# Energy Management
# Modular Power Analyzers
# Type WM2-96

CARLO GAVAZZI

- **Class 1 (current/voltage)**
- **Modular power analyzer**
- **Front size: 96x96 mm**
- **3-dgt/6-dgt µP-based indicator**
- **Manual or automatic scrolling of system and single phase: kW, kVAr, PF, kWh, kVArh, A, $V_{L-L}$ avg, VL1-N, VL2-N, VL3-N.**
- **TRMS measurement of distorted waves (voltage/current)**
- **All configuration functions selectable by built-in key-pad**
- **Password protection of programming parameters**
- **Degree of protection (front): IP 65**
- **Optional pulse output (according to DIN43864)**
- **Optional serial RS 422 /485 port**
- **MODBUS, JBUS protocol.**

## Product Description

µP-based modular power analyzer with a built-in configuration key-pad. The power, power factor, current and voltage are system and single phase measurements and indications. The housing is easy to mount on a panel and ensures a degree of protection (front) of IP 65.

## Ordering Key **WM2-96 AV53D XXX**

**Model**
**Range code**
**System**
**Power supply**
**1st output**
**2nd output**

## Type Selection

**Range code**

**AV5:** 250/433 VAC - 5 AAC (max. 300 V (L-N)/ 520 V (L-L) - 6 A)
**AV7:** 400/690 VAC - 5 AAC (max. 480 V (L-N)/ 830 V (L-L) - 6 A) [1]

**System**

**3:** One phase, three-phase system, 3 or 4 wires, balanced load; three phase system, 3 or 4 wires, unbalanced load

**Power supply**

**A:** 24 VAC, -15% +10%, 50/60 Hz [1] [2]
**B:** 48 VAC, -15%+10%, 50/60 Hz [1] [2]
**C:** 115 VAC, -15% +10%, 50/60 Hz [1] [2]
**D:** 230 VAC, -15% +10%, 50/60 Hz (standard) [2]
**L:** 18 to 60 VDC/AC [3]
**H:** 90 to 260 VDC/AC [3]

**1st output (pulse)**

**XX:** No output (standard)
**O1:** Single open collector output (30V/100mADC) [1]
**O2:** Dual open collector output, the second one is the copy of the first one, like "O1" [1]
**R1:** Single relay output, (AC1-8AAC, 250VAC) [1]
**R2:** Dual relay output, the second one is the copy of the first one, like "R1" [1]

**2nd output**

**X:** No output (standard)
**S:** Serial port, RS 485 multidrop bidirectional [1]

[1] On request
[2] **Warning: this power supply cannot be used if the RS485 module is needed**
[3] Compatible with any kind of output

## Input Specifications

| | |
|---|---|
| **Accuracy (48 to 62 Hz)** | Un: 250V (AV5), 400V (AV7)<br>In: 5A |
| Voltage/current (@ 25°C ± 5°C, R.H. ≤ 60%) | ±0.5% f.s. (0 to 1.2 In, 0.5 to 1.2 Un) |
| Active power (@ 25°C ± 5°C, R.H. ≤ 60%) | ±1% f.s. (PF ≥ 0.7 L/C, 0 to 1.2 In, 0.5 to 1.2 Un) |
| Reactive power (@ 25°C ± 5°C, R.H. ≤ 60%) | ±1% f.s. (PF ≥ 0.7 L/C, 0 to 1 In, 0 to 1 Un) |
| Power factor (PF) (@ 25°C ± 5°C, R.H. ≤ 60%) | ±1% f.s., PF ≥ 0.7 L/C, (0.6 to 1.2 In, 1 to 1.2 Un) |
| Energy (@ 25°C ± 5°C, R.H. ≤ 60%) | ±1% RDG (kWh), ±2% RDG (kvarh), (PF ≥ 0.7L/C, 0 to 1.2 In, 0.5 to 1.2 Un) |
| **Additional errors** | |
| Humidity | < 0.3% f.s., 60% to 90% R.H. |
| Power supply | ±0.5% rdg, -15 +10% p.s. |
| Magnetic field | < 0.1% f.s. @ 400 A/m |

| | |
|---|---|
| **Rated input** | |
| Current | 2 inputs (one/three-phase balanced load)<br>6 inputs (one/three-phase unbalanced load) |
| Voltage | 2 inputs (one/three-phase balanced load)<br>4 inputs (one/three-phase unbalanced load) |
| Insulation | among the voltage and the current inputs: 2000Vrms; among the current inputs: 2000 Vrms |
| **Temperature drift** | ±250 ppm/°C |
| **Display** | Backlighted LCD, h 13mm, 3-dgt (instantaneous meas.) 6-dgt (energies) |

