIPTION

The instrument is a digital meter able to measure the electrical parameters on three-phase systems. It provides accurate measurements even by distorted waveform.

LCD display provides the three-phase quantities. The working parameters can be easily set up by instrument keypad.

The instrument is a compact, cost effective meter operating both as a stand-alone device or as an integral part of a more extensive energy monitoring and management network.

The instrument replaces multiple analog meters as well as single function meters such as voltmeters, ammeters, wattmeters, varmeters, frequency-meters, powerfactor-meters, energy-meters, etc.



5. INSTALLATION

NOTE. The equipment complies with the 89/366/EEC, 73/23/EEC standards and following amendments. However, if not properly installed, it may generate a magnetic field and radio interference. This is why compliance with EMC standards on electromagnetic compatibility is essential.

5.1 ENVIRONMENTAL REQUIREMENTS

The environment in which the instrument is installed must satisfy the following features:

- indoor area
- operating temperature between -25°C and +55°C
- max humidity 80% (no condensation)
- up to 2000 m over sea-level altitude

NOTE. The instrument must not be exposed to sun rays.

5.2 MOUNTING

Fastening to DIN rail (EN 60715) is provided for the instrument.

To mount it on the DIN rail, use a screwdriver as a lever on the plastic hook at the instrument bottom. This operation will allow the instrument to fit on the rail.

6. SAFETY MEASURES

DANGER! This warning means that a dangerous voltage may be present on the terminals even for short periods.

WARNING! Electrical instrument connections must be carried out only by skilled technicians who are aware of the risks involved to the presence of voltage.

Before connecting, check the following:

1. The conductor wires are not powered.
2. The instrument is connected according to the appropriate diagram.
3. The power supply corresponds to the values on the instrument specification.
4. The instrument has been installed in a vibration-free and a suitable temperature environment.
5. The terminals are no longer accessible after being connected.
6. The wiring is carried out in accordance with the standards in force in the Country where the instrument will be installed.
7. A circuit breaker and an over-current device (eg. 250 mA T type fuse) are installed between the instrument power supply and the electrical system.
8. The connections are made respecting the polarities.
   - L1 of the voltage input = L1 of the amperometric input.
   - L2 of the voltage input = L2 of the amperometric input.
   - L3 of the voltage input = L3 of the amperometric input.
9. Input and output polarities are respected when using Rogowski coils.
10. The terminals are fixed in such a way that the connection wires cannot be accidentally disconnected.

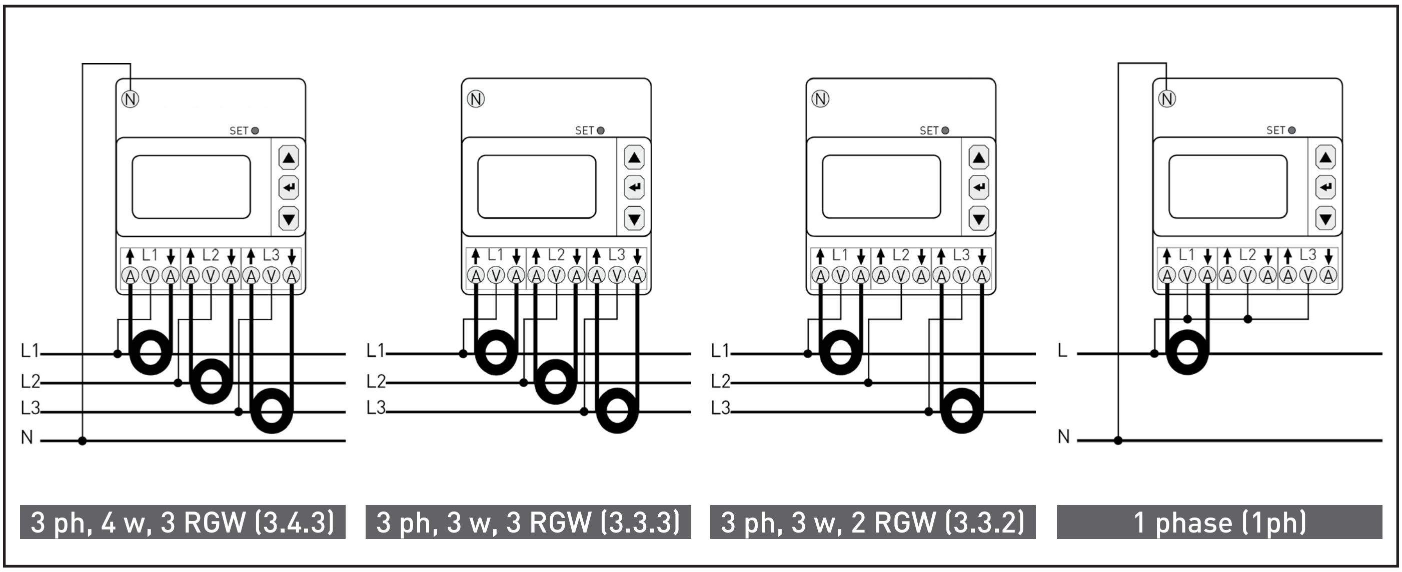
7. ELECTRICAL CONNECTIONS

WARNING! The instrument installation and use must be carried out only by qualified staff. Switch off the voltage before device installation.

7.1 CURRENT AND VOLTAGE INPUTS

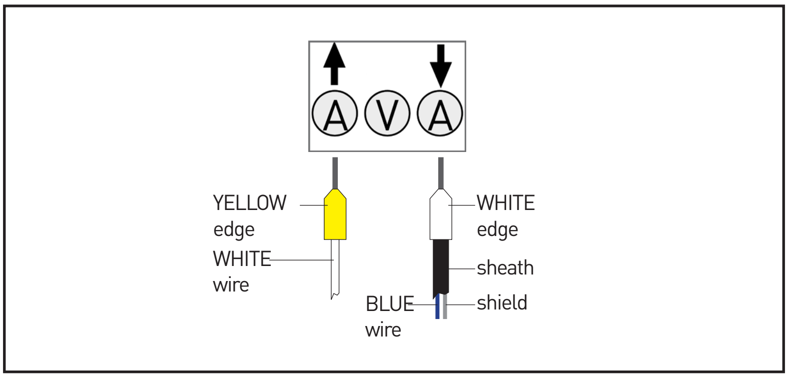
DANGER! This section describes the measurement voltage and current inputs susceptible to dangerous voltage levels.

WARNING! Before carrying out connections, check if there is no voltage/current in the conductor wires. DO NOT CONNECT conductors under voltage/current.



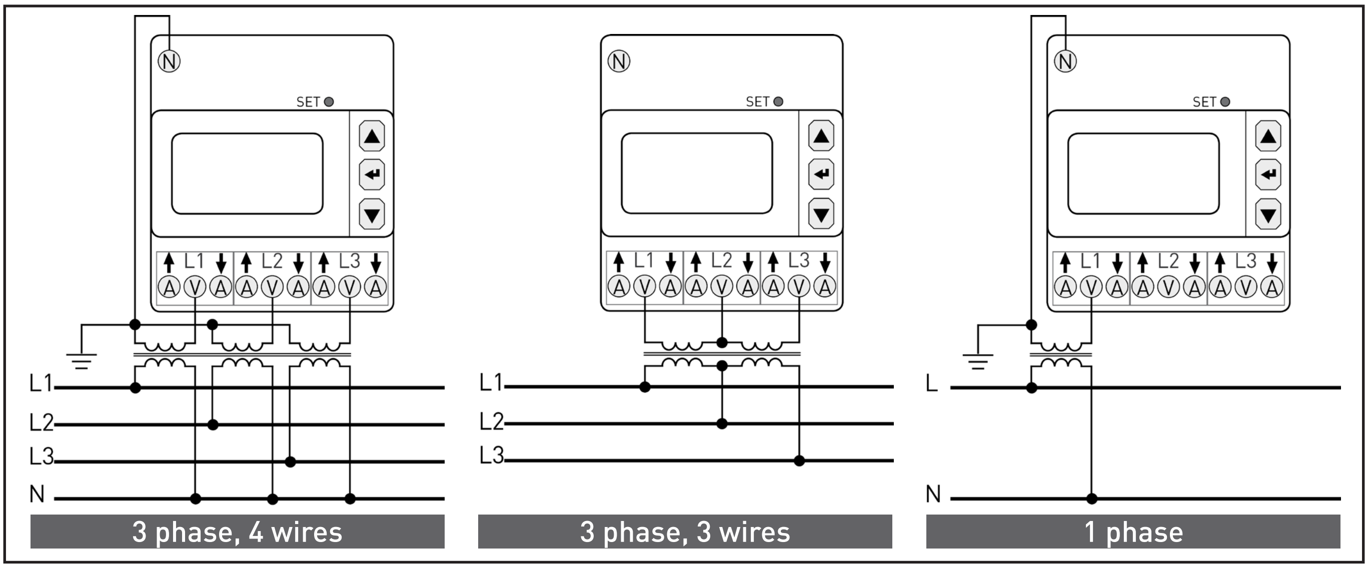
Instrument with Rogowski coils

For Rogowski coil insertion, connect the yellow coil edge to the terminal ↑ (signal), and the white coil edge to the terminal ↓ (common).



Detail of Rogowski coil connection

Wiring diagrams using voltage transformers:



Instrument with voltage transformer

For wiring mode selection, refer to section 8.14.1.

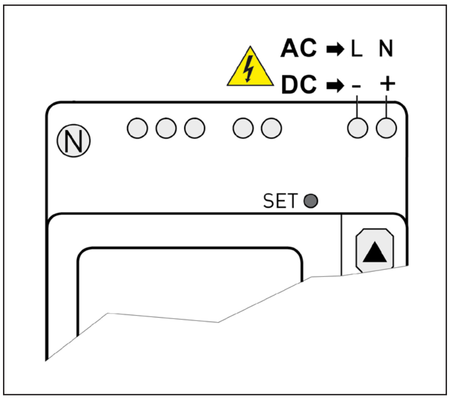
7.2 POWER SUPPLY

DANGER! This section describes the AUX supply input susceptible to dangerous voltage levels.

WARNING! Before carrying out connections, check if there is no voltage/current in the conductor wires. DO NOT CONNECT conductors under voltage/current.

WARNING! Install a circuit breaker and an over-current device (eg. 250 mA T type fuse) between the instrument power supply and the electrical system.

WARNING! Before connecting the instrument to the network, check the network voltage corresponds to the value on the instrument specification.

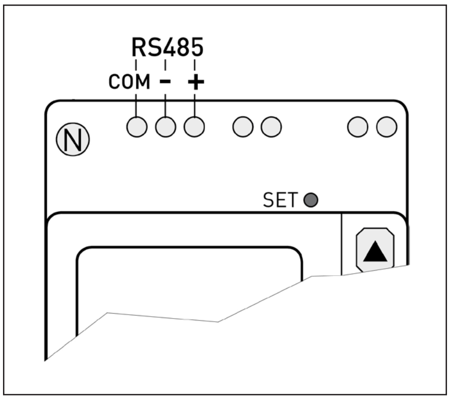


AUX power input

The instrument is auxiliary powered (AUX) in range 85...265 VAC / 110 VDC ±15%.

7.3 RS485 COMMUNICATION PORT

WARNING! Before carrying out connections, check if there is no voltage/current in the conductor wires. DO NOT CONNECT conductors under voltage/current.



RS485 port

The RS485 serial communication port allows to manage the instrument in local or remote mode by PC.

For a local connection, a converter is needed to adapt the PC USB port to the RS485 network.

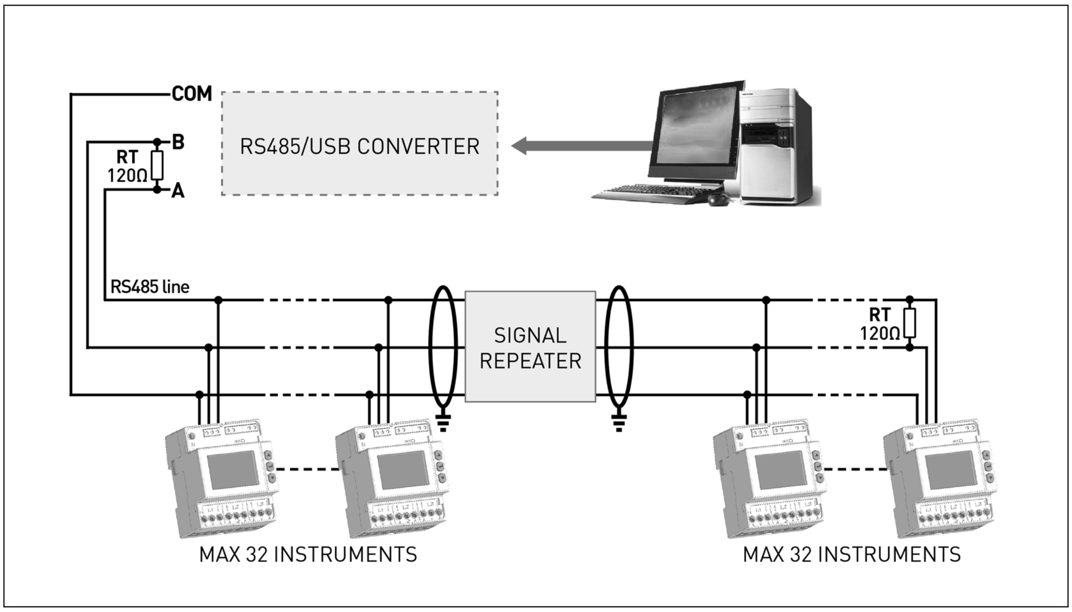
The RS485 standard interface allows a multi-point connection. If there are more than 32 instruments to be connected, insert a signal repeater. Each repeater can manage up to 32 instruments.

The connection provides a third conductor to the terminal (COM) to ensure the same reference level to all network devices.

When there are strong electromagnetic disturbances, which may affect communication, a shielded cable (with two twisted signal conductors) should be used. The terminal resistances (RT=120...150Ω) must be installed on the converter side and on the last instrument connected along the line. Thanks to these resistances, the reflected signal along the line is reduced. However, in case of short distances (max 100 m) or low communication speed (<9600 bps) there is no need of resistances.

NOTE. The value of each resistance must not be lower than 120 Ω in order to avoid an overload of line drivers.

The maximum recommended distance for a connection is 1 km at 9600 bps. For longer distances, lower communication speed (bps), low-attenuation cables or signal repeaters are needed.

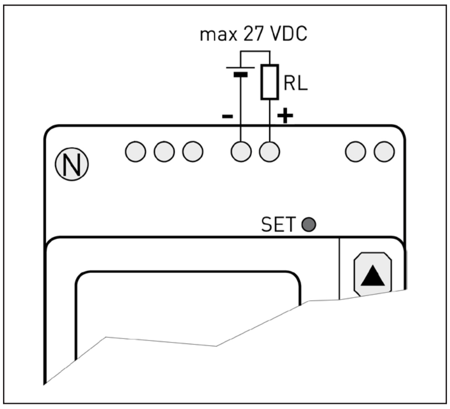


Connection to the RS485 network

7.5 DIGITAL OUTPUT

WARNING! Before carrying out connections, check if there is no voltage/current in the conductor wires. DO NOT CONNECT conductors under voltage/current.

The instrument is provided with a passive optoisolated digital output for pulse emission or alarm. For digital output setup, refer to section 8.13.1.



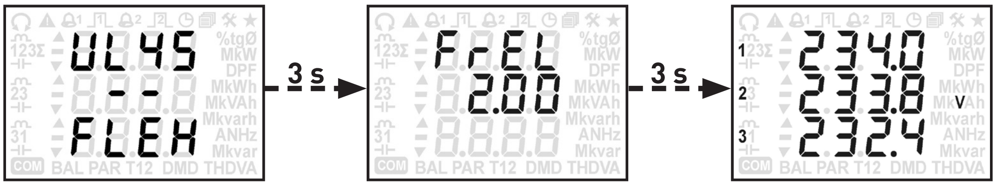
Digital output

MANUAL
Use&Programming

8. USE AND CONFIGURATION

At first instrument power on, the following pages will be displayed.

Instrument name | Firmware release | Real time values



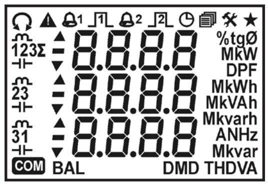
The page sequence is the same for the further power on times, except for Real time value page. After Firmware release page, it will be displayed:

- Home page (if set, refer to section 8.3).
- Last page displayed before switching off (if no Home page is set).

NOTE. At instrument power on, the display is backlighted. After 30 s of instrument keyboard inactivity, the backlight goes off automatically. Press any key to turn on the backlight again.

8.1 SYMBOLS ON DISPLAY

The display test can be performed, on any page except for Setup pages, by pressing simultaneously ▲ , ▼ and ↵ buttons for at least 10 s.

