

## Configurable Rogowski Coil signal conditioner

### Ref: AI-PMUL

The universal Rogowski coil integrator AI-PMUL compliments LEM's flexible clip-around coil ART and ARU range. The design is based on digital processing to give combined dynamic range, precision and versatility of use. It offers a wide range of outputs both RMS and instantaneous. AI-PMUL is DIN rail mounted and can be stacked for multiphase application without spacing thanks to its low power dissipation.



### Features

- Accuracy Class 0.5 (IEC 61869-2)<sup>1</sup>
- Linearity error  $\leq 0.10\%$
- Protection degree IP2X
- DIN rail mounted 35mm
- Push-in terminal
- 4 selectable true RMS output signals  
0-20mA, 4-20mA, 0-5V, 0-10V
- 2 selectable instantaneous output signals  
225mV, 333mV
- 6 selectable sensitivities depending on Rogowski coil  
22.5, 70, 80, 85, 100, 120 mV/kA @ 50Hz
- 12 selectable ranges  
100A, 200A, 300A, 400A, 500A, 600A, 800A, 1000A,  
1500A, 2000A, 4000A, 5000A
- Ambient operating temperature  $-25^{\circ}\text{C} \dots +70^{\circ}\text{C}$ .

### Advantages

- Compact design for DIN rail assembly
- High accuracy Class 0.5 (IEC 61869-2)<sup>1</sup>
- Setup by user via Select / Edit buttons
- Clear status via bi-color led

### Applications

- MV/LV substations: Transformer Condition Monitoring
- Power metering: current measurement for active power calculation
- Building sub-metering: energy efficiency monitoring, consumption analysis and cost allocation
- Power quality monitoring: electrical loads and distribution system equipment
- Fault Detection, Insulation and Repair (FDIR): insulate the site of the fault
- Remote Terminal Units (RTU)

### Standards

- Safety: IEC 61010-1: 2010
- EMC: IEC 61326-1: 2012

### Options

- Cross Power Plug-in: side contacts to stack up to 3 Integrator modules and use only one power supply.

<sup>1</sup> AI-PMUL Integrator fulfill accuracy class limit define by IEC 61869-2 even if this standard does not apply to Rogowski integrator. See detailed curve of accuracy given in this document.

## Insulation coordination

| Parameter  | Symbol | Unit | Value | Comment  |
|--|--------|------|-------|--|
| RMS voltage for AC insulation test, 50 Hz, 1 min | $U_d$  | kV   | 1,5   | Between power supply 24 V and Rogowski connection + output |
| Case material                                    | -      | -    | V0    | According to UL 94   |

## Environmental characteristics

| Parameter                          |       | Unit | Min | Typ | Max  | Comment |
|------------------------------------|-------|------|-----|-----|------|---------|
| Ambient operating temperature      | $T_A$ | °C   | -25 |     | 70   |         |
| Ambient storage temperature        | $T_s$ | °C   | -40 |     | 85   |         |
| Relative humidity (non-condensing) | $RH$  | %    |     |     | 95   |         |
| Altitude above sea level           |       | m    |     |     | 2000 |         |
| Mass                               | $m$   | g    |     | 58  |      |         |

## Mechanical characteristics

| Parameter         | Symbol | Unit | Value       | Comment |
|-------------------|--------|------|-------------|---------|
| General tolerance | -      | mm   | ±1          |         |
| Dimension         | -      | mm   | 100x78x15   |         |
| Mounting          | -      | -    | DIN rail 35 |         |

## Power Supply

| Parameter  | Symbol      | Unit | Min | Typ | Max | Comment |
|--|-------------|------|-----|-----|-----|---------|
| Supply voltage   | $U_{c\ DC}$ | V    | +10 | +24 | +32 |         |
| Current consumption  | $I_c$       | mA   |     |     | 100 | @ 24 V  |
| Auxiliary supply through micro-USB<br>(for product configuration only) |             | V    |     | 5   |     |         |

## Input Signal

| Paramete   | Symbol | Unit  | Data  | Comment  |
|--|--------|-------|---|--|
| Rogowski coil sensitivity selection                  |        |       | With push buttons   | See product configuration description                            |
| Selection indication                                 |        |       | LED bi-color  | Green : Current range<br>Red : Sensitivity & Output              |
| Rogowski coil sensitivities                          |        | mV/kA | 22.5, 70, 80, 85, 100, 120                                      | At 50Hz  |
| Typical input impedance                              |        | kΩ    | 10  |  |
| Rated frequency                                      | $f_r$  | Hz    | 50 - 60   | Automatic recognition of grid frequency                          |
| Frequency bandwidth                                  | $BW$   | Hz    | 10 - 1500   | Measurement bandwidth  |
| Current measurement range selection                  |        |       | With push buttons   | See product configuration description                            |
| Current measurement range                            |        | A     | 100, 200, 300, 400, 500, 600, 800, 1000, 1500, 2000, 4000, 5000 |  |
| Overcurrent measurement range                        |        | %     | 120   | Overcurrent based on maximum value of the range selected         |
| Short time withstand current on primary <sup>2</sup> |        | kA-3s | 130   | Worst case scenario with a Rogowski coil sensitivity of 120mV/kA |

