Technical
Information

# New Isolated Voltage Measuring Transducers for Traction Applications. The AV 100 series


LEM

# New Isolated Voltage Measuring Transducers for Traction Applications. The AV 100 series

*by Brian Carter and Stéphane Rollier*

*Measuring voltages up to 1500 $V_{RMS}$ is taking less and less space thanks to LEM with the new AV 100 transducers series. This series is the latest product developed for compact and low cost voltage measurements from 50 V to 1500 V nominal.*

*No less than 8 models are available in an unique optimised mechanical design to cover the voltage measurements of 50, 125, 150, 250, 500, 750, 1000 & 1500 $V_{RMS}$.*

*Their main applications area is in traction inverters but they are also adapted for any industrial application.*

*To work, they just need to be connected to the voltage to measure without any additional resistors to insert and a standard DC power supply ±12 to 24 V.*
*Despite a drastic improvement on cost compared to existing models, the AV 100 series does not compromise in terms of performances and quality. Response time is as fast as 13 µs. Linearity errors are within ± 0.1 % and overall accuracy reached between -40°C up to +85°C is of ±1.7 % of $V_{PN}$.*

*Finally, for those who are familiar to LEM, CE marking and material compliance to UL94V0 on our products are a must.*

## AV 100 Transducers Technology: Isolating Amplifier Technology

Until now, LEM proposed mainly voltage transducers based on the Hall effect Closed Loop technology to realise the voltage measurements. It is the well-known LV 100 series.

This series brings all the required results. However, today, a new requirement appears: The restricted dimensions due to the installations having to be smaller and smaller. This led LEM to develop a new measurement technology based on the isolating amplifier technology giving birth to the **AV 100 series**.

To measure voltage ($V_P$), the AV 100 series uses only well-known electronic components, the main one being an isolating amplifier. The voltage to measure ($V_P$) is directly applied on the transducer primary connections through an internal resistor network and some components allowing the signal to feed an isolation amplifier.

Thanks to it, an isolated signal is recovered and then conditioned in order to supply a current at the transducer output connections, which is an exact representation of the primary voltage (Fig.1).

**Isolating Amplifier technology features**

- Any kind of signal, DC, AC, pulsed, complex can be measured.
- Galvanic isolation between primary (high power) and secondary circuits (electronic circuit).
- Short dynamic response for a good frequency Bandwidth.
- Fast response time
- Small volume needed.

