Current Transducer IN 2000-S

For the electronic measurement of current: DC, AC, pulsed..., with galvanic separation between the primary and the secondary circuit.

Features
- Closed loop (compensated) current transducer using an extremely accurate zero flux detector
- Electrostatic shield between primary and secondary circuit
- 9-pin D-Sub male secondary connector
- Status signal to indicate the transducer state
- LED indicator confirms normal operation
- Metal housing to improve immunity to EMC & power dissipation
- Operating temperature −40 °C to 85 °C.

Advantages
- Very high accuracy
- Excellent linearity
- Extremely low temperature drift
- Wide frequency bandwidth
- High immunity to external fields
- No insertion losses
- Very low noise on output signal
- Low noise feedback to primary conductor.

Applications
- Feed back element in high performance gradient amplifiers for MRI
- Feedback element in high-precision, high-stability power supplies
- Calibration unit
- Energy measurement
- Medical equipment.

Standards
- EN 61000-6-2: 2005
- EN 61000-6-3: 2007
- EN 61010-1: 2010.

Application Domain
- Industrial
- Laboratory
- Medical.
# Insulation coordination

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated insulation RMS voltage, basic insulation</td>
<td>$U_b$</td>
<td>V</td>
<td>1000</td>
<td>IEC 61010-1 conditions - over voltage cat III - pollution degree 2</td>
</tr>
<tr>
<td>Rated insulation RMS voltage, reinforced insulation</td>
<td>$U_b$</td>
<td>V</td>
<td>1000</td>
<td>IEC 61010-1 conditions - over voltage cat III - pollution degree 2</td>
</tr>
<tr>
<td>RMS voltage for AC insulation test, 50 Hz, 1 min</td>
<td>$U_d$</td>
<td>kV</td>
<td>6</td>
<td>Between primary and secondary + shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V DC</td>
<td>100</td>
<td>Between secondary and test winding</td>
</tr>
<tr>
<td>Impulse withstand voltage 1.2/50 μs</td>
<td>$U_W$</td>
<td>kV</td>
<td>12.8</td>
<td></td>
</tr>
<tr>
<td>Clearance (pri. - sec.)</td>
<td>$d_{CI}$</td>
<td>mm</td>
<td>21</td>
<td>Shortest distance through air</td>
</tr>
<tr>
<td>Creepage distance (pri. - sec.)</td>
<td>$d_{CP}$</td>
<td>mm</td>
<td>22</td>
<td>Shortest path along device body</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>$CTI$</td>
<td></td>
<td>250</td>
<td></td>
</tr>
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</table>

# Environmental and mechanical characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient operating temperature</td>
<td>$T_A$</td>
<td>°C</td>
<td>−40</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient storage temperature</td>
<td>$T_S$</td>
<td>°C</td>
<td>−40</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative humidity</td>
<td>$RH$</td>
<td>%</td>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>See drawing in page 8</td>
</tr>
<tr>
<td>Mass</td>
<td>$m$</td>
<td>kg</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Electrical data**

At $T_a = 25 \, ^\circ C$, $\pm U_C = \pm 15 \, V$, unless otherwise noted.