## Output Signal

| Parameter                                  | Symbol          | Unit  | Min | T                      | Max  | Comment                   |
|--|-----------------|-------|-----|------------------------|------|---------------------------|
| 0-20 mA true RMS current output mode       | $I_{out}$       | mA    | 0   | -                      | 24   | 20 mA @ 100% I range      |
| 4-20 mA true RMS current output mode       | $I_{out}$       | mA    | 4   | -                      | 23.2 | 20 mA @ 100% I range      |
| 0-5 V true RMS voltage output mode         | $U_{out}$       | V     | 0   | -                      | 6    | 5 V @ 100% I range        |
| 0-10 V true RMS voltage output mode        | $U_{out}$       | V     | 0   | -                      | 12   | 10 V @ 100% I range       |
| 225mV instantaneous voltage output mode    | $U_{out}$       | mV    | 0   | -                      | 270  | 225 mV rms @ 100% I range |
| 333mV instantaneous voltage output mode    | $U_{out}$       | mV    | 0   | -                      | 400  | 333 mV rms @ 100% I range |
| Load resistance (all current output mode)  | $R_L$           | Ω     | 0   | -                      | 500  |                           |
| Load resistance (all voltage output mode)  | $R_L$           | kΩ    | 1   | -                      | -    |                           |
| Temperature drift (all output mode)        | $TCS$           | ppm/K | -   | -                      | 150  | In range -25 °C +70 °C    |
| Phase displacement @ 50/60 Hz <sup>3</sup> | $\Delta\phi$    | °     | -   | -                      | 0.5  |                           |
| Accuracy                                   | ?               |       | -   | Class 0.5 <sup>4</sup> | -    |                           |
| Linearity error                            | $\varepsilon_L$ | %     |     |                        | 0.1  |                           |

<sup>2</sup> Maximum AI-PMUL input voltage of 16 V for 3s equivalent of measurement of short time current of 130 kA for 3s with a Rogowski coil of 120mV/kA sensitivity. For higher short time current rated network please consult our technical team

<sup>3</sup> Value for instantaneous signal output and steady state primary current

<sup>4</sup> AI-PMUL Integrator fulfill accuracy class limit define by IEC 61869-2 even if this standard does not apply to Rogowski integrator. See detailed curve of accuracy given in this document.

## Definition of typical, minimum and maximum values

Minimum and maximum values for specified limiting and safety conditions have to be understood as such as well as values shown in “typical” graphs.

On the other hand, measured values are part of a statistical distribution that can be specified by an interval with upper and lower limits and a probability for measured values to lie within this interval.

Unless otherwise stated (e.g. “100 % tested”), the LEM definition for such intervals designated with “min” and “max” is that the probability for values of samples to lie in this interval is 99.73 %.

For a normal (Gaussian) distribution, this corresponds to an interval between  $-3$  sigma and  $+3$  sigma. If “typical” values are not obviously mean or average values, those values are defined to delimit intervals with a probability of 68.27 %, corresponding to an interval between  $-\sigma$  and  $+\sigma$  for a normal distribution.

Typical, minimum and maximum values are determined during the initial characterization of the product.

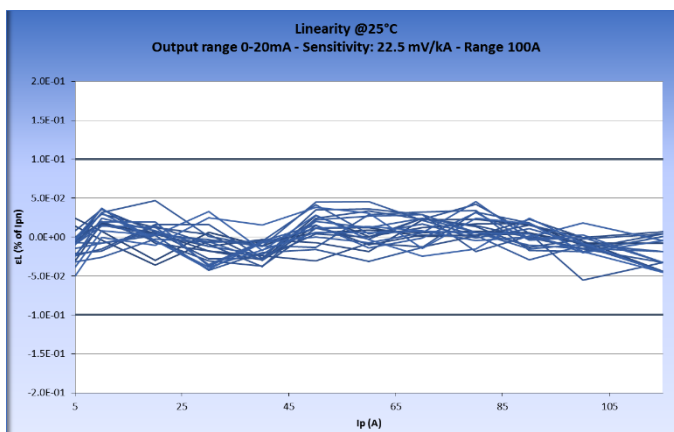
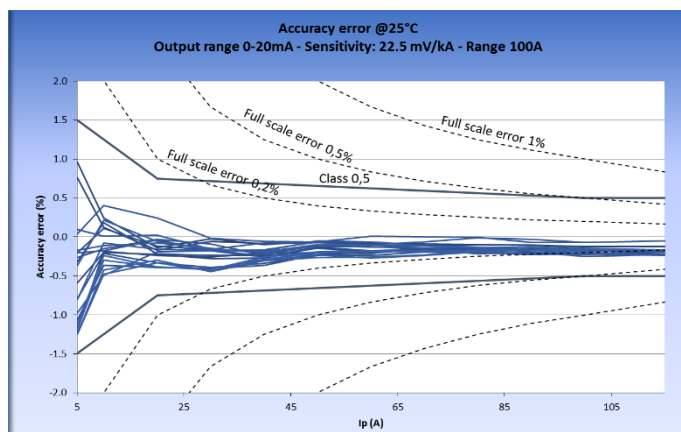
## Compatibility between current range selected and Coil sensibility selected

