Energy Management
Modular Power Quality Analyzer
Type WM23-96

- **Accuracy ±0.5 F.S. (current/voltage)**
- **Three-phase modular power analyzer**
- **Backlighted LCD 4x3 1/2 DGT Display**
- **Front size: 96x96 mm**
- **Measurements of phase and system variables: W, W_{dmd}, var, VA, VA_{dmd}, PF, V_{L-N}, V_{L-L}, A, An, Hz, THD-A, THD-V**
- **TRMS measurement of distorted waves (voltages/currents)**
- **Measurement of MAX values: W L1, W L2, W L3, W$\sum$, W_{dmd} (AL1-AL2-AL3 max on request)**
- **Measurement of MIN values: PF L1, PF L2, PF L3, PF $\sum$**
- **Harmonic analysis (FFT) up to the 16th harmonic (current and voltage)**
- **Instantaneous variables read-out: 4x3 1/2 digit**
- **Up to 2 optional relay or open collector outputs**
- **1 optional analogue output**
- **MODBUS, JBUS Protocol**
- **Protection degree (front): IP 65**
- **Universal power supply: 18-60VAC/VDC, 90-260 VAC/VDC**

- **Phases asymmetry control**
- **Optional RS 232 serial port**
- **Optional RS 422/485 serial port**

Product Description

µP-based three-phase modular power quality analyzer with built-in programming key-pad.
Particularly recommended for a detailed analysis of the electrical variables and of the power quality. Housing for panel mounting and IP65 (front) protection degree.

Ordering Key

WM23-96AV53H XX XX XX XX X

Model
Range Code
System
Power Supply
Slot A
Slot B
Slot C
Slot D
Options

Type selection

Range code

AV4: 208VLL/5(6)AAC -20% ≤ Un ≤+20%
AV5: 400VLL/5(6)AAC -20% ≤ Un ≤+15%
AV6: 100VLL/5(6)AAC -20% ≤ Un ≤+15%
AV7: 660VLL/5(6)AAC -30% ≤ Un ≤+15%
50-60 Hz for all input modules. Module not removable.

System

3: Three-phase, unbalanced load, with or without neutral

Power supply

A: 24 VAC -15 +10% 50-60Hz
B: 48 VAC -15 +10% 50-60Hz
C: 115VAC -15 +10% 50-60Hz
D: 230 VAC -15 +10% 50-60Hz
L: 18 to 60VAC/VDC
H: 90 to 260VAC/VDC

Slot A (signal retransmission)

XX: None
A1: Single analogue output, 20mADC
A2: Single analogue output, ±5mADC
A3: Single analogue output, ±10mADC
A4: Single analogue output, ±20mADC
B1: Dual analogue output, 20mADC
B2: Dual analogue output, ±5mADC
B3: Dual analogue output, ±10mADC
B4: Dual analogue output, ±20mADC
V1: Single analogue output, 10VDC
V2: Single analogue output, ±1VDC
V3: Single analogue output, ±5VDC
V4: Single analogue output, ±10VDC
W1: Dual analogue output, 10VDC
W2: Dual analogue output, ±1VDC
W3: Dual analogue output, ±5VDC
W4: Dual analogue output, ±10VDC

Slot B (communication)

XX: None
S1: Serial port, RS485 multidrop, bidirectional

NOTE: max. digital output (alarms and/or pulses): 2, any exceeding output is redundant.

NOTE: the second analogue output is intended as redundant type only.

NOTE: with the A, B, C, D types power supply, only an open collector module or a single relay output module can be used. The instrument can be fully equipped only with L and H type power supply.

Slot C (redundant output or digital inputs)

XX: None
R1: Single relay output (AC1-8AAC, 250VAC)
R2: Dual relay output (AC1-8AAC, 250VAC)
O1: Single open collector output (30V/100mADC)
O2: Dual open collector output (30V/100mADC)
D1: 3 digital inputs
D2: 3 digital inputs + aux output

Slot D (alarm output)

XX: None
R1: Single relay output, (AC1-8AAC, 250VAC)
R2: Dual relay output, (AC1-8AAC, 250VAC)
O1: Single open collector output (30V/100mADC)
O2: Dual open collector output (30V/100mADC)

Options

X: None
S: RS232 serial port
A: displaying and recording of AL1-AL2-AL3 max instead of WL1-WL2-WL3 max.
Y: Options: S+A above.