## Input Specifications (cont.)

| | |
|---|---|
| **Decimal point position** | Instantaneous measurements:<br>Automatic selection according to the current transformer ratio of the CT being connected (max. indication - single phase):<br>CT ratio ≤ 5 : 11.11 (25.00A)<br>CT ratio ≤50.0: 111.1 (250.0A)<br>CT ratio ≤ 500.0 : 1111 (2500A)<br>CT ratio ≤ 999.9 : 11110 (6000A)<br>Energy measurements:<br>max. resolution:1 Wh/1 VArh<br>min. resolution: 1 kWh/1 kVArh |
| **Max. and min. indication** | |
| Voltage | Max. 600 min. 0 |
| Current (CT ratio = 1) | Max. 6.00 min. 0.00 |
| PF | Max. 1.00 min. 0.00 |
| Power (CT ratio = 1) | Max. 5.40 min. 0.00 |
| Active energy | Max. 999999 min. –199999 |
| Reactive energy | Max. 999999 min. 0 |
| **Sampling rate** | 3 times / second |
| **Measurements** | |
| System variables | kW, kVAr, PF, $V_{L-L}$, A, |
| Total energies | kWh, kvarh |
| Partial energies | kWh, kvarh<br>(the meters are reset automatically when the values reach 14999*CT ratio) |
| Single phase variables | kW, kVAr, PF, $V_{L-N}$, A |
| Measurement method | TRMS measurement of a distorted voltage/current wave |
| | Coupling type: Direct<br>Crest factor: ≥ 3 |
| **Ranges (impedances)** | 250 V/433 V (≥400kΩ)<br>5 AAC (≤ 0.3 VA / ≤ 0.1Ω)<br>400V/690V (≥650kΩ) |
| **Frequency range** | 48 to 62 Hz |
| **Over-load protection** | Un: 250V (AV5), 400V (AV7)<br>In: 5A |
| Continuous: voltage/current | 1.2 Un /In |
| For 1 s | |
| Voltage: | 2 Un |
| Current: | 20 In |
| **Keyboard** | 4 keys:<br>”ΔΛ”:<br>- to enter programming phase and password confirmation;<br>- for value programming and basic measurement scrolling.<br>“L”:<br>- for confirmation of new programmed values and going ahead to the next programming step,<br>- single phase measurement scrolling.<br>“R”:<br>- for the reset of the partial counted active and/or reactive energy. |

## Output Specifications

| | |
|---|---|
| **Pulse output** (on request) | |
| Number of outputs | 1, independent |
| Static type (according to DIN 43864) | From 0.1 to 999.9 programmable pulses for kWh, KVArh, open collector (NPN transistor)<br>$V_{ON}$ 1.2 VDC/ max. 100 mA<br>$V_{OFF}$ 30 VDC max. |
| Relay type | 1 x SPDT<br>AC 1 - 8A, 250VAC<br>DC 12 - 5A,24VDC<br>AC 15 - 2.5A, 250VAC<br>DC 13 - 2.5A, 24VDC |
| Pulse duration | 200 ms (ON), ≥ 200 ms (OFF) |
| Insulation | By means of optocouplers, 4000 $V_{rms}$ output to measuring input, 4000 $V_{rms}$ output to supply input. |
| **Serial port** (on request) | |
| Type | RS422/RS485;<br>Multidrop bidirectional (static and dynamic variables) |
| Connections | 4 wires, max. distance 1200m, termination directly on the module |
| Addresses | 1 to 255, selectable by key-pad |
| Protocol | MODBUS/JBUS |
| Data (bidirectional) | |
| Dynamic (reading only) | System variables:<br>P, Q, PF, $V_{L-L}$,<br>energies,<br>Single phase variables:<br>$P_{L1}$, $Q_{L1}$, $PF_{L1}$, $V_{L1-N}$, $A_{L1}$,<br>$P_{L2}$, $Q_{L2}$, $PF_{L2}$, $V_{L2-N}$, $A_{L2}$,<br>$P_{L3}$, $Q_{L3}$, $PF_{L3}$, $V_{L3-N}$, $A_{L3}$ |
| Static (writing only) | All programming data, reset of energy:<br>- partial kWh<br>- partial kVArh<br>- total kWh<br>- total kVArh<br>Stored energy (EEPROM)<br>≤ 999999 kWh<br>≤ 999999 kVArh |
| Data format | 1-start bit, 8-data bit, no parity/even parity, 1 stop bit |
| Baud-rate | 1200, 2400, 4800 and 9600 selectable bauds |
| Insulation | By means of optocouplers, 4000 Vrms output to measuring inputs<br>4000 Vrms output to supply input |

