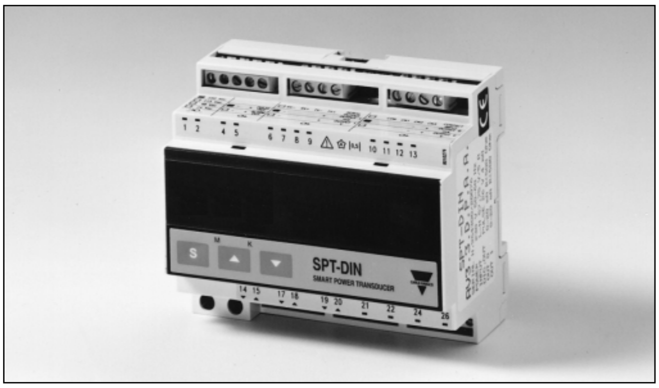
Energy Management
Smart Power Transducer
Type SPT-DIN

CARLO GAVAZZI



- **16-bits µP-based smart power transducer**
- **Measurements of: W, Wavg, VA, VAr, PF, Wh, VAh, VArh, Amax (among the phases), V_{L-L} avg, VL1-N, VL2-N, VL3-N, Hz L1.**
- **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 50**
- **Optional independent alarm setpoint**
- **Optional analogue output (20 mA DC/±10 mA DC/ ±5 mA DC/10 VDC/±1VDC)**
- **Optional serial RS 422/485 output**
- **MODBUS, JBUS protocol.**

Product Description

16-bit µP-based smart power transducer with a built-in configuration key-pad. The house is for DIN-rail mounting and ensures a degree of protection (front) of IP 50.

Ordering Key

SPT-DINAV51DXAX

Model
Range code
System
Power supply
Auxiliary output
1st output/input
2nd output

Type Selection

Range code

AV1: 100/√3/100 VAC-1 AAC (max. 130/√3 (L-N)/ 130 V (L-L) - 1.2 A) 1)
AV3: 100/√3/100 VAC-5 AAC (max. 130/√3 (L-N)/ 130 V (L-L) - 6 A) 1)
AV4: 250/433 VAC - 1 AAC (max. 300 V (L-N)/ 520 V (L-L) - 1.2 A) 1)
AV5: 250/433 VAC - 5 AAC (max. 300 V (L-N)/ 520 V (L-L) - 6 A) (standard)

System

1: One phase, three-phase system (3 or 4 wires, balanced load)
3: Three phase system (3 or 4 wires, unbalanced load)

Power supply

A: 24 VAC, -15% +10%, 50/60 Hz 1)
B: 48 VAC, -15% +10%, 50/60 Hz 1)
C: 115 VAC, -15% +10%, 50/60 Hz 1)
D: 230 VAC, -15% +10%, 50/60 Hz (standard)

Auxiliary output

X: No output (standard)
D: Alarm set-point, static, AC type 1)
P: Pulse, static, DC type 1)

1st output/input

D: 3 digital inputs (managed only by means of the serial communication) 1)
A: Analogue output, 20 mADC (standard)
B: Analogue output, ±10 mA 1)
C: Analogue output, ±5 mA 1)
V: Analogue output, 10 VDC 1)
U: Analogue output, 0 to ±1 VDC 1)

2nd output

X: No output (standard)
S: Serial output, RS 485 multidrop bidirectional 1)
A: Analogue output, 20 mADC 1)
B: Analogue output, ±10 mA1)
C: Analogue output, ±5 mA1)
V: Analogue output, 10 VDC 1)
U: Analogue output, 0 to ±1 VDC 1)

Note: Only for B and C outputs, the 2nd output can only be a B, C or S one.

1) On request

Input Specifications

Number of inputs	
Current	2 (system code: 1) 6 (system code: 3)
Voltage	2 (system code: 1) 4 (system code: 3)
Digital	4, for 3 free of voltage contacts (inputs managed only by the serial communication) Reading voltage/current: 24 VDC/1 mA
Accuracy	
Voltage/current/energy	±0.5% f.s. includes also: frequency, power supply and output load influences
Frequency	±0.5% f.s. (45 to 500 Hz)
Active power (@ 25°C ± 5°C, R.H. ≤ 60%)	±0.5% f.s. (PF 0.7 L/C, 0.6 to 1 In, 0.9 to 1.1 Un) ±1% f.s. (PF 0.3 L/C, 0.2 to 1.2 In, 0.7 to 1.2 Un)

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Input Specifications (cont.)