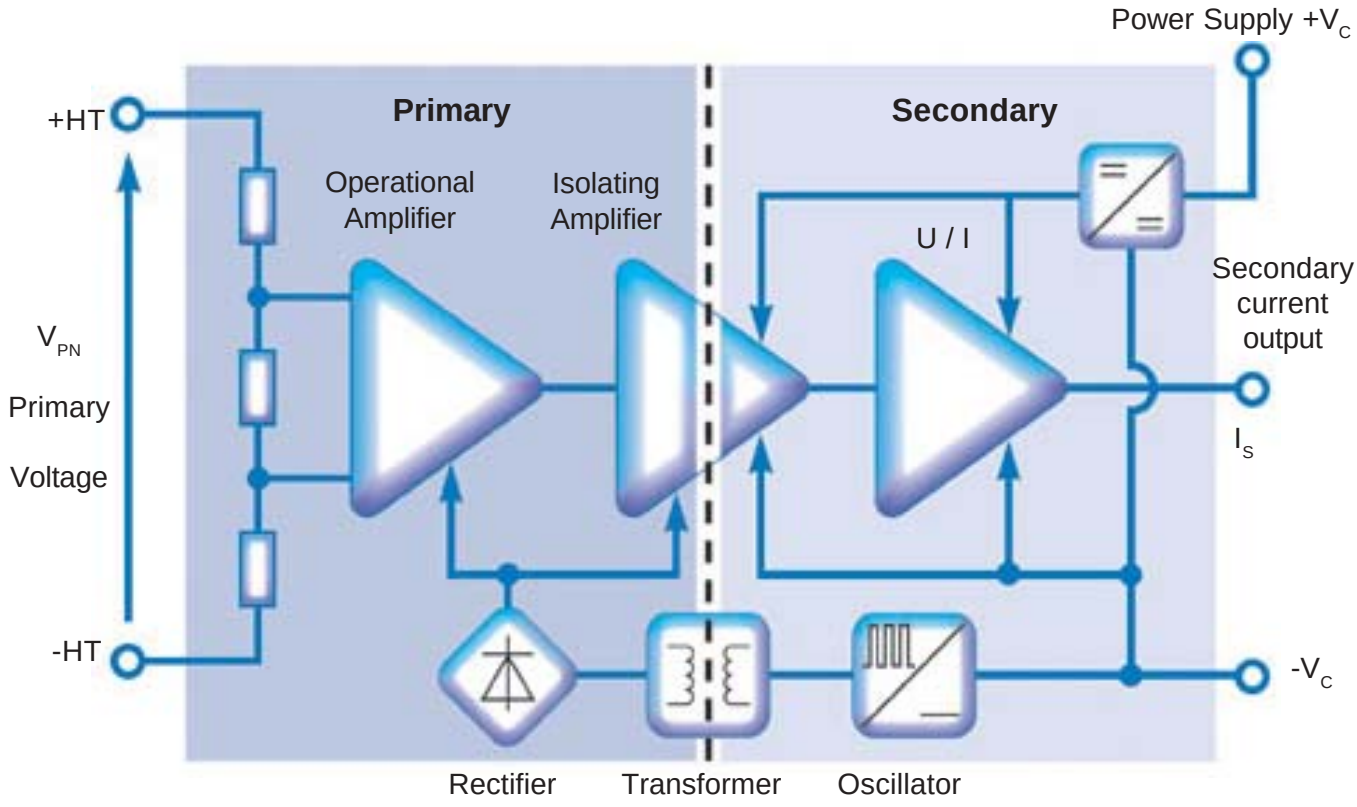



*Fig. 1. AV 100 Operation principle: Isolating Amplifier Technology.*

The technology used had to ensure at least the same galvanic isolation and similar bandwidth than the Hall effect based technology for the voltage measurement. This has been achieved and even more as the bandwidth reached is not linked to the model chosen.

But the main advantage is certainly coming beyond question from the dimensions, with a common compact design for each model from 50 to 1500 $V_{RMS}$ nominal. Indeed, the usual large heatsink used for the power dissipation of the integrated primary resistors is not needed anymore in the AV 100 transducers.

This is a non negligible space reduction. For comparison, around 271 $cm^3$ of volume is gained with the use of the AV 100 Series vs the LV 100 Series (fig. 2).
The AV 100 series delivers a current output of 50 mA for $V_{PN}$ and can measure both DC and AC voltages, as well as the complex voltage waveforms. The output current is always a true image of the primary voltage.

Each model of the series allows a voltage measuring range of 1.5 times the nominal voltage value.
The secondary connections offer a double solution in each product for the fastening, either 3 x M5 threaded studs for a "strong" and ensured connection or 3 x Faston (6.35 x 0.8 mm) for a quick installation.
As standard characteristic, the AV 100 series has been designed in order to work into applications with operating temperature range from -40°C to +85°C.

In addition to the space reduction, the AV 100 series is cost saving solution to achieve voltage measurements, that benefits the customer.

**5 years' warranty**

The experience and know-how acquired over the last 3 decades have allowed LEM to meet their objectives for this new generation.

LEM Components has produced and sold more than a hundred million of highly reliable current and voltage transducers on the market during the last three decades.
The experience acquired in all the applications, and the high quality level allow us to offer a "Five Years warranty" on all data sheet specifications of these products.

**Standards**

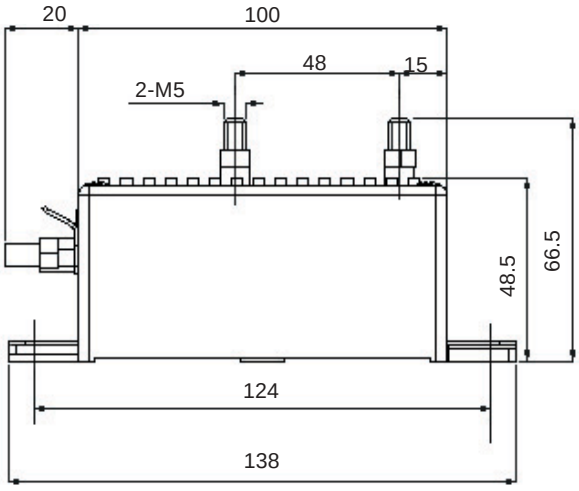
All materials used for AV 100 series are UL94V0 and the transducers are CE marked in accordance with the European Directive 89/336/EEC and thus satisfy the derived local EMC regulations.