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Input Specifications

Number of analogue inputs	
Current	3
Voltage	4
Digital Inputs	
AQ1038	Number of inputs: 3 (voltage free)
Use	Synchronization of the W-VAdmd measurements Input 1: lock of programming Inputs 2 and 3: W-VA dmd measurements synchronization
Reading voltage	24VDC/1mA
AQ1042	Number of inputs: 3 + inputs power supply
Input frequency	Max 20Hz, dutycycle 50%
Output voltage	16V<+Aux<24VDC
Output current	Max 15mA
Open contact resistance	Min 100kΩ
Insulation	4000VRMS
Accuracy (display, RS232, RS485)	In=5A; Pn= In* Un Un: F.S. range AV4-5-6-7
Current	±(0.5% In +2DGT)
Phase-neutral voltage	±(0.5% Un +2DGT)
Phase-phase voltage	±(1% Un +2DGT)
Frequency	±0.1Hz
Active power (@ 25°C ± 5°C, R.H. ≤ 60%)	±(1% Pn +2DGT)
Reactive Power (@ 25°C ± 5°C, R.H. ≤ 60%)	±(2% Pn +2DGT)
Apparent power (@ 25°C ± 5°C, R.H. ≤ 60%)	±(1% Pn +2DGT)
Harmonic distortion (@ 25°C ± 5°C, R.H. ≤ 60%)	±3% F.S. (up to 16th harmonic) (F.S.: 100%)
Additional errors	
Humidity	≤0.3% F.S. from 60% to 90% H.R.
Temperature drift	≤ 200ppm/°C
Display	Back-lighted LCD 4x3½ digit 70 x 38mm
Display refresh time	700ms
Measurements	Current, voltage, power, power factor, frequency, harmonic distortion. TRMS measurement of a distorted wave.
Coupling type	Direct
Input impedance	
208VLL 5(6)AAC (AV4):	>200 kΩ
400VLL 5(6)AAC (AV5):	>900 kΩ
100VLL 5(6)AAC (AV6):	>200 kΩ
660VLL 5(6)AAC (AV7):	>900 kΩ

Output Specifications

Analogue Outputs	(on request)
Number of outputs	Up to 1 (+1 redundant)
Accuracy	±0.2% f.s. (@ 25°C ±5°C, R.H. ≤60%)
Range	0 to 20 mADC, 0 to ±20 mADC 0 to ±10 mADC, 0 to ±5 mADC 0 to 10 VDC, 0 to ±10 VDC 0 to ±5 VDC 0 to ±1 VDC
Scaling factor:	Programmable within the whole range of retransmission; it allows the retransmission management of all values from: 0 and 20 mADC,
Response time	≤ 900 ms typical (filter excluded, FFT excluded)
Ripple	≤1% acc. to IEC 60688-1, EN 60688-1
Total temperature drift	≤ 500 ppm/°C
Load: 20 mADC	≤ 600 Ω
±20 mADC	≤ 550 Ω
±10 mADC	≤ 1100 Ω
± 5 mADC	≤ 2200 Ω
10 VDC	≥ 10 kΩ
±10 VDC	≥ 10 kΩ
± 5 VDC	≥ 10 kΩ
± 1 VDC	≥ 10 kΩ
Insulation	By means of optocouplers, 4000 V_{RMS} output to measuring input 4000 V_{RMS} output to supply input
RS422/RS485	(on request) Multidrop bidirectional (static and dynamic variables)
Connections	2 or 4 wires, max. distance 1200m, termination directly on the instrument
Addresses	255, selectable by key-pad
Protocol	MODBUS/JBUS (RTU)
Data (bidirectional)	
Dynamic (reading only)	System and phase variables: see table “display pages”
Static (writing only)	All the configuration parameters, activation of the static output.
Data format	1 start bit, 8 data bit, no parity, 1 stop bit
Baud-rate	9600 bauds
Insulation	By means of optocouplers, 4000 V_{RMS} output to measuring input 4000 V_{RMS} output to supply input
RS232	(on request) bidirectional (static and dynamic variables)
Connections	3 wires, max. distance 15m,
Data format	1 start bit, 8 data bit no parity, 1 stop bit
Baud-rate	9600 bauds

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Output Specifications (cont.)

Protocol other data	MODBUS/JBUS (RTU) as per RS422/485
Digital outputs	(on request) To be used as alarms or remote control.
Alarm outputs Number of outputs Alarm type Variables to be controlled Set-point adjustment Hysteresis On-time delay Relay status	(on request) up to 2, independent Up alarm, down alarm see the “List of the variables that can be connected...” from 0 to 100% of the electrical scale from 0 to 100% of the electrical scale 0 to 255s Selectable, normally de-energized and normally energized

Output type	Relay, SPDT type AC 1-8A @ 250VAC DC 12-5A @ 24VDC AC 15-2.5A @ 250VAC DC 13-2.5A @ 24VDC
Min. response time	≤ 150 ms, filter excluded, FFT excluded, setpoint on-time delay: “0 s”
Insulation	By means of optocouplers, 4000 V_{RMS} output to measuring input, 4000 V_{RMS} output to supply input.
Note	The outputs can be either relay type or open collector type (V_{ON} 1.2VDC/Max. 100mA, V_{OFF} 30VDC Max.). Insulation like relay outputs.