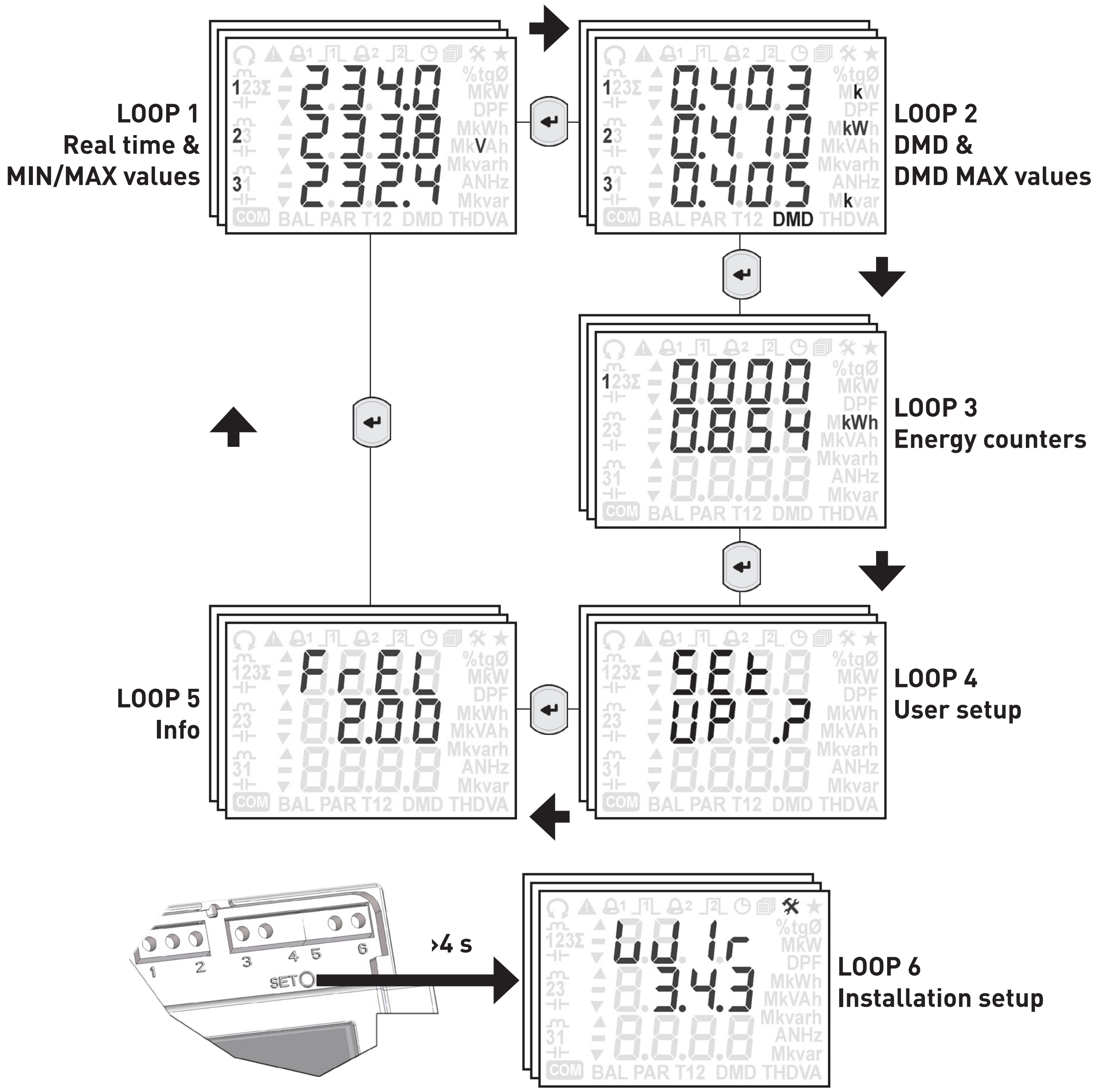


SYMBOL	MEANING	WHERE
	Phase sequence status	
	Correct phase sequence (123/CCW).	Measurement pages
	Wrong phase sequence (132/CW).	Measurement pages
▲ BLINKING	Undefined phase sequence (e.g. 2 phases are shortcircuited, 1 or more phases are missing).	Measurement pages
NOT DISPLAYED	Single phase insertion.	Measurement pages
1	**Info/status on digital output in Alarm mode**	
1	Setup page for digital output in Alarm mode.	User setup, page for digital output in alarm mode
	Active alarm for digital output.	Measurement pages
	Info/status on digital output in Pulse mode	
	Setup page for digital output in Pulse mode.	User setup, page for digital output in pulse mode
	Pulse emission on digital output.	Measurement pages
FAST BLINKING	Pulse overlapping on digital output.	Measurement pages
▲	**General warning**	
▲	Overtaken measurement fullscale.	Measurement pages
▲ BLINKING	Too high FSA*PT product.	Installation setup, during FSA, PT setup
▲ BLINKING	Full memory, data recording is stopped (FILL recording mode).	Any page except Setup
▲ BLINKING	Undefined phase sequence (e.g. 2 phases are shortcircuited, 1 or more phases are missing).	Measurement pages

SYMBOL	MEANING	WHERE
	Clock status	
	Setup page for date and time.	User setup, page for date&time
	Info page for date and time.	Info, page for date&time
BLINKING	Undefined date and time (no clock setup after power on).	Any page except Setup
	Memory/data recording status	
	Setup page for data recording.	User setup, page for data recording
	Active data recording.	Any page except Setup
BLINKING	Memory in overlapping (RING recording mode).	Any page except Setup
⚠ BLINKING	Full memory, data recording is stopped (FILL recording mode).	Any page except Setup
	Setup pages	Any page of Setup
★	**Home page**	
★	The displayed page is set as Home page.	Home page
COM	**Communication status**	
COM	Page for communication parameters.	Installation setup, Baud, Par, Addr pages
	Active communication.	Any page except Setup
	Inductive and capacitive values	
	Inductive value.	Energy counters, power factors, reactive powers, DPF
	Capacitive value.	Energy counters, power factors, reactive powers, DPF
▲ ▼	Maximum & minimum values	
▲	Maximum value.	Real time value pages
	Maximum demand (DMD) value.	DMD value pages
▼	Minimum value.	Real time value pages

8.2 PAGE STRUCTURE

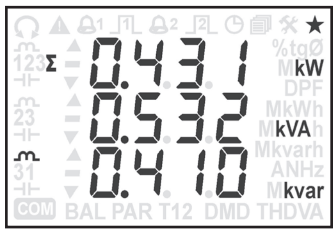
Up to 6 page loops are available on the the instrument display. Each loop corresponds to a specific type of data displayed on more pages. Inside each loop it is possible to scroll the available pages. With ↵ change the loop 1...6. The loop 6 can be accessed by pressing SET button for at least 4 s. Use ▲ or ▼ to scroll pages inside each loop. Special note for Loop 4: the loop 4 can be accessed by pressing ↵ for at least 3 s on the **Setup?** page.



8.3 HOME PAGE

The Home page is a preset page displayed after 2 minutes of instrument keyboard inactivity. Only measurement pages can be set as Home page.

To set the displayed page as Home, press ↵ button for at least 5 s, the symbol ★ will be shown to indicate that Home page was set. To disable it, on the Home page press ↵ button for at least 5 s, the symbol ★ will disappear.



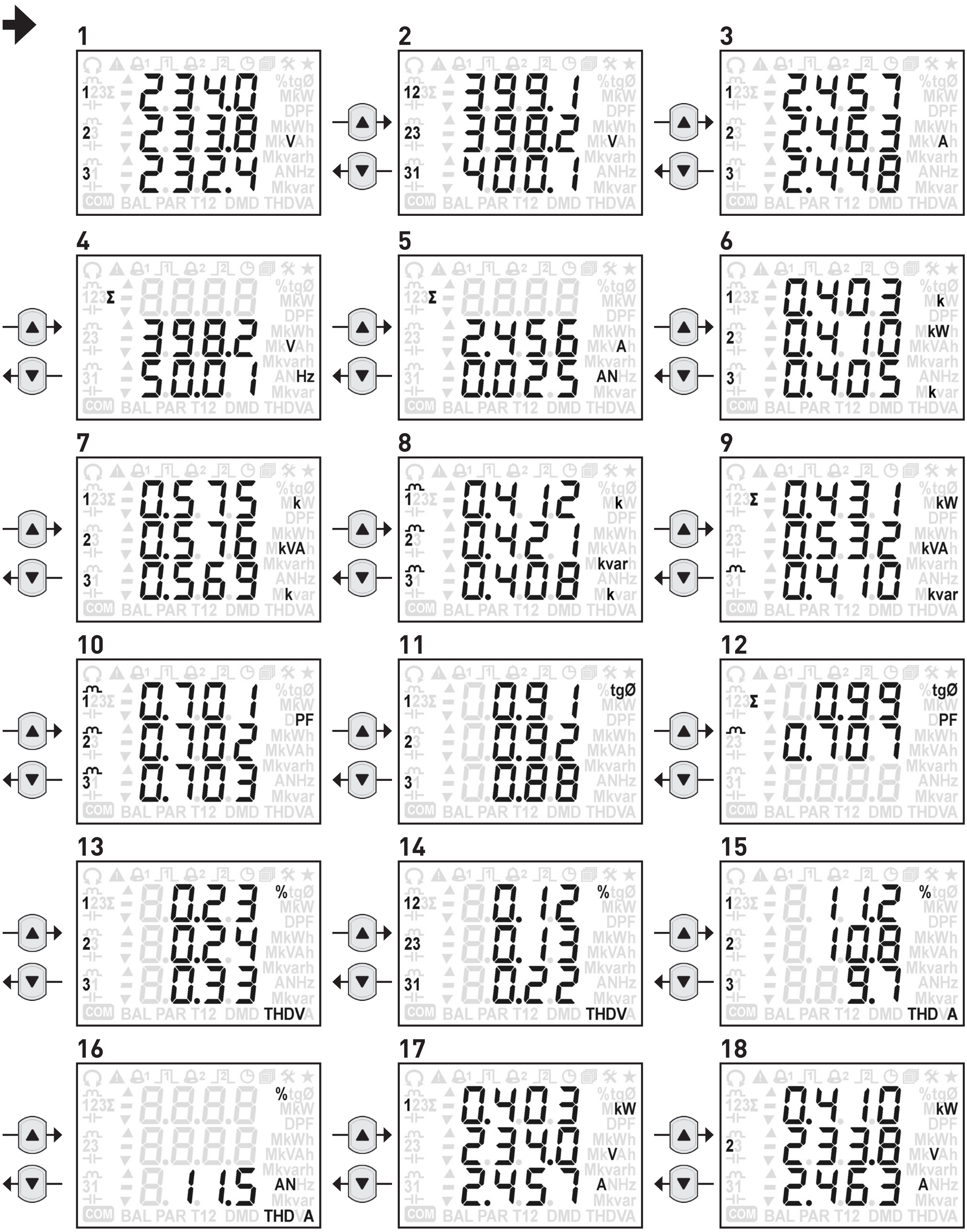
8.4 LOOP 1 - REAL TIME VALUES

In this loop, the real time and the corresponding min/max values are displayed according to the set wiring mode.

Scroll the loop pages with ▲ or ▼ button.

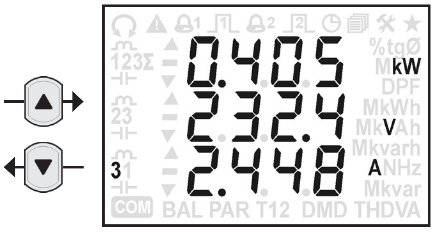
The following pages refer to the instrument with 3 phase, 4 wire, 3 current insertion.

NOTE. The pages with the THD parameters can display "_ _ _ _" instead of values, when the voltage or current RMS values are lower than the threshold values defined for FFT calculation (refer to chapter 9).

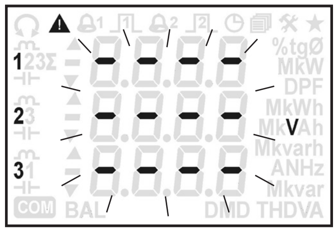


MANUAL Use&Programming

19



8.5 MEASUREMENT OVERFLOW

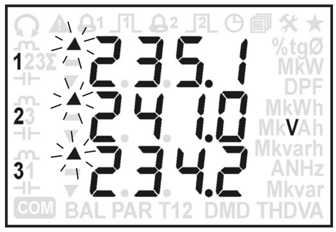


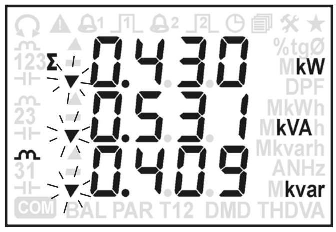
According to EN 61010-2-030, in case of too high value supplied to the device, the display must inform the user precisely that it is a dangerous overflow (OVF) situation. When an overflow condition occurs, for the relative parameter “**----**” and ⚠ symbol are blinking on display. Max limit values for voltages and currents over which OVF indication occurs:

	Max limit values		
V (Line-Neutral)	300 VRMS		
A (Line)	700 A	→	with 500 A scale
	5600 A	→	with 4000 A scale
	28000 A	→	with 20000 A scale

The overflow condition can be detected also in MODBUS protocol, by reading the $201C register. This register gives the possibility to know if the overflow occurs, with no indication on the parameters involved in this condition.

8.6 REAL TIME MIN/MAX VALUES





To show the maximum values of the displayed real time parameters (only voltage and current values), press ▲ and ↵ buttons simultaneously for at least 2 s. The “▲” symbol will start to blink and the maximum values will be displayed for about 6 s.

<u>Minimum values are available only for system powers</u>. To show the minimum values of the displayed system powers, press ▼ and ↵ buttons simultaneously for at least 2 s. The “▼” symbol will start to blink and the minimum values will be displayed for about 6 s.

8.7 REAL TIME PARAMETER TABLE

The following table shows the parameters available according to the instrument model and the set wiring mode. The column "DISPLAY PAGE" shows the number of the corresponding device page shown in section 8.4.

PARAMETER	DISPLAY PAGE	MAX (▲) VALUE	MIN (▼) VALUE	WIRING MODES (●=available)			
				3ph, 4w, 3c	3ph, 3w, 3c	3ph, 3w, 2c	1phase
V1 • Phase 1-N voltage	1	▲		●			●
V2 • Phase 2-N voltage	1	▲		●			
V3 • Phase 3-N voltage	1	▲		●			
V12 • Line 12 voltage	2	▲		●	●	●	
V23 • Line 23 voltage	2	▲		●	●	●	
V31 • Line 31 voltage	2	▲		●	●	●	
V∑ • System voltage	4	▲		●	●	●	
A1 • Phase 1 current	3	▲		●	●	●	●
A2 • Phase 2 current	3	▲		●	●	●	
A3 • Phase 3 current	3	▲		●	●	●	
AN • Neutral current *	5	▲		●			
A∑ • System current	5	▲		●	●	●	
P1 • Phase 1 active power	6	▲ (+/-)		●			●
P2 • Phase 2 active power	6	▲ (+/-)		●			
P3 • Phase 3 active power	6	▲ (+/-)		●			
P∑ • System active power	9	▲ (+/-)	▼	●	●	●	
S1 • Phase 1 apparent power	7	▲ (+/-)		●			●
S2 • Phase 2 apparent power	7	▲ (+/-)		●			
S3 • Phase 3 apparent power	7	▲ (+/-)		●			
S∑ • System apparent power	9	▲ (+/-)	▼	●	●	●	
Q1 • Phase 1 reactive power	8	▲ (+/-)		●			●
Q2 • Phase 2 reactive power	8	▲ (+/-)		●			
Q3 • Phase 3 reactive power	8	▲ (+/-)		●			
Q∑ • System reactive power	9	▲ (+/-)	▼	●	●	●	
PF1 • Phase 1 power factor	10	▲ (+/-)		●			●
PF2 • Phase 2 power factor	10	▲ (+/-)		●			
PF3 • Phase 3 power factor	10	▲ (+/-)		●			
PF∑ • System power factor	12	▲ (+/-)		●	●	●	
TANØ1 • Phase 1 tangent Ø	11	▲ (+/-)		●			●
TANØ2 • Phase 2 tangent Ø	11	▲ (+/-)		●			
TANØ3 • Phase 3 tangent Ø	11	▲ (+/-)		●			
TANØ∑ • System tangent Ø	12	▲ (+/-)		●	●	●	
THDV1 • Phase 1-N voltage THD	14	▲		●			●
THDV2 • Phase 2-N voltage THD	14	▲		●			
THDV3 • Phase 3-N voltage THD	14	▲		●			
THDV12 • Line 12 voltage THD	15	▲		●	●	●	
THDV23 • Line 23 voltage THD	15	▲		●	●	●	
THDV31 • Line 31 voltage THD	15	▲		●	●	●	
THDA1 • Phase 1 current THD	16	▲		●	●	●	●
THDA2 • Phase 2 current THD	16	▲		●	●		
THDA3 • Phase 3 current THD	16	▲		●	●	●	
THDAN • Neutral current THD*	17	▲		●			
F • Frequency	4			●	●	●	●

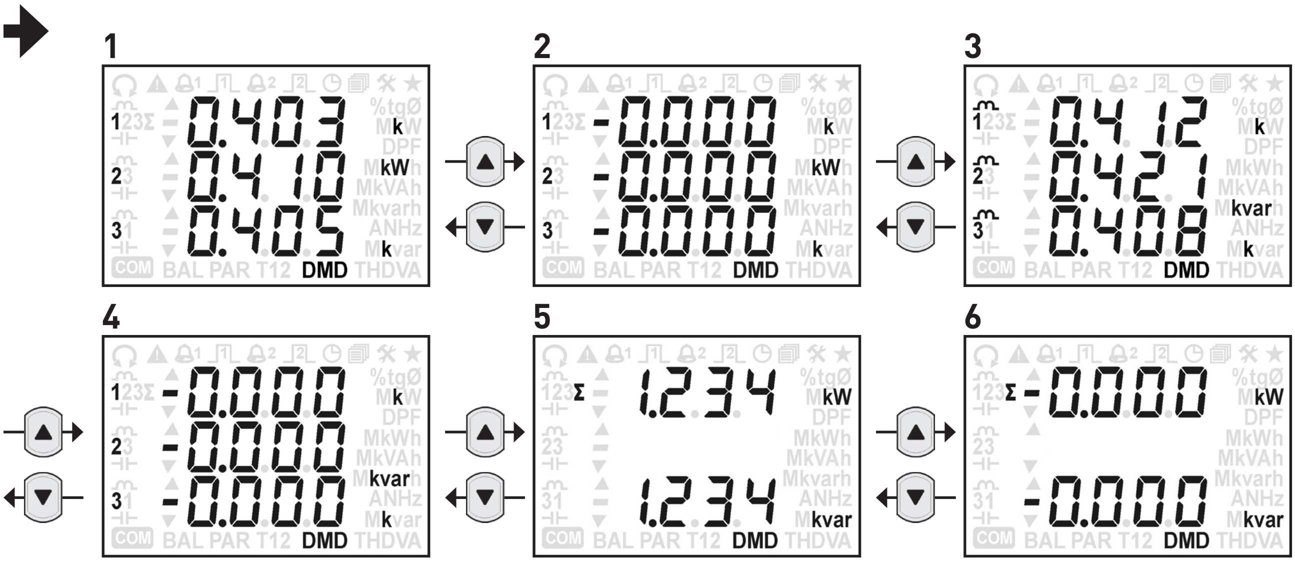
* The neutral current and the derivative parameters (AN, THDAN) are not available if the set FSA value is different for each phase.