Current range and coil sensitivity should be chosen according to the table hereunder.

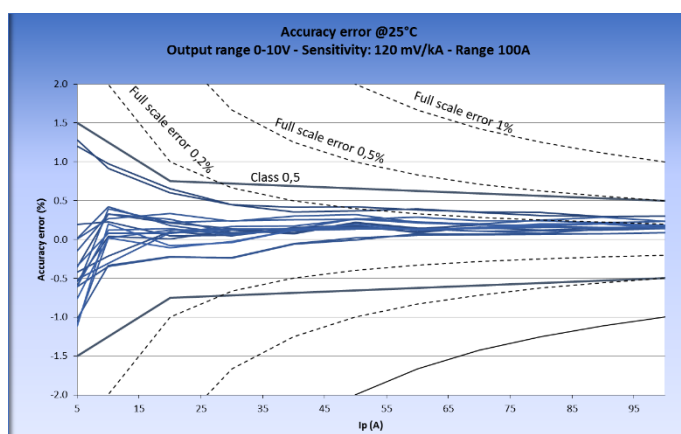
|                        |      | Coil sensibility selected |    |    |    |     |     |
|------------------------|------|---------------------------|----|----|----|-----|-----|
|                        |      | 22.5                      | 70 | 80 | 85 | 100 | 120 |
| Current Range Selected | 100  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 200  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 300  | ok                        | ok | ok | ok |     |     |
|                        | 400  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 500  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 600  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 800  | ok                        | ok | ok | ok | ok  | ok  |
|                        | 1000 | ok                        | ok | ok | ok | ok  | ok  |
|                        | 1500 | ok                        | ok | ok | ok | ok  | ok  |
|                        | 2000 | ok                        | ok | ok | ok | ok  |     |
|                        | 4000 | ok                        |    |    |    |     |     |
|                        | 5000 | ok                        |    |    |    |     |     |

## Typical performance characteristics

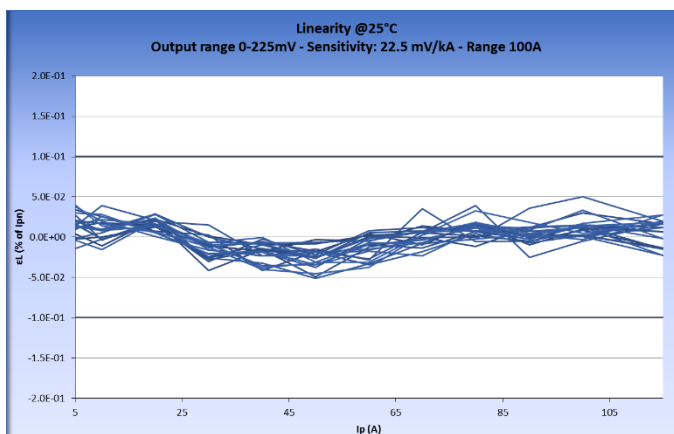
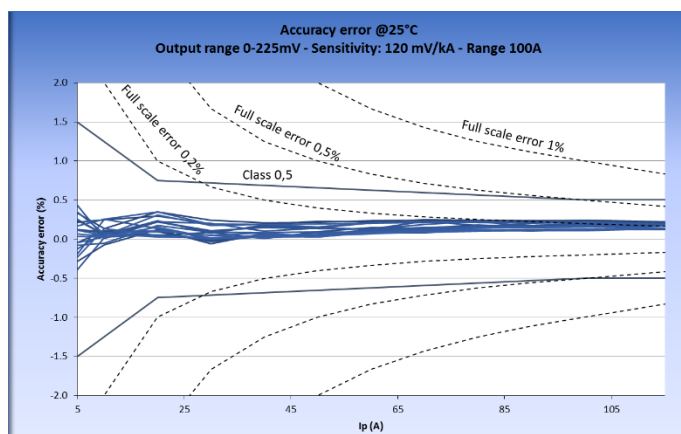
### Output 0-20mA Range 1000A Sensitivity 22.5 mV/kA