Software Functions

Password 1st level 2nd level	Numeric code of max 4 digits; 2 protection levels of the programming data Password “0”, no protection Password from 1 to 1000, all data are protected.
Transformer ratio	CT from 1 to 5000 VT from 1.0 to 1999, where CT x VT ≤ 10000
Power demand (dmd) Integration time	Programmable from 1 to 30 min
Filter Filter operating range Filtering coefficient Filter action	From 0 to 99.9% of the input electrical scale 1 to 16 Measurements, alarms, serial port (fundamental variables: V, A, W and their derived ones).
Page Variables Three-phase system with neutral	Up to 4 by page Page 1: V L1, V L2, V L3, V LNΣ Page 2: V L12, V L13, V L31, VΣ Page 3: A L1, A L2, AL3, An Page 4: PF L1, PF L2, PF L3, PFΣ

Page 5: PF L1(min), PF L2 (min), PF L3 (min)
Page 6: W L1, W L2, W L3
Page 7: W L1 (max), W L2 (max), W L3 (max)
Page 7: “A” option: AL1 (max) AL2 (max) AL3 (max)
Page 8: var L1, var L2, var L3
Page 9: VA L1, VA L2, VA L3
Page 10: AL1 (alarm 1)
Page 11: AL2 (alarm 2)
Page 12: WΣ, PFΣ, varΣ, Hz
Page 13: WΣ, PFΣ, VAΣ, Hz
Page 14: WΣ (max), PFΣ (min)
Page 15: W dmd, VA dmd, r.t.
Page 16: W dmd (max), VA dmd (max)
Page 17: THD VL1, THD VL2, THD VL3
Page 17: THD AL1, THD AL2, THD AL3

Supply Specifications

AC voltage	90 to 260 VDC/VAC 18 to 60VDC/VAC 24 VAC -15+10% 50-60Hz 48 VAC -15+10% 50-60Hz
	115VAC -15+10% 50-60Hz 230 VAC -15+10% 50-60Hz
Power consumption	≤ 30VA/12W (90 to 260V) ≤ 20VA/12W (18 to 60V)

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General Specifications

Operating temperature	0 to +50°C (32 to 122°F) (R.H. < 90% non condensing)
Storage temperature	-10 to +60°C (14 to 140°F) (R.H. < 90% non consensing)
Installation category	Cat. III (IEC 60664)
Pollution degree	2
Key-pad lock	by means of a rotary switch placed behind the display or by means of a contact (in case of presence of the digital inputs module)
Insulation	4000 V_{RMS} between all inputs/outputs to ground
Dielectric strength	4000 V_{RMS} for 1 minute
EMC	
Emissions	EN50082-1 (class A) residential, commercial and light industry environment
Immunity	EN 61000-6-2 (class A) industrial environment
Other standards	
Safety	IEC 61010-1, EN 61010-1
Product	IEC 60688-1, EN 60688-1
Approvals	CE
Connections 5(6)A	Screw-type, max 2.5 mm² wires (2 x 1.5mm²)
Housing	
Dimensions	96x96x140 mm
Material	ABS, NORYL, PC (front) self-extinguishing: UL 94 V-0
Protection degree	Front: IP65 Connections: IP20
Weight	Approx. 400 g (packing incl.)

Function Description

Input/analogue output scaling capability

Working of the analogue output (Y) versus the input variable (X) - (input/output scaling capability)

Figure A

The sign of measured quantity and output quantity remains the same. The output quantity is proportional to the measured quantity.

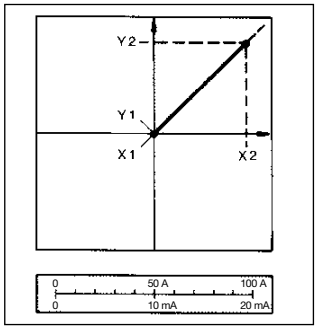


Figure B

The sign of measured quantity and output quantity changes simultaneously. The output quantity is proportional to the measured quantity.

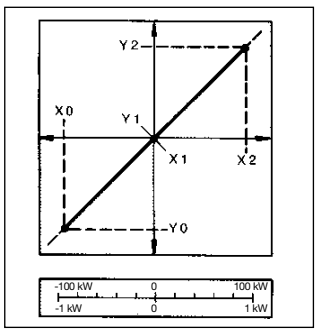


Figure C

The sign of measured quantity and output quantity remains the same. From X0 to X1, the output variable is 0. The range X1...X2 is delineated on the entire output range.

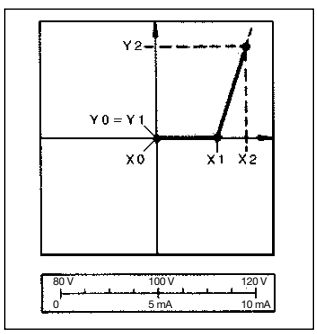


Figure D

The sign of measured quantity and output quantity remains the same. With the measured quantity being zero, the output quantity already has the value Y1 = 0.2 (live zero output).

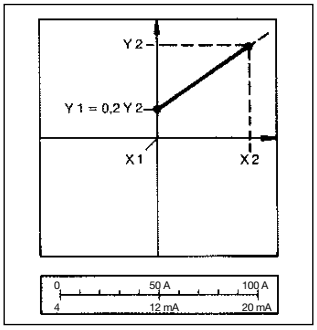


Figure E

The sign of the measured quantity changes but that of the output quantity remains the same. The output quantity steadily increases from the value X1 to the value X2 of the measured quantity.