Lines with a * in the comment column apply over the $-40 \ldots 85 \, ^\circ C$ ambient temperature range.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary continuous direct current</td>
<td>$I_{P_{\text{NDC}}}$</td>
<td>A</td>
<td>$-2000$</td>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary nominal RMS current</td>
<td>$I_{P_{N}}$</td>
<td>A</td>
<td>$-2000$</td>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary current, measuring range</td>
<td>$I_{P_{M}}$</td>
<td>A</td>
<td>$-3000$</td>
<td>3000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring resistance</td>
<td>$R_m$</td>
<td>$\Omega$</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary current nominal</td>
<td>$I_{S_{N}}$</td>
<td>V</td>
<td>$-1$</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of secondary turns</td>
<td>$N_s$</td>
<td></td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance of secondary winding</td>
<td>$R_{s}$</td>
<td>$\Omega$</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overload capability 1)</td>
<td>$I_p$</td>
<td>kA</td>
<td>$-10$</td>
<td>10</td>
<td></td>
<td>$@$ pulse of 100 ms</td>
</tr>
<tr>
<td>Supply voltage positive</td>
<td>$+U_C$</td>
<td>V</td>
<td>14.25</td>
<td>15</td>
<td>15.75</td>
<td></td>
</tr>
<tr>
<td>Supply voltage negative</td>
<td>$-U_C$</td>
<td>V</td>
<td>$-15.75$</td>
<td>$-15$</td>
<td>$-14.25$</td>
<td></td>
</tr>
<tr>
<td>Current consumption positive</td>
<td>$+I_C$</td>
<td>mA</td>
<td>180</td>
<td>200</td>
<td>225</td>
<td>Add $I_s$ for total current consumption</td>
</tr>
<tr>
<td>Current consumption negative</td>
<td>$-I_C$</td>
<td>mA</td>
<td>80</td>
<td>89</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Output RMS noise current 0 … 10 Hz 2)</td>
<td>$I_{no}$</td>
<td>ppm</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output RMS noise current 0 … 10 kHz 2)</td>
<td>$I_{no}$</td>
<td>ppm</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output RMS noise current 0 … 160 kHz 2)</td>
<td>$I_{no}$</td>
<td>ppm</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output peak-to-peak noise current 2)</td>
<td>$I_{oppp}$</td>
<td>ppm</td>
<td></td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical offset current + self magnetization + effect of earth magnetic field 2)</td>
<td>$I_{OE}$</td>
<td>ppm</td>
<td>$-10$</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature coefficient of $I_{OE} @ I_p = 0$ A</td>
<td>$TCI_{OE}$</td>
<td>ppm/K</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset stability 2)</td>
<td></td>
<td>ppm/month</td>
<td>$-1$</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linearity error 2)</td>
<td>$\varepsilon_L$</td>
<td>ppm</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step response time to 90 % of $I_{PN_{DC}}$</td>
<td>$t_r$</td>
<td>$\mu$s</td>
<td>1</td>
<td></td>
<td></td>
<td>$di/dr$ of 100 A/$\mu$s</td>
</tr>
<tr>
<td>Frequency bandwidth (±1dB)</td>
<td>$BW$</td>
<td>kHz</td>
<td>130</td>
<td></td>
<td></td>
<td>Small-signal bandwidth, 0.5 % of $I_{PN}$</td>
</tr>
<tr>
<td>Frequency bandwidth (±3dB)</td>
<td>$BW$</td>
<td>kHz</td>
<td>140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test current</td>
<td>$I_t$</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of turns (test winding)</td>
<td>$N_t$</td>
<td></td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start-up time</td>
<td>$t_{start}$</td>
<td>s</td>
<td>2</td>
<td>5</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1) Single pulse only, not AC. The transducer may require a few seconds to return to normal operation when autoreset system is running

2) All ppm figures refer to full-scale which corresponds to a secondary nominal RMS current of 1 A.
Overload protection - Electrical specification - Status

The overload occurs when the primary current $I_P$ exceeds a trip level such that the fluxgate detector becomes completely saturated and, consequently, the transducer will switch from normal operation to overload mode. This trip level is guaranteed to be greater than $I_{P_M}$ and its actual value depends on operating conditions such as temperature and measuring resistance.

When this happens, the transducer will automatically begin to sweep in order to lock on the primary current again.

The overload conditions will be:

- The secondary current $I_S$ generated is a low frequency signal.
- The signal normal operation status (between pin 3 and 8 of the D-sub connector) switches to V+. In other words, the output transistor is switched off (i.e., no current from collector to emitter). See the status port wiring below.
- The green LED indicator (normal operation status) turns off.

The measuring can resume when the primary current returns in the measuring range between $-I_{P_N}$ and $+I_{P_N}$. Then the signal normal operation status switches to GND and the green LED indicator (normal operation status) is again lit.