Accuracy (cont.)	
Reactive power	
(@ 25°C ± 5°C, R.H. ≤ 60%)	±0.5% f.s. (PF 0.7 L/C, 0.6 to 1 In, 0.9 to 1.1 Un) ±1% f.s. (PF 0.3 L/C, 0.2 to 1.2 In, 0.7 to 1.2 Un)
Apparent power	
(@ 25°C ± 5°C, R.H. ≤ 60%)	±0.5% f.s., (0.6 to 1 In, 0.9 to 1.1 Un) ±1% f.s., (0.2 to 1.2 In, 0.7 to 1.2 Un)
Additional errors	
Humidity	< 0.3%, 60% to 90% R.H.
Input frequency	< 0.4%, 62 to 400 Hz
Magnetic field	< 0.5% @ 400 A/m
Ripple	≤ 1% according to IEC 60688-1 and EN 60688-1
Sampling rate	1900 Hz
Display	7-segment, LED, h 14.2 mm
Max. and min. indication	Max. 999, min. -999
Measurements	W, Wavg, VA, VAr, PF, Wh, VAh, VArh, Imax (among the phases), Vdelta avg, VL1-N, VL2-N, VL3-N, Hz L1. TRMS measurement of a distorted wave voltage/current Coupling type : Direct Crest factor: ≥ 3

Ranges (impedances)	
AV1 (Un/In):	100 V /√3/100 V (250 kΩ) - 1 AAC (≤ 0.3 VA)
AV3 (Un/In):	100 V /√3/100 V (250 kΩ) - 5 AAC (≤ 0.3 VA)
AV4 (Un/In):	250 V/433 V (1 MΩ) - 1 AAC (≤ 0.3 VA)
AV5 (Un/In):	250 V/433 V (1 MΩ) - 5 AAC (≤ 0.3 VA)
Frequency range	48 to 62 Hz
Over-load protection	
Continuous: voltage/current	1.2 x rated input
For 1 s	
Voltage:	2 x rated input
Current:	20 x rated input
Keyboard	3 keys: ”S” for enter programming phase and password confirmation, ”UP” and “DOWN” for value programming/function selection

Output Specifications

Analogue outputs	
Number of outputs	1 (standard) + 1 (on request)
Range	0 to 20 mADC, 0 to ±10 mADC, 0 to ±5 mADC, 0 to 10 VDC, 0 to ± 1 VDC
Scaling factor	Programmable within the whole range of retransmission; it allows the retransmission management of all values from 0 to 20 mA, 0 to ±10 mADC, 0 to ±5 mADC 0 to 10 V, 0 to ± 1 VDC
Response time	≤ 250 ms typical (filter excluded)
Temperature drift	300 ppm/°C
Load: 20 mA output	≤ 500 Ω
±10 mA output	≤ 500 Ω
±5 mA output	≤ 1000 Ω
10 V output	≥ 10 kΩ
± 1 V output	≥ 10 kΩ
Insulation	By means of optocouplers, 2000 V_{rms} output to measuring input 4000 V_{rms} output to supply input

Serial output (on request)	
Type	RS422/RS485;
Multidrop	bidirectional (static and dynamic variables)
Connections	4 wires, max. distance 1200m, termination and/or line bias by means of DIP-switches directly on the transducer
Addresses	255, selectable by key-pad
Protocol	MODBUS/JBUS
Data (bidirectional)	
Dynamic (reading only)	System variables: P, P_{AVG}, S, Q, PF, V_{L-L}, f, energy and status of digital inputs, setpoint output and status of the energy overflow bit, Single phase variables: P_{L1}, S_{L1}, Q_{L1}, PF_{L1}, V_{L1-N}, A_{L1}, P_{L2}, S_{L2}, Q_{L2}, PF_{L2}, V_{L2-N}, A_{L2}, P_{L3}, S_{L3}, Q_{L3}, PF_{L3}, V_{L3-N}, A_{L3}
Static (writing only)	All programming data, reset of energy, reset of energy overflow bit, activation of static output. Stored energy (EEPROM) ≥ 250,000.000 kWh
Data format	1-start bit, 8-data bit, no parity/even parity, 1 stop bit

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Output Specifications (cont.)