EN50155 standard is the reference standard used at LEM to guarantee the overall performances of the transducers in the railway environment for electrical, environmental and mechanical parameters.

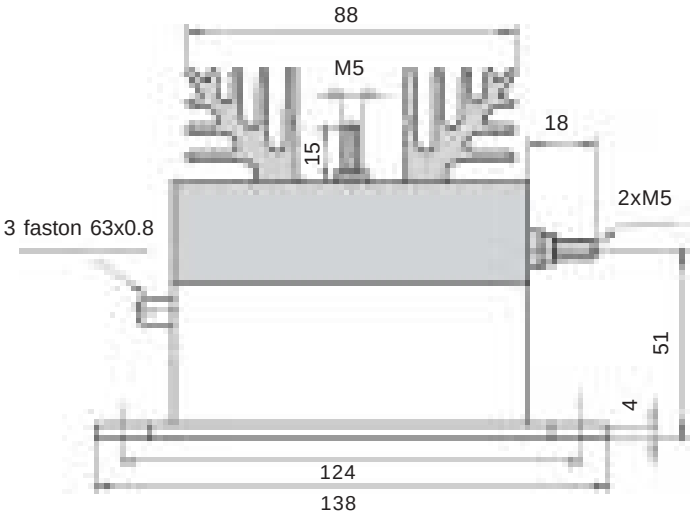
The EN 50124-1 has been the tool used by LEM for the AV 100 series design to define the Clearances and Creepage distances to respect in Railway applications for the insulation levels.

The products are complying with the NFF 16101/2 standards for fire and smoke classification (tests report for materials available on request).

Approval to UL 508 is pending.




AV 100




LV 100

*Fig. 2. AV 100 vs LV 100 dimensions.*

### Measuring resistor $R_M$ Calculation

The AV 100 series supplies a current as output. This current can be transformed into a voltage thanks to the insertion of a load resistor called measuring resistor $R_M$ at the output. The value for $R_M$ is indicated in each data sheet and is limited to a max value called $R_{Mmax}$, max measuring resistor. $R_{Mmax}$ has been defined in regards with the available voltage at the transducer output (voltage drop due notably to the positive electronic side) and the max. voltage measured. $R_{Mmax}$ can be easily calculated with the following formula:

$$R_{Mmax} = \left( \frac{V_{Cmin} - 5.1}{I_{Smax}} - 31 \right) \times 0.9$$

- $V_{Cmin}$ = Minimum Power supply.
- 5.1 Volts = Internal voltage drop due to diodes and transistors.
- $I_{Smax}$ = Max measured secondary current = $(V_{Pmax}/V_{PN}) \times I_{SN.}$
- 31 Ohms = Secondary internal resistance.
- 0.9 = Security coefficient.

The $R_{Mmax}$ values indicated into the data sheets are the values calculated for $V_{Pmax.}$

### AV 100 Series Performances vs existing voltage measurements solutions performances

| Voltage transducers | LV 100-1500 | AV 100-1500 | Competition* |
|---|---|---|---|
| **Overall accuracy (-40 °C to +85 °C)** | ±3.5 % | ±1.7 % | ±1.7 % |
| **Response time at 90 %**** | 55 µs | 33 µs | 38 µs |
| **Capacity common mode perturbation level*** (% of $V_{PN}$)** | 32 % | 3 % | 4.2 % |
| **Low frequency common mode perturbation level *** (% of $V_{PN}$)** | <4.4 % after 10 µs | <5 % after 20 µs | <50 % after 18 µs |
| **Bandwidth** | 7.8 kHz | 13 kHz | 13 kHz |
| **Insulation voltage level** | 9 kV/50 Hz/ 1 min | 6.5 kV/50 Hz/ 1 min | 6.5 kV/50 Hz/ 1 min |
| **Noise level** | < 0.2 % | 1.5 % | 1 % |

* Using isolating Amplifier Technology
** to a voltage step of 1500 V
*** Voltage applied = 1500 V with a dv/dt = 4000 V/µs

### Typical Traction applications

- Auxiliary and main converters.
  - Input voltage
  - DC link
  - Output phase motor voltages
- Chopper.
- Battery charger.
- Sub-Stations and others.