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## Software Functions

| | |
|---|---|
| **Password** | Numeric code of max. 3 digits; 2 protection levels of the programming data |
| 1st level | Password "0", no protection |
| 2nd level | Password from 1 to 255, all data are protected |
| **Measurement scrolling** | |
| System: | Active power (kW), reactive power (kVAr), power factor (cos φ), current (A), average phase-phase voltage (V) total and partial active energy (kWh), total and partial reactive energy (kVArh) Partial energy meters: the counters of kWh and kVArh are automatically reset when the energy reaches the value (14999*CT). Example: the CT is a 100A/5A so the ratio is 20, consequently the maximum counted energy is 299980 kWh or kVArh. |
| Single phase: | Active power (kW), reactive power (kVAr), power factor (cos φ), current (A), phase-neutral voltage (V) |
| **Transformer ratio** | For CT up to 5000 A |
| **Programmable ratio** | 0.1 to 999.9 |
| **Digital Filter** | |
| Filter operating range | 0 to 100% of the input electrical scale |
| Filtering coefficient | 1 to 64 |
| Filter action | On the display and on the variable being transmitted by the serial communication port. |

## Supply Specifications

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

## 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-condensing) |
| **Insulation reference voltage** | 300 Vrms to ground |
| **Insulation** | 4000 Vrms between all inputs/outputs to ground |
| **Dielectric strength** | 4000 Vrms for 1 minute |
| **Noise rejection** | |
| CMRR | 100 dB, 48 to 62 Hz |
| **EMC** | EN 50081-2, EN 50082-2 |
| **Safety standards** | IEC 61010-1, EN 61010-1 |
| **Other standards** | Pulse output: DIN43864 |
| **Approvals** | CE UL, CSA |
| **Connector** | Screw-type, max. 2.5 mm² wires x 2 |
| **Housing** | |
| Dimensions | 96 x 96 x 140 mm |
| Material | ABS, self-extinguishing: UL 94 V-0 |
| **Degree of protection** | Front: IP65 |
| **Weight** | Approx. 500 g (packing included) |

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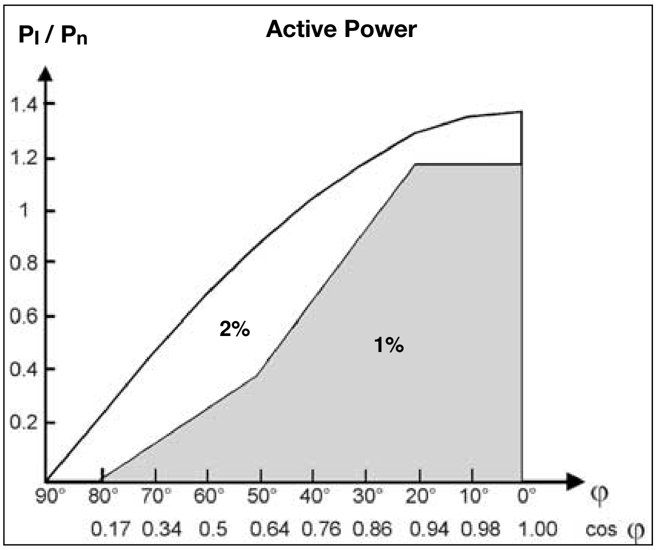
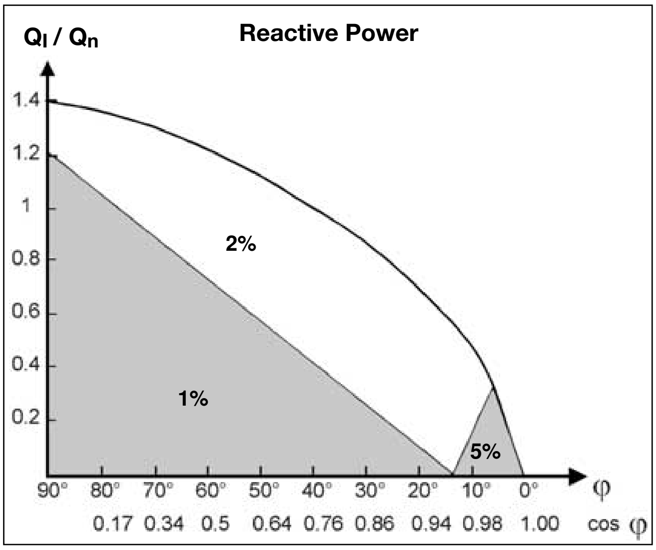
# Mode of Operation