Serial output (cont.)	
Baud-rate	1200, 2400, 4800 and 9600 selectable bauds
Insulation	By means of optocouplers, 4000 V_{rms} output to measuring inputs 4000 V_{rms} output to supply input
Temperature drift	200 ppm/°C
Pulse output	
Type	From 1 to 999 programmable pulses for kWh, KVAh, KVArh, MWh, MVAh, MVArh, open collector (NPN transistor) V_{ON} 0.6 VDC/ max. 4 mA V_{OFF} 26 VDC max.
Pulse duration	20 ms (ON), ≥ 20 ms (OFF)
Insulation	By means of optocouplers, 4000 V_{rms} output to measuring input, 4000 V_{rms} output to supply input.

Alarms (on request)	
Number of setpoints	1 independent
Alarm type	Up alarm, down alarm
Setpoint adjustment	0 to 100% of the electrical scale
Hysteresis	0 to 100% of the electrical scale
On-time delay	0 to 255 s
Relay status	Normally de-energized
Output type	Static by TRIAC; performances: 24 VAC to 250 VAC, max 50 mA.
Min. response time	300 ms, filter excluded, setpoint on-time delay: "0"
Insulation	2000 V_{rms} output to measuring input, 4000 V_{rms} output to supply input

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 499, all data are protected
Measurement selection	System's active power (W), system's apparent power (VA), system's reactive power (VAr), average active power (Wavg), system's power factor (cos φ), maximum current (I max), average phase-phase voltage, phase-neutral voltage-phase 1, phase-neutral voltage-phase 2, phase-neutral voltage-phase 3, frequency-phase 1. System's (+) active energy, system's apparent energy, system's reactive energy, systems (+/-) active energy

Transformer ratio	For CT up to 5000 A, For VT up to 100 kV (1MV)
Scaling factor	
Operating mode	Electrical scale: compression/ expansion of the input scale to be connected to 1 or 2 analogue outputs and to the alarm output.
Electrical range	Programmable within the whole measuring range
Filter	
Filter operating range	0 to 99.9% of the input electrical scale
Filtering coefficient	1 to 255
Filter action	Both analogue and serial outputs (fundamental variables: V, A, W and their derived ones)

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
Power consumption	≤ 10 VA

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Function Description

Input and output scaling capability
Working of the analogue outputs (y) versus input variables (x)

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

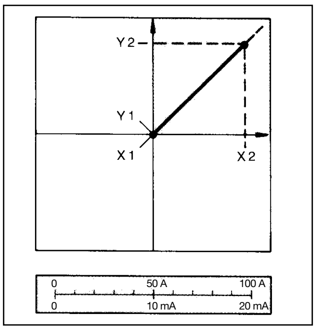


Figure B
The sign of measured quantity and output quantity changes simultaneously. The output quantity is proportional to the measured quantity.

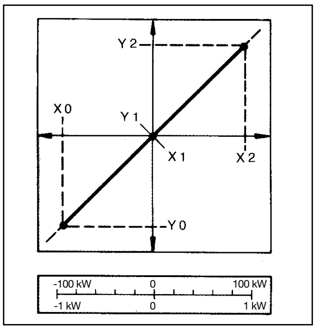


Figure C
The sign of measured quantity and output quantity remains the same. On the range X0...X1, the output quantity is zero. The range X1...X2 is delineated on the entire output range Y0 = Y1...Y2 and thus presented in strongly expanded form.

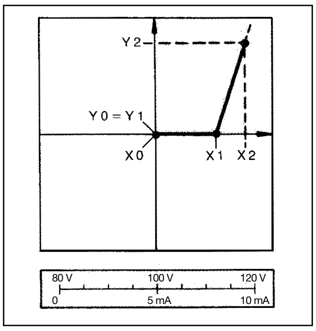


Figure D
The sign of measured quantity and output quantity remains the same. With the measured quantity being zero, the output quantity already has the value Y1 = 0.2 Y2.
Live zero output.

