Current transducer LF 310-S

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

Features
● Bipolar and insulated current measurement up to 500 A
● Current output
● Closed loop (compensated) current transducer
● Panel mounting.

Advantages
● High accuracy
● Very low offset drift over temperature.

Applications
● Windmills inverters
● Test and measurement
● Substations
● AC variable speed and servo motor drives
● Statics converters for DC motors drives
● Battery supplied applications
● Uninterruptible Power Supplies (UPS)
● Switched Mode Power Supplies (SMPS)
● Power supplies for welding applications.

Standards
● EN 50178: 1997
● UL 508: 2010.

Application Domain
● Industrial.
Absolute maximum ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum supply voltage (working) (-40 .. 85 °C)</td>
<td>±$U_c$</td>
<td>V</td>
<td>21</td>
</tr>
<tr>
<td>Primary conductor temperature</td>
<td>$T_B$</td>
<td>°C</td>
<td>100</td>
</tr>
<tr>
<td>Maximum steady state input current (-40 .. 85 °C)</td>
<td>$I_{PN}$</td>
<td>A</td>
<td>300</td>
</tr>
</tbody>
</table>

Absolute maximum ratings apply at 25 °C unless otherwise noted. Stresses above these ratings may cause permanent damage. Exposure to absolute maximum ratings for extended periods may degrade reliability.

UL 508: Ratings and assumptions of certification

File # E189713 Volume: 2 Section: 7

Standards

- USR indicated investigation to the Standard for Industrial Control Equipment UL 508.
- CNR Indicated investigation to the Canadian standard for Industrial Control Equipment CSA C22.2 No. 14-13

Conditions of acceptability

When installed in the end-use equipment, consideration shall be given to the following:

1. These devices must be mounted in a suitable end-use enclosure.

2. The terminal have not been evaluated for field wiring.

3. Low voltage circuits are intended to be powered by a circuit derived from an isolating source (such as transformer, optical isolator, limiting impedance or electro-mechanical relay) and having no direct connection back to the primary circuit (other than through the grounding means).

Marking

Only those products bearing the UL or UR Mark should be considered to be Listed or Recognized and covered under UL’s Follow-Up Service. Always look for the Mark on the product.
## 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>Rms voltage for AC insulation test, 50 Hz, 1 min</td>
<td>$U_d$</td>
<td>kV</td>
<td>3.8</td>
<td>100 % tested in production</td>
</tr>
<tr>
<td>Impulse withstand voltage 1.2/50 μs</td>
<td>$\tilde{U}_{W}$</td>
<td>kV</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>$R_{IS}$</td>
<td>MΩ</td>
<td>1000</td>
<td>measured at 3.8 kV AC</td>
</tr>
<tr>
<td>Partial discharge extinction rms voltage @ 10 pC</td>
<td>$U_e$</td>
<td>kV</td>
<td>2</td>
<td>with centered bar</td>
</tr>
</tbody>
</table>

- Case material: -
  - V0 according to UL 94

- Comparative tracking index: CTI
  - 600

### Application example
- 600 V
  - CAT III, PD2
  - Reinforced insulation, non uniform field according to EN 50178, IEC 61010

- 1000 V
  - CAT III, PD2
  - Basic insulation, non uniform field according to EN 50178, IEC 61010

### 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>-50</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>$m$</td>
<td>g</td>
<td>107</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Electrical data LF 310-S**

At $T_a = 25$ °C, $±U_C = ±15$ V, unless otherwise noted. Lines with a * in the conditions column apply over the -40 .. 85 °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>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary nominal rms current</td>
<td>$I_{PN}$</td>
<td>A</td>
<td>300</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary current, measuring range</td>
<td>$I_{PM}$</td>
<td>A</td>
<td>-500</td>
<td>500</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Measuring resistance</td>
<td>$R_M$</td>
<td>Ω</td>
<td>0</td>
<td></td>
<td></td>
<td>* See derating on figure 1</td>
</tr>
<tr>
<td>Secondary nominal rms current</td>
<td>$I_{SN}$</td>
<td>A</td>
<td>0.15</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output range</td>
<td>$I_S$</td>
<td>A</td>
<td>-0.25</td>
<td>0.25</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>$±U_C$</td>
<td>V</td>
<td>11.4</td>
<td>±21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>$I_C$</td>
<td>mA</td>
<td>35</td>
<td></td>
<td></td>
<td>$I_p = 0$, $±U_C = ±15$ V</td>
</tr>
<tr>
<td>Electrical Offset current, referred to primary</td>
<td>$I_{OE}$</td>
<td>mA</td>
<td>200</td>
<td></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>1500</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theoretical sensitivity</td>
<td>$G_{th}$</td>
<td>1/2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity error</td>
<td>$ε_G$</td>
<td>%</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature coefficient of $G$</td>
<td>$TCG$</td>
<td>ppm/K</td>
<td>15</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic offset current, referred to primary</td>
<td>$I_{OM}$</td>
<td>A</td>
<td>0.15</td>
<td></td>
<td></td>
<td>After $3 \times I_p$</td>
</tr>
<tr>
<td>Magnetic offset current, referred to primary</td>
<td>$I_{OM}$</td>
<td>mA</td>
<td>30</td>
<td></td>
<td>25 °C; $I_{PM}$</td>
<td></td>
</tr>
<tr>
<td>Linearity error</td>
<td>$ε_L$</td>
<td>% of $I_{PN}$</td>
<td>0.05</td>
<td>±$I_{PN}$ range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall accuracy at $I_{PN}$</td>
<td>$X_{a}$</td>
<td>% of $I_{PN}$</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output rms current noise referred to primary</td>
<td>$I_{no}$</td>
<td>mA</td>
<td>30</td>
<td></td>
<td>1 Hz to 100 kHz</td>
<td></td>
</tr>
<tr>
<td>Reaction time @ 10 % of $I_{PN}$</td>
<td>$t_{ra}$</td>
<td>µs</td>
<td>0.5</td>
<td></td>
<td></td>
<td>$R_L &gt; 10$ Ω, $di/dt &gt; 100$ A/µs</td>
</tr>
<tr>
<td>Step response time to 90 % of $I_{PN}$</td>
<td>$t_r$</td>
<td>µs</td>
<td>0.5</td>
<td></td>
<td></td>
<td>$R_L &gt; 10$ Ω, $di/dt &gt; 100$ A/µs</td>
</tr>
<tr>
<td>Frequency bandwidth</td>
<td>$BW$</td>
<td>kHz</td>
<td>100</td>
<td></td>
<td></td>
<td>$R_L &gt; 50$ Ω, -3dB</td>
</tr>
</tbody>
</table>