**Accuracy class of the instrument as a relation of $P_I/P_n$ and cos φ (power factor)**




**Test conditions:**
V = 0.8 to 1.2 Un,
I = 0.1 to 1.2 In,
f = 48 to 62 Hz




**Test conditions:**
V = 0.8 to 1.2 Un,
I = 0.1 to 1.2 In,
f = 48 to 62 Hz

| Input | Star voltage | Delta voltage | Current |
|---|---|---|---|
| AV5 | Un: 250 V | Un: 430 V | In: 5 A |

**$P_I/Q_I$ (installation power)**
One phase system:

$P_I = U_I \cdot I_I \cdot \cos\varphi$
$Q_I = U_I \cdot I_I \cdot \sin\varphi$

Three phase, 3-wire system:

$P_I = \sqrt{3} \cdot U_I \cdot I_I \cdot \cos\varphi$
$Q_I = \sqrt{3} \cdot U_I \cdot I_I \cdot \sin\varphi$

Three phase, 4-wire system:

$P_I = 3 \cdot U_I \cdot I_I \cdot \cos\varphi$
$Q_I = 3 \cdot U_I \cdot I_I \cdot \sin\varphi$

where:
$U_I$ = the real star voltage of the electrical system being measured.
I = the maximum phase current of the electrical system being measured.
Cos φ = the average cos φ of the electrical system being measured.

**Pn /Qn (rated power of the instrument):**
One phase system:

$P_n = Q_n = U_n \cdot I_n \cdot CT(ratio)$

Three phase, 3-wire system:

$P_n = Q_n = \sqrt{3} \cdot U_n \cdot I_n \cdot CT(ratio)$

Three phase, 4-wire system:

$P_n = Q_n = 3 \cdot U_n \cdot I_n \cdot CT(ratio)$

where:
$U_n$ = the rated input voltage of WM2-96.
$I_n$ = the rated input current of WM2-96.
CT (ratio) = the value of the current transformer ratio.

**Example 1:**
Model AV5.3 (3-wire system).

$U_I$ = 400 V (delta voltage)
$I_I$ = 265 A (single phase current)
Cos φ = 0.85 (system power factor) (CT=300A)
$U_n$ = 430 V
$I_n$ = 5 A

$$\text{CT (ratio)} = \frac{300}{5} = 60$$

$$P_I = \sqrt{3} \cdot U_I \cdot I_I \cdot \cos\varphi = \sqrt{3} \cdot 400 \cdot 265 \cdot 0.85 = 155.87\ \text{kW}$$

$$P_n = \sqrt{3} \cdot U_n \cdot I_n \cdot \text{CT (ratio)} = \sqrt{3} \cdot 430 \cdot 5 \cdot 60 = 233.17\ \text{kW}$$

$$\frac{P_I}{P_n} = \frac{155.87}{223.17} = 0.698$$

**Example 2:**
Model AV5.3 (4-wire system).

$U_I$ = 230 V
$I_I$ = 110 A (CT=300A)

Cos φ = 0.85 (sin φ = 0.52)
$U_n$ = 250 V
$I_n$ = 5 A

$$\text{CT (ratio)} = \frac{300\ \text{A}}{5\ \text{A}} = 60$$

$$Q_n = 3 \cdot U_I \cdot I_I \cdot \sin\varphi = 3 \cdot 230 \cdot 110 \cdot 0.52 = 39.46\ \text{kvar}$$

$$Q_n = 3 \cdot U_n \cdot I_n \cdot \text{CT (ratio)} = 3 \cdot 250 \cdot 5 \cdot 60 = 225\ \text{kvar}$$

$$\frac{P_I}{P_n} = \frac{39.46}{225} = 0.175$$

In both examples the accuracy of the measurement is 1% f.s. when considering the changing of the measured voltage from 0.9 Un to 1 Un and the measured current from 0.1 In to 0.9 In with a cos φ of 0.85 (sin φ 0.52).

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## Mode of Operation (cont.)