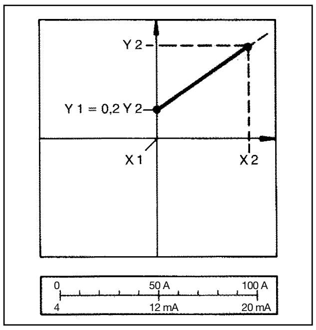


Figure E
The sign of the measured quantity changes but that of the output quantity remains the same. The output quantity steadily increases from value X1 to value X2 of the measured quantity.

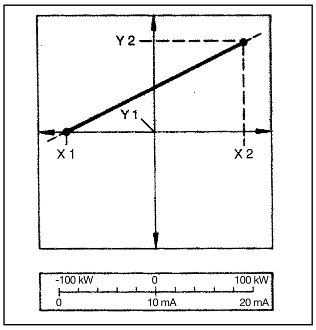
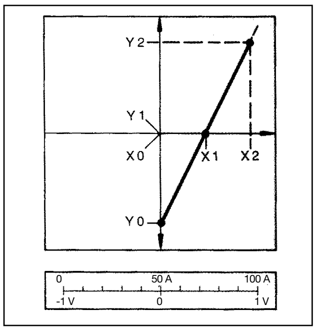


Figure F
The sign of the measured quantity remains the same, that of the output quantity changes as the measured quantity leaves range X0...X1 and passes to range X1...X2 and vice versa.



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 V_{rms} to ground
Insulation	4000 V_{rms} between all inputs/ outputs to ground
Dielectric strength	4000 V_{rms} for 1 minute
Noise rejection	
CMRR	100 dB, 48 to 62 Hz
EMC	EN 50081-2, EN 50082-2

Safety standards	
Safety requirements:	IEC 601010-1, EN 61010-1
Products requirements:	IEC 60688-1, EN 60688-1
Connector	Screw-type, max. 2.5 mm^2 wires
Housing	
Dimensions	6 DIN modules, 58.5 x 89 x 107 mm
Material	ABS, self-extinguishing: UL 94 V-0
Degree of protection	Front: IP50
Weight	Approx. 500 g (packing included)
Approval	CE

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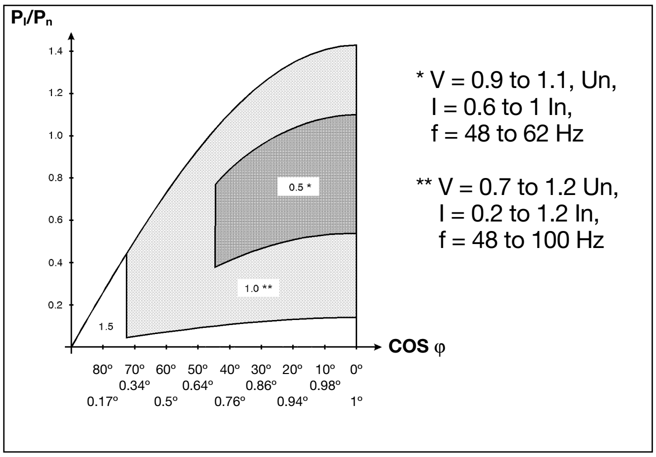
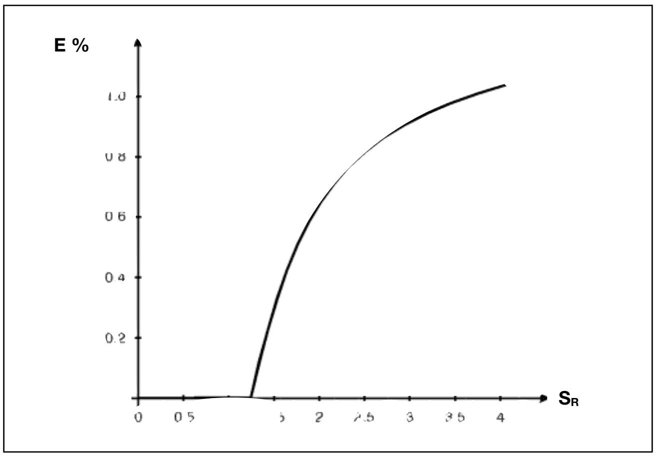
Mode of Operation