### Unipolar Power Supply

The AV 100 series can be supplied by an unipolar supply. This leads of course to an unipolar voltage measurement. If the transducer is power supplied only with a positive power supply, this one will measure only positive voltage, and the argument is valid for the reverse.

*AV 100 using a positive unipolar power supply*

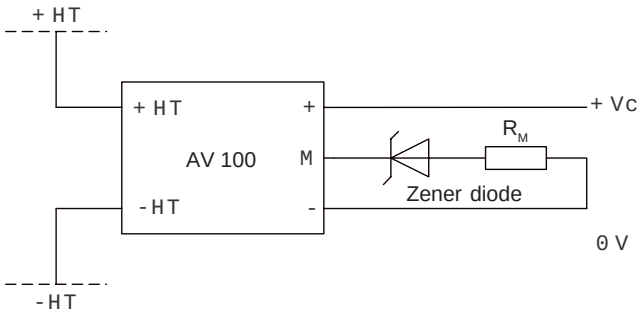



*Fig. 3. Connections drawing to respect when a positive unipolar power supply is used with the AV 100*

In these conditions of use, a Zener diode must be inserted as represented Fig. 3 and its voltage value must be at least > 2 volts = $V_{Zener.}$
The max measuring resistance allowed on the output in order to measure the + $V_{Pmax}$ indicated into the data sheet is given by the following formula:

$$R_{Mmax} = \left( \frac{+V_{Cmin} - 5.1 - V_Z}{I_{Smax}} - 31 \right) \times 0.9$$

*AV 100 using a negative unipolar power supply*

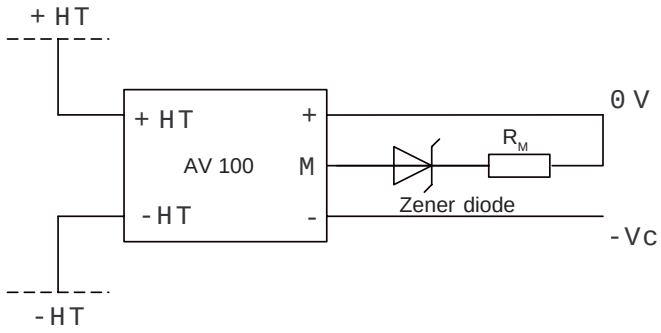



*Fig. 4. Connections drawing to respect when a negative unipolar power supply is used with the AV 100*

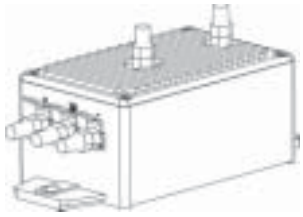
In these conditions of use, a Zener diode must be inserted as represented Fig. 4 and its voltage value must be at least > 5.1 volts = $V_{Zener.}$
The max measuring resistance allowed on the output in order to measure the - $V_{Pmax}$ indicated into the data sheet is given by the following formula:

$$R_{Mmax} = \left( \frac{|-V_{Cmin}| - 2 - V_Z}{I_{Smax}} - 31 \right) \times 0.9$$

# Voltage Transducer AV100 Series

$V_{PN}$ = 50...1500 V

For the electronic measurement of voltages: DC, AC, pulsed..., with a galvanic isolation between the primary circuit (high voltage) and the secondary circuit (electronic circuit).