**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, maximal and minimal values are determined during the initial characterization of a product.
Typical performance characteristics

Figure 1: Maximum measuring resistance

Figure 2: Typical noise power density of $e_{no}$ ($R_m$) with $R_m = 10 \, \Omega$

Figure 3: Typical total output current noise (primary referred, rms) with $R_m = 10 \, \Omega$

Figure 2 (noise voltage density) shows if there are discrete frequencies in the output.

Figure 3 shows the cumulative output current noise referred to primary.

To calculate the noise in a frequency band $f_1$ to $f_2$, the formula is:

$$I_{no}(f_1 to f_2) = \sqrt{I_{no}(f_2)^2 - I_{no}(f_1)^2}$$

with $I_{no}(f)$ read from figure 3 (typical, rms value).

Example:
What is the noise from $10^3$ to $10^6$ Hz?
Figure 3 gives $I_{no}(10^3 \, \text{Hz}) = 3.19 \, \text{mA}$ and $I_{no}(10^6 \, \text{Hz}) = 84.4 \, \text{mA}$.

The output current noise (rms) is therefore:

$$\sqrt{(84.4 \times 10^{-3})^2 - (3.19 \times 10^{-3})^2} = 84.34 \, \text{mA} \text{ referred to primary}$$
Performance parameters definition

**Figure 4: Typical step response**

**Figure 5: Maximum linearity error**
Performance parameters definition

The schematic used to measure all electrical parameters are:

![Schematic Diagram]

**Figure 6: Standard characterization schematics for voltage output transducers (R<sub>M</sub> = 50 Ω unless otherwise noted)**

**Transducer simplified model**

The static model of the transducer at temperature T<sub>A</sub> is:

\[
I_S = G \cdot I_P + \text{error}
\]

In which:

- \(I_S\): secondary current (A)
- \(G\): sensitivity of the transducer (A/A)
- \(I_P\): primary current (A)
- \(I_{PM}\): primary current, measuring range (A)
- \(T_B\): ambient operating temperature (°C)
- \(I_{OE}\): electrical offset current (A)
- \(I_{OM}\): magnetic offset current (A)
- \(\epsilon_G\): sensitivity error at 25 °C
- \(\epsilon_{GT}(T_B)\): thermal drift of sensitivity at temperature T<sub>A</sub>
- \(\epsilon_L\): 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:

\[
\text{error} = I_{OE} + \epsilon_G \cdot I_P + \epsilon_{GT}(T_B) \cdot G \cdot I_P + \epsilon_L \cdot G \cdot I_{PM} + I_{OM}
\]

**Sensitivity and linearity**

To measure sensitivity and linearity, the primary current (DC) is cycled from 0 to \(I_{PM}\), then to \(-I_{PM}\) and back to 0 (equally spaced \(I_{PM}/10\) steps).

The sensitivity \(G\) is defined as the slope of the linear regression line for a cycle between \pm \(I_{PM}\).

The linearity error \(\epsilon_L\) is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of the maximum measured value.

**Magnetic offset**

Due to its working principle, this type of transducer has no magnetic offset current \(I_{OM}\).

**Electrical offset**

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

The temperature variation \(I_{OE}(T_B)\) of the electrical offset current \(I_{OE}\) is the variation of the electrical offset from 25 °C to the considered temperature.

**Overall accuracy**

The overall accuracy \(X_G\) is the error at \pm \(I_{PM}\) relative to the rated value \(I_{OE}\).

It includes all errors mentioned above.

**Response and reaction times**

The response time \(t_r\) and the reaction time \(t_{ra}\) are shown in the next figure.

Both slightly depend on the primary current \(dI/dt\). They are measured at nominal current.

![Response Time Diagram]

**Figure 7: Response time \(t_r\) and reaction time \(t_{ra}\)**
**Dimensions** (in mm)

**Mechanical characteristics**
- General tolerance ± 1 mm
- Transducer fastening
  - Vertical position: 2 holes ⌀ 4.3 mm
  - 2 M4 steel screws
  - Recommended fastening torque 2.1 N·m
- Transducer fastening
  - Horizontal position: 4 holes ⌀ 4.3 mm
  - 4 M4 steel screws
  - Recommended fastening torque 2.1 N·m
- Connection of secondary: Molex 6410 connector

**Remarks**
- Installation of the transducer is to be done without primary current or secondary voltage present.
- 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.

**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 connection, 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.