8.8 LOOP 2 - DMD VALUES

In this loop, the demand values (DMD) and the corresponding max values are displayed according to the instrument model and the set wiring mode. The demand values are calculated according to the set DMD calculation mode and integration time (refer to section 8.13.2).

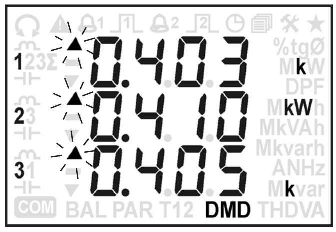
Scroll the loop pages with ▲ or ▼ button.

The following pages refer to the instrument with 3 phase, 4 wire, 3 current insertion.



8.9 DMD MAX VALUE

To show the maximum values of the displayed DMD parameters (except for power balance values), press ▲ and ↵ buttons simultaneously for at least 2 s. The "▲" symbol will start to blink and the maximum values will be displayed for about 6 s.



8.10 DMD PARAMETER TABLE

The following table shows the parameters available according to the instrument model and the set wiring mode. The column "DISPLAY PAGE" shows the number of the corresponding device page shown in section 8.8.

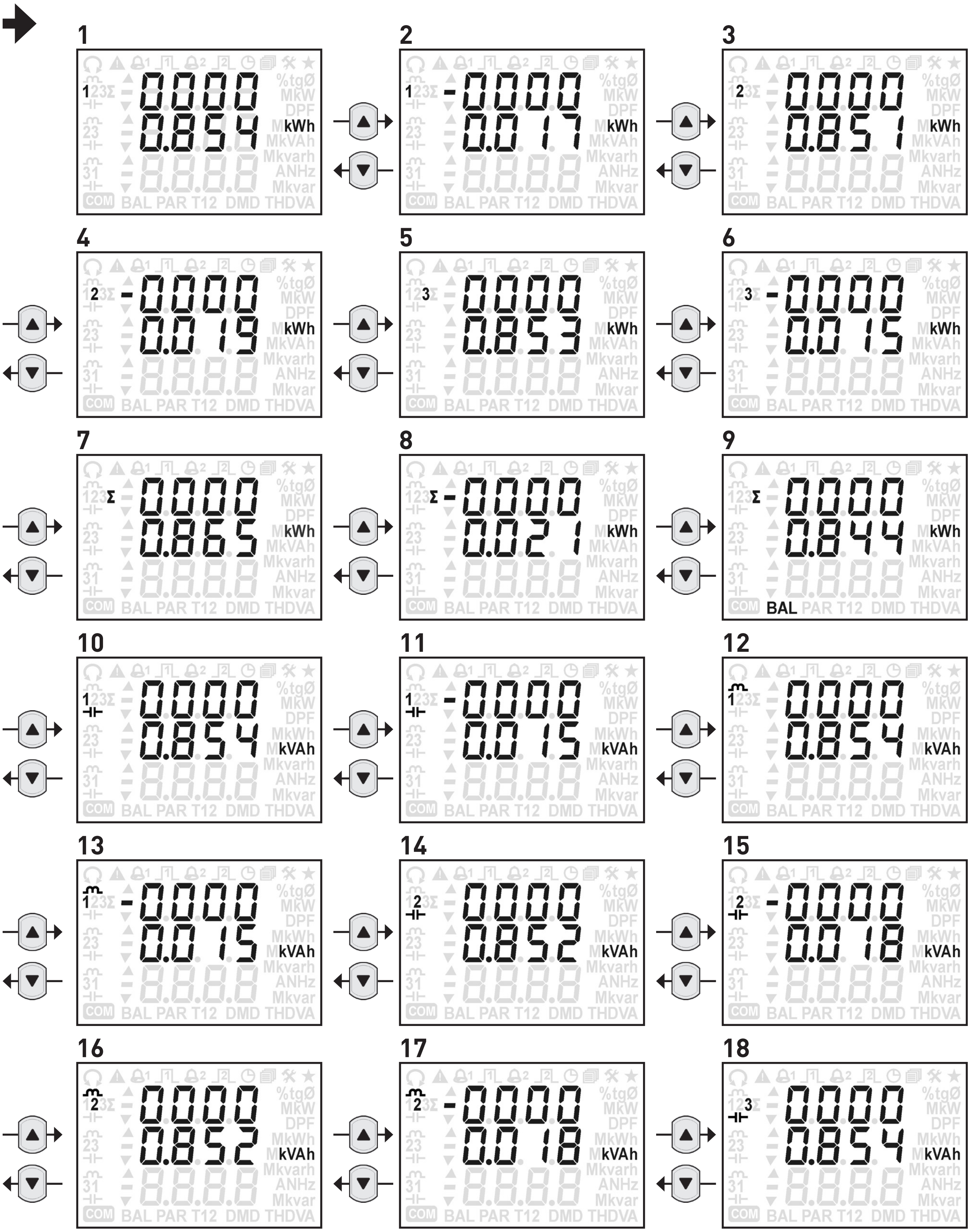
In 1 phase insertion, BALANCE values are resulting from the difference between the phase 1 imported power DMD and the phase 1 exported power DMD ($L1_{imp}$ - $L1_{exp}$).

PARAMETER	DISPLAY PAGE	MAX (▲) VALUE	WIRING MODES (●=available)			
			3ph, 4w, 3c	3ph, 3w, 3c	3ph, 3w, 2c	1phase
$+P1_{DMD}$ • Phase 1 imported active power DMD	3	▲	●			●
$-P1_{DMD}$ • Phase 1 exported active power DMD	4	▲	●			●
$+P2_{DMD}$ • Phase 2 imported active power DMD	3	▲	●			
$-P2_{DMD}$ • Phase 2 exported active power DMD	4	▲	●			
$+P3_{DMD}$ • Phase 3 imported active power DMD	3	▲	●			
$-P3_{DMD}$ • Phase 3 exported active power DMD	4	▲	●			
$+P\Sigma_{DMD}$ • System imported active power DMD	9	▲	●	●	●	
$-P\Sigma_{DMD}$ • System exported active power DMD	10	▲	●	●	●	
$+Q1_{DMD}$ • Phase 1 imported reactive power DMD	7	▲	●			●
$-Q1_{DMD}$ • Phase 1 exported reactive power DMD	8	▲	●			●
$+Q2_{DMD}$ • Phase 2 imported reactive power DMD	7	▲	●			
$-Q2_{DMD}$ • Phase 2 exported reactive power DMD	8	▲	●			
$+Q3_{DMD}$ • Phase 3 imported reactive power DMD	7	▲	●			
$-Q3_{DMD}$ • Phase 3 exported reactive power DMD	8	▲	●			
$+Q\Sigma_{DMD}$ • System imported reactive power DMD	9	▲	●	●	●	
$-Q\Sigma_{DMD}$ • System exported reactive power DMD	10	▲	●	●	●	

8.11 LOOP 4 - ENERGY COUNTERS

In this loop, the energy counters are displayed according to the set wiring mode. Scroll the loop pages with ▲ or ▼ button.

The following pages refer to the instrument with 3 phase, 4 wire, 3 current insertion.



19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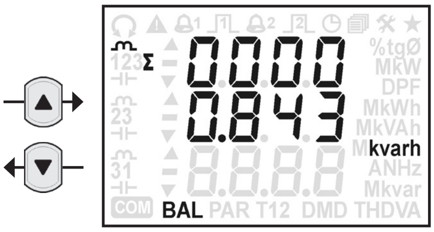


47

8.12 ENERGY COUNTER TABLE

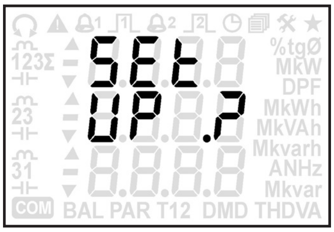
The following table shows the parameters available according to the instrument model and the set wiring mode. The column "DISPLAY PAGE" shows the number of the corresponding device page shown in section 8.11.

In 1 phase insertion, BALANCE values are resulting from the difference between the phase 1 imported energy and the phase 1 exported energy ($L1_{imp}$ - $L1_{exp}$).

PARAMETER	DISPLAY PAGE	WIRING MODES (●=available)			
		3ph, 4w, 3c	3ph, 3w, 3c	3ph, 3w, 2c	1phase
+kWh1 • Phase 1 imported active energy	1	●			●
-kWh1 • Phase 1 exported active energy	2	●			●
+kWh2 • Phase 2 imported active energy	3	●			
-kWh2 • Phase 2 exported active energy	4	●			
+kWh3 • Phase 3 imported active energy	5	●			
-kWh3 • Phase 3 exported active energy	6	●			
+kWh∑ • System imported active energy	7	●	●	●	
-kWh∑ • System exported active energy	8	●	●	●	
kWh∑BAL • Balance of system active energy (imp-exp)	9	●	●	●	●
+kVAh1-C • Phase 1 imported capacitive apparent energy	10	●			●
-kVAh1-C • Phase 1 exported capacitive apparent energy	11	●			●
+kVAh1-L • Phase 1 imported inductive apparent energy	12	●			●
-kVAh1-L • Phase 1 exported inductive apparent energy	13	●			●
+kVAh2-C • Phase 2 imported capacitive apparent energy	14	●			
-kVAh2-C • Phase 2 exported capacitive apparent energy	15	●			
+kVAh2-L • Phase 2 imported inductive apparent energy	16	●			
-kVAh2-L • Phase 2 exported inductive apparent energy	17	●			
+kVAh3-C • Phase 3 imported capacitive apparent energy	18	●			
-kVAh3-C • Phase 3 exported capacitive apparent energy	19	●			
+kVAh3-L • Phase 3 imported inductive apparent energy	20	●			
-kVAh3-L • Phase 3 exported inductive apparent energy	21	●			

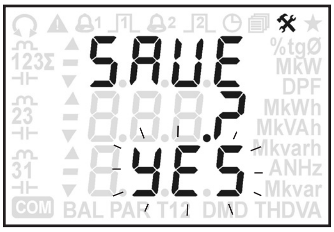
PARAMETER	DISPLAY PAGE	WIRING MODES (●=available)			
		3ph, 4w, 3c	3ph, 3w, 3c	3ph, 3w, 2c	1phase
+kVAh∑-C • System imported capacitive apparent energy	22	●	●	●	
-kVAh∑-C • System exported capacitive apparent energy	23	●	●	●	
+kVAh∑-L • System imported inductive apparent energy	24	●	●	●	
-kVAh∑-L • System exported inductive apparent energy	25	●	●	●	
kVAh∑BAL-C • Balance of system capacitive apparent en. (imp-exp)	26	●	●	●	●
kVAh∑BAL-L • Balance of system inductive apparent en. (imp-exp)	27	●	●	●	●
kVAh∑BAL • Balance of system apparent energy (BAL-C + BAL-L)	28	●	●	●	●
+kvarh1-C • Phase 1 imported capacitive reactive energy	29	●			●
-kvarh1-C • Phase 1 exported capacitive reactive energy	30	●			●
+kvarh1-L • Phase 1 imported inductive reactive energy	31	●			●
-kvarh1-L • Phase 1 exported inductive reactive energy	32	●			●
+kvarh2-C • Phase 2 imported capacitive reactive energy	33	●			
-kvarh2-C • Phase 2 exported capacitive reactive energy	34	●			
+kvarh2-L • Phase 2 imported inductive reactive energy	35	●			
-kvarh2-L • Phase 2 exported inductive reactive energy	36	●			
+kvarh3-C • Phase 3 imported capacitive reactive energy	37	●			
-kvarh3-C • Phase 3 exported capacitive reactive energy	38	●			
+kvarh3-L • Phase 3 imported inductive reactive energy	39	●			
-kvarh3-L • Phase 3 exported inductive reactive energy	40	●			
+kvarh∑-C • System imported capacitive reactive energy	41	●	●	●	
-kvarh∑-C • System exported capacitive reactive energy	42	●	●	●	
+kvarh∑-L • System imported inductive reactive energy	43	●	●	●	
-kvarh∑-L • System exported inductive reactive energy	44	●	●	●	
kvarh∑BAL-C • Balance of system capacitive reactive en. (imp-exp)	45	●	●	●	●
kvarh∑BAL-L • Balance of system inductive reactive en. (imp-exp)	46	●	●	●	●
kvarh∑BAL • Balance of system reactive energy (BAL-C + BAL-L)	47	●	●	●	●

8.13 LOOP 5 - USER SETUP



In this loop, pages for general instrument setup are displayed according to the instrument model.

To access User setup loop, on **Setup?** page press ↵ button for at least 3 s. The first User setup page will be displayed. Scroll the loop pages with ▲ or ▼ button.

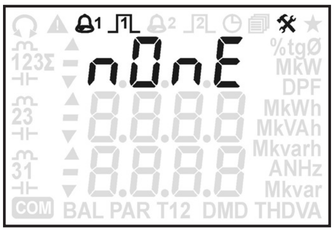


To exit from User setup loop, press ↵ for at least 3 s. A new page will be displayed to save the settings. With ▲ or ▼ button select the blinking item:

- **YES**=exit and save the settings
- **NO**=exit without saving the settings
- **CONT**=continue to scroll User setup pages

Confirm with ↵button. Selecting **YES** or **NO**, the first Info page (instrument firmware release) will be displayed. Selecting **CONT**, the last User setup page will be displayed.

8.13.1 Digital output settings (DO)



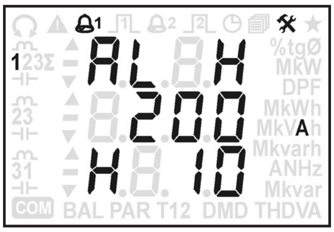
At first User setup access, the digital output is disabled (NONE) and no parameter is associated. To enable the digital output, press ↵ button, the NONE item will start to blink. With ▲ or ▼ button select the mode (**AL H**, **AL L**, **PULS**). Confirm with ↵ button.

<u>In case of ALARM MODE selection</u>

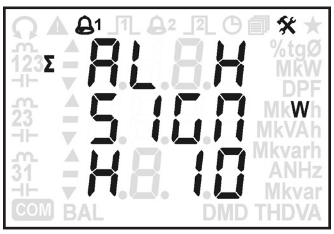
In alarm mode, the digital output functionality can change according to the associated parameter. For further details, refer to the following table:

MODE	PARAMETER TO BE ASSOCIATED	FUNCTION DESCRIPTION
AL H	Real time values, DMD values	The output is activated (closed) when the associated parameter value is higher than the set threshold, considering also the set hysteresis.
	Active power sign	The output is activated (closed) when the active power* sign becomes negative, considering also the set delay.
AL L	Real time values, DMD values	The output is activated (closed) when the associated parameter value is lower than the set threshold, considering also the set hysteresis.
	Active power sign	The output is activated (closed) when the active power* sign becomes positive, considering also the set delay.

* Note. The active power parameter considered for sign changing depends on the set wiring:
3phase wiring=System active power, 1phase wiring=Phase 1 active power

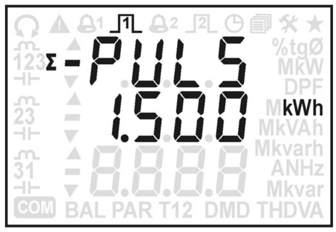


1. The symbols which identify the parameter type (e.g. A1=phase 1 current) will start to blink. With ▲ or ▼ button select the parameter to be associated to the digital output and confirm with ↵ button. Selectable parameters: Real time values (refer to section 8.7), active power sign (SIGN) or DMD values (refer to section 8.10). The **Active power sign** parameter can be identified by **SIGN** displayed on the second row.
2. **In case of real time or DMD parameter selection**, the second row will display threshold value. After parameter selection, the threshold first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digits. The value range changes according to the selected parameter. **In case of Active power sign parameter selection**, the second row will display the SIGN static text instead of the threshold value.



3. **In case of real time or DMD parameter selection**, the third row will display hysteresis value. After threshold selection, the hysteresis first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digit. Value range: 0...50%. **In case of Active power sign parameter selection**, the third row will display the delay value. After parameter selection, the delay first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digit. Value range: 1...60s. By programming this value, the output is activated (closed) if the sign remains changed after the set delay. E.g. Digital output set as AL H SIGN with 10s delay: the output is activated (closed) if the sign changes from + to - and this condition lasts more than 10s. Then, if the sign returns to +, the output is disactivated (opened) immediately, delay has no effect in the returning to normal condition.