## Electrical data

| Primary nominal RMS or DC voltage | Primary Voltage measuring range | RMS voltage for AC isolation test [1] (50 Hz/1min) | Type |
|---|---|---|---|
| $V_{PN}$ (V) | $V_{Pmax}$ (V) | $V_d$ (kV) | |
| 50 | ± 75 | 3.3 | AV 100- 50 |
| 125 | ± 187.5 | 3.3 | AV 100- 125 |
| 150 | ± 225 | 3.3 | AV 100- 150 |
| 250 | ± 375 | 3.3 | AV 100- 250 |
| 500 | ± 750 | 3.3 | AV 100- 500 |
| 750 | ± 1125 | 4.3 | AV 100- 750 |
| 1000 | ± 1500 | 5.5 | AV 100-1000 |
| 1500 | ± 2250 | 6.5 | AV 100-1500 |

| | | | | |
|---|---|---|---|---|
| $\hat{V}_P$ | Not measurable overload | 2 x $V_{Pmax}$ (1s/h) | | $V_{DC}$ |
| $R_M$ | Measuring resistance | $R_{M\ min}$ | $R_{M\ max}$ | |
| | @ $V_C$=11.4V | 0 | 47 | Ω |
| | @ $V_C$=22.8V | 0 | 184 | Ω |
| $I_{SN}$ | Secondary nominal RMS current | 50 | | mA |
| $V_C$ | Supply voltage (± 5 %) | DC ± 12 .. 24 | | V |
| $I_c$ | Current consumption | 50+$I_S$ | | mA |
| | Max Common mode voltage and | $U_{HT+}$ +$U_{HT-}$ ≤ 4.2 kV DC<br>$\lvert U_{HT+} - U_{HT-} \rvert \leq V_{Pmax}$ | | |
| $V_e$ | RMS voltage for partial discharge | 1.1 [2] | | kV |
| | extinction @ 10 pC | 2.2 [3] | | kV |

## Accuracy - Dynamic performance data

| | | | |
|---|---|---|---|
| $X_G$ | Overall Accuracy @ $V_{PN}$, $T_A$ = + 25°C | ± 0.7 | % |
| $X_G$ | Overall Accuracy @ $V_{PN}$, $T_A$ = - 25 .. + 70°C | ± 1.5 | % |
| $X_G$ | Overall Accuracy @ $V_{PN}$, $T_A$ = - 40 .. + 85°C | ± 1.7 | % |
| $\varepsilon_L$ | Linearity @ $T_A$ = 25°C | < 0.1 | % |
| $I_O$ | Offset current @ $V_P$ = 0, $T_A$ = 25°C | ± 0.15 | mA |
| $t_r$ | Response time @ 10 % of $V_{Pmax}$ | Between 10 and 13 | µs |
| f | Frequency bandwidth (- 3 dB) | DC .. 13 | kHz |

## General data

| | | | |
|---|---|---|---|
| $T_A$ | Ambient operating temperature | - 40 .. + 85 | °C |
| $T_S$ | Ambient storage temperature | - 50 .. + 90 | °C |
| m | Mass | 425 | g |
| | Standards | EN 50155<br>EN 50124-1<br>NFF16101/2 | |

**Notes** [1] Between primary and secondary
[2] For models AV 100-50 ... 750
[3] For models AV 100-1000 & AV 100-1500

## Features

- Insulated plastic case recognized according to UL 94-V0.
- Included primary resistor