**Waveform of the signals that can be measured**

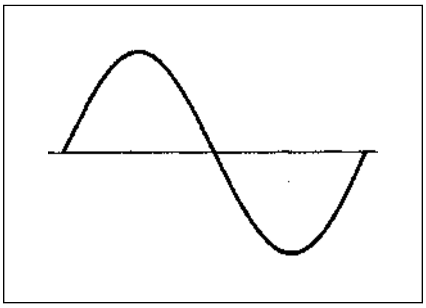


**Figure G**
**Sine wave, undistorted**

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

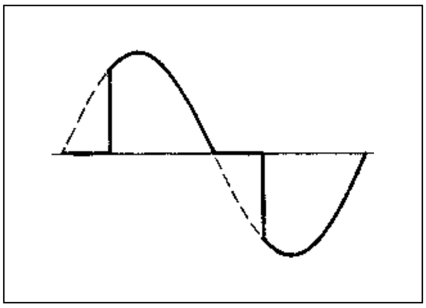


**Figure H**
**Sine wave, indented**

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

Frequency spectrum 3rd to 16th harmonic
Required result: additional error < 1%

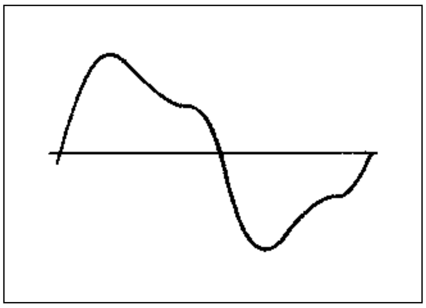


**Figure I**
**Sine wave, distorted**

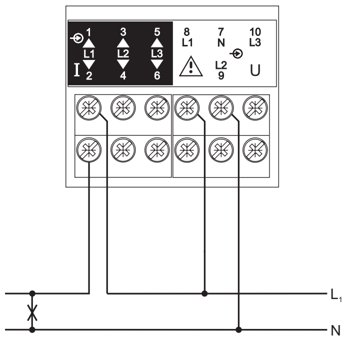
| | |
|---|---|
| Fundamental content | 70...90% |
| Harmonic content | 10...30% |

Frequency spectrum 3rd to 15th harmonic
Required result: additional error < 0.5%

## Wiring Diagrams

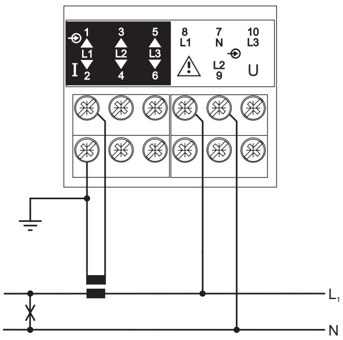
**Single phase input connections**

Fig. 1



Direct connection

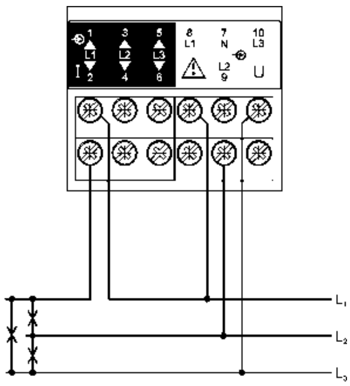
Fig. 2



CT connection

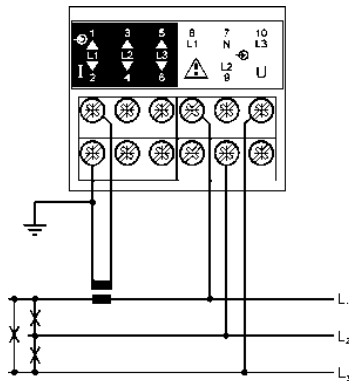
**Three phase 3-wire input connections - Balanced loads**

Fig. 3



Direct connection (3-wire system)

Fig. 4



CT connection (3-wire system)

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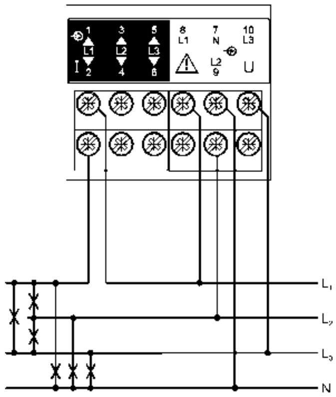
## Wiring Diagrams (cont.)