Accuracy class of the meter as a relation of P_I/P_n and cos φ



Trends of the "E" error depending on the S_R scale ratio



Input	Star voltage	Delta voltage	Current
AV1	Un: 100 V/√3	Un: 100 V	In: 1 A
AV3	Un: 100 V/√3	Un: 100 V	In: 5 A
AV4	Un: 230 V	Un: 398 V	In: 1 A
AV5	Un: 230 V	Un: 398 V	In: 5 A

P_I (installation power)
One phase system:

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

Three phase, 3-wire system:

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

Three phase, 4-wire system:

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

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

P_n (rated power of transducer)
One phase system:

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

Three phase, 3-wire system:

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

Three phase, 4-wire system:

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

where:
U_n = the rated input voltage of SPT-DIN depending on the model, see table above.
I_n = the rated input current of SPT-DIN depending on the model, see table above.
VT (ratio) = the value of the voltage transformer ratio.
CT (ratio) = the value of the current transformer ratio.

Example 1:
Model AV3.3 (3-wire system).

U_I = 6 kV (delta voltage)
I_I = 265 A (single phase current)
Cos φ = 0.85 (system power factor)
U_n = 100 V
I_n = 5 A

$$VT\ (ratio) = \frac{6\ kV}{100} = 60$$

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

$$P_I = \sqrt{3} \cdot U_I \cdot I_I \cdot \cos\varphi = \sqrt{3} \cdot 6000 \cdot 265 \cdot 0.85 = 2.33\ MW$$

$$P_n = \sqrt{3} \cdot U_n \cdot I_n \cdot VT(ratio) \cdot CT(ratio) = \sqrt{3} \cdot 100 \cdot 5 \cdot 60 \cdot 60 = 3.12\ MW$$

$$\frac{P_I}{P_n} = \frac{2.33}{3.12} = 0.75$$

Example 2:
Model AV3.3 (4-wire system).

U_I = 6 kV / √3
I_I = 265 A
Cos φ = 0.85
U_n = 100 V / √3
I_n = 5 A

$$VT\ (ratio) = \frac{6\ kV / \sqrt{3}}{100 / \sqrt{3}} = 60$$

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

$$P_I = 3 \cdot U_I \cdot I_I \cdot \cos\varphi = 3 \cdot 6000 / \sqrt{3} \cdot 265 \cdot 0.85 = 2.33\ MW$$

$$P_n = 3 \cdot U_n \cdot I_n \cdot VT(ratio) \cdot CT(ratio) = 3 \cdot 100 / \sqrt{3} \cdot 5 \cdot 60 \cdot 60 = 3.12\ MW$$

$$\frac{P_I}{P_n} = \frac{2.33}{3.12} = 0.75$$

In both examples the accuracy of the measurement is 0.5% f.s. when considering the changing of the measured voltage from 0.9 Un to 1.1 Un and the measured current from 0.6 In to 1 In with a cos φ of 0.85. The accuracy of the output is connected to the accuracy of the measurement plus the scale ratio of both input (Hi.E - Lo.E) and output (Hi.A - Lo.A) as shown in the graph above (E% versus S_R).

Regarding S_R:

$$S_R = \frac{AFS \cdot (Hi.A - Lo.A)}{100 \cdot (Hi.E - Lo.E)} \leq 1.25$$

AFS = automatic electrical full scale calculated value.
S_R = scale ratio.
There is not any additional error on the output signal if $S_R \leq 1.25$.

Example 3:

AFS = 3.30 MW
Lo.E = 0 MW
Hi.E = 3.30 MW
Lo.A = 20%
Hi.A = 99.9%

$$S_R = \frac{3.30\ (99.9-20)}{100\ (3.30-0)} = 0.8$$

0.8 ≤ 1.25 no additonal errors

Example 4:

AFS = 3.30 MW
Lo.E = 1.00 MW
Hi.E = 3.30 MW
Lo.A = 20%
Hi.A = 99.9%

$$S_R = \frac{3.30\ (99.9-20)}{100\ (3-1)} = 1.32$$

1.32 ≥ 1.25 means that there is an additional error of 0.2% f.s. according to the graph at the previous page.

