ENERGY.3-O-DIS-RS

ANALIZADOR DE RED TRIFÁSICO

Remberg®

CE

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User Manual
THREE-PHASE NETWORK ANALYSER
Read all the instructions carefully

- ENERGY.3-O.... is a direct-connection digital multimeter for three-phase systems and up to 90A true root mean square measurements (TRMS). A serial output RS-485 makes it possible to display and store data on a PC.

English

SAFETY INSTRUCTIONS

During the installation and operation of the device, observe the following instructions:

1) The device must be installed by a qualified person

2) The device must be installed in an electrical panel which, after installation, leaves terminals inaccessible
3) The electrical system in the building where the device is installed must feature a switch or circuit breaker: this must be near the device and in a position that can be easily reached by operators
4) A protection device against over-currents must be installed in the electrical system, upstream of the instrument
5) Connect the device as shown in the diagrams of this manual
6) Before making contact with terminals, ensure that conductors to be connected to the device are not live
7) Do not power or connect the device if any part of it is damaged.

NOTE: Network analyzer is aimed for use in places with over-voltage category III and pollution degree, 2 as per EN 61010-1

TECHNICAL SPECIFICATIONS

- Power supply: 400 V AC (-15%/+10%), 50/60 Hz (terminals 2 and 3)
- Electrical quantities measured:
  – Phase voltage, voltage between lines (chain), and system voltage
  – Phase and system current
  – Active, reactive, and apparent phase and system power
  – Active and reactive phase and total system Energy (zeroable)
  – Phase and system power factor (cos φ)
  – Frequency
- Connection type:
  – 3-wire connection with neutral
  – 3-wire connection without neutral: only for symmetrical and balanced systems
- Voltmetric inputs: V_{max} = 440 V rms (phase – phase)
  V_{max} = 3x253 V rms (phase – neutral)
- Amperometric inputs: I_b = 10 A; I_{max} = 90 A
- Insulated serial output RS-485, for communication protocol MODBUS RTU
- Termination:
  – voltmetric inputs: 4-pole terminal strip; maximum section of wires: 2.5 mm^2
  – RS485 serial line: 2-pole terminal strip; maximum section of wires: 2.5 mm^2
  – amperometric inputs: direct connection, with the current wires inserted into the suitable holes; maximum section of current leads: 25 mm^2; maximum diameter of through hole: 12,5 mm
- Maximum consumption (device only):
  – voltage circuits < 2.5 VA
  – current circuits < 2.5 VA
  – power supply < 4VA
- Display: LCD display
- Dimensions: 7 DIN sizes
- Operating temperature: -10 °C ÷ +45 °C
- Storage temperature: -10 °C ÷ +60 °C
- Relative humidity: 10% ÷ 90% non condensing
- Protection rating: IP20/IP51 on the front

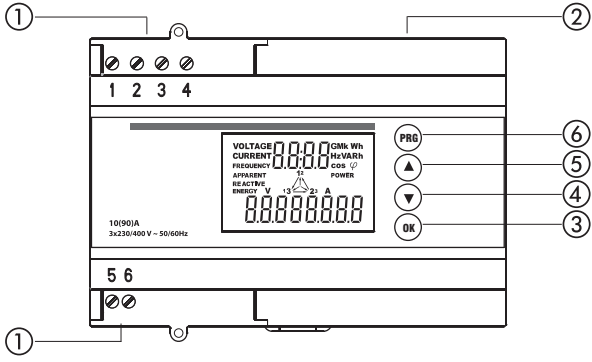
RESOLUTION AND ACCURACY

- Voltage
  – Maximum reading: 266V (phase - neutral)
  – Accuracy: ±0.5% full scale ± 1 digit (full scale: 253V)
  – Resolution: 1V