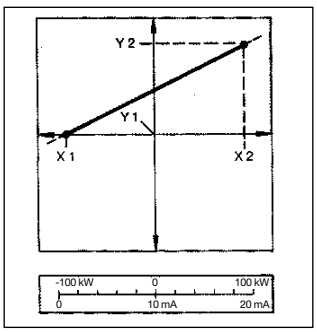
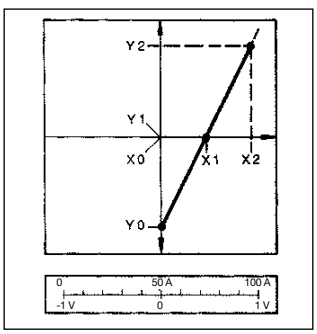


Figure F

The sign of the measured quantity remains the same, that of the output quantity changes as the measured quantity leaves range X0...X1 and passes to range X1...X2.



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Mode of operation

Waveform of the signals that can be measured

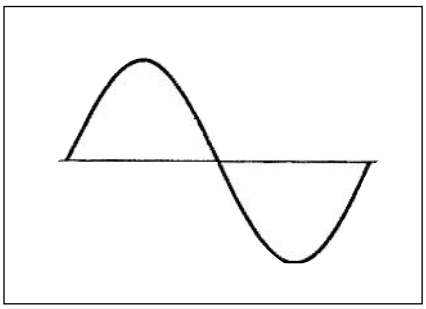

Figure G
Sinewave, undistorted

Fundamental content	100%
Harmonic content	0%
A_{rms} =	1.1107 | $\overline{A}$ |

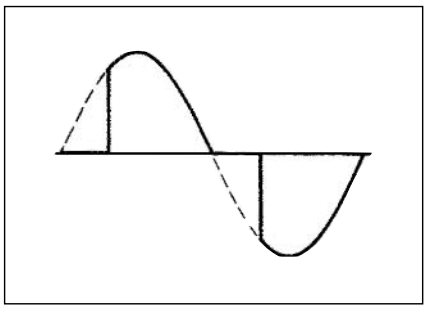

Figure H
Sinewave, indented

Fundamental content	10...100%
Harmonic content	0...90%

Frequency spectrum: 3rd to 16th harmonic

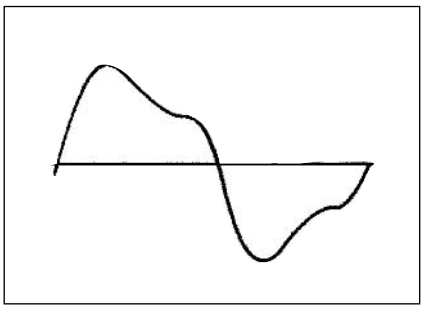

Figure I
Sinewave, distorted

Fundamental content	70...90%
Harmonic content	10...30%

Frequency spectrum: 3rd to 16th harmonic

Harmonic Analysis

Analysis principle	FFT
Harmonic measurement	
Current	Up to 16th harmonic
Voltage	Up to 16th harmonic
Type of harmonics	THD (V_{L1}) THD (V_{L2}) THD (V_{L3}) THD (A_{L1}) THD (A_{L2}) THD (A_{L3})

Display pages	THD %
Others	The harmonic distortion can be measured in both 3-wire or 4-wire systems.

Display pages

Variables that can be displayed in case of a three-phase system, 4-wire connection.

No	1st variable	2nd variable	3rd variable	4th variable	Notes
1	V L1	V L2	V L3	V LN Σ	Σ = system
2	V L1-2	V L2-3	V L3-1	V Σ	Σ = system
3	A L1	A L2	A L3	An	An= neutral current
4	PF L1	PF L2	PF L3	PF Σ	Σ = system
5	PF L1 (min)	PF L2 (min)	PF L3 (min)		
6	W L1	W L2	W L3		
7	W L1 (max)	W L2 (max)	W L3 (max)		With “A” option: AL1-AL2-AL3 max
8	var L1	var L2	var L3		
9	VA L1	VA L2	VA L3		
10	AL 1				variable connected to alarm 1
11	AL 2				variable connected to alarm 2
12	W Σ	PF Σ	var Σ	Hz	Σ = system
13	W Σ	PF Σ	VA Σ	Hz	Σ = system
14	W Σ (max)	PF Σ (min)			Σ = system
15	W dmd	VA dmd	r.t.		r.t.= symbol of communication Rx/Tx on the serial port
16	W dmd (max)	VA dmd (max)			
17	THD V L1	THD V L2	THD V L3		total harmonic distortion
18	THD A L1	THD A L2	THD A L3		total harmonic distortion