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Mode of Operation (cont.)

Waveform of the signals that can be measured

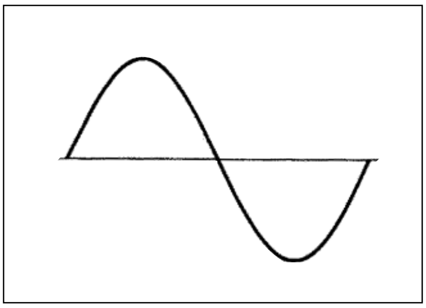


Figure G
Sine wave, undistorted

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

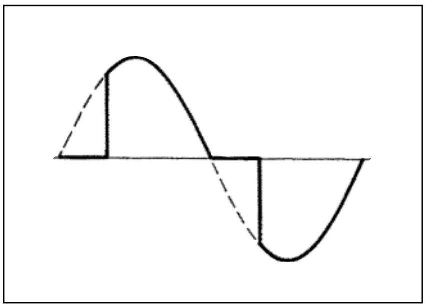


Figure H
Sine wave, indented

Fundamental content 10...100%
Harmonic content 0...90%
Frequency spectrum 3rd to 16th harmonic
Required result: additional error < 1%

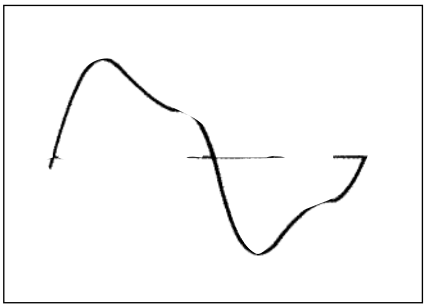


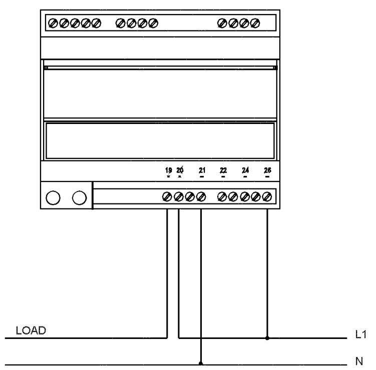
Figure I
Sine wave, distorted

Fundamental content 70...90%
Harmonic content 10...30%
Frequency spectrum 3rd to 15th harmonic
Required result: additional error < 0.5%

Wiring Diagrams

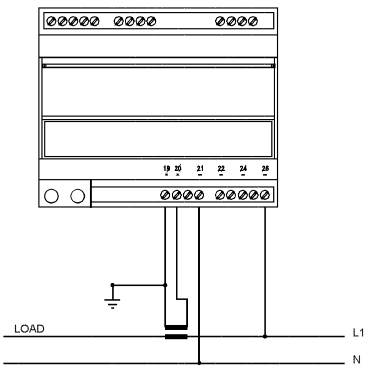
Single phase input connections
SPT-DIN AV1/AV3/AV4/AV5.1