<u>In case of PULSE MODE selection</u>



1. The symbols which identify the parameter type (e.g. -Wh∑=system exported active energy) will start to blink. With ▲ or ▼ button select the parameter to be associated to the digital output and confirm with ↵ button. Selectable parameters: Energy counters except balance values (refer to section 8.14).
2. The pulse value first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digits. The value range changes according to the selected parameter.

<u>CONSIDERATIONS ON THE PULSE VALUE SETUP</u>

Digital output can generate energy pulses with a maximum frequency of 8 pulse/s. The number of "pulses / kWh, kVAh, kvarh" must be set according to this condition to prevent overlapping. If higher number is set, overlap may occur.

Suppose maximum instant power:	Pmax = 5000 kW
Maximum energy / 1h:	5000000 Wh
Maximum pulse rate:	8 pulse/s = 8 x 3600 pulse/h = 28800 pulse/h
Maximum pulse weight:	5000000/28800 = 173.6 Wh/pulse → 174 Wh/pulse

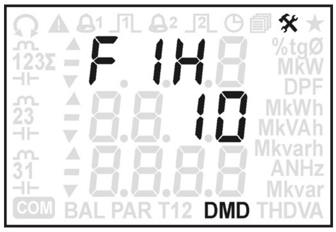
Similar calculation can be made for any type of energy. If pulse overlap condition occurs, the error situation is shown at display by a fast blinking of symbol ⎍, or it can be also identified in MODBUS protocol by reading the $201C register.

8.13.2 DMD calculation setup

WARNING! If the DMD mode or the integration time is modified, the instrument will reset the DMD & DMD MAX values and restart the DMD period.

The following DMD calculation mode is available:

- **Fixed window (FIX)**: the DMD value is updated only at the end of the DMD period.



The integration time will start to blink. With ▲ or ▼ button select the value and confirm with ↵ button. Selectable values according to the DMD mode: 5, 10, 15, 30, 45, 60 minutes.

8.13.3 Real time clock

By this page, it is possible to set date and time. Set always date & time before starting the data recording.

WARNING! Summer time (DST) is not managed automatically. In case of time changes, check and set again the clock.

WARNING! The instrument date&time could be lost in case of:
- **instrument upgrade**
- **instrument switching off**

In this cases, it is suggested to check and set again the instrument clock.

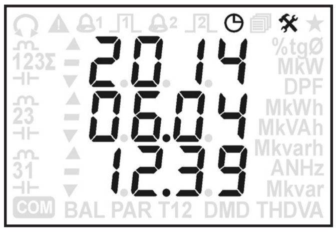
WARNING! If the date&time is lost or modified, the recording is automatically stopped. It is suggested to download the recorded data and set again date&time. Restart the recording by setting the rate, the old recorded data will be deleted.

The date and time are represented in the following format:

YYYY (year, e.g. 2014)

MM.DD (month and day, e.g. June 4th)

hh.mm (hours and minutes, e.g. 12:39)



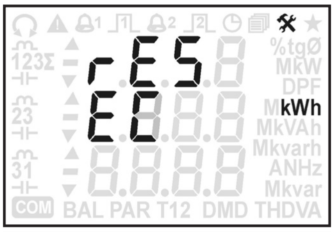
To set the date and time, press ↵ button, the year first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digits.

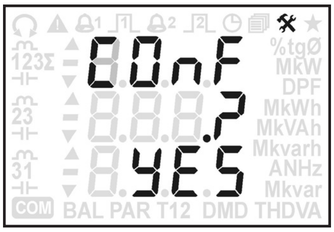
8.13.4 Energy counter reset

By this page, it is possible to reset an energy counter group. According to the displayed symbols, the energy counter group can be identified as follows:

- **kWh**: imported active energies (+kWh1, +kWh2, +kWh3, +kWh∑)
- **-kWh**: exported active energies (-kWh1, -kWh2, -kWh3, -kWh∑)
- **kVAh**: imported apparent energies (+kVAh1-L, +kVAh1-C, +kVAh2-L, +kVAh2-C, +kVAh3-L, +kVAh3-C, +kVAh∑-L, +kVAh∑-C)
- **-kVAh**: exported apparent energies (-kVAh1-L, -kVAh1-C, -kVAh2-L, -kVAh2-C, -kVAh3-L, -kVAh3-C, -kVAh∑-L, -kVAh∑-C)
- **kvarh**: imported reactive energies (+kvarh1-L,+kvarh1-C, +kvarh2-L, +kvarh2-C, +kvarh3-L,+kvarh3-C, +kvarh∑-L, +kvarh∑-C)
- **-kvarh**: exported reactive energies (-kvarh1-L,-kvarh1-C, -kvarh2-L, -kvarh2-C, -kvarh3-L, -kvarh3-C, -kvarh∑-L, -kvarh∑-C)

⚠ **WARNING! This function will erase the selected counter group: the reset data will not be retrievable.**





To reset an energy counter group, press ↵ button, the symbols which identify the counter group (e.g. kWh=imported active energies) will start to blink. With ▲ or ▼ button select the counter group to be reset and confirm with ↵ button.

A confirmation page (**CONF?**) will be displayed. With ▲ or ▼ button select the blinking item:

- **YES**=reset the selected counter group
- **NO**=no reset is performed

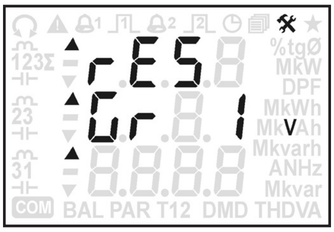
Confirm with ↵button. The last displayed page will be shown.

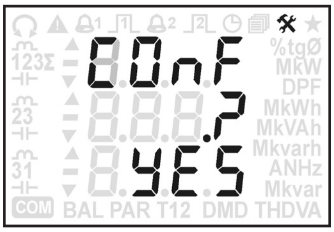
8.13.5 MAX value reset

By this page, it is possible to reset MAX values in groups. According to the displayed symbols, the MAX value group can be identified as follows:

- **Gr 1 (V)**: MAX voltages (V1, V2, V3, V12, V23, V31, V∑)
- **Gr 2 (A)**: MAX currents (A1, A2, A3, AN, A∑)

⚠ **WARNING! This function will erase the selected MAX value group: the reset data will not be retrievable.**





To reset a MAX value group, press ↵ button, the symbols which identify the group (e.g. V=MAX voltages) will start to blink. With ▲ or ▼ button select the group to be reset and confirm with ↵ button.

A confirmation page (**CONF?**) will be displayed. With ▲ or ▼ button select the blinking item:

- **YES**=reset the selected MAX value group
- **NO**=no reset is performed

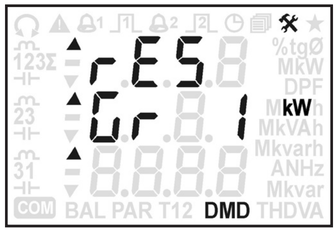
Confirm with ↵button. The last displayed page will be shown.

8.13.6 DMD MAX value reset

By this page, it is possible to reset DMD MAX values in groups. According to the displayed symbols, the DMD MAX value group can be identified as follows:

- **Gr 1 (kW)**: DMD MAX imported active powers (+P1, +P2, +P3, +P∑)
- **Gr 2 (-kW)**: DMD MAX exported active powers (-P1, -P2, -P3, -P∑)
- **Gr 3 (kVA)**: DMD MAX imported reactive powers (+Q1, +Q2, +Q3, +Q∑)
- **Gr 4 (-kVA)**: DMD MAX exported reactive powers (-Q1, -Q2, -Q3, -Q∑)

⚠ **WARNING! This function will erase the selected DMD MAX value group: the reset data will not be retrievable.**



To reset a DMD MAX value group, press ↵ button, the symbols which identify the group (e.g. +P=DMD MAX imported active powers) will start to blink. With ▲ or ▼ button select the group to be reset and confirm with ↵ button.

A confirmation page (**CONF?**) will be displayed. With ▲ or ▼ button select the blinking item:

- **YES**=reset the selected DMD MAX value group
- **NO**=no reset is performed

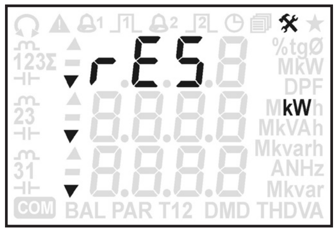
Confirm with ↵button. The last displayed page will be shown.

8.13.7 MIN value reset

By this page, it is possible to reset MIN powers. According to the displayed symbols, the power type can be identified as follows:

- **kW**: MIN system active power (P∑)
- **kVA**: MIN system apparent power (S∑)
- **kvar**: MIN system reactive power (Q∑)

⚠ **WARNING! This function will erase the selected MIN powers: the reset data will not be retrievable.**



To reset MIN powers, press ↵ button, the symbols which identify the power type (e.g. kW=MIN system active power) will start to blink. With ▲ or ▼ button select the power type to be reset and confirm with ↵ button.

A confirmation page (**CONF?**) will be displayed. With ▲ or ▼ button select the blinking item:

- **YES**=reset the selected MIN powers
- **NO**=no reset is performed

Confirm with ↵button. The last displayed page will be shown.

8.13.8 Data recording setup

WARNING! If the recording setup is modified, the recorded data will be deleted and it will not be retrievable.

WARNING! If the date&time is lost or modified, the recording is automatically stopped. It is suggested to download the recorded data and set again date&time. Restart the recording by setting the rate, the old recorded data will be deleted.

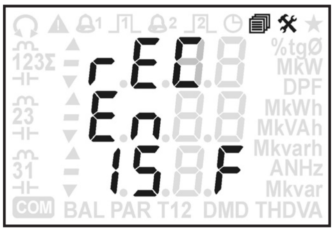
It is possible to record AVG active&reactive powers.

The following table shows the parameters automatically enabled for AVG recording. The parameters are available according to the set wiring mode.

PARAMETER	WIRING MODES (●=available)			
	3ph, 4w, 3c	3ph, 3w, 3c	3ph, 3w, 2c	1phase
P1 • Phase 1 active power (+/-)	●			●
P2 • Phase 2 active power (+/-)	●			
P3 • Phase 3 active power (+/-)	●			
P∑ • System active power (+/-)	●	●	●	
Q1 • Phase 1 reactive power (+/-)	●			●
Q2 • Phase 2 reactive power (+/-)	●			
Q3 • Phase 3 reactive power (+/-)	●			
Q∑ • System reactive power (+/-)	●	●	●	

NOTE. The sign (+/-) means +=imported value, -=exported value.

Refer to the following description.

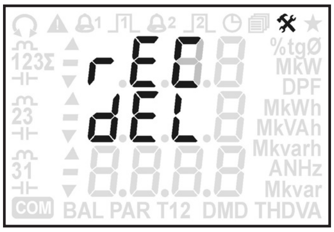


1. To change the recording setup, press ↵ button. The item on the second row (En or dIS) will start to blink. With ▲ or ▼ button select **En** to enable the recording, **dIS** to disable it. Confirm with ↵ button.
2. After enabling/disabling, the recording rate will start to blink.With ▲ or ▼ button select the rate and confirm with ↵ button. Selectable values: 0 (disable), 1, 5, 10, 15, 30, 45, 60 minutes.
3. After rate selection, the recording mode will start to blink (F or r).With ▲ or ▼ button select the mode and confirm with ↵ button. Selectable modes:
    - **F**=FILL mode; the instrument records data up to filling the available space, when the space is filled in, any recording is stopped.
    - **r**=RING mode; the instrument records data continuously. When the memory space is filled in, the oldest data is overwritten by the new data.

8.13.9 Data recording deletion

WARNING! This function will erase all recorded data without change recording setup: the deleted data will not be retrievable.

The data recording deletion erases AVG active&reactive recordings.



To delete all recorded data, press ↵ button, a confirmation page (**CONF?**) will be displayed. With ▲ or ▼ button select the blinking item:

- **YES**=delete all recorded data.
- **NO**=no deletion is performed

Confirm with ↵ button. The last displayed page will be shown.

8.14 LOOP 7 - INSTALLATION SETUP

In this loop, pages for the installation setup are displayed according to the instrument model and its wiring mode.

To access Installation setup loop, on any page (except for User setup pages) press **SET** button for at least 3 s. The first Installation setup page will be displayed. Scroll the loop pages with ▲ or ▼ button.

To exit from Installation setup loop, press ↵ for at least 3 s. A new page will be displayed to save the settings. With ▲ or ▼ button select the blinking item:

- **YES**=exit and save the settings
- **NO**=exit without saving the settings
- **CONT**=continue to scroll Installation setup pages

Confirm with ↵ button. Selecting **YES** or **NO**, the first Info page (instrument firmware release) will be displayed. Selecting **CONT**, the last Installation setup page will be displayed.

8.14.1 Wiring mode selection

⚠ **WARNING! If the wiring mode is modified, the instrument will:**

- **reset all MIN/MAX values, all DMD values, all energy counters**
- **set digital output to the default settings (disabled)**
- **set the default recording setup (disabled) and delete all recorded data**

By this page, it is possible to select the wiring mode, according to the real instrument connection. Available wiring mode:

- **3.4.3**: 3 phases 4 wires 3 currents
- **3.3.3**: 3 phases 3 wires 3 currents
- **3.3.2**: 3 phases 3 wires 2 currents
- **1Ph**: 1 phase

To change the wiring mode, press ↵ button, the corresponding item will start to blink. With ▲ or ▼ button select the mode and confirm with ↵ button.

8.14.2 Current full scale (FSA) setup mode

⚠ **WARNING! If the FSA setup mode is modified, the instrument will:**

- **reset all MIN/MAX values, all DMD values, all energy counters**
- **set digital output to the default settings (disabled)**
- **set the default recording setup (disabled) and delete all recorded data**

By this page, current full scale setup mode can be selected between:

- **ALL**: a single current full scale common for all phases.
- **SEP**: current full scale separated for each phase (1, 2, 3).

To change the mode, press ↵ button, the corresponding item will start to blink. With ▲ or ▼ button select the mode and confirm with ↵ button.

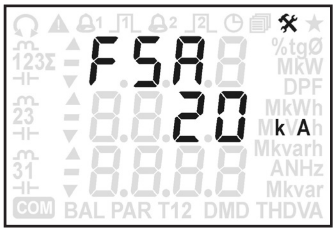
8.14.3 Current full scale (FSA) setup

WARNING! If the current full scale (FSA) is modified, the instrument will:

- **reset all MIN/MAX values, all DMD values, all energy counters**
- **set digital output to the default settings (disabled)**
- **set the default recording setup (disabled) and delete all recorded data**

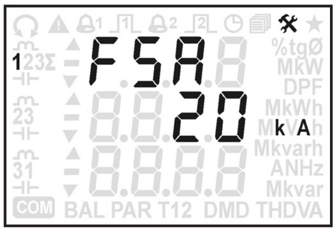
WARNING! The current full scale value (FSA) depends on the PT ratio. If the FSA*PT product is too high, an error symbol starts to blink on the display and the FSA must be set again. The FSA must be set considering the following formula: FSA * PT primary * 3 < 9999 MW

The current full scale page can be different according to the selection made for FSA setup mode (ALL or SEP). Refer to the following description.



In case of "ALL" FSA setup mode

1. To change the full scale, press ↵ button, the value will start to blink. With ▲ or ▼ button select the value and confirm with ↵ button. Selectable values: 500A / 4kA / 20kA.



In case of "SEP" FSA setup mode

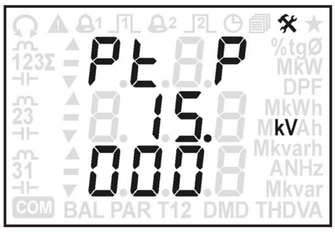
1. To change the phase 1 full scale, press ↵ button, the value will start to blink. With ▲ or ▼ button select the value and confirm with ↵ button. Selectable values: 500A / 4kA / 20kA.
2. After phase 1 full scale setup, press ▲ button to go to the phase 2 full scale page. The phase index can be identified by the corresponding symbol shown on the display left side. To set current full scale for phase 2 and 3, repeat the same procedure of points 1 and 2.

8.14.4 PT ratio setup

WARNING! If the PT ratio is modified, the instrument will:

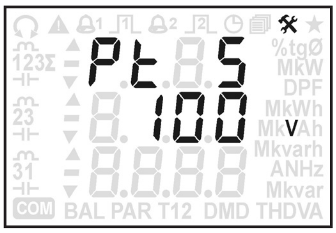
- **reset all MIN/MAX values, all DMD values, all energy counters**
- **set digital output to the default settings (disabled)**
- **set the default recording setup (disabled) and delete all recorded data**

WARNING! The PT ratio depends on the FSA (Rogowski coils). If the FSA*PT product is too high, an error symbol starts to blink on the display and the PT ratio must be set again. The PT ratio must be set considering the following formula: FSA * PT primary * 3 < 9999 MW



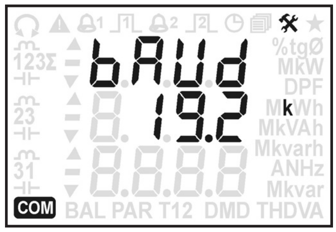
The pages for PT primary and secondary setup are common for all phases. To set PT primary and secondary values, refer to the following description.

1. To change the PT primary, press ↵ button, the first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digits. Value range: 0.001...999.999 kV. For direct connection set 1, PT secondary will be automatically set to 1 too.
2. After PT primary setup, press ▲ button to go to the PT secondary page.
3. To change the PT secondary, press ↵ button, the value will start to blink. With ▲ or ▼ button select the value and confirm with ↵ button. Value range: 80...150 V. If PT primary was set to 1, PT secondary is automatically fixed to 1 and it is not programmable.