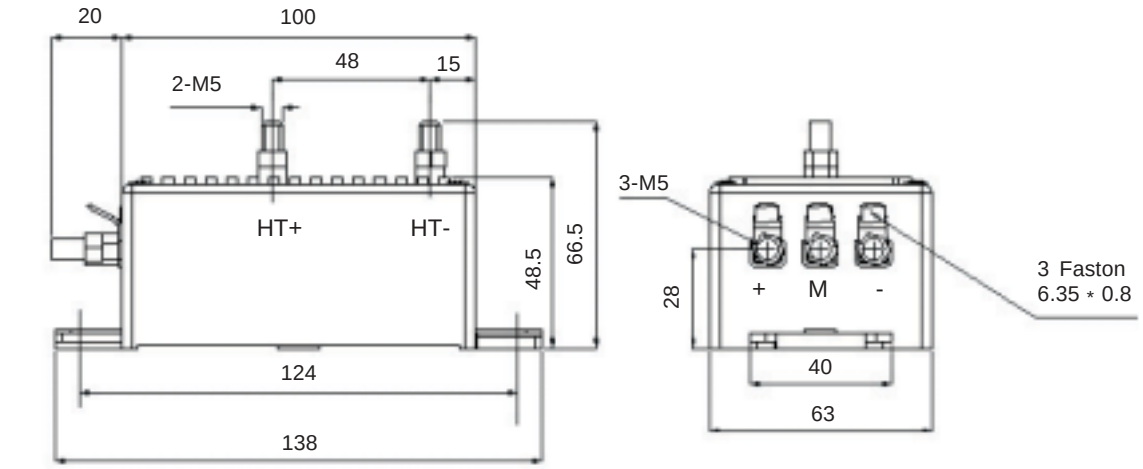
### Advantages

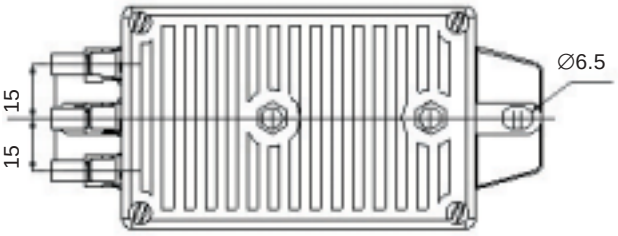
- Low power
- Excellent accuracy
- Very good linearity
- Low thermal drift
- Low response time
- High bandwidth
- High immunity to external interference
- Low disturbance in common mode.

### Applications

- AC variable speed drives and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Power supplies for welding applications.

## Dimensions in mm (1 mm = 0.0394 inch)

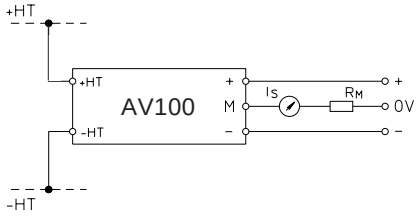



### Secondary terminals

Terminal + : Supply voltage +12 .. 24 V
Terminal M : Measure
Terminal - : Supply voltage - 12 .. 24V

### Connection




### Mechanical characteristics

- General tolerance ± 1 mm
- Fastening 2 holes 6.5 mm ∅
  Distance between holes axes : 124mm
- Fastening & connection of primary 2 x M5
- Fastening & connection of secondary 3 x M5 or 3 Faston 6.35 x 0.8mm
  Output connections must be made with screened cables.
- Fastening torque: 2.2 Nm

### Remarks

- $\mathbf{I}_S$ is positive when $\mathbf{V}_P$ is applied on terminal +HT.
- This is a standard model. For different versions, please contact us.


# 5 Years Warranty on LEM Transducers

LEM designs and manufactures high quality and high reliability products for its customers over the entire world.

Since 1972, we have delivered several million current and voltage transducers which are, for most of them, still in operation on traction vehicles, industrial motor drives, UPS systems and many other applications requiring high quality standards.

Our 5 years warranty applies on all LEM transducers delivered from the 1st. of January 1996 and is valid in addition to the legal warranty. The warranty granted on our Transducers is for a period of 5 years (60 months) from the date of their delivery.

During this period we shall replace or repair at our cost all defective parts (provided the defect is due to defective material or workmanship).

Further claims as well as claims for the compensation of damages, which do not occur on the delivered material itself, are not covered by this warranty.

All defects must be notified to us immediately and faulty material must be returned to the factory along with a description of the defect.

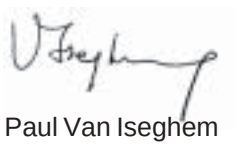
Warranty repairs and or replacements are carried out at our discretion. The customer bears the transport costs. An extension of the warranty period following repairs undertaken under warranty cannot be granted.

The warranty will be invalidated if the buyer has modified or repaired, or has had repaired by a third party the material without LEM's written consent.

The warranty does not cover any damage caused by incorrect conditions of use and cases of force majeure. No responsibility will apply except legal requirements regarding product liability.

The warranty explicitly excludes all claims exceeding the above conditions.

LEM, Geneva, January 1. 2001
Business Area Components



Paul Van Iseghem
President of LEM Components

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