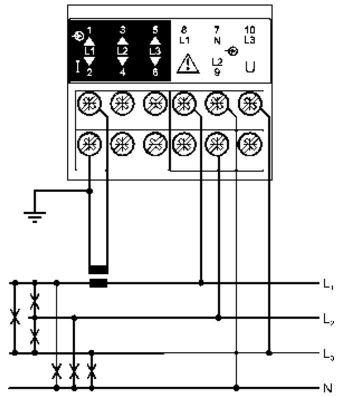
**Three phase, 4-wire input connections - Balanced loads**

Fig. 5



Direct connection (4-wire system)

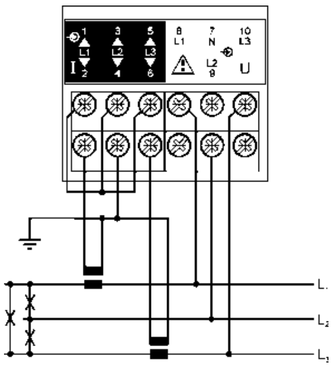
Fig. 6



CT connection (4-wire system)

**Three-phase, 3-wire input ARON connections - Unbalanced load**

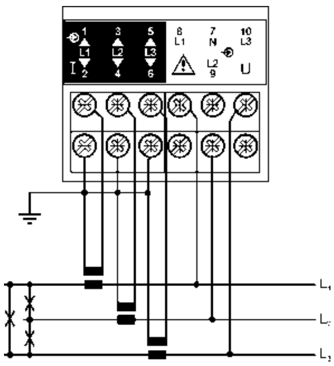
Fig. 7



CT connection (3-wire system)

**Three-phase, 3-wire input connections - Unbalanced load**

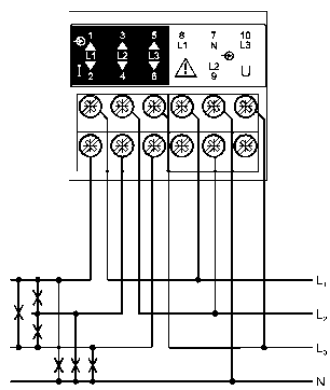
Fig. 8



CT connection (3-wire system)

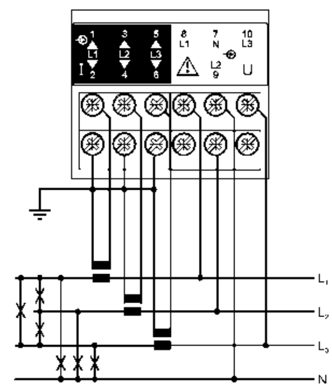
**Three phase, 4-wire input connections - Unbalanced load**

Fig. 9



Direct connection (4-wire system)

Fig. 10



CT connection (4-wire system)

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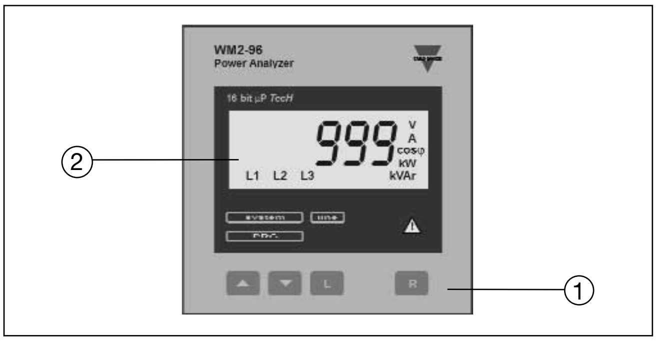
## Front Panel Description




1. **Key-pad**
   Set-up and programming procedures are easily controlled by the 4 pushbuttons.

   ▲ and ▼
   - To scroll all the basic measurements (system variables)
   - To increase or decrease programming values
   - To enter into the programming procedure and select programming functions together with the "L" key.