8.14.5 Communication speed selection

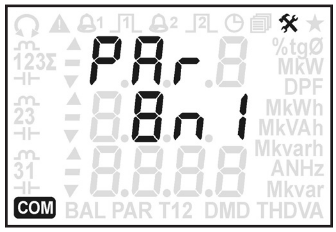
By this page, it is possible to select the communication speed. Selectable values: 300, 600, 1.2k, 2.4k, 4.8k, 9.6k, 19.2k, 38.4k, 57.6k bps. Example: 19.2k=19200 bps



To change the value, press ↵ button, the corresponding item will start to blink. With ▲ or ▼ button select the communication speed and confirm with ↵ button.

8.14.6 MODBUS mode selection

By this page, it is possible to select the MODBUS mode. Selectable values:

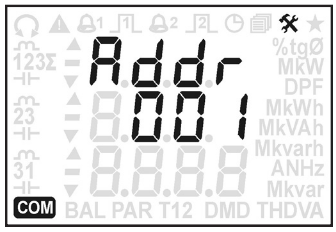


- **8N1**: RTU mode (8 data bits, none parity, 1 stop bit).
- **7E2**: ASCII mode (7 data bits, even parity, 2 stop bits).

To change the value, press ↵ button, the corresponding item will start to blink. With ▲ or ▼ button select the MODBUS mode and confirm with ↵ button.

8.14.7 MODBUS address setup

By this page, it is possible to set the MODBUS address in decimal format. Value range: 1...247

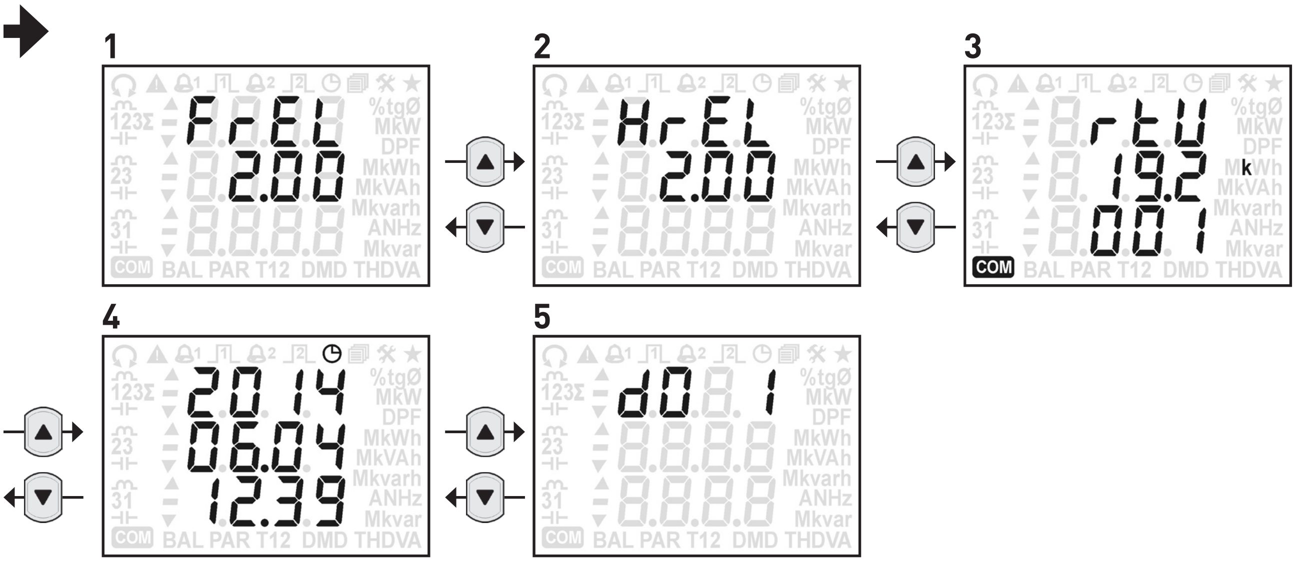


To change the value, press ↵ button, the first digit will start to blink. With ▲ or ▼ button select the digit and confirm with ↵ button. Repeat the same procedure for the other digits.

8.15 LOOP 6 - INFO

In this loop, the instrument information is displayed.

Scroll the loop pages with ▲ or ▼ button.



The following table shows the information available on display. The column "PAGE" shows the number of the corresponding device page just shown in this section.

INSTRUMENT NFORMATION	PAGE
Firmware release	1
Hardware version	2
Communication settings: • MODBUS mode, communication speed, MODBUS address	3
Clock (YYYY, MM.DD, hh.mm)	4
Available digital output number: • DO=digital output	5

9. TECHNICAL SPECIFICATIONS

AUXILIARY POWER SUPPLY	
Voltage range:	85...265 VAC / 110 VDC ±15%
Safety:	300 V CAT III
Maximum consumption:	1.6 VA - 1 W
T type fuse (to be mounted externally):	250 mA
Frequency:	50/60 Hz
VOLTAGE INPUTS	
Voltage range:	3x10/17 ... 3x285/495 VAC - 50/60 Hz
Safety:	300 V CAT III
Minimum voltage value for FFT calculation:	20/35 VAC (multiplied by PT ratio in case of PT use) with direct connection
CURRENT INPUTS	
Maximum value:	3 selectable scales (FSA) 500 A (700 A max), 4000 A (5600 A max)
	or 20000 A (28000 A max)
Starting current (I_{st})	0.3 A for FSA 500 A, 1 A for FSA 4000 A, 10 A for FSA 20000 A
Minimum current value for FFT calculation:	70 A for FSA 500 A, 400 A for FSA 4000 A, 1500 A for FSA 20000 A
	2% harmonic accuracy ±2 digits
TYPICAL ACCURACY	
Voltage:	±0.2% reading in 10% FS...FS range (FS=Full Scale value)
Current:	±0.4% reading in 5% FS...FS range
Power:	±0.5% reading ±0.1% FS (PF=1)
Frequency:	±0.1% reading ±1 digit in 45...65 Hz range
Active energy:	Class 1 according to IEC/EN 62053-21
Reactive energy:	Class 2 according to IEC/EN 62053-23
DISPLAY & KEYBOARD	
Display:	Backlighted LCD, 43x29 mm
	3 rows, 4 digits + symbols
Keyboard:	3 front buttons + 1 protected button
COMMUNICATION PORT	
Type:	RS485 optoisolated
Protocols:	MODBUS RTU/ASCII
Baud rate:	300 ... 57600 bps
DIGITAL OUTPUT (DO)	
Type:	Electronic passive optoisolated and polarised output
Maximum values (according to IEC/EN 62053-31):	27 VDC - 27 mA
Energy pulse length (only for DO in pulse mode):	50 ±2ms ON time
Maximum frequency:	8 pulses/s (8 Hz)
Maximum output reaction time (only for DO in alarm mode):	1 s
WIRE DIAMETER FOR TERMINALS	
Measuring terminals (A & V):	1.5 ... 6 mm^2
Terminals for digital output, AUX input, RS485 port:	0.14 ... 2.5 mm^2
SIZE & WEIGHT	
LxHxP, W:	72x90x65 mm, max 436 g
ENVIRONMENTAL CONDITIONS	
Operating temperature:	-25°C ... +55°C (3K6)
Storage temperature:	-25°C ... +75°C (2K3)
Max humidity (without condensation):	80%
Altitude for product use:	< 2000 m
Sinusoidal vibration amplitude:	50 Hz ±0.075 mm
Protection degree - frontal part:	IP51 (granted only in case of installation in a cabinet with at least IP51 protection degree)
Protection degree - terminals:	IP20
Pollution degree:	2
Installation and use:	Internal
STANDARD COMPLIANCE (for the parts applicable for the instrument)	
Directives:	2014/30/EU, 2014/35/EU
Safety:	EN 61010-1, EN 61010-2-030, EN 61010-2-032
EMC:	EN 61326-1, EN 55011, EN 61000-4-2, EN61000-4-3, EN61000-4-4,
	EN61000-4-5, EN61000-4-6, EN61000-4-11, EN61000-6-2

MODBUS
Communication Protocol

1. DESCRIPTION

MODBUS RTU/ASCII is a master-slave communication protocol, able to support up to 247 slaves connected in a bus or a star network.

The protocol uses a simplex connection on a single line. In this way, the communication messages move on a single line in two opposite directions.

Master-slave messages can be:

- **Reading (Function code $03 / $04)**: the communication is between the master and a single slave. It allows to read information about the queried instrument.
- **Writing (Function code $10)**: the communication is between the master and a single slave. It allows to change the instrument settings.
- **Broadcast**: the communication is between the master and all the connected slaves. It is always a write command (Function code $10) requiring MODBUS address $00, and has no response by slaves. This functionality can be used only with register $2040.

In a multi-point type connection (MODBUS RTU/ASCII), **slave address** (called also **MODBUS address**) allows to identify each instrument during the communication. Each instrument is preset with a default slave address (01) and the user can change it.

<u>COMMUNICATION FRAME STRUCTURE</u>

RTU mode:

Bit per byte: 1 Start, 8 Bit, None, 1 Stop (8N1)

Name	Length	Function
START FRAME	4 chars idle	At least 4 character time of silence (MARK condition)
ADDRESS FIELD	8 bits	Instrument MODBUS address
FUNCTION CODE	8 bits	Function code ($03 / $04 / $10)
DATA FIELD	n x 8 bits	Data + length will be filled depending on the message type
ERROR CHECK	16 bits	Error check (CRC)
END FRAME	4 chars idle	At least 4 character time of silence between frames

ASCII mode:

Bit per byte: 1 Start, 7 Bit, Even, 2 Stop (7E2)

Name	Length	Function
START FRAME	1 char	Message start marker. Starts with colon ":" ($3A)
ADDRESS FIELD	2 chars	Instrument MODBUS address
FUNCTION CODE	2 chars	Function code ($03 / $04 / $10)
DATA FIELD	n chars	Data + length will be filled depending on the message type
ERROR CHECK	2 chars	Error check (LRC)
END FRAME	2 chars	Carriage return - line feed (CRLF) pair ($0D & $0A)

1.1 LRC GENERATION

The Longitudinal Redundancy Check (LRC) field is one byte, containing an 8–bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The receiving device recalculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error results. The LRC is calculated by adding together successive 8–bit bytes in the message, discarding any carries, and then two's complementing the result. The LRC is an 8–bit field, therefore each new addition of a character that would result in a value higher than 255 decimal simply 'rolls over' the field's value through zero. Because there is no ninth bit, the carry is discarded automatically.

A procedure for generating an LRC is:

1. Add all bytes in the message, excluding the starting 'colon' and ending CR LF. Add them into an 8–bit field, so that carries will be discarded.
2. Subtract the final field value from $FF, to produce the ones–complement.
3. Add 1 to produce the twos–complement.

PLACING THE LRC INTO THE MESSAGE

When the the 8–bit LRC (2 ASCII characters) is transmitted in the message, the high–order character will be transmitted first, followed by the low–order character. For example, if the LRC value is $52 (0101 0010):

Colon ':'	Addr	Func	Data Count	Data	Data	....	Data	LRC Hi '5'	LRC Lo'2'	CR	LF

C-FUNCTION TO CALCULATE LRC

```
*pucFrame - pointer on "Addr" of message
usLen - length message from "Addr" to end "Data"

UCHAR prvucMBLRC( UCHAR * pucFrame, USHORT usLen )
{
    UCHAR           ucLRC = 0;  /* LRC char initialized */

    while( usLen-- )
    {
        ucLRC += *pucFrame++;   /* Add buffer byte without carry */
    }

    /* Return twos complement */
    ucLRC = ( UCHAR ) ( -( ( CHAR ) ucLRC ) );
    return ucLRC;
}
```

1.2 CRC GENERATION

The Cyclical Redundancy Check (CRC) field is two bytes, containing a 16–bit value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first preloading a 16–bit register to all 1's. Then a process begins of applying successive 8–bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits, and the parity bit, do not apply to the CRC.

During generation of the CRC, each 8–bit character is exclusive ORed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive ORed with a preset, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eight) shift, the next 8–bit character is exclusive ORed with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the characters of the message have been applied, is the CRC value.

A calculated procedure for generating a CRC is:

1. Load a 16–bit register with $FFFF. Call this the CRC register.
2. Exclusive OR the first 8–bit byte of the message with the low–order byte of the 16–bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero–filling the MSB. Extract and examine the LSB.
4. (If the LSB was 0): Repeat Step 3 (another shift).
   (If the LSB was 1): Exclusive OR the CRC register with the polynomial value $A001 (1010 0000 0000 0001).
5. Repeat Steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8–bit byte will have been processed.
6. Repeat Steps 2 through 5 for the next 8–bit byte of the message. Continue doing this until all bytes have been processed.
7. The final contents of the CRC register is the CRC value.
8. When the CRC is placed into the message, its upper and lower bytes must be swapped as described below.

MODBUS
Communication Protocol

PLACING THE CRC INTO THE MESSAGE

When the 16–bit CRC (two 8–bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte.

For example, if the CRC value is $35F7 (0011 0101 1111 0111):

Addr	Func	Data Count	Data	Data	....	Data	CRC lo F7	CRC hi 35

CRC GENERATION FUNCTIONS - With Table

All of the possible CRC values are preloaded into two arrays, which are simply indexed as the function increments through the message buffer. One array contains all of the 256 possible CRC values for the high byte of the 16–bit CRC field, and the other array contains all of the values for the low byte. Indexing the CRC in this way provides faster execution than would be achieved by calculating a new CRC value with each new character from the message buffer.

```
/*CRC table for calculate with polynom 0xA001 with init value 0xFFFF, High half word*/
rom unsigned char CRC_Table_Hi[] = {
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
    0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
    0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,
    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81,
    0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
    0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,
    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
    0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
    0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,
    0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
    0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
    0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,
    0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,  0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
    0x40
};
/*CRC table for calculate with polynom 0xA001 with init value 0xFFFF, Low half word*/
rom unsigned char  CRC_Table_Lo[] = {
    0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC5, 0xC4,
    0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09,
    0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD,
    0x1D, 0x1C, 0xDC, 0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
    0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6, 0xF7,
    0x37, 0xF5, 0x35, 0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A,
    0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA, 0xEE,
    0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
    0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1, 0x63, 0xA3, 0xA2,
    0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F,
    0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79, 0xBB,
    0x7B, 0x7A, 0xBA, 0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
    0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0, 0x50, 0x90, 0x91,
    0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C,
    0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98, 0x88,
    0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
    0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80,
    0x40
};

unsigned short ModBus_CRC16( unsigned char * Buffer, unsigned short Length )
{
    unsigned char CRCHi = 0xFF;
    unsigned char CRCLo = 0xFF;
    int           Index;
      unsigned short ret;

    while( Length-- )
    {
        Index = CRCLo ^ *Buffer++ ;
        CRCLo = CRCHi ^ CRC_Table_Hi[Index];
        CRCHi = CRC_Table_Lo[Index];
    }
      ret=((unsigned short)CRCHi << 8);
    ret|= (unsigned short)CRCLo;
    return ret;
}
```

CRC GENERATION FUNCTIONS - Without Table

```
unsigned short ModBus_CRC16( unsigned char * Buffer, unsigned short Length )
{
/* ModBus_CRC16 Calculatd CRC16 with polynome 0xA001 and init value 0xFFFF
Input *Buffer - pointer on data
Input Lenght - number byte in buffer
Output - calculated CRC16
*/
	unsigned int cur_crc;

	cur_crc=0xFFFF;
	do
	{
		unsigned int i = 8;
		cur_crc = cur_crc ^ *Buffer++;
			do
		{
			if (0x0001 & cur_crc)
			{
				cur_crc >>= 1;
				cur_crc ^= 0xA001;
			}
			else
			{
				cur_crc >>= 1;
			}
		}
		while (--i);
	}
	while (--Length);

	return cur_crc;
}
```

2. COMMAND STRUCTURE

The master communication device can send reading or writing commands to the slave (instrument). In this section, the tables describe the reading command structure (Query) and the writing command structure. Both commands are followed by a response sent by slave.

These tables refer to a master-slave communication in MODBUS RTU.

READING COMMAND STRUCTURE (function code $03/$04)

The master communication device can send commands to the instrument to read its status, setup and the measured values. More registers can be read, at the same time, sending a single command, only if the registers are consecutive (see chapter 4). Values contained both in Query and Response messages are in hex format.

Structure	Example	Byte
Slave address	01	-
Function code	03	-
Starting register	00	High
	00	Low
Words to be read	00	High
	02	Low
CRC	0B	High
	C4	Low

Query example: 0103000000020BC4

Structure	Example	Byte
Slave address	01	-
Function code	03	-
Data bytes	04	-
Requested reading data	00	High
	03	Low
	92	High
	10	Low
CRC	9F	High
	66	Low

Response example: 010304000392109F66

MODBUS Communication Protocol

WRITING COMMAND STRUCTURE (function code $10)

The master communication device can send commands to the instrument for setup. More settings can be carried out, at the same time, sending a single command, only if the relevant registers are consecutive (see chapter 4). Values contained both in Command and Response messages are in hex format.

Structure	Example	Byte
Slave address	01	-
Function code	10	-
Starting register	20	High
	3C	Low
Words to be written	00	High
	02	Low
Data bytes	04	-
Programming data to be written	00	High
	00	Low
	00	High
	03	Low
CRC	2E	High
	29	Low

Command example: 0110203C000204000000032E29

Structure	Example	Byte
Slave address	01	-
Function code	10	-
Starting register	20	High
	3C	Low
Written words	00	High
	02	Low
CRC	04	High
	8A	Low

Response example: 0110203C0002048A

2.3 FLOATING POINT AS PER IEEE STANDARD

The basic format allows a IEEE standard floating-point number to be represented in a single 32 bit format, as shown below:

$$N.n = (-1)^S \; 2^{e'-127} \; (1.f)$$

where **S** is the sign bit, **e'** is the first part of the exponent and **f** is the decimal fraction placed next to 1. Internally the exponent is 8 bits in length and the stored fraction is 23 bits long.