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Used Calculation Formula

Phase Variables

Instantaneous effective voltage

$$V_{1N} = \sqrt{\frac{1}{n} \cdot \sum_{1}^{n} (V_{1N})_i^2}$$

Instantaneous effective current

$$A_1 = \sqrt{\frac{1}{n} \cdot \sum_{1}^{n} (A_1)_i^2}$$

Instantaneous apparent power

$$VA_1 = V_{1N} \cdot A_1$$

Instantaneous active power

$$W_1 = \frac{1}{n} \cdot \sum_{1}^{n} (V_{1N})_i \cdot (A_1)_i$$

Instantaneous reactive power

$$VAr_1 = \sqrt{(VA_1)^2 - (W_1)^2}$$

Instantaneous power factor

$$\cos\phi_1 = \frac{W_1}{VA_1}$$

System variables

Three-phase active power

$$W_\Sigma = W_1 + W_2 + W_3$$

Equivalent three-phase voltage

$$V_\Sigma = \frac{V_{12} + V_{23} + V_{31}}{3}$$

Three-phase apparent power

$$VA_\Sigma = \sqrt{W_\Sigma^2 + VAr_\Sigma^2}$$

Three-phase reactive power

$$VAr_\Sigma = (VAr_1 + VAr_2 + VAr_3)$$

Three-phase power factor

$$\cos\phi_\Sigma = \frac{W_\Sigma}{VA_\Sigma}$$ (TPF)

Neutral current

$$An = \overline{A}_{L1} + \overline{A}_{L2} + \overline{A}_{L3}$$

Total harmonic distortion

$$THD_i = \frac{\sqrt{\sum_{n=2}^{n=last} T_{n,i}^2}}{T_{1,i}}$$

Where:

i = considered phase (L1, L2 or L3)

T = considered variable (V or A)

n = harmonic order

List of the variables that can be connected to:

- **Alarm outputs**
- **Analogue outputs**

N°	Variable	3-phase + neutral	3-phase no neutral	Note
1	$V_{L-N}\Sigma$	x	x	Σ = system
2	$V_{L-L}\Sigma$	x	x	Σ = system
3	WΣ	x	x	Σ = system
4	varΣ	x	x	Σ = system
5	VAΣ	x	x	Σ = system
6	PFΣ	x	x	Σ = system
7	THD V (1)	x	x	if FFT is activated
8	THD A (1)	x	x	if FFT is activated
9	A n	x	x	
10	VA dmd	x	x	
11	W dmd	x	x	
12	ASY	x	x	asymmetry

(1) The highest value among the three phases
(2) The RS232 communication port works as alternative of the RS485 module.

The possible module combinations

Basic unit	Slot A	Slot B	Slot C	Slot D
Single analogue output	●			
Dual analogue output	●			
RS485 port		●		
Single relay output			●	
Single open collector output			●	
Dual relay output			●	●
Dual open collector output			●	●
3 digital inputs			●	
3 digital inputs + AUX			●	
Basic unit	**Slot E**			
RS232 port	●			

The available modules

Type	N. of channels	Ordering Code
WM23-96 400V L-L 5A (base)		AH2300
WM23-96 208V L-L 5A (base)		AH2301
WM23-96 100V L-L 5A (base)		AH2302
WM23-96 660V L-L 5A (base)		AH2303
WM23-96 400V L-L 5A (base)	"A" opt.	AH2300A
WM23-96 208V L-L 5A (base)	"A" opt.	AH2301A
WM23-96 100V L-L 5A (base)	"A" opt.	AH2302A
WM23-96 660V L-L 5A (base)	"A" opt.	AH2303A
24VAC power supply		AP1025
48VAC power supply		AP1024
115VAC power supply		AP1023
230VAC power supply		AP1022
18-60VAC/DC power supply		AP1021
90-260VAC/DC power supply		AP1020
20mADC analogue output	1	AO1050
10VDC analogue output	1	AO1051
±5mADC analogue output	1	AO1052
±10mADC analogue output	1	AO1053
±20mADC analogue output	1	AO1054
±1VDC analogue output	1	AO1055
±5VDC analogue output	1	AO1056
±10VDC analogue output	1	AO1057
20mADC analogue output	2	AO1026
10VDC analogue output	2	AO1027
±5mADC analogue output	2	AO1028
±10mADC analogue output	2	AO1029
±20mADC analogue output	2	AO1030
±1VDC analogue output	2	AO1031
±5VDC analogue output	2	AO1032
±10VDC analogue output	2	AO1033
Relay output	1	AO1058
Relay output	2	AO1035
Open collector output	1	AO1059
Open collector output	2	AO1036
Digital inputs	3	AQ1038
Digital inputs + AUX	3	AQ1042
RS485 serial port (2)	1	AR1034
RS232 serial port (2)	1	AR1039

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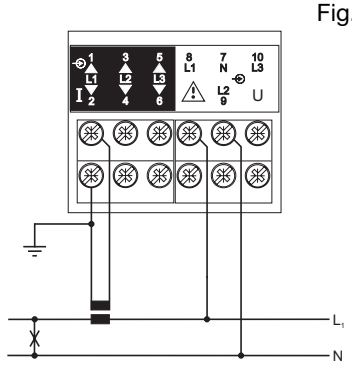
Wiring Diagrams