- Current
  - Minimum reading: 0.10A
  - Maximum reading: 95.0A
  - Accuracy: ±0.5% full scale ± 1 digit (full scale: 90A)
  - Resolution: 0.01A (range 0.10÷9.99A) or 0.1A (range 10.0÷90.0A)
- Active power
  - Accuracy: ± 1% full scale ± 1 digit at 50Hz (full scale: 100W, 1kW, 10kW, 100kW)
  - Resolution: 0.1W (range 0÷99.9W) - 1W (range 100W÷999W) - 0.01kW (range 0.01kW÷9.99kW) - 0.1kW (range 10kW÷100kW)
- Reactive power
  - Accuracy: ±1% full scale ± 1 digit (full scale: 100Var, 1kVar, 10kVar, 100kVar)
  - Resolution: 0.1Var (range 0÷99.9Var) - 1Var (range 100Var÷999Var) - 0.01kVar (range 0.01kVar÷9.99kVar) - 0.1kVar (range 10kVar÷100kVar)
- Active energy
  - Accuracy: class 1 to standard EN 62053-21 (I_b=10A; I_{max}=90A)
  - Resolution: 0.1 kWh
- Reactive energy
  - Accuracy: class 3 to standard EN 62053-23 (I_b=10A; I_{max}=90A)
  - Resolution: 0.1 kVarh
- Power factor (cos φ)
  - Accuracy: ±1% ± 1 digit
  - Resolution: 0.01
- Frequency
  - Accuracy: ±0.1 Hz ± 1 digit (from 47 Hz a 63 Hz)
  - Resolution: 0.1 Hz

DESCRIPTION

FRONT VIEW

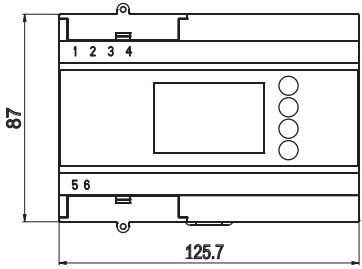


TERMINALS AND KEYS

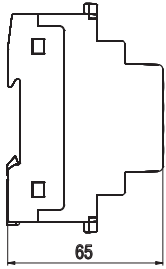
① Terminal 1: Neutral (required for non-symmetrical non-balanced systems)
Terminals 2, 3, 4: voltage inputs (L1, L2, L3)
Terminals 5 (-) and 6 (+): Serial communication line RS-485
② Through holes for direct current connection to L1, L2, L3
③ Key to be used to confirm and view system quantities
④ Previous page Key
⑤ Next page key
⑥ Programming key

DIMENSIONS (mm)

FRONT VIEW

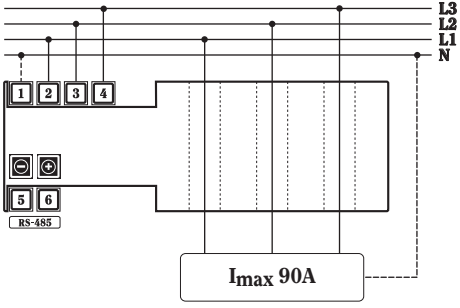


SIDE VIEW



INSTALLATION

WIRING DIAGRAM



NOTE:
Connection of the neutral conductor may ONLY be omitted for balanced symmetrical three-phase systems

INSTALLATION

Network analyzer may only be used in three-phase systems 230V AC Phase-neutral, with 400V AC Phase-Phase voltage between lines.

As for installation directions, follow the diagram on page 28:
- for 4-wire three-phase systems (3 phases + neutral) also with non-symmetrical and/or non-balanced systems, connect the neutral lead to terminal 1
- for 3-wire three-phase symmetrical and balanced systems, it is possible not to connect the neutral lead

For correct measurement, the 3 phase leads coming from the distribution panel must be inserted in the through holes vertically from above; failure to do so will cause a connection-error warning to appear on the display. In case of a connection error, the display will indicate which phase or phases are misconnected (cfr. “ERROR MESSAGES – MISCONNECTION”).

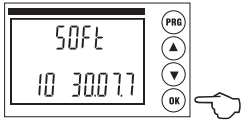
SELECTING PROGRAMMING PARAMETERS

The following functions are accessed by holding down the PRG key for at least 2 seconds:
- viewing built-in software version and date
- backlighting control
- zeroing total active and reactive energy values
- configuring serial output RS-485

To scroll the various parameters and confirm the values entered, press the OK key. To change the values or alter the option, press ▲ or ▼.