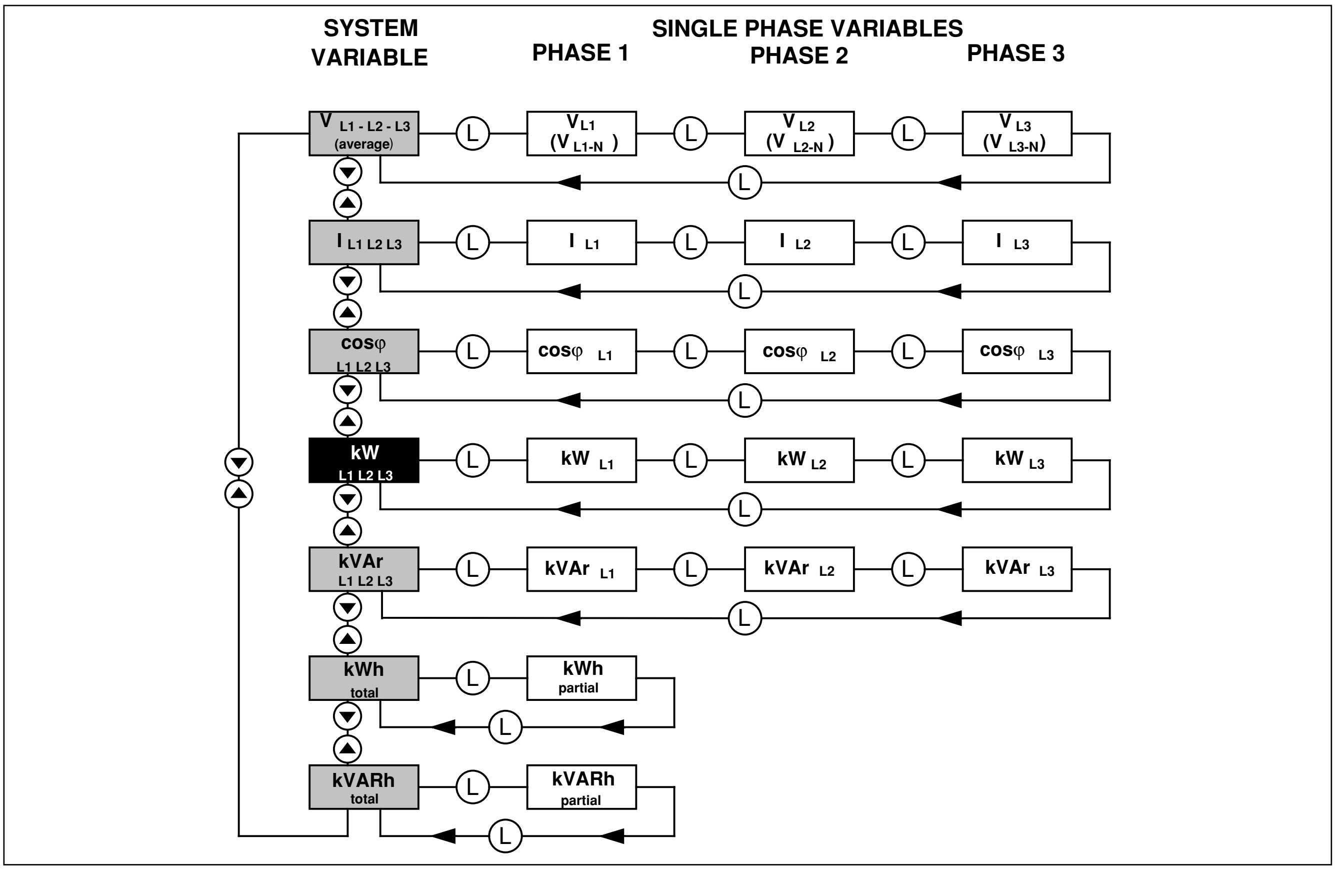
   "L":
   To scroll all the single phase variable of each basic measurement

   "R":
   To reset the partial counted energies (kWh, kVArh).

2. **Display**
   Instantaneous measurements:
   - 3-digit (maximum read-out 999)
   Energies:
   - 6-digit (maximum read-out 999999).

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

## Sequence of the variables on the display



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## The available modules

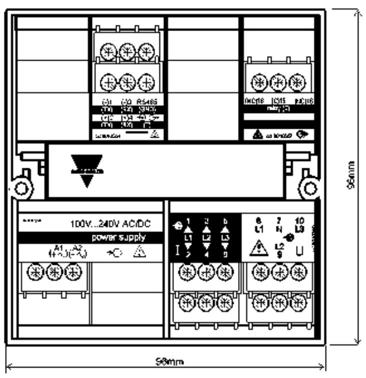
| Type | N. of channels | Ordering code | Note |
|---|---|---|---|
| WM2-96 base + AV5.3 input | | AB1012 | |
| WM2-96 base + AV7.3 input | | AB1013 | |
| 24VAC power supply | | AP1025 | Neither UL nor CSA approved |
| 48VAC power supply | | AP1024 | Neither UL nor CSA approved |
| 115VAC power supply | | AP1023 | Neither UL nor CSA approved |
| 230VAC power supply | | AP1022 | Neither UL nor CSA approved |
| 18-60VAC/DC power supply | | AP1021 | |
| 90-260VAC/DC power supply | | AP1020 | |
| RS485 port | 1 | AR1034 | |
| Relay output | 1 | AO1058 | |
| Relay output | 2 | AO1035 | The second output can be used as redoundant output |
| Open collector output | 1 | AO1059 | |
| Open collector output | 2 | AO1036 | The second output can be used as redoundant output |