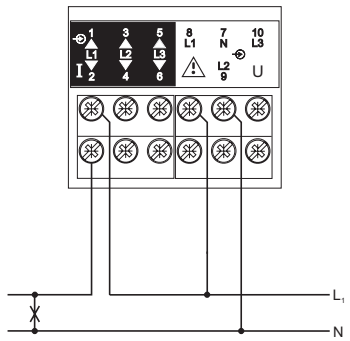
Single phase

Fig. 1



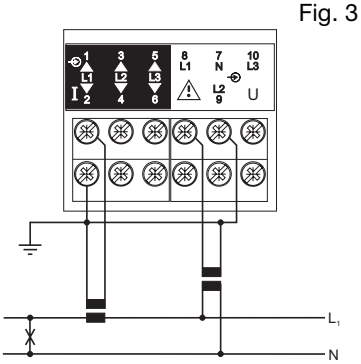
CT connection

Fig. 2



Direct connection

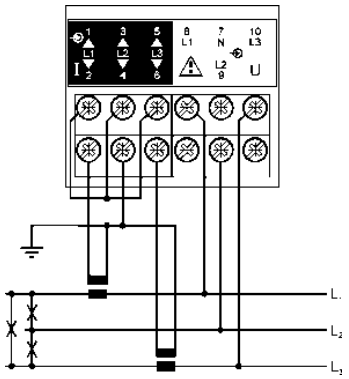
Fig. 3



CT and VT connection

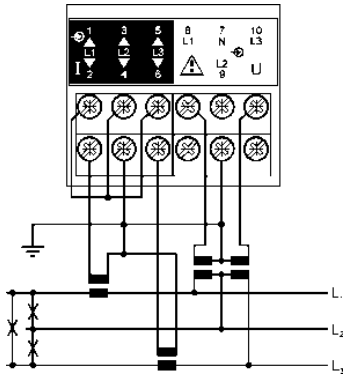
Three-phase - Unbalanced load

Fig. 4



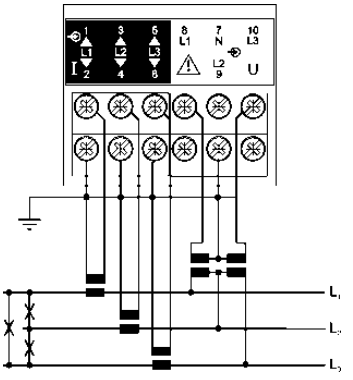
CT connection (3-wire system) ARON

Fig. 5



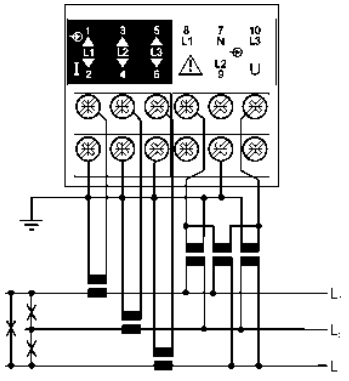
CT and VT connection (3-wire system) ARON

Fig. 6



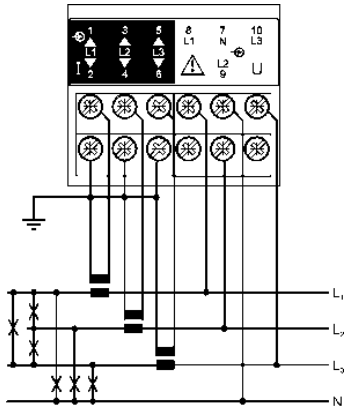
CT and VT connection (3-wire system)

Fig. 7



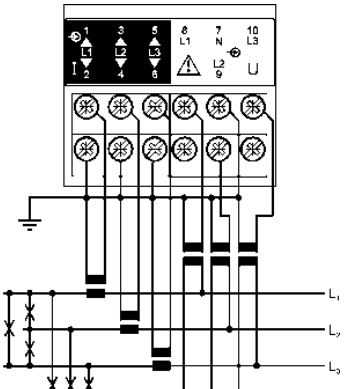
CT and VT connection (3-wire system)

Fig. 8



CT connection (4-wire system)

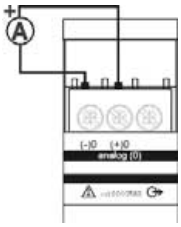
Fig. 9



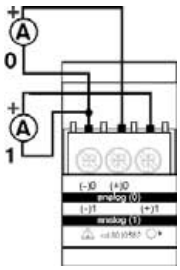
CT and VT connection (4-wire system)

CARLO GAVAZZI

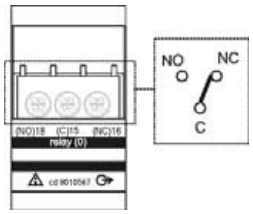
Wiring diagrams (optional modules)



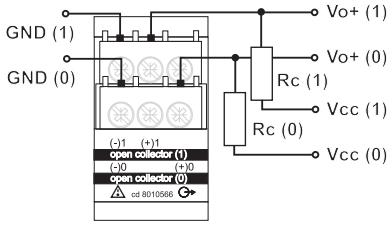
1 analogue output (mA)



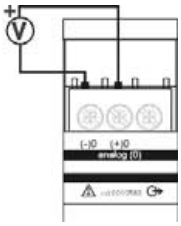
2 analogue outputs (mA)



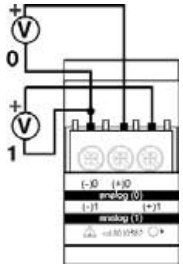
1 relay outputs



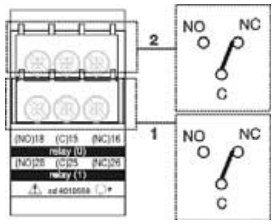
Open collector output connection.
This wiring diagram is valid also for the open collector module with one output.
The load resistances (RC) must be designed so that the close contact current is lower than 100mA; the VDC voltage must be lower than or equal to 30VDC.