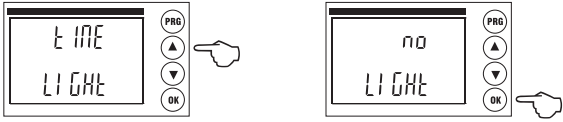
As soon as the last page is confirmed the programming mode is exited; this also occurs if no key is pressed for at least 25 seconds: in this case, the parameter that was not confirmed using the OK key, is not stored.

1) DATE AND VERSION OF BUILT-IN SOFTWARE



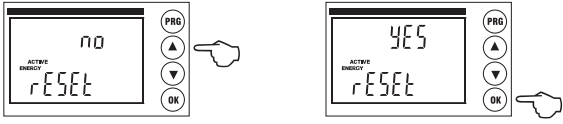
- These values cannot be altered
- To move on to the next page (backlighting control), press OK

2) BACKLIGHTING CONTROL



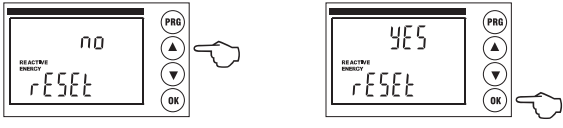
- Press the key ▲ or ▼ to respectively select “NO” (backlighting off) or “TIME” (backlighting ON for 60s after any key is pressed)
- Press the OK key to confirm the selection and move on to the next page (Zeroing Active Energy meter)

3) ZEROING THE ACTIVE-ENERGY METER



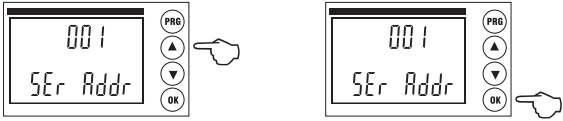
- Press the key ▲ to select “NO” or ▼ for “YES”
- Press the OK key to confirm the selection and move on to the next page (Zeroing the Reactive Energy meter)

4) ZEROING THE REACTIVE-ENERGY METER



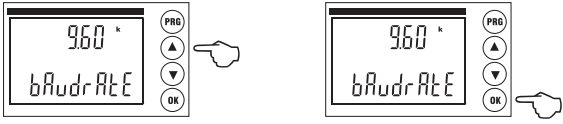
- Press ▲ to select “NO” or ▼ to select “YES”
- Press the OK key to confirm the selection and move on to the next page (RS-485 address)

5) RS-485 ADDRESS



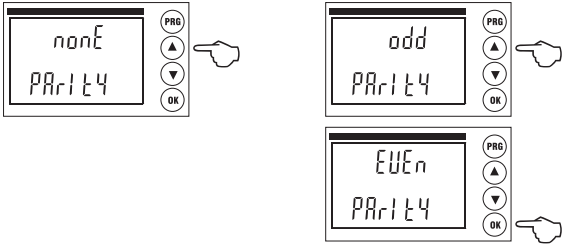
- The address range is between 1 and 247
- Press the PRG key to select the digit to be altered (units, tens, hundreds)
- Press the key ▲ or ▼ to select the value
- Press the OK key to confirm the address and move on to the next page (RS-485 communication speed)

6) RS-485 COMMUNICATION SPEED



- The available Communication speed options are 1200, 2400, 4800, 9600 baud
- Press the key ▲ or ▼ to select the desired speed
- Press the OK key to confirm the address and move on to the next page (RS-485 Parity bit)

7) RS-485 PARITY BIT



- Available Parity bit options are “NONE”, “EVEN” and “ODD”
- Press the key ▲ or ▼ to select the desired parity bit

- Press the OK key to confirm and exit programming (all the display segments will be viewed for 2 seconds. Then the main page will be displayed)

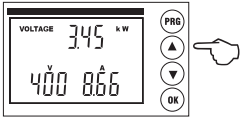
READING OF QUANTITIES

On powering up the device the main page is viewed, which reads system voltage, system current and system active power.

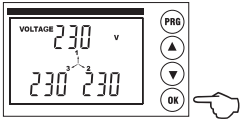
From the main page, press the key ▲ to scroll all the other measurement pages. When on the last page, press the key ▲, to go back to the main page. Press the key ▼ to view the previous page.

To view the system quantities or the energy for every single phase (active or reactive), press the OK key.