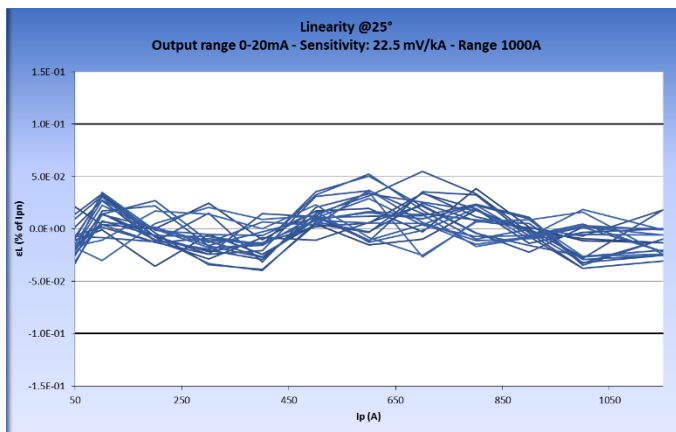
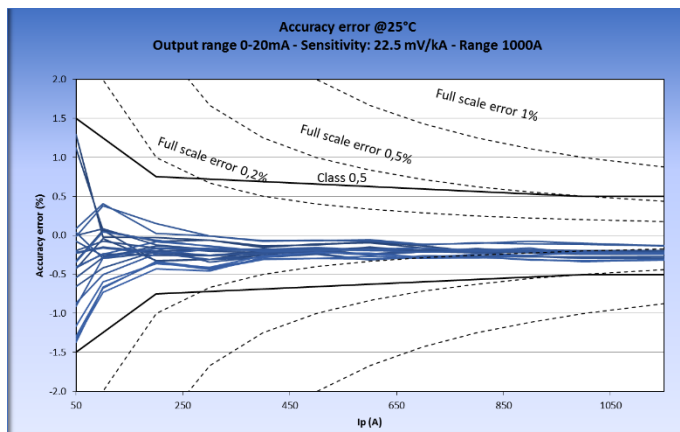
### Output 0-10V Range 1000A Sensitivity 22.5 mV/kA



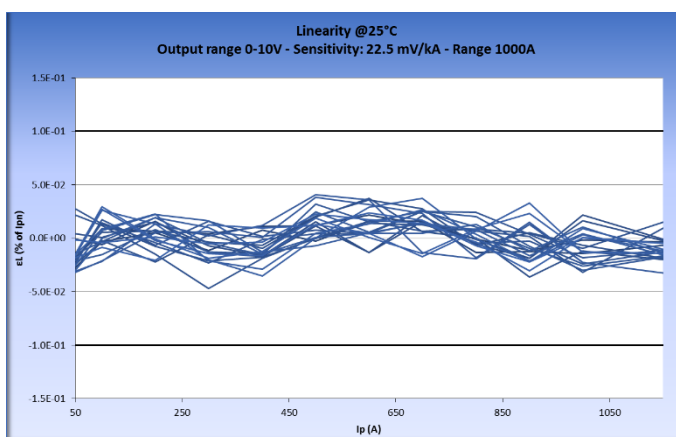
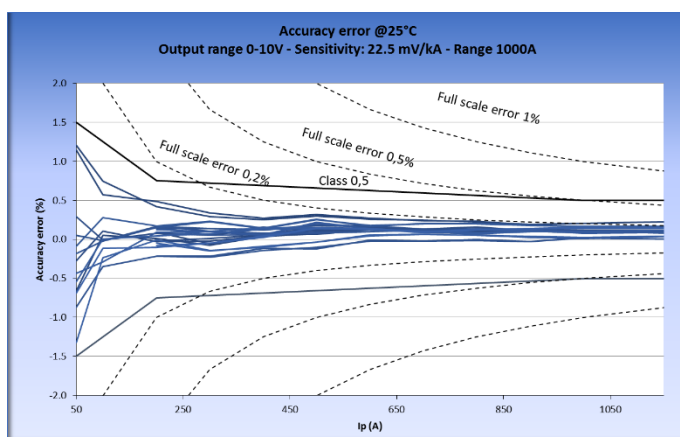
### Output 0-225mV Range 1000A Sensitivity 22.5 mV/kA