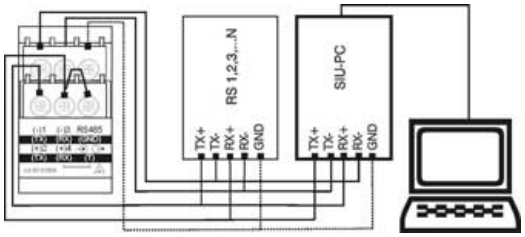
1 analogue output (V)



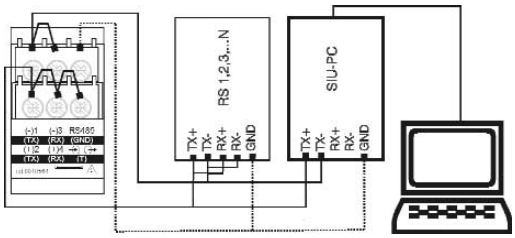
2 analogue outputs (V)



2 relay outputs

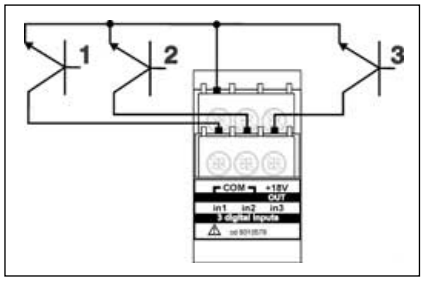


4-wire connection of RS485 serial port



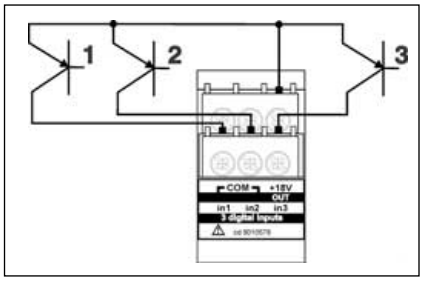
2-wire connection of RS485 serial port

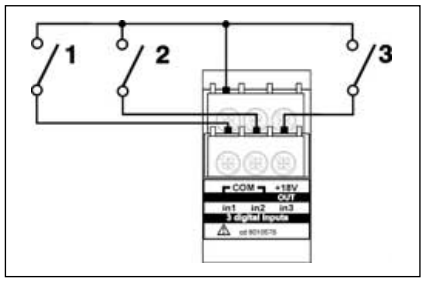
Wiring diagrams: digital input modules



Connection by means of NPN transistors.
Digital input module:
AQ1042.

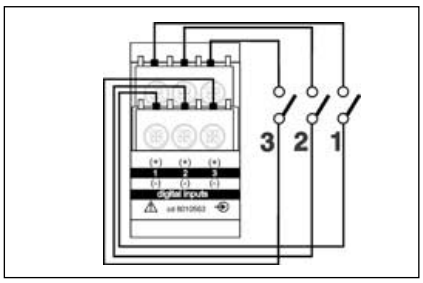
Connection by means of PNP transistors.
Digital input module:
AQ1042.



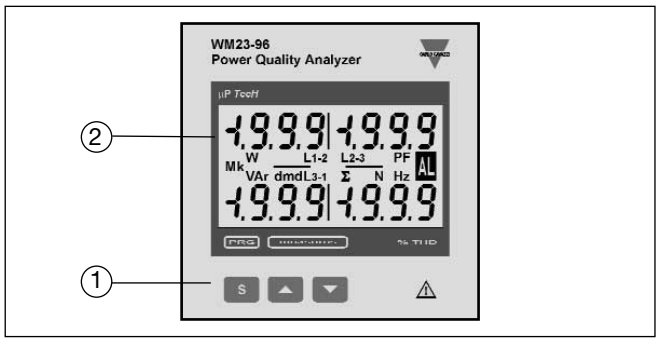


Connection by means of contacts.
Digital input module:
AQ1042.

Connection by means of contacts.
Digital input module:
AQ1038.