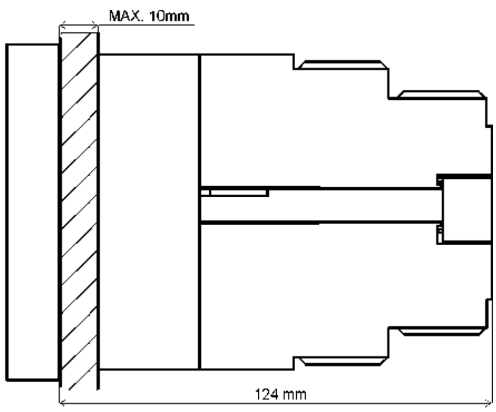
## The possible module combinations

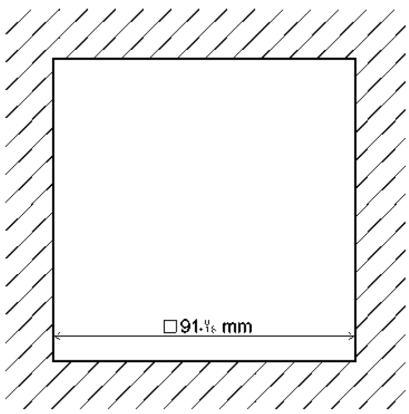
| Slot | B | D |
|---|---|---|
| **Basic unit** | **Out 1** | **Out 2** |
| RS485 port | ● | |
| Single relay output (pulse) | | ● |
| Single open collector output (pulse) | | ● |

| Slot | B | D |
|---|---|---|
| **Basic unit** | **Out 1** | **Out 2** |
| RS485 port | ● | |
| Dual relay output (pulse) | | ● |
| Dual open collector output (pulse) | | ● |

## Dimensions



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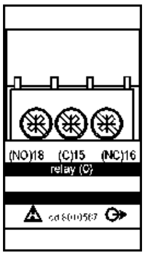
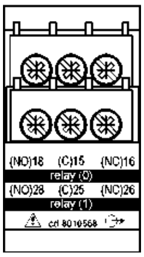
## Terminal boards

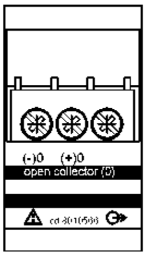
### Digital output modules



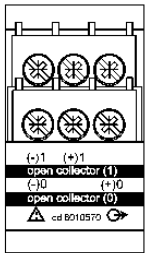

**AO1058**
Single relay output




**AO1035**
Dual relay output

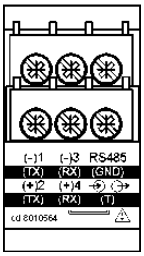



**AO1059**
Single open collector output



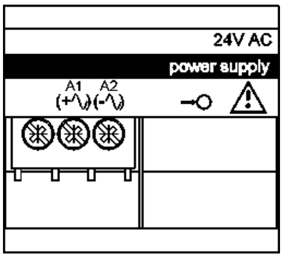

**AO1036**
Dual open collector output

### Other input/output modules

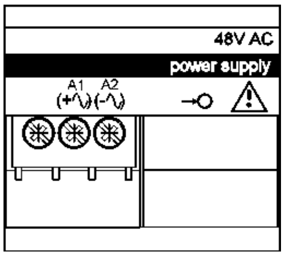



**AR1034**
RS485 port

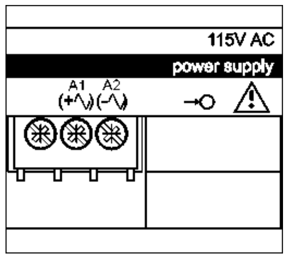
### Power supply modules



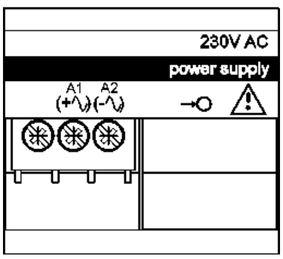

**AP1025**
24VAC power supply



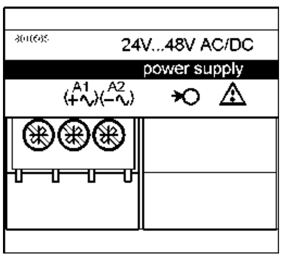

**AP1024**
48VAC power supply



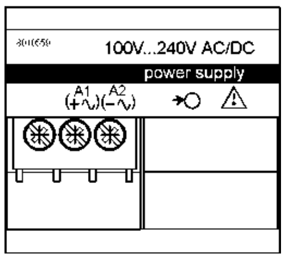

**AP1023**
115VAC power supply




**AP1022**
230VAC power supply




**AP1021**
18-60VAC/DC power supply




**AP1020**
90-260 VAC/DC power supply