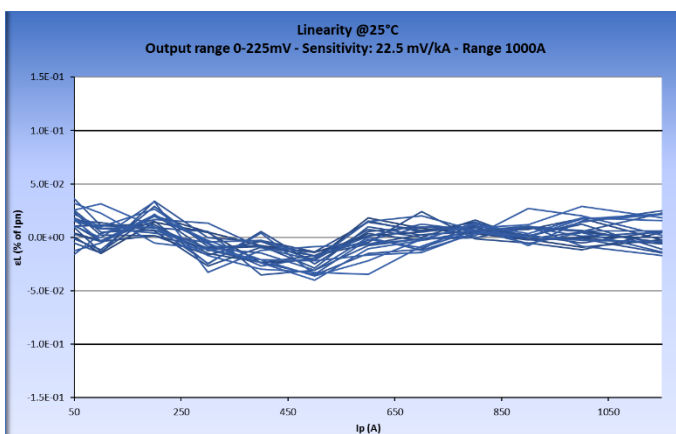
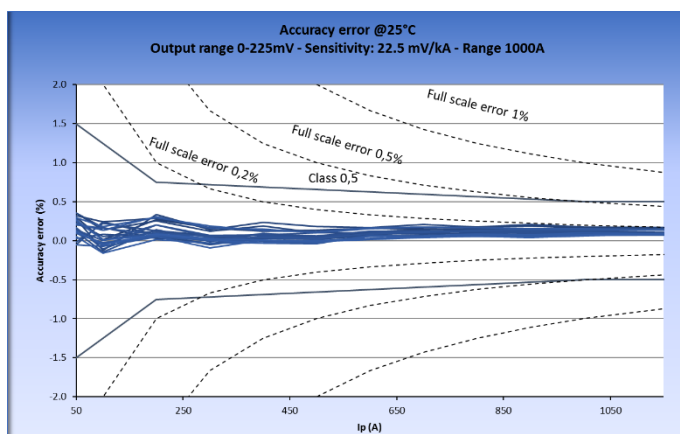
### Output 0-20 mA Range 100 A Sensitivity 22.5 mV/kA