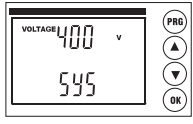
Main page
(system power, voltage and current)



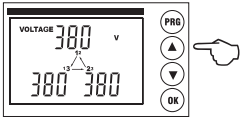
Phase voltage



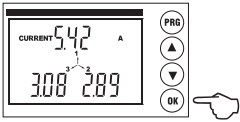
System voltage



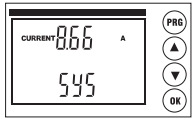
Voltage between lines (chain)



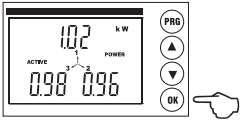
Phase current



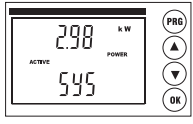
System current



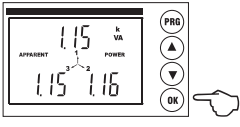
Phase active power



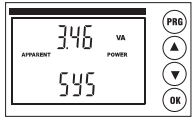
System active power



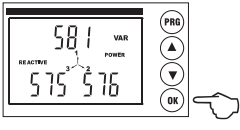
Phase apparent power



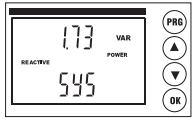
System apparent power



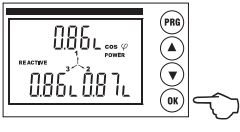
Phase reactive power



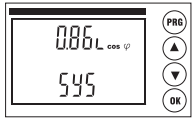
System reactive power



Phase power factor (*)

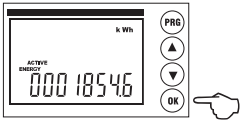


System power factor

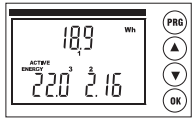


(*) Depending on load type, “c” stands for capacitive power factor, whereas “L” stands for inductive phase shift

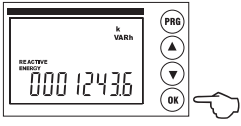
Total active energy



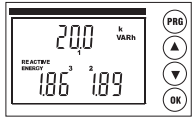
Phase active energy



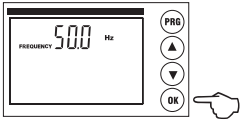
Total reactive energy



Phase reactive energy



Frequency



SERIAL COMMUNICATION

The reference document for all the aspects of the Modbus, as well as the only official specification of the protocol in question, is that found in the web site www.modbus.org. The data communication system based on the Modbus protocol makes it possible to connect up to 247 instruments to a common RS485 line. The communication takes place in half duplex, and only the master (PC/PLC) is able to initiate the question and answer type dialogue with the slaves (address 0) without obtaining any reply.

CHARACTERISTICS OF THE MODBUS PROTOCOL

- Type of Modbus coding: RTU (Remote Terminal Unit)
- Transmission speed (Baud rate): 9600, 4800, 2400, 1200 bps (selectable by the user)
- Byte format transmitted: 1 start bit, 8 data bits, parity bit: none odd, even (as selected), 1 stop bit

The default configuration on leaving the factory for the communication parameters (which can be selected from the keyboard only) is: baud rate = 9600 bps, parity bit = none, address = 1.

MESSAGE STRUCTURE

The message is structured in various fields (start, address, function, data, CRC check, end), made up of 1 or more characters each; the characters permitted for each field are the hexadecimals 0…9, A…F; the entire message has to be sent with no interruptions, and if there is a pause lasting more than a transmission time of 1.5 characters the receiver has to recognise the incomplete message condition and assume that the following byte is the start of a new message. The start and end of the message can be recognised by a silent interval of at least 3.5 characters. The message can be summed up as follows:

START	ADDRESS	FUNCTION	DATA	CRC CHECK	END
T1-T2-T3-T4	8 BITS	8 BITS	#X 8 BITS	16 BITS	T1-T2-T3-T4

ERROR CHECK CALCULATION PROCEDURE

The Cyclical Redundancy Check (CRC) field is made up of two bytes and contains a 16 bit binary value. This value is calculated by the transmitter device, which inserts the CRC in the message. The receiver device recalculates the CRC during the reception of

the message and compares the value calculated with that received in the message. If the two values do not coincide, an error condition is generated.