Fig. 1



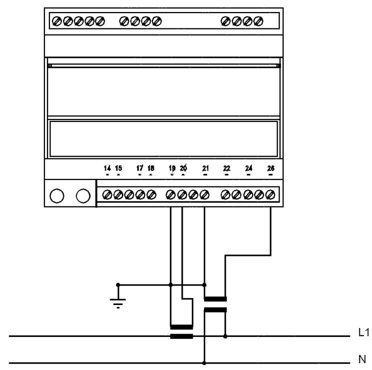
Direct connection

Fig. 2



CT connection

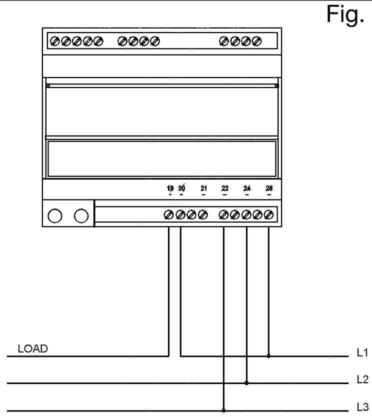
Fig. 3



CT and VT connection

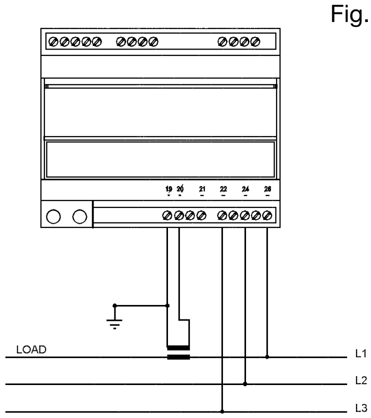
Three phase input connections - Balanced loads
SPT-DIN AV1/AV3/AV4/AV5.1

Fig. 4



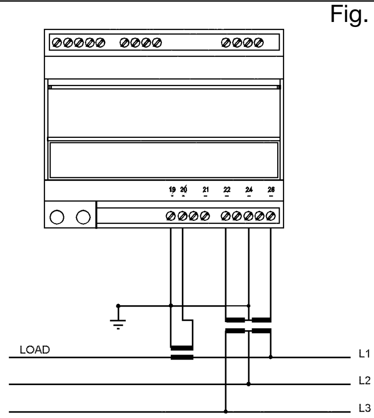
Direct connection (3-wire system)

Fig. 5



CT connection (3-wire system)

Fig. 6

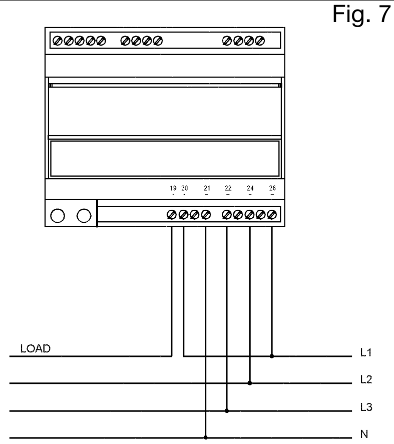


CT and VT connection (3-wire system)

Wiring Diagrams (cont.)

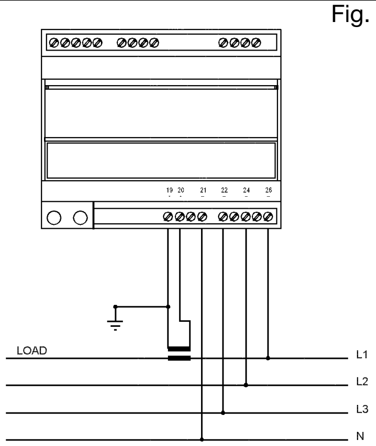
Three phase input connections - Balanced loads
SPT-DIN AV1/AV3/AV4/AV5.1

Fig. 7



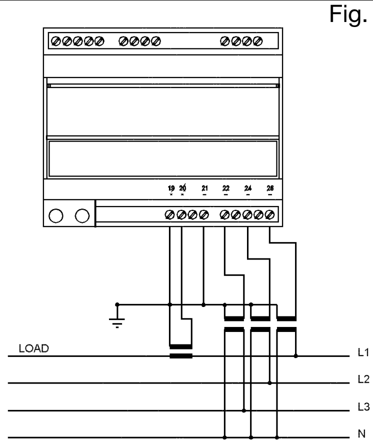
Direct connection (4-wire system)

Fig. 8



CT connection (4-wire system)

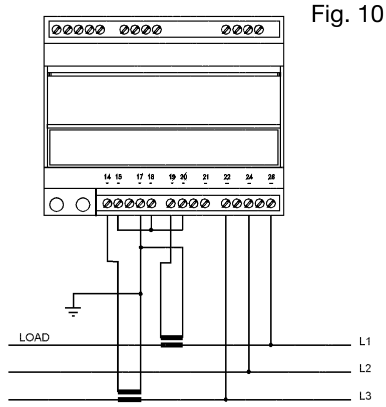
Fig. 9



CT and VT connection (4-wire system)