Front Panel Description



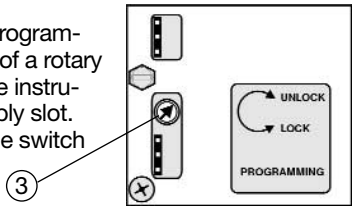
1. **Key-pad**
   The programming of configuration parameters and the display are easily controlled by means of the 3 push buttons:

   - "S" to enter into the programming phase and to confirm the password
   - ▲ and ▼
   - for value programming
   - for function selections
   - for page scrolling

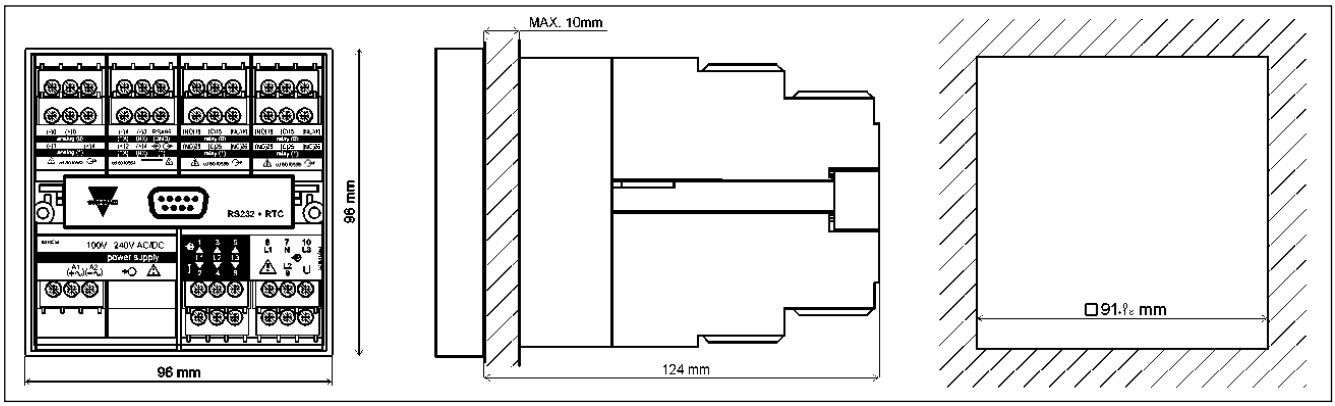
2. **Display**
   Instantaneous measurements:
   - 4x3 1/2 digit (maximum read-out 1999)

   Alphanumeric indications by means of LCD display for:
   - Displaying the configuration parameters
   - Displaying all the measured variables.

3. **Programming lock**
   It's possible to lock the programming key-pad by means of a rotary switch located behind the instrument into the power supply slot. Turn counterclockwise the switch to lock the proramming key-pad.

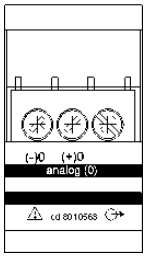


Dimensions



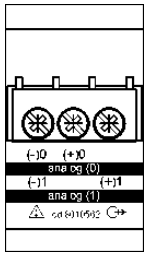
Terminal boards

Single analogue output modules



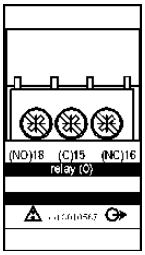
AO1050 (20mADC)
AO1051 (10VDC)
AO1052 (±5mADC)
AO1053 (±10mADC)
AO1054 (±20mADC)
AO1055 (±1VDC)
AO1056 (±5VDC)
AO1057 (±10VDC)

Dual analogue output modules

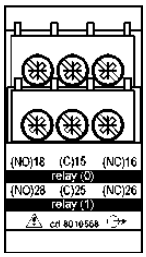


AO1026 (20mADC)
AO1027 (10VDC)
AO1028 (±5mADC)
AO1029 (±10mADC)
AO1030 (±20mADC)
AO1031 (±1VDC)
AO1032 (±5VDC)
AO1033 (±10VDC)

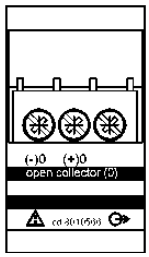
Digital output modules



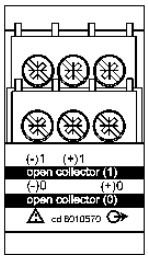
AO1058
Single relay output



AO1035
Dual relay output

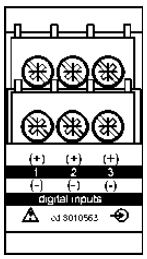


AO1059
Single open collector output

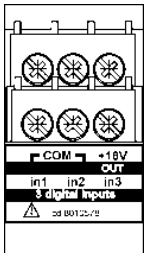


AO1036
Dual open collector output

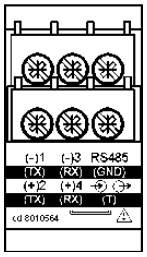
Other input/output modules



AQ1038
3 digital inputs



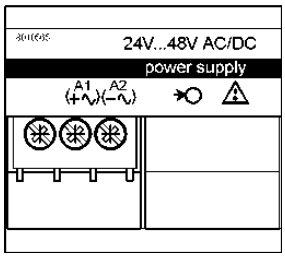
AQ1042
3 digital inputs + aux



AR1034
RS422/485 communication port

AR1039
RS232 communication port

Power supply modules



AP1021
18-60 VAC/DC power supply
AP1020
90-260 VAC/DC power supply
AP1025
24VAC power supply
AP1024
48VAC power supply
AP1023
115VCA power supply
AP1022
230VCA power supply