### Output 0-10 V Range 100 A Sensitivity 22.5 mV/kA



### Output 0-225 mV Range 100 A Sensitivity 22.5 mV/kA

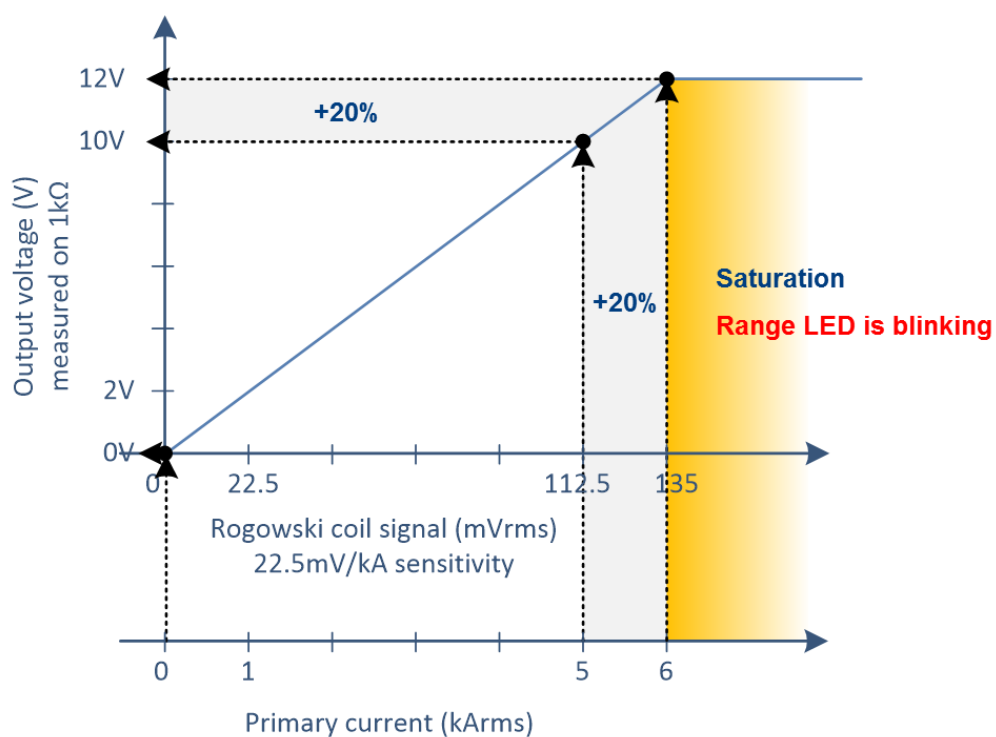


## Example of application

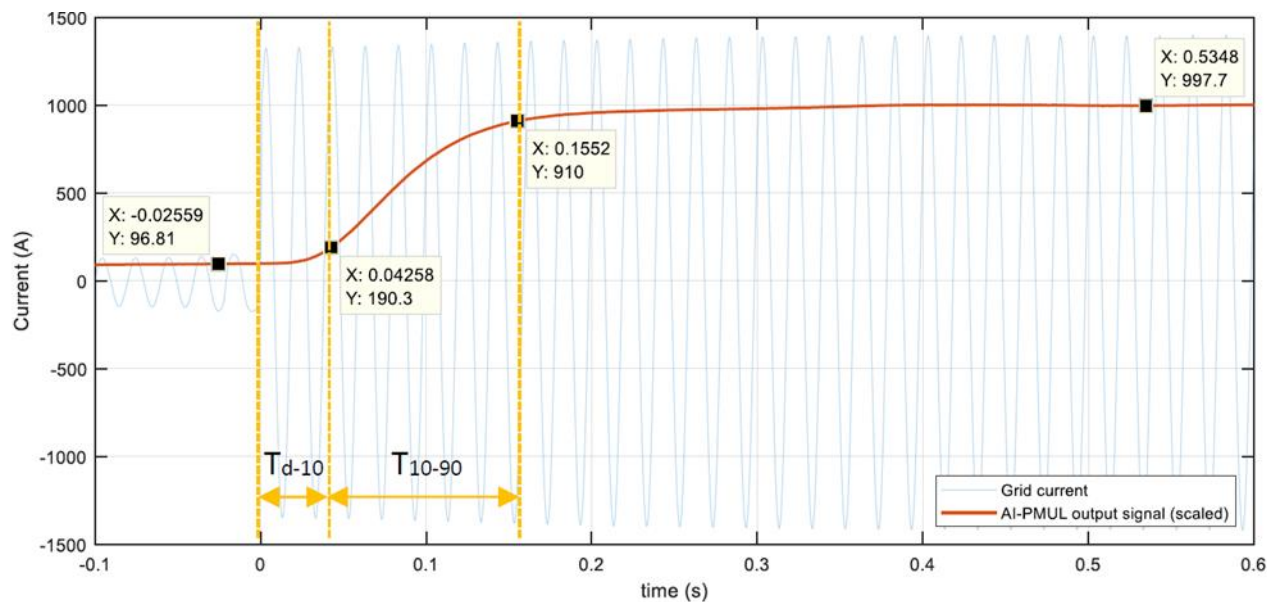
### Product configuration

- Range (green LED): 5000A
- Output signal (red LED): 0-10V
- Sensitivity (red LED): 22.5mV/kA

The graph hereafter give conversion between the primary current, the voltage output of Rogowski coil and the output voltage of the AI-PMUL.