A round to nearest method is applied to the calculated value of floating point.

The floating-point format is shown as follows:

```
=====================
 | S  | e + 127 |    f     |
=====================
31   30       23 22       0 <--
                          bit number
```

where:

	bit length
Sign	1
Exponent	8
Fraction	23 + (1)
Total	m = 32 + (1)
Exponent	
Min e'	0
Max e'	255
Bias	127

NOTE. Fractions (decimals) are always shown while the leading 1 (hidden bit) is not stored.

<u>EXAMPLE OF CONVERSION OF VALUE SHOWN WITH FLOATING POINT</u>

Value read with floating point:

$45AACC00_{(16)}$

Value converted in binary format:

$$\underbrace{0}_{\text{sign}}\underbrace{10001011}_{\text{exponent}}\;\underbrace{01010101100110000000000}_{\text{fraction}}\;(_2)$$

sign = 0

exponent = $10001011(_2) = 139(_{10})$

fraction = $01010101100110000000000(_2) / 8388608\ (_{10}) =$

$= 2804736\ (_{10}) / 8388608\ (_{10}) = 0.334350585\ (_{10})$

$N.n = (-1)^S\; 2^{e'-127}\; (1+f) =$

$= (-1)^0\; 2^{139-127}\; (1.334350585) =$

$= (+1)\; (4096)\; (1.334350585) =$

$= 5465.5$

3. EXCEPTION CODES

When the slave (instrument) receives a not-valid query or command, an error response is sent. In this section, the table describes the error response structure following to a not-valid query or command. This table refers to a master-slave communication in MODBUS RTU.

Values contained in Response messages are in hex format.

Structure	Example	Byte
Slave address	01	-
Function code + $80 (e.g. 03+80, 04+80, 10+80, according to the query/command)	83	-
Exception code	01	-
CRC	F0	High
	80	Low

Response example: 018301F080

Exception codes for MODBUS RTU/ASCII are following described:

$01 **ILLEGAL FUNCTION**: the function code received in the query is not an allowable action.

$02 **ILLEGAL DATA ADDRESS**: the data address received in the query is not an allowable address (e.g. the combination of register and transfer length is invalid).

$03 **ILLEGAL DATA VALUE**: a value contained in the query data field is not an allowable value.

$04 **ILLEGAL RESPONSE LENGTH**: the request would generate a response with size bigger than that available for MODBUS protocol.

4. REGISTER TABLES

NOTE. Highest number of registers (or bytes) which can be read with a single command:
- **in RTU mode: 127 registers**
- **in ASCII mode: 63 registers**

NOTE. Highest number of registers which can be programmed with a single command:
- **in RTU mode: 29 registers**
- **in ASCII mode: 13 registers**

NOTE. The register values are in hex format ($).

NOTE. The following registers describe all parameters for any instrument configuration. Refer to the instrument configuration before sending reading/writing commands: some register parameters may not be available.

TABLE HEADER	MEANING
Parameter	Measuring parameter to be read
Register description	Description of the register to be read / written
F. code (Hex)	Function code in hex format. It identifies the command type (reading / writing)
Sign	If this column is checked, the read register value can have positive or negative sign. The negative values are represented with 2's complement.
INTEGER	Details for INTEGER type registers
IEEE	Details for IEEE standard type registers
Register (Hex)	Register address in hex format
Words	Number of word to be read / written for the register (length)
M.U.	Measuring unit of parameter
Data meaning	Description of data received by a response of a reading command
Programmable data	Description of data which can be sent for a writing command

4.1 READING REGISTERS (FUNCTION CODE $03 / $04)

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
REAL TIME VALUES								
V1 • Phase 1-N voltage	03 / 04		0000	2	mV	1000	2	V
V2 • Phase 2-N voltage	03 / 04		0002	2	mV	1002	2	V
V3 • Phase 3-N voltage	03 / 04		0004	2	mV	1004	2	V
V12 • Line 12 voltage	03 / 04		0006	2	mV	1006	2	V
V23 • Line 23 voltage	03 / 04		0008	2	mV	1008	2	V
V31 • Line 31 voltage	03 / 04		000A	2	mV	100A	2	V
V∑ • System voltage	03 / 04		000C	2	mV	100C	2	V
A1 • Phase 1 current	03 / 04	X	000E	2	mA	100E	2	A
A2 • Phase 2 current	03 / 04	X	0010	2	mA	1010	2	A
A3 • Phase 3 current	03 / 04	X	0012	2	mA	1012	2	A
AN • Neutral current*	03 / 04	X	0014	2	mA	1014	2	A
A∑ • System current	03 / 04	X	0016	2	mA	1016	2	A
P1 • Phase 1 active power	03 / 04	X	0018	4	mW	1018	2	W
P2 • Phase 2 active power	03 / 04	X	001C	4	mW	101A	2	W
P3 • Phase 3 active power	03 / 04	X	0020	4	mW	101C	2	W
P∑ • System active power	03 / 04	X	0024	4	mW	101E	2	W
S1 • Phase 1 apparent power	03 / 04	X	0028	4	mVA	1020	2	VA
S2 • Phase 2 apparent power	03 / 04	X	002C	4	mVA	1022	2	VA
S3 • Phase 3 apparent power	03 / 04	X	0030	4	mVA	1024	2	VA
S∑ • System apparent power	03 / 04	X	0034	4	mVA	1026	2	VA
Q1 • Phase 1 reactive power	03 / 04	X	0038	4	mvar	1028	2	var
Q2 • Phase 2 reactive power	03 / 04	X	003C	4	mvar	102A	2	var
Q3 • Phase 3 reactive power	03 / 04	X	0040	4	mvar	102C	2	var
Q∑ • System reactive power	03 / 04	X	0044	4	mvar	102E	2	var
PF1 • Phase 1 power factor	03 / 04	X	0048	2	0,001	1030	2	-
PF2 • Phase 2 power factor	03 / 04	X	004A	2	0,001	1032	2	-
PF3 • Phase 3 power factor	03 / 04	X	004C	2	0,001	1034	2	-
PF∑ • System power factor	03 / 04	X	004E	2	0,001	1036	2	-
Reserved	03 / 04		0050	2		1038	2	
Reserved	03 / 04		0052	2		103A	2	
Reserved	03 / 04		0054	2		103C	2	
TANØ1 • Phase 1 tangent Ø	03 / 04	X	0056	2	0,001	103E	2	-
TANØ2 • Phase 2 tangent Ø	03 / 04	X	0058	2	0,001	1040	2	-
TANØ3 • Phase 3 tangent Ø	03 / 04	X	005A	2	0,001	1042	2	-
TANØ∑ • System tangent Ø	03 / 04	X	005C	2	0,001	1044	2	-
THDV1 • Phase 1-N voltage THD	03 / 04		005E	2	m%	1046	2	%
THDV2 • Phase 2-N voltage THD	03 / 04		0060	2	m%	1048	2	%
THDV3 • Phase 3-N voltage THD	03 / 04		0062	2	m%	104A	2	%
THDV12 • Line 12 voltage THD	03 / 04		0064	2	m%	104C	2	%
THDV23 • Line 23 voltage THD	03 / 04		0066	2	m%	104E	2	%
THDV31 • Line 31 voltage THD	03 / 04		0068	2	m%	1050	2	%
THDA1 • Phase 1 current THD	03 / 04		006A	2	m%	1052	2	%
THDA2 • Phase 2 current THD	03 / 04		006C	2	m%	1054	2	%
THDA3 • Phase 3 current THD	03 / 04		006E	2	m%	1056	2	%
THDAN • Neutral current THD*	03 / 04		0070	2	m%	1058	2	%

* The neutral current and the derivative parameters (AN, THDAN) are not available if the set FSA value is different for each phase.

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
REAL TIME VALUES								
F • Frequency	03 / 04		0072	2	mHz	105A	2	Hz
Phase sequence ($00=123-CCW, $01=321-CW, $02=not defined)	03 / 04		0074	2	-	105C	2	-
Reserved	03 / 04		0076	2	0,1h	105E	2	
Reserved	03 / 04		0078	2	0,1h	1060	2	
DEMAND VALUES (DMD)								
Reserved	03 / 04		010E	2		110E	2	
Reserved	03 / 04		0110	2		1110	2	
Reserved	03 / 04		0112	2		1112	2	
Reserved	03 / 04		0114	2		1114	2	
Reserved	03 / 04		0116	2		1116	2	
$+P1_{DMD}$ • Phase 1 imported active power DMD	03 / 04		0118	4	mW	1118	2	W
$-P1_{DMD}$ • Phase 1 exported active power DMD	03 / 04		011C	4	mW	111A	2	W
$+P2_{DMD}$ • Phase 2 imported active power DMD	03 / 04		0120	4	mW	111C	2	W
$-P2_{DMD}$ • Phase 2 exported active power DMD	03 / 04		0124	4	mW	111E	2	W
$+P3_{DMD}$ • Phase 3 imported active power DMD	03 / 04		0128	4	mW	1120	2	W
$-P3_{DMD}$ • Phase 3 exported active power DMD	03 / 04		012C	4	mW	1122	2	W
$+P\sum_{DMD}$ • System imported active power DMD	03 / 04		0130	4	mW	1124	2	W
$-P\sum_{DMD}$ • System exported active power DMD	03 / 04		0134	4	mW	1126	2	W
Reserved	03 / 04		0138	4		1128	2	
Reserved	03 / 04		013C	4		112A	2	
Reserved	03 / 04		0140	4		112C	2	
Reserved	03 / 04		0144	4		112E	2	
Reserved	03 / 04		0148	4		1130	2	
Reserved	03 / 04		014C	4		1132	2	
Reserved	03 / 04		0150	4		1134	2	
Reserved	03 / 04		0154	4		1136	2	
Reserved	03 / 04		0158	4		1138	2	
Reserved	03 / 04		015C	4		113A	2	
$+Q1_{DMD}$ • Phase 1 imported reactive power DMD	03 / 04		0160	4	mvar	113C	2	var
$-Q1_{DMD}$ • Phase 1 exported reactive power DMD	03 / 04		0164	4	mvar	113E	2	var
$+Q2_{DMD}$ • Phase 2 imported reactive power DMD	03 / 04		0168	4	mvar	1140	2	var
$-Q2_{DMD}$ • Phase 2 exported reactive power DMD	03 / 04		016C	4	mvar	1142	2	var
$+Q3_{DMD}$ • Phase 3 imported reactive power DMD	03 / 04		0170	4	mvar	1144	2	var
$-Q3_{DMD}$ • Phase 3 exported reactive power DMD	03 / 04		0174	4	mvar	1146	2	var
$+Q\sum_{DMD}$ • System imported reactive power DMD	03 / 04		0178	4	mvar	1148	2	var
$-Q\sum_{DMD}$ • System exported reactive power DMD	03 / 04		017C	4	mvar	114A	2	var
Reserved	03 / 04		0180	4		114C	2	
Reserved	03 / 04		0184	2		114E	2	
Reserved	03 / 04		0186	2		1150	2	
Reserved	03 / 04		0188	2		1152	2	
Reserved	03 / 04		018A	2		1154	2	
Reserved	03 / 04		018C	2		1156	2	
Reserved	03 / 04		018E	2		1158	2	
Reserved	03 / 04		0190	2		115A	2	
Reserved	03 / 04		0192	2		115C	2	

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
MAXIMUM VALUES								
$V1_{MAX}$ • Phase 1-N voltage MAX	03 / 04		0200	2	mV	1200	2	V
$V2_{MAX}$ • Phase 2-N voltage MAX	03 / 04		0202	2	mV	1202	2	V
$V3_{MAX}$ • Phase 3-N voltage MAX	03 / 04		0204	2	mV	1204	2	V
$V12_{MAX}$ • Line 12 voltage MAX	03 / 04		0206	2	mV	1206	2	V
$V23_{MAX}$ • Line 23 voltage MAX	03 / 04		0208	2	mV	1208	2	V
$V31_{MAX}$ • Line 31 voltage MAX	03 / 04		020A	2	mV	120A	2	V
$V\Sigma_{MAX}$ • System voltage MAX	03 / 04		020C	2	mV	120C	2	V
$A1_{MAX}$ • Phase 1 current MAX	03 / 04		020E	2	mA	120E	2	A
$A2_{MAX}$ • Phase 2 current MAX	03 / 04		0210	2	mA	1210	2	A
$A3_{MAX}$ • Phase 3 current MAX	03 / 04		0212	2	mA	1212	2	A
AN_{MAX} • Neutral current MAX*	03 / 04		0214	2	mA	1214	2	A
$A\Sigma_{MAX}$ • System current MAX	03 / 04		0216	2	mA	1216	2	A
Reserved	03 / 04		0218	4		1218	2	
Reserved	03 / 04		021C	4		121A	2	
Reserved	03 / 04		0220	4		121C	2	
Reserved	03 / 04		0224	4		121E	2	
Reserved	03 / 04		0228	4		1220	2	
Reserved	03 / 04		022C	4		1222	2	
Reserved	03 / 04		0230	4		1224	2	
Reserved	03 / 04		0234	4		1226	2	
Reserved	03 / 04		0238	4		1228	2	
Reserved	03 / 04		023C	4		122A	2	
Reserved	03 / 04		0240	4		122C	2	
Reserved	03 / 04		0244	4		122E	2	
Reserved	03 / 04		0248	4		1230	2	
Reserved	03 / 04		024C	4		1232	2	
Reserved	03 / 04		0250	4		1234	2	
Reserved	03 / 04		0254	4		1236	2	
Reserved	03 / 04		0258	4		1238	2	
Reserved	03 / 04		025C	4		123A	2	
Reserved	03 / 04		0260	4		123C	2	
Reserved	03 / 04		0264	4		123E	2	
Reserved	03 / 04		0268	4		1240	2	
Reserved	03 / 04		026C	4		1242	2	
Reserved	03 / 04		0270	4		1244	2	
Reserved	03 / 04		0274	4		1246	2	
Reserved	03 / 04		0278	2		1248	2	
Reserved	03 / 04		027A	2		124A	2	
Reserved	03 / 04		027C	2		124C	2	
Reserved	03 / 04		027E	2		124E	2	
Reserved	03 / 04		0280	2		1250	2	
Reserved	03 / 04		0282	2		1252	2	
Reserved	03 / 04		0284	2		1254	2	
Reserved	03 / 04		0286	2		1256	2	

* The neutral current and the derivative parameters (AN, THDAN) are not available if the set FSA value is different for each phase.

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
MAXIMUM VALUES								
Reserved	03 / 04		0288	2		1258	2	
Reserved	03 / 04		028A	2		125A	2	
Reserved	03 / 04		028C	2		125C	2	
Reserved	03 / 04		028E	2		125E	2	
Reserved	03 / 04		0290	2		1260	2	
Reserved	03 / 04		0292	2		1262	2	
Reserved	03 / 04		0294	2		1264	2	
Reserved	03 / 04		0296	2		1266	2	
Reserved	03 / 04		0298	2		1268	2	
Reserved	03 / 04		029A	2		126A	2	
Reserved	03 / 04		029C	2		126C	2	
Reserved	03 / 04		029E	2		126E	2	
Reserved	03 / 04		02A0	2		1270	2	
Reserved	03 / 04		02A2	2		1272	2	
Reserved	03 / 04		02A4	2		1274	2	
Reserved	03 / 04		02A6	2		1276	2	
Reserved	03 / 04		02A8	2		1278	2	
Reserved	03 / 04		02AA	2		127A	2	
Reserved	03 / 04		02AC	2		127C	2	
Reserved	03 / 04		02AE	2		127E	2	
Reserved	03 / 04		02B0	2		1280	2	
Reserved	03 / 04		02B2	2		1282	2	
$+P1_{DMDMAX}$ • Phase 1 imported active power DMD MAX	03 / 04		02B4	4	mW	1284	2	W
$-P1_{DMDMAX}$ • Phase 1 exported active power DMD MAX	03 / 04		02B8	4	mW	1286	2	W
$+P2_{DMDMAX}$ • Phase 2 imported active power DMD MAX	03 / 04		02BC	4	mW	1288	2	W
$-P2_{DMDMAX}$ • Phase 2 exported active power DMD MAX	03 / 04		02C0	4	mW	128A	2	W
$+P3_{DMDMAX}$ • Phase 3 imported active power DMD MAX	03 / 04		02C4	4	mW	128C	2	W
$-P3_{DMDMAX}$ • Phase 3 exported active power DMD MAX	03 / 04		02C8	4	mW	128E	2	W
$+P\Sigma_{DMDMAX}$ • System imported active power DMD MAX	03 / 04		02CC	4	mW	1290	2	W
$-P\Sigma_{DMDMAX}$ • System exported active power DMD MAX	03 / 04		02D0	4	mW	1292	2	W
Reserved	03 / 04		02D4	4		1294	2	
Reserved	03 / 04		02D8	4		1296	2	
Reserved	03 / 04		02DC	4		1298	2	
Reserved	03 / 04		02E0	4		129A	2	
Reserved	03 / 04		02E4	4		129C	2	
Reserved	03 / 04		02E8	4		129E	2	
Reserved	03 / 04		02EC	4		12A0	2	
Reserved	03 / 04		02F0	4		12A2	2	
$+Q1_{DMDMAX}$ • Phase 1 imported reactive power DMD MAX	03 / 04		02F4	4	mvar	12A4	2	var
$-Q1_{DMDMAX}$ • Phase 1 exported reactive power DMD MAX	03 / 04		02F8	4	mvar	12A6	2	var
$+Q2_{DMDMAX}$ • Phase 2 imported reactive power DMD MAX	03 / 04		02FC	4	mvar	12A8	2	var
$-Q2_{DMDMAX}$ • Phase 2 exported reactive power DMD MAX	03 / 04		0300	4	mvar	12AA	2	var
$+Q3_{DMDMAX}$ • Phase 3 imported reactive power DMD MAX	03 / 04		0304	4	mvar	12AC	2	var
$-P3_{DMDMAX}$ • Phase 3 exported reactive power DMD MAX	03 / 04		0308	4	mvar	12AE	2	var
$+Q\Sigma_{DMDMAX}$ • System imported reactive power DMD MAX	03 / 04		030C	4	mvar	12B0	2	var
$-Q\Sigma_{DMDMAX}$ • System exported reactive power DMD MAX	03 / 04		0310	4	mvar	12B2	2	var