MODBUS FUNCTIONS IMPLEMENTED

Read input register (04)
Force multiple coil (15)*

* messages addressable to all slave (slave address = 0)

Read input register (4):
Function for the reading of the registers in which the measurements are memorised. The instrument allows to obtain the value of all available measurements (33) with a single request.

The measurements available are:

V = system voltage
I = system current
P = active system power
Q = reactive system power
A = apparent system power
PF = system power factor
Ea = total active energy
Er = total reactive energy
f = frequency (phase 1)
V12, V23, V31 = concatenated voltage
Vn = phase voltage (n = 1, 2, 3)
In = phase current (n = 1, 2, 3)
Pn = active phase power (n = 1, 2, 3)
An = apparent phase power (n = 1, 2, 3)
Qn = reactive phase power (n = 1, 2, 3)
PFn = phase power factor (n = 1, 2, 3)
ϕn = phase shift between voltage and corresponding current (n = 1, 2, 3)

The two bytes to indicate the register are obtained by removing the indicative and subtracting one from the register number.
For example: 30009 → 0009 → (0009-1) =0008

List of register inputs: each pair of registers contains the value of an electrical dimension measured, expressed in IEEE floating point format. The two energy meters

are expressed by means of an internal number in 32 bits.

Address	N. words	Dimension	Unit		Address	N. words	Dimension	Unit
30001	2	V	[V]		30035	2	P2	[W]
30003	2	I	[A]		30037	2	P3	[W]
30005	2	P	[W]		30039	2	A1	[VA]
30007	2	A	[VA]		30041	2	A2	[VA]
30009	2	Q	[var]		30043	2	A3	[VA]
30011	2	PF	---		30045	2	Q1	[var]
30013	2	f	[Hz]		30047	2	Q2	[var]
30015	2	V12	[V]		30049	2	Q3	[var]
30017	2	V23	[V]		30051	2	PF1	---
30019	2	V31	[V]		30053	2	PF2	---
30021	2	V1	[V]		30055	2	PF3	---
30023	2	V2	[V]		30057	2	ϕ1	°
30025	2	V3	[V]		30059	2	ϕ2	°
30027	2	I1	[A]		30061	2	ϕ3	°
30029	2	I2	[A]		30063	2	Ea	[kW/10]
30031	2	I3	[A]		30065	2	Er	[kvar/10]
30033	2	P1	[W]					

All the measurements contained in the input registers (with the exception of energy meters) are expressed in standard floating point numerical format IEEE-754, which encodes a floating point number of 32 bits, made up of: 1 sign bit, 8 exponent bits and 23 mantissa bits, arranged as follows:

Sign	Exponent	Mantissa
1 Bit	8 Bit	23 Bit
MSB		LSB

The value is encoded as:

$$-1^{s} * (1+m) * 2^{(e-127)}$$

s: sign bit. If the value is negative, this is equal to 1, if positive it is equal to 0.

e: exponent encoded at 8 bits, calculated with an offset of +127.
m: mantissa encoded at 23 bits, calculated by subtracting 1, in such a way as to obtain numbers always between 1 and 1.999999881 ($2-(2^{-23})$), which can be encoded in negative powers of 2.

Force multiple coil (15 = Fhex)
This function is used to carry out commands on the instrument.
According to the Moodbus RTU protocol the string (hexadecimal) to send for this function is the following:

Slave address	0-F7	(0-F7hex = 0-247)
Function	F	(Fhex = 15)
Coil Address Hi	0	(n.u.)
Coil Address Lo	0	(fixed)
Quantity of coils Hi	0	(n.u.)
Quantity of coils Lo	3	(fixed)
Byte Count	1	(fixed)
Force Data Hi	1/2/4	
Force Data Lo	0	(n.u.)
CRC1	---	
CRC2	---	