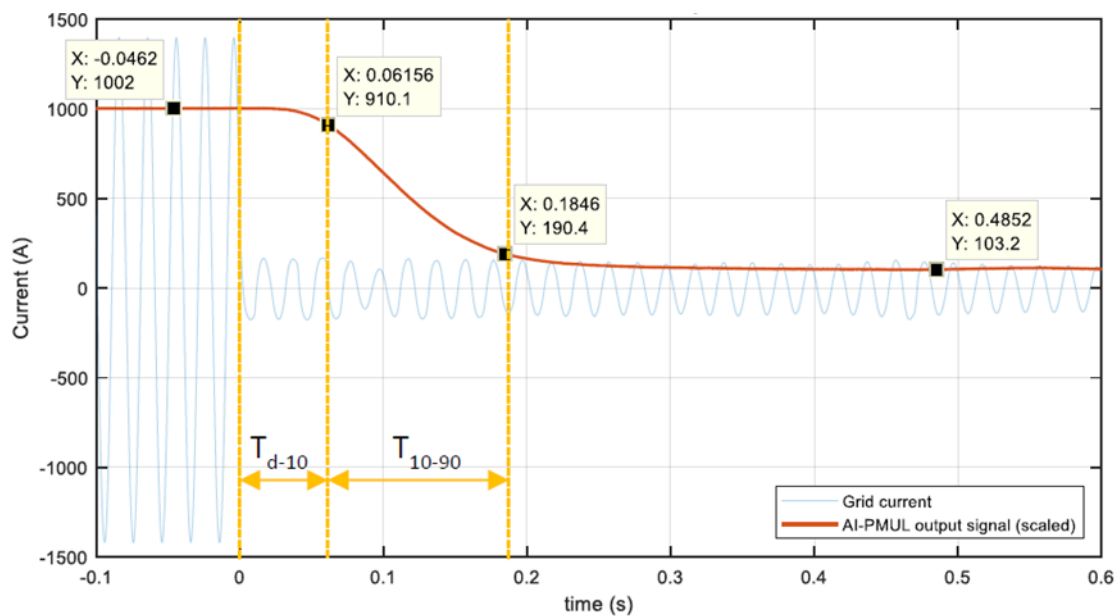


## Example of typical transient response output 0-10V



### Current rise

- $T_{d-10} < 45\text{ms}$
- $T_{10-90} < 115\text{ms}$

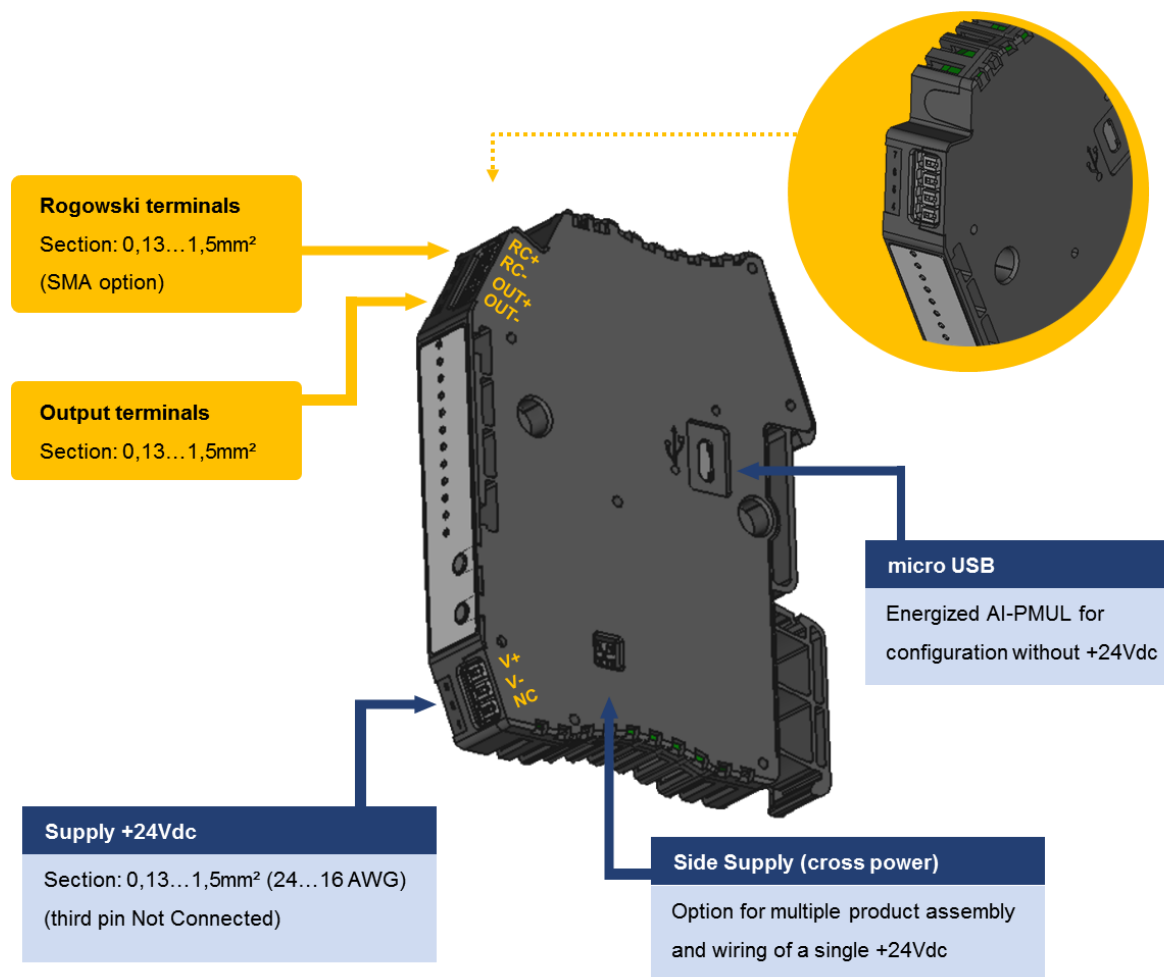


### Current fall

- $T_{d-10} < 65\text{ms}$
- $T_{10-90} < 125\text{ms}$



## Connections and Interfaces



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| Parameter        | Symbol | Unit            | Min  | Typ     | Max | Comment |
|------------------|--------|-----------------|------|---------|-----|---------|
| Type             |        |                 |      | Push-in |     |         |
| Clamping range   |        | mm <sup>2</sup> | 0.13 | -       | 1.5 |         |
| Cross section    |        | AWG             | 24   | -       | 16  |         |
| Stripping length |        | mm              | 8    | -       | -   |         |