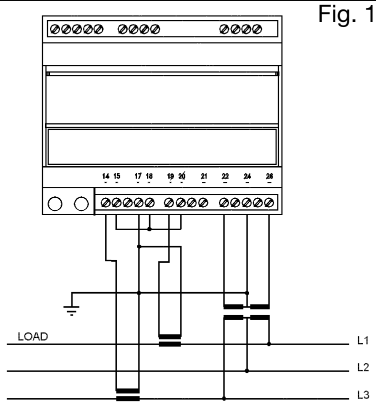
Three-phase, 3-wire ARON input connections - Unbalanced loads
SPT-DIN AV1/AV3/AV4/AV5.3

Fig. 10



CT connection (3-wire system)

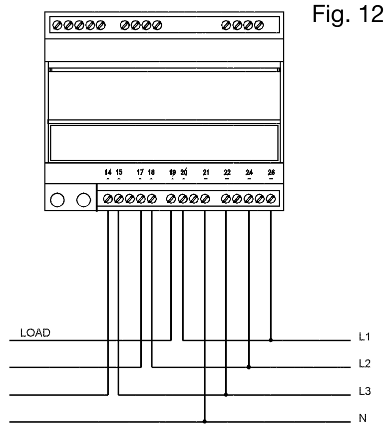
Fig. 11



CT and VT connection (3-wire system)

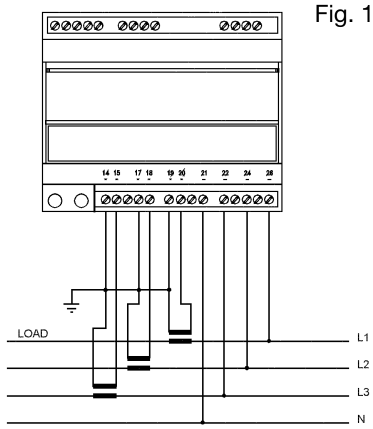
Three phase, 4-wire input connections - Unbalanced loads
SPT-DIN AV1/AV3/AV4/AV5.3

Fig. 12



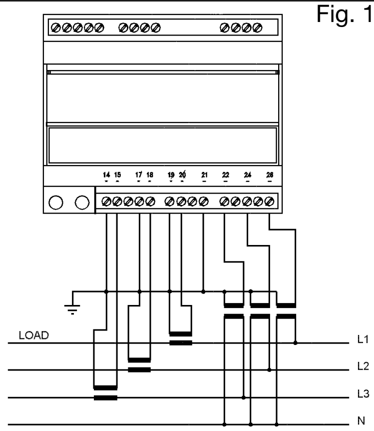
Direct connection (4-wire system)

Fig. 13



CT connection (4-wire system)

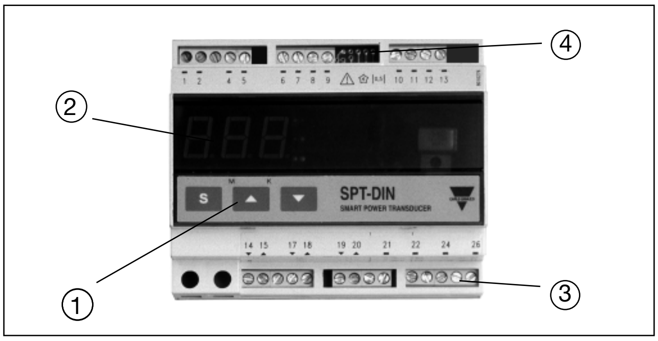
Fig. 14



CT and VT connection (4-wire system)

CARLO GAVAZZI

Front Panel Description



1. **Key-pad**
   Set-up and programming procedures are easily controlled by the 3 pushbuttons.

   “S”
   - Selection key to select programming function (transducer configuration) and alarm detection.

   ” ▲ ” and ” ▼ ”
   - Up and down keys for increasing or decreasing programming values.
   - Selecting programming functions and transducer configuration together with the ”S” key.

2. **Display**
   3 -digit (maximum read-out 999).

   Alphanumeric indication by means of 7-segment display for:
   - Displaying only the configuration parameters

3. **Connection terminal blocks**

4. **Dip-switch**
   - For the selection of 2/4 wire connection, line biasing and/or line termination (only in case of RS 485 option)

Dimensions