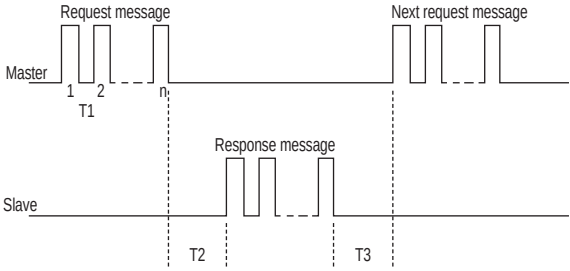
Meaning of the implemented commands: Force Data Hi
bit 0 = 1 set both active and reactive energy meters to zero
bit 1 = 1 set the only active energy meter to zero
bit 2 = 1 set the only reactive energy meter to zero

COMMUNICATION ERRORS DETECTED

"No response". Data format error, CRC error, etc (it is therefore not possible to be certain that the message is correctly addressed).
"Exception response". The possible error codes are:
01 – illegal function
02 – illegal data address
03 – illegal data value

SERIAL COMMUNICATION TIMES

The communication protocol has no restrictions with regard to the response time of a slave device interrogated by a master (time T2), or with regard to time T3, that is, the time lapsing between the end of a response and the start of a new interrogation by the master.



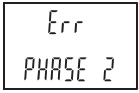
However, these parameters take on particular importance in the setting up of a network made up of a large number of instruments, in fact if T2 and T3 are not restricted by determined maximum values, the time needed by the master (PC) to interrogate the entire rate may be excessive. It is also necessary to set the minimum values to avoid problems of conflict between different devices. The accepted values are listed inside this table:

Time	Description	Min/Typ/Max values
T1	Inter-character timeout: 1.5 (one character duration)	Max =12ms (a 1200bps) Max =6ms (a 2400bps) Max =3ms (a 4800bps) Max =1.5ms (a 9600bps)
T2	Slave response time	Min = 25ms Typ = 30ms Max =100ms
T3	Minimum time between two request messages from the Master	Min = 100ms Typ > 1s

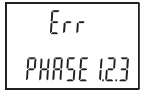
ERROR MESSAGES

MISCONNECTION

In the first two minutes after power-up, misconnection is indicated by the reading “Err PHASE” and the relevant phase number.

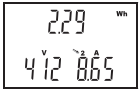


Misconnection of phase 2

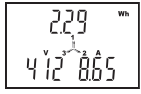


Misconnection of phases 1, 2 ,3

Two minutes after power up the “Err PHASE” reading disappears. The arrow corresponding to the misconnected phase will then flash on the display.
The latter warning will stay on the display until the error is removed



Misconnection of phase 2
(arrow 2 flashing)

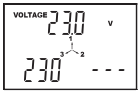


Misconnection of phases 1, 2 ,3
(arrows 1,2,3 flashing)

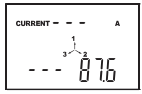
Possible error causes are:
- one or more phase leads from the distribution panel may have been inserted upward into the current-measuring through holes
- the phase connected to the voltage input terminals (2,3,4) is not the same one inserted into the corresponding through hole. For instance: the phase connected to terminal 2 (phase 1) may have been inserted in the middle through hole (phase 2)

OVER-VOLTAGE OR OVER-CURRENT ERROR

This occurs when the TRMS value of one or more input phases exceeds a voltage of 265V or a current of 95A. This error is indicated by the flashing of all display pages. Voltage or current overflow is indicated by three dashes “**---**” on the relevant field



V2 > 266V

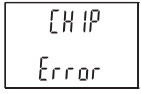


I1 and I3 > 95A

The device resumes correct value readings when voltage and/or current get back into the admitted ranges (V ≤ 253 and I ≤ 90A respectively).

CONFIGURATION ERROR

Every 30 seconds the software checks configuration settings in some internal registries; if an invalid datum is detected, the device is automatically reconfigures until the error disappears.
During these steps, the device does not measure any quantity and reads “CHIP Error”



Configuration error

If the error warning stays on even after disconnecting and reconnecting the device from the mains, the latter must be considered as faulty.

REFERENCE STANDARDS

Conformity to EC directives
2006/95/EC (LVD)
2004/108/EC (EMC)
is declared with reference to the following harmonised standards:

- **Safety**: EN 61010-1
- **Electromagnetic compatibility**: EN 61000-6-2 and EN 61000-6-4
- **Metering requirements**: EN 62052-21 and EN 62053-23