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
MINIMUM VALUES								
$P\Sigma_{MIN}$ • System active power MIN	03 / 04		0314	4	mW	12B4	2	W
$S\Sigma_{MIN}$ • System apparent power MIN	03 / 04		0318	4	mVA	12B6	2	VA
$Q\Sigma_{MIN}$ • System reactive power MIN	03 / 04		031C	4	mvar	12B8	2	var
ENERGY COUNTERS								
+kWh1 • Phase 1 imported active energy	03 / 04		0400	4	0,1Wh	1400	2	Wh
-kWh1 • Phase 1 exported active energy	03 / 04		0404	4	0,1Wh	1402	2	Wh
+kWh2 • Phase 2 imported active energy	03 / 04		0408	4	0,1Wh	1404	2	Wh
-kWh2 • Phase 2 exported active energy	03 / 04		040C	4	0,1Wh	1406	2	Wh
+kWh3 • Phase 3 imported active energy	03 / 04		0410	4	0,1Wh	1408	2	Wh
-kWh3 • Phase 3 exported active energy	03 / 04		0414	4	0,1Wh	140A	2	Wh
+kWh∑ • System imported active energy	03 / 04		0418	4	0,1Wh	140C	2	Wh
-kWh∑ • System exported active energy	03 / 04		041C	4	0,1Wh	140E	2	Wh
kWh∑BAL • Balance of system active energy (imp-exp)	03 / 04		0420	4	0,1Wh	1410	2	Wh
+kVAh1-C • Phase 1 imported capacitive apparent energy	03 / 04		0424	4	0,1VAh	1412	2	VAh
-kVAh1-C • Phase 1 exported capacitive apparent energy	03 / 04		0428	4	0,1VAh	1414	2	VAh
+kVAh1-L • Phase 1 imported inductive apparent energy	03 / 04		042C	4	0,1VAh	1416	2	VAh
-kVAh1-L • Phase 1 exported inductive apparent energy	03 / 04		0430	4	0,1VAh	1418	2	VAh
Reserved	03 / 04		0434	4		141A	2	
Reserved	03 / 04		0438	4		141C	2	
+kVAh2-C • Phase 2 imported capacitive apparent energy	03 / 04		043C	4	0,1VAh	141E	2	VAh
-kVAh2-C • Phase 2 exported capacitive apparent energy	03 / 04		0440	4	0,1VAh	1420	2	VAh
+kVAh2-L • Phase 2 imported inductive apparent energy	03 / 04		0444	4	0,1VAh	1422	2	VAh
-kVAh2-L • Phase 2 exported inductive apparent energy	03 / 04		0448	4	0,1VAh	1424	2	VAh
Reserved	03 / 04		044C	4		1426	2	
Reserved	03 / 04		0450	4		1428	2	
+kVAh3-C • Phase 3 imported capacitive apparent energy	03 / 04		0454	4	0,1VAh	142A	2	VAh
-kVAh3-C • Phase 3 exported capacitive apparent energy	03 / 04		0458	4	0,1VAh	142C	2	VAh
+kVAh3-L • Phase 3 imported inductive apparent energy	03 / 04		045C	4	0,1VAh	142E	2	VAh
-kVAh3-L • Phase 3 exported inductive apparent energy	03 / 04		0460	4	0,1VAh	1430	2	VAh
Reserved	03 / 04		0464	4		1432	2	
Reserved	03 / 04		0468	4		1434	2	
+kVAh∑-C • System imported capacitive apparent energy	03 / 04		046C	4	0,1VAh	1436	2	VAh
-kVAh∑-C • System exported capacitive apparent energy	03 / 04		0470	4	0,1VAh	1438	2	VAh
+kVAh∑-L • System imported inductive apparent energy	03 / 04		0474	4	0,1VAh	143A	2	VAh
-kVAh∑-L • System exported inductive apparent energy	03 / 04		0478	4	0,1VAh	143C	2	VAh
Reserved	03 / 04		047C	4		143E	2	
Reserved	03 / 04		0480	4		1440	2	
kVAh∑BAL-C • Balance of system capacitive apparent en. (imp-exp)	03 / 04		0484	4	0,1VAh	1442	2	VAh
kVAh∑BAL-L • Balance of system inductive apparent en. (imp-exp)	03 / 04		0488	4	0,1VAh	1444	2	VAh
kVAh∑BAL • Balance of system apparent energy (BAL-C + BAL-L)	03 / 04		048C	4	0,1VAh	1446	2	VAh
+kvarh1-C • Phase 1 imported capacitive reactive energy	03 / 04		0490	4	0,1varh	1448	2	varh
-kvarh1-C • Phase 1 exported capacitive reactive energy	03 / 04		0494	4	0,1varh	144A	2	varh
+kvarh1-L • Phase 1 imported inductive reactive energy	03 / 04		0498	4	0,1varh	144C	2	varh
-kvarh1-L • Phase 1 exported inductive reactive energy	03 / 04		049C	4	0,1varh	144E	2	varh

Parameter	F. code (Hex)	Sign	INTEGER			IEEE		
			Register (Hex)	Words	M.U.	Register (Hex)	Words	M.U.
ENERGY COUNTERS								
+kvarh2-C • Phase 2 imported capacitive reactive energy	03 / 04		04A0	4	0,1varh	1450	2	varh
-kvarh2-C • Phase 2 exported capacitive reactive energy	03 / 04		04A4	4	0,1varh	1452	2	varh
+kvarh2-L • Phase 2 imported inductive reactive energy	03 / 04		04A8	4	0,1varh	1454	2	varh
-kvarh2-L • Phase 2 exported inductive reactive energy	03 / 04		04AC	4	0,1varh	1456	2	varh
+kvarh3-C • Phase 3 imported capacitive reactive energy	03 / 04		04B0	4	0,1varh	1458	2	varh
-kvarh3-C • Phase 3 exported capacitive reactive energy	03 / 04		04B4	4	0,1varh	145A	2	varh
+kvarh3-L • Phase 3 imported inductive reactive energy	03 / 04		04B8	4	0,1varh	145C	2	varh
-kvarh3-L • Phase 3 exported inductive reactive energy	03 / 04		04BC	4	0,1varh	145E	2	varh
+kvarh∑-C • System imported capacitive reactive energy	03 / 04		04C0	4	0,1varh	1460	2	varh
-kvarh∑-C • System exported capacitive reactive energy	03 / 04		04C4	4	0,1varh	1462	2	varh
+kvarh∑-L • System imported inductive reactive energy	03 / 04		04C8	4	0,1varh	1464	2	varh
-kvarh∑-L • System exported inductive reactive energy	03 / 04		04CC	4	0,1varh	1466	2	varh
kvarh∑BAL-C • Balance of system capacitive reactive en. (imp-exp)	03 / 04		04D0	4	0,1varh	1468	2	varh
kvarh∑BAL-L • Balance of system inductive reactive en. (imp-exp)	03 / 04		04D4	4	0,1varh	146A	2	varh
kvarh∑BAL • Balance of system reactive energy (BAL-C + BAL-L)	03 / 04		04D8	4	0,1varh	146C	2	varh

Register description	F. code (Hex)	INTEGER		Data meaning
		Register (Hex)	Words	
INSTRUMENT INFORMATION				
Serial number	03 / 04	2000	6	10 ASCII characters, $00...$FF
Firmware release	03 / 04	2006	2	Convert the read hexadecimal value in decimal format. e.g. $64=100=rel. 1.00
Hardware version	03 / 04	2008	2	Convert the read hexadecimal value in decimal format. e.g. $64=100=rev. 1.00
Model	03 / 04	200A	2	$06=Rogowski inputs, BASIC
COM features	03 / 04	200C	2	$02=RS485 port (MODBUS RTU/ASCII)
Reserved	03 / 04	200E	2	
Digital output number	03 / 04	2010	2	$01=1
Reserved	03 / 04	2012	4	
Calibration date	03 / 04	2016	2	UnixTime format. Convert the read hexadecimal value in decimal format. e.g. 0837B4C0=1378684800 →09/09/13, 00:00:00
Reserved	03 / 04	2018	4	
Error code	03 / 04	201C	2	Bit encoding (0=disabled, 1=active): b1(LSb)=wrong phase sequence (132) b2=overflow parameter/s b3=date&time lost, recordings automatically disabled b4=unable to generate pulses on digital output enabled in pulse mode e.g. $0000$0006=0110 →overflow parameter/s and date&time lost occurred

4.2 READING AND WRITING REGISTERS (FUNCTION CODE $03 / $04 / $10)

WARNING! If PT ratio, wiring mode or current full scale is modified, the instrument will:
- **reset all MIN/MAX values, all DMD values, all energy counters**
- **set to the default settings digital output (disabled)**
- **set the default recording setup (disabled) and delete all recorded data**

Register description	F. code (Hex)	INTEGER		Programmable data
		Register (Hex)	Words	
INSTRUMENT GENERAL SETUP				
MODBUS address	03 / 04 / 10	2026	2	$01...$F7 (1...247)
Communication speed	03 / 04 / 10	2028	2	$01=300 bps $02=600 bps $03=1200 bps $04=2400 bps $05=4800 bps $06=9600 bps $07=19200 bps $08=38400 bps $09=57600 bps
MODBUS mode	03 / 04 / 10	202A	2	$00=7E2 (ASCII) $01=8N1 (RTU)
Phase 1 current full scale (FSA1)	03 / 04 / 10	202C	2	$01F4=500 A $0FA0=4000 A $4E20=20000 A
Reserved	03 / 04 / 10	202E	2	
Phase 2 current full scale (FSA2)	03 / 04 / 10	2030	2	$01F4=500 A $0FA0=4000 A $4E20=20000 A
Reserved	03 / 04 / 10	2032	2	
Phase 3 current full scale (FSA3)	03 / 04 / 10	2034	2	$01F4=500 A $0FA0=4000 A $4E20=20000 A
Reserved	03 / 04 / 10	2036	2	
PT primary	03 / 04 / 10	2038	2	$00001...$F423F (1...999999V) (for direct insertion, set PT_{pri}=1. PT_{sec}=1 will be set automatically)
PT secondary	03 / 04 / 10	203A	2	$50...$96 (80...150V) (if $PT_{pri}=1 \rightarrow PT_{sec}=1$ automatically preset, not programmable)
Wiring mode	03 / 04 / 10	203C	2	$01=3 phases, 4 wires, 3 currents $02=3 phases, 3 wires, 2 currents $03=1 phase $04=3 phases, 3 wires, 3 currents
Mode for DMD value calculation	03 / 04 / 10	203E	2	$00=fixed window
Integration time for DMD value calculation	03 / 04 / 10	2040	2	$05=05 min $0A=10 min $0F=15 min $1E=30 min $2D=45 min $3C=60 min

Register description	F. code (Hex)	INTEGER		Programmable data
		Register (Hex)	Words	
INSTRUMENT GENERAL SETUP				
Maximum and DMD max value reset	10	2042	2	\$01=V1, V2, V3, V12, V23, V31, V∑ \$02=A1, A2, A3, AN, A∑ \$10=+$P1_{DMD}$, +$P2_{DMD}$, +$P3_{DMD}$, +$P∑_{DMD}$ \$11=-$P1_{DMD}$, -$P2_{DMD}$, -$P3_{DMD}$, -$P∑_{DMD}$ \$14=+$Q1_{DMD}$, +$Q2_{DMD}$, +$Q3_{DMD}$, +$Q∑_{DMD}$ \$15=-$Q1_{DMD}$, -$Q2_{DMD}$, -$Q3_{DMD}$, -$Q∑_{DMD}$ \$16=ALL
Minimum value reset	10	2044	2	\$01=P∑ \$02=S∑ \$03=Q∑ \$04=ALL
DMD value reset	10	2046	2	\$02=+$P1_{DMD}$, +$P2_{DMD}$, +$P3_{DMD}$, +$P∑_{DMD}$ \$03=-$P1_{DMD}$, -$P2_{DMD}$, -$P3_{DMD}$, -$P∑_{DMD}$ \$06=+$Q1_{DMD}$, +$Q2_{DMD}$, +$Q3_{DMD}$, +$Q∑_{DMD}$ \$07=-$Q1_{DMD}$, -$Q2_{DMD}$, -$Q3_{DMD}$, -$Q∑_{DMD}$ \$0A=ALL
Energy counter reset	10	2048	2	\$01=+kWh1, +kWh2, +kWh3, +kWh∑ \$02=-kWh1, -kWh2, -kWh3, -kWh∑ \$03=+kVAh1, +kVAh2, +kVAh3, +kVAh∑ (L&C) \$04=-kVAh1, -kVAh2, -kVAh3, -kVAh∑ (L&C) \$05=+kvarh1, +kvarh2, +kvarh3, +kvarh∑ (L&C) \$06=-kvarh1, -kvarh2, -kvarh3, -kvarh∑ (L&C) \$07=ALL
Real time clock The writing command can be sent also in broadcast by using \$00 MODBUS address. For broadcast function, no instrument response is sent.	03 / 04 / 10	204A	2	UnixTime format. READING MODE - Convert the read hexadecimal value in decimal format. e.g. \$522E\$5FD4=1378770900 →09/09/13, 23:55:00 WRITING MODE - Convert the UnixTime decimal value in hexadecimal format. e.g. to set: 09/09/13, 23:55:00→1378770900= \$522E\$5FD4 value to be set
Digital output mode	03 / 04 / 10	204C	2	\$00=disabled \$01=alarm high or active power sign change from + to - \$02=alarm low or active power sign change from - to + \$03=pulse
Digital output parameter	03 / 04 / 10	204E	2	Refer to the "Parameter codes" table

Register description	F. code (Hex)	INTEGER		Programmable data
		Register (Hex)	Words	
INSTRUMENT GENERAL SETUP				
Digital output setup according to the mode: • Alarm (AL): Threshold referred to the set parameter • Pulse (PULS): Pulse weight numerical value	03 / 04 / 10	2050	4	In Alarm mode: $0001... full scale value of the set parameter. The measuring unit changes according to the set parameter. The value is always expressed with the milli (m) coefficient: e.g. $38270=230000mV=230V For Phase sequence and Active power sign parameters, set $0000. In Pulse mode: $0001...$270F (1...9999) e.g. $0A00=2560=2.56 kWh / pulse with pulse value format X.XXX kWh, VAh, varh / pulse (value $01 in register $2054)
Digital output setup according to the mode: • Alarm (AL): Hysteresis value • Pulse (PULS): Pulse value format	03 / 04 / 10	2054	2	In Alarm mode: $00...$32 (0...50%) For Phase sequence parameter, set $00. For Active power sign parameter: $01...$3C (1...60s) In Pulse mode: $01=X.XXX kWh, VAh, varh / pulse $02=XX.XX kWh, VAh, varh / pulse $03=XXX.X kWh, VAh, varh / pulse $04=X.XXX MWh, VAh, varh / pulse $05=XX.XX MWh, VAh, varh / pulse $06=XXX.X MWh, VAh, varh / pulse $07=XXXX MWh, VAh, varh / pulse
Number of the stored AVG recordings	03 / 04	2100	2	e.g. $007F=127 recordings
Timestamp of the first AVG recording	03 / 04	2102	2	UnixTime format. Convert the read hexadecimal value in decimal format. e.g. $522E$5FD4=1378770900 →09/09/13, 23:55:00
Timestamp of the last AVG recording	03 / 04	2104	2	UnixTime format. Convert the read hexadecimal value in decimal format. e.g. $522E$5FD4=1378770900 →09/09/13, 23:55:00
Status of AVG recording	03 / 04	2106	2	Bit encoding: b1(LSb)=status (0=stopped, 1=active) b2=memory full (0=no, 1=yes) b3=memory overwritten (0=no, 1=yes) e.g. $0000$0002=010 →recording stopped, memory full and no memory overwritten
Mode of AVG recording	03 / 04 / 10	2108	2	$01=fill, $02=ring
Rate of AVG recording	03 / 04 / 10	210A	2	$00=disabled $01=01 minute $05=05 minutes $0A=10 minutes $0F=15 minutes $1E=30 minutes $2D=45 minutes $3C=60 minutes

CODE (Hex)	Description	DIGITAL OUTPUT AL=Alarm PLS=Pulse
PARAMETER CODES		
0000	None	AL, PLS
0001	V1 • Phase 1-N voltage	AL
0002	V2 • Phase 2-N voltage	AL
0003	V3 • Phase 3-N voltage	AL
0004	V12 • Line 12 voltage	AL
0005	V23 • Line 23 voltage	AL
0006	V31 • Line 31 voltage	AL
0007	V∑ • System voltage	AL
0008	A1 • Phase 1 current	AL
0009	A2 • Phase 2 current	AL
000A	A3 • Phase 3 current	AL
000B	AN • Neutral current*	AL
000C	A∑ • System current	AL
000D	P1 • Phase 1 active power	AL
000E	P2 • Phase 2 active power	AL
000F	P3 • Phase 3 active power	AL
0010	P∑ • System active power	AL
0011	S1 • Phase 1 apparent power	AL
0012	S2 • Phase 2 apparent power	AL
0013	S3 • Phase 3 apparent power	AL
0014	S∑ • System apparent power	AL
0015	Q1 • Phase 1 reactive power	AL
0016	Q2 • Phase 2 reactive power	AL
0017	Q3 • Phase 3 reactive power	AL
0018	Q∑ • System reactive power	AL
0019	PF1 • Phase 1 power factor	AL
001A	PF2 • Phase 2 power factor	AL
001B	PF3 • Phase 3 power factor	AL
001C	PF∑ • System power factor	AL
0020	TANØ1 • Phase 1 tangent Ø	AL
0021	TANØ2 • Phase 2 tangent Ø	AL
0022	TANØ3 • Phase 3 tangent Ø	AL
0023	TANØ∑ • System tangent Ø	AL
0024	THDV1 • Phase 1-N voltage THD	AL
0025	THDV2 • Phase 2-N voltage THD	AL
0026	THDV3 • Phase 3-N voltage THD	AL
0027	THDV12 • Line 12 voltage THD	AL
0028	THDV23 • Line 23 voltage THD	AL
0029	THDV31 • Line 31 voltage THD	AL
002A	THDA1 • Phase 1 current THD	AL
002B	THDA2 • Phase 2 current THD	AL
002C	THDA3 • Phase 3 current THD	AL
002D	THDAN • Neutral current THD*	AL
002E	F • Frequency	AL
002F	Phase sequence	AL
0032	Active power sign	AL
0045	$+P1_{DMD}$ • Phase 1 imported active power DMD	AL
0046	$-P1_{DMD}$ • Phase 1 exported active power DMD	AL
0047	$+P2_{DMD}$ • Phase 2 imported active power DMD	AL

* The neutral current and the derivative parameters (AN, THDAN) are not available if the set FSA value is different for each phase.