## AI-P1A series: name and codification

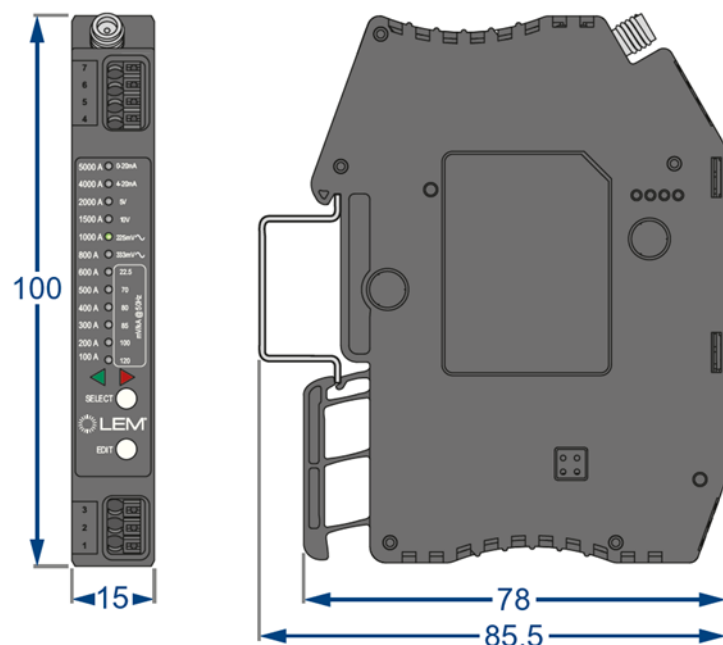
AI-PMUL

**Family:**  
AC Integrator

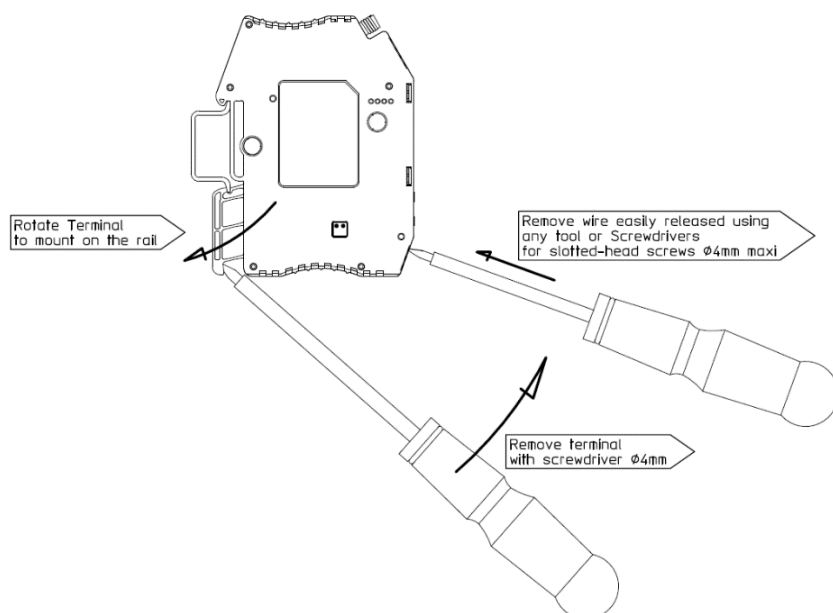
**Case type / Output signal:**  
P: DIN RAIL mounting MUL Multiple output

| Description                                | Item Number    | Comments   |
|--|----------------|--|
| AI-PMUL                                    | 90.T5.99.000.0 | Integrator Low Power standard for automation applications.                 |
| AI ACCESSORY KIT M2<br>CROSS POWER PLUG-IN | 90.T8.98.001.0 | Cross Power plug-in accessory: Kit to connect 2 integrators power supplies |
| AI-PMUL/SP1                                | 90.T5.99.001.0 | Reserved number for customer   |

## Dimensions (in mm)



## Install and remove



## Safety and warning notes

**In order to guarantee safe operation of the signal conditioner and to be able to make proper use of all features and functions, please read these instructions thoroughly!**

**Safe operation can only be guaranteed if the signal conditioner is used for the purpose it has been designed for and within the limits of the technical specifications.**

### **Caution**

Ignoring the warnings can lead to serious injury and/or cause damage! The electric measuring signal conditioner may only be installed and put into operation by qualified personnel that have received an appropriate training. The corresponding national regulations shall be observed during installation and operation of the signal conditioner and any electrical conductor. The signal conditioner shall be used in electric/electronic equipment with respect to applicable standards and safety requirements and in accordance with all the related systems and components manufacturers' operating instructions.

Product must be powered by limited power source. Product shall be operated with Rogowski Coil compliant with IEC 61010-2-032. Consistency of measurements during maintenance operations shall be checked. Consistency of measurement during commissioning and maintenance shall be checked with suitable means (ammeter clamp). Product shall not saturate.

### **Caution, Possibility of electric shock**

When operating the signal conditioner, certain parts next to the signal conditioner may carry hazardous live voltage. The user shall ensure to take all measures necessary to protect against electrical shock. Certain parts may contain conducting parts that shall not be accessible after installation. A protective enclosure or additional insulation barrier may be necessary. Installation and maintenance shall be done with the main power supply disconnected except if there are no hazardous live parts in or in close proximity to the system and if the applicable national regulations are fully observed.

Safe and trouble-free operation of this signal conditioner can only be guaranteed if transport, storage and installation are carried out correctly and operation and maintenance are carried out with care. The signal conditioner shall not be opened or modified. If not working, the signal conditioner shall be replaced by an equivalent device. To avoid electrical burn, electric shock or arc flash, do not install Rogowski coils on or remove them from hazardous live conductors. Any connection to the product shall be in safety extra low voltage.