**Status/Interlock port wiring**

![Active Low Output diagram]

- The photocoupler is driven as follows:
  - **ON**: Transducer is OK (Normal Operation)
  - **OFF**: Transducer is not OK

**Active Low Output**

- $I_{CE_{max}}$: 30 mA
- $I_{CE_{min}}$: 2 mA

**DC Power Supply**

- $V^+$: 4 .. +24V
- $R_{min}$ (kΩ) = $(V^+ (V) - 0.4 V) / 30 mA$
- $R_{max}$ (kΩ) = $(V^+ (V) - 0.4 V) / 2 mA$
The following table shows how the normal operation status acts as below:

<table>
<thead>
<tr>
<th>Normal operation status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.7 V</td>
<td>The transducer is OK (Normal operation)</td>
</tr>
<tr>
<td>V+</td>
<td>The transducer is not OK (Overload mode or supply fault)</td>
</tr>
</tbody>
</table>

**Maximum measuring resistor versus primary current and temperature**

\[ \pm U_c = \pm 14.25 \text{ V}, \]
Performance parameters definition

The schematic used to measure all electrical parameters is shown below:

![Schematic diagram]

**Transducer simplified model**

The static model of the transducer at temperature $T_A$ is:

$$I_S = K_N \cdot I_P + \varepsilon$$

In which

$$\varepsilon = I_{OE} \text{ at 25 °C} + I_{OT}(T_A) + \varepsilon_L I_{PM} K_N$$

Where,

$$I_{OE}(T_A) = T C I_{OE} | T_A - 25 °C | I_{PM} K_N$$

- $I_S$: secondary current (A)
- $K_N$: conversion ratio (1: $N_S$)
- $I_P$: primary current (A)
- $I_{PM}$: primary current, measuring range (A)
- $T_A$: ambient operating temperature (°C)
- $I_{OE}$: electrical offset current (A)
- $I_{OT}$: temperature variation of $I_{OE}$ at $T_A$ (A)
- $\varepsilon_L$: linearity error

This is the absolute maximum error. As all errors are independent, a more realistic way to calculate the error would be to use the following formula:

$$\varepsilon = \sqrt{\sum_{i=1}^{N} \varepsilon_i^2}$$

**Linearity**

To measure linearity, the primary current (DC) is cycled from 0 to $I_{PM}$, then to $-I_{PM}$ and back to 0. The linearity error $\varepsilon_L$ is the maximum positive or negative difference between the measured points and the linear regression line, expressed in parts per million (ppm) of full-scale which corresponds to the maximum measured value.

**Electrical offset**

The electrical offset current $I_{OE}$ is the residual output current when the input current is zero.

The temperature variation $I_{OT}$ of the electrical offset current $I_{OE}$ is the variation of the electrical offset from 25 °C to the considered temperature.

**Response time**

The response time $t_r$ is shown in the next figure. It depends on the primary current $dI/dt$ and it’s measured at nominal current.

![Response time graph]
Safety

This transducer must be used in limited-energy secondary circuits according to IEC 61010-1.

⚠️

This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer’s operating instructions.

⚠️

Caution, risk of electrical shock

When operating the transducer, certain parts of the module can carry hazardous voltage (e.g. primary busbar, power supply). Ignoring this warning can lead to injury and/or cause serious damage. This transducer is a build-in device, whose conducting parts must be inaccessible after installation. A protective housing or additional shield could be used. Main supply must be able to be disconnected.

Remark

Installation of the transducer must be done unless otherwise specified on the datasheet, according to LEM Transducer Generic Mounting Rules. Please refer to LEM document N°ANE120504 available on our Web site: Products/Product Documentation.
Dimensions (in mm)

Connection

- Normal operation status (Pins 3 and 8)
  Normal operation means:
  - $\pm 15$ V ($\pm U_C$) present
  - zero detector is working
  - compensation current $\leq I_{PM}$ DC
  - green LED indicator is lit.

Mechanical characteristics

- General tolerance $\pm 0.75$ mm
- Transducer fastening
  - Horizontal mounting 4 holes $\varnothing 7$ mm
  - with 2 slots gap along transducer
  - 4 $\times$ M6 steel screws
  - Recommended fastening torque 5.5 N-m
- Connection of secondary on D-SUB-9, UNC 4-40
- All mounting recommendations are given for a standard mounting. Screws with flat and spring washers.

Remarks

- $I_S$ is positive when $I_P$ flows in the direction of the arrow.
- We recommend that a shielded output cable and plug are used to ensure the maximum immunity against electrostatic fields.
- Temperature of the primary conductor should not exceed $100$ °C.
- We recommend to fix the potential of the housing to the ground.
- Installation of the transducer must be done unless otherwise specified on the datasheet, according to LEM Transducer Generic Mounting Rules. Please refer to LEM document N°ANE120504 available on our Web site: Products/Product Documentation.