CODE (Hex)	Description	DIGITAL OUTPUT AL=Alarm PLS=Pulse
PARAMETER CODES		
0048	$-P2_{DMD}$ • Phase 2 exported active power DMD	AL
0049	$+P3_{DMD}$ • Phase 3 imported active power DMD	AL
004A	$-P3_{DMD}$ • Phase 3 exported active power DMD	AL
004B	$+P\sum_{DMD}$ • System imported active power DMD	AL
004C	$-P\sum_{DMD}$ • System exported active power DMD	AL
0057	$+Q1_{DMD}$ • Phase 1 imported reactive power DMD	AL
0058	$-Q1_{DMD}$ • Phase 1 exported reactive power DMD	AL
0059	$+Q2_{DMD}$ • Phase 2 imported reactive power DMD	AL
005A	$-Q2_{DMD}$ • Phase 2 exported reactive power DMD	AL
005B	$+Q3_{DMD}$ • Phase 3 imported reactive power DMD	AL
005C	$-Q3_{DMD}$ • Phase 3 exported reactive power DMD	AL
005D	$+Q\sum_{DMD}$ • System imported reactive power DMD	AL
005E	$-Q\sum_{DMD}$ • System exported reactive power DMD	AL
00D7	+kWh1 • Phase 1 imported active energy	PLS
00D8	-kWh1 • Phase 1 exported active energy	PLS
00D9	+kWh2 • Phase 2 imported active energy	PLS
00DA	-kWh2 • Phase 2 exported active energy	PLS
00DB	+kWh3 • Phase 3 imported active energy	PLS
00DC	-kWh3 • Phase 3 exported active energy	PLS
00DD	+kWh∑ • System imported active energy	PLS
00DE	-kWh∑ • System exported active energy	PLS
00E0	+kVAh1-C • Phase 1 imported capacitive apparent energy	PLS
00E1	-kVAh1-C • Phase 1 exported capacitive apparent energy	PLS
00E2	+kVAh1-L • Phase 1 imported inductive apparent energy	PLS
00E3	-kVAh1-L • Phase 1 exported inductive apparent energy	PLS
00E6	+kVAh2-C • Phase 2 imported capacitive apparent energy	PLS
00E7	-kVAh2-C • Phase 2 exported capacitive apparent energy	PLS
00E8	+kVAh2-L • Phase 2 imported inductive apparent energy	PLS
00E9	-kVAh2-L • Phase 2 exported inductive apparent energy	PLS
00EA	+kVAh2 • Phase 2 imported apparent energy	PLS
00EB	-kVAh2 • Phase 2 exported apparent energy	PLS
00EC	+kVAh3-C • Phase 3 imported capacitive apparent energy	PLS
00ED	-kVAh3-C • Phase 3 exported capacitive apparent energy	PLS
00EE	+kVAh3-L • Phase 3 imported inductive apparent energy	PLS
00EF	-kVAh3-L • Phase 3 exported inductive apparent energy	PLS
00F2	+kVAh∑-C • System imported capacitive apparent energy	PLS
00F3	-kVAh∑-C • System exported capacitive apparent energy	PLS
00F4	+kVAh∑-L • System imported inductive apparent energy	PLS
00F5	-kVAh∑-L • System exported inductive apparent energy	PLS
00FB	+kvarh1-C • Phase 1 imported capacitive reactive energy	PLS
00FC	-kvarh1-C • Phase 1 exported capacitive reactive energy	PLS
00FD	+kvarh1-L • Phase 1 imported inductive reactive energy	PLS
00FE	-kvarh1-L • Phase 1 exported inductive reactive energy	PLS
00FF	+kvarh2-C • Phase 2 imported capacitive reactive energy	PLS
0100	-kvarh2-C • Phase 2 exported capacitive reactive energy	PLS
0101	+kvarh2-L • Phase 2 imported inductive reactive energy	PLS
0102	-kvarh2-L • Phase 2 exported inductive reactive energy	PLS
0103	+kvarh3-C • Phase 3 imported capacitive reactive energy	PLS
0104	-kvarh3-C • Phase 3 exported capacitive reactive energy	PLS

CODE (Hex)	Description	DIGITAL OUTPUT AL=Alarm PLS=Pulse
PARAMETER CODES		
0105	+kvarh3-L • Phase 3 imported inductive reactive energy	PLS
0106	-kvarh3-L • Phase 3 exported inductive reactive energy	PLS
0107	+kvarh∑-C • System imported capacitive reactive energy	PLS
0108	-kvarh∑-C • System exported capacitive reactive energy	PLS
0109	+kvarh∑-L • System imported inductive reactive energy	PLS
010A	-kvarh∑-L • System exported inductive reactive energy	PLS

Register description	F. code (Hex)	INTEGER		Programmable data
		Register (Hex)	Words	
RECORDING DOWNLOAD				
Prepare data for downloading	10	F000	2	\$01=prepare AVG recording
Delete recorded data (irreversible operation)	10	F002	2	\$01=delete AVG recording
Read the record/s block previously downloaded (do not consider the first word). The download block always contains an integer record number. For the block structure refer to the description of \$F101 register.	03 / 04	F100	1+ ≤124	Set the word number considering that the download block must contain an integer record number + 1 word. Each record contains only the enabled parameters + timestamp. Example: 109 words=\$006D
Download and read the first/next record/s block. Example Active&reactive powers, 16 values; the record length is 2(timestamp)+16 words=18(\$12); the download block will contain 6 records.	03 / 04	F101	≤124	Set the word number considering that the download block must contain an integer record number. Each record contains only the enabled parameters + timestamp. Example: 108 words=\$006C

Register description	Value format	Words
AVG RECORDING PARAMETER BLOCK (FIXED)		
Timestamp of the record block	UnixTime	2
$+P1_{AVG}$ • Phase 1 imported active power AVG	0.005% FS	1
$-P1_{AVG}$ • Phase 1 exported active power AVG	0.005% FS	1
$+P2_{AVG}$ • Phase 2 imported active power AVG	0.005% FS	1
$-P2_{AVG}$ • Phase 2 exported active power AVG	0.005% FS	1
$+P3_{AVG}$ • Phase 3 imported active power AVG	0.005% FS	1
$-P3_{AVG}$ • Phase 3 exported active power AVG	0.005% FS	1
$+P\Sigma_{AVG}$ • System imported active power AVG	0.005% FS	1
$-P\Sigma_{AVG}$ • System exported active power AVG	0.005% FS	1
$+Q1_{AVG}$ • Phase 1 imported reactive power AVG	0.005% FS	1
$-Q1_{AVG}$ • Phase 1 exported reactive power AVG	0.005% FS	1
$+Q2_{AVG}$ • Phase 2 imported reactive power AVG	0.005% FS	1
$-Q2_{AVG}$ • Phase 2 exported reactive power AVG	0.005% FS	1
$+Q3_{AVG}$ • Phase 3 imported reactive power AVG	0.005% FS	1
$-Q3_{AVG}$ • Phase 3 exported reactive power AVG	0.005% FS	1
$+Q\Sigma_{AVG}$ • System imported reactive power AVG	0.005% FS	1
$-Q\Sigma_{AVG}$ • System exported reactive power AVG	0.005% FS	1

4.3 CONSIDERATIONS ON THE FULL SCALE VALUE CALCULATION

The phase power full scale is the result of a multiplication between PT primary and phase X current full scale (X=1, 2 or 3). If the PT primary and secondary values are set to 1 (direct connection), the phase power full scale is the result of a multiplication between 290V and phase X current full scale (X=1, 2 or 3).

For the current full scale value to be used in the formula, consider the following values according to the selected instrument scale:

Scale 500A → FS_A = 700A

Scale 4000A → FS_A = 5600A

Scale 20000A → FS_A = 28000A

<u>Example: formula for phase 1 power full scale</u>

$FS_{P1,S1,Q1} = PT_{pri} * FS_{A1}$ if $PT_{pri}=PT_{sec}=1 \rightarrow FS_{P1,S1,Q1} = 290V * FS_{A1}$

The system power full scale is the result of a multiplication between 3 and PT primary and max phase current full scale. If the PT primary and secondary values are set to 1 (direct connection), the system power full scale is the result of a multiplication between 3 and 290V and max phase current full scale.

<u>Example: formula for system power full scale</u>

$FS_{P\Sigma,S\Sigma,Q\Sigma} = 3 * PT_{pri} * FS_{AMAX}$ if $PT_{pri}=PT_{sec}=1 \rightarrow FS_{P\Sigma,S\Sigma,Q\Sigma} = 3 * 290V * FS_{AMAX}$

5. READING COMMAND EXAMPLES

In this chapter, some reading command examples are described.

These tables refer to a master-slave communication in MODBUS RTU.

Values contained both in Query and Response messages are in hex format.

CURRENT VALUE READING

Query example: 0103000E000A0EA4

Example	Byte	Description
01	-	Slave address
03	-	Function code
00	High	Starting register
0E	Low	
00	High	10 words to be read
0A	Low	
0E	High	CRC
A4	Low	

Response example: 010314000009990000099F0000099000000019000000998C070

Example	Byte	Description
01	-	Slave address
03	-	Function code
14	-	20 data bytes
00	High	2457 mA phase 1 current (A1)
00	Low	
09	High	
99	Low	
00	High	2463 mA phase 2 current (A2)
00	Low	
09	High	
9F	Low	
00	High	2448 mA phase 3 current (A3)
00	Low	
09	High	
90	Low	
00	High	25 mA neutral current (AN)
00	Low	
00	High	
19	Low	
00	High	2456 mA system current (A∑)
00	Low	
09	High	
98	Low	
C0	High	CRC
70	Low	

WIRING MODE READING

Query example: 0103203C0002C70F

Example	Byte	Description
01	-	Slave address
03	-	Function code
20	High	Starting register
3C	Low	
00	High	2 words to be read
02	Low	
C7	High	CRC
0F	Low	

Response example: 01030400018599

Example	Byte	Description
01	-	Slave address
03	-	Function code
04	-	4 data bytes
00	High	3 phase, 4 wire, 3 current wiring mode
00	Low	
00	High	
01	Low	
85	High	CRC
99	Low	

6. WRITING COMMAND EXAMPLES

In this chapter, some writing command examples are described.

These tables refer to a master-slave communication in MODBUS RTU.

Values contained in Command, Query and Response messages are in hex format.

WIRING MODE SETUP

Command example: 0110203C000204000000032E29

Example	Byte	Description
01	-	Slave address
10	-	Function code
20	High	Starting register
3C	Low	
00	High	2 words to be written
02	Low	
04	-	4 data bytes
00	High	Set 1 phase wiring mode
00	Low	
00	High	
03	Low	
2E	High	CRC
29	Low	

Response example: 0110203C0002048A

Example	Byte	Description
01	-	Slave address
10	-	Function code
20	High	Starting register
3C	Low	
00	High	2 written words
02	Low	
04	High	CRC
8A	Low	

MODBUS
Communication Protocol

DATE&TIME SETUP

Command example: 0110204A000204522E5FD43FA7

Example	Byte	Description
01	-	Slave address
10	-	Function code
20	High	Starting register
4A	Low	
00	High	2 words to be written
02	Low	
04	-	4 data bytes
52	High	Set 9th September 2013, 23:55:00
2E	Low	
5F	High	
D4	Low	
3F	High	CRC
A7	Low	

Response example: 0110204A0002DE6B

Example	Byte	Description
01	-	Slave address
10	-	Function code
20	High	Starting register
4A	Low	
00	High	2 written words
02	Low	
DE	High	CRC
6B	Low	

RECORDING DOWNLOAD

1° STEP: prepare data for downloading

Command example: 0110F000000204000000016B36

Example	Byte	Description
01	-	Slave address
10	-	Function code
F0	High	Starting register
00	Low	
00	High	2 words to be written
02	Low	
04	-	4 data bytes
00	High	Prepare data for downloading
00	Low	
00	High	
01	Low	
6B	High	CRC
36	Low	

Response example: 0110F000000272C8

Example	Byte	Description
01	-	Slave address
10	-	Function code
F0	High	Starting register
00	Low	
00	High	2 written words
02	Low	
72	High	CRC
C8	Low	

2° STEP: perform the data download by a reading command

Query example: 0104F101006C931B

Example	Byte	Description
01	-	Slave address
04	-	Function code
F1	High	Starting register
01	Low	
00	High	108 words to be read
6C	Low	
0B	High	CRC
3B	Low	

Response example:
01 04 D8
53FDAEF0 05FC 0000 05FB 0000 05FA 0000 05FB 0000 002E 0000 002D 0000 0030 0000 002F 0000
53FDAF2C 0955 0000 0953 0000 0953 0000 0954 0000 003C 0000 003C 0000 003F 0000 003D 0000
53FDAF68 10BB 0000 10B9 0000 10B8 0000 10BA 0000 0057 0000 0057 0000 005B 0000 0059 0000
53FDAFA4 10C4 0000 10C2 0000 10C1 0000 10C2 0000 0057 0000 0057 0000 005B 0000 0059 0000
53FDAFE0 10BF 0000 10BD 0000 10BC 0000 10BE 0000 0057 0000 0058 0000 005C 0000 0059 0000
53FDB01C 10C1 0000 10BF 0000 10BE 0000 10BF 0000 0057 0000 0058 0000 005C 0000 0059 0000
A26C

Example	Byte	Description	
01	-	Slave address	
04	-	Function code	
D8	-	216 data bytes	
53	High	27th August 2014, 10:12:00 record block	1ST RECORD
FD	Low		
AE	High		
F0	Low		
05	High	0,111 kW phase 1 imported active power AVG $(+P1_{AVG})$	
FC	Low		
00	High	0 kW phase 1 exported active power AVG $(-P1_{AVG})$	
00	Low		
05	High	0,111 kW phase 2 imported active power AVG $(+P2_{AVG})$	
FB	Low		
00	High	0 kW phase 2 exported active power AVG $(-P2_{AVG})$	
00	Low		
05	High	0,111 kW phase 3 imported active power AVG $(+P3_{AVG})$	
FA	Low		
00	High	0 kW phase 3 exported active power AVG $(-P3_{AVG})$	
00	Low		
05	High	0,333 kW system imported active power AVG $(+P\sum_{AVG})$	
FB	Low		
00	High	0 kW system exported active power AVG $(-P\sum_{AVG})$	
00	Low		
00	High	0,003 kvar phase 1 imported reactive power AVG $(+Q1_{AVG})$	
2E	Low		
00	High	0 kvar phase 1 exported reactive power AVG $(-Q1_{AVG})$	
00	Low		
00	High	0,003 kvar phase 2 imported reactive power AVG $(+Q2_{AVG})$	
2D	Low		
00	High	0 kvar phase 2 exported reactive power AVG $(-Q2_{AVG})$	
00	Low		
00	High	0,003 kvar phase 3 imported reactive power AVG $(+Q3_{AVG})$	
30	Low		
00	High	0 kvar phase 3 exported reactive power AVG $(-Q3_{AVG})$	
00	Low		
00	High	0,010 kvar system imported reactive power AVG $(+Q\sum_{AVG})$	
2F	Low		
00	High	0 kvar system exported reactive power AVG $(-Q\sum_{AVG})$	
00	Low		
53	High	27th August 2014, 10:13:00 record block	2ND RECORD
FD	Low		
AF	High		
2C	Low		
09	High	0,172 kW phase 1 imported active power AVG (+P1	
55	Low		
A2	High	CRC	
6C	Low		

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