Current transducer LF 510-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 0.8 kA
- Current output
- Closed loop (compensated) current transducer
- Panel mounting.

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

Applications
- Windmill 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
- EN 50155: 2007

Application Domains
- Industrial
- Traction.
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>±25.2</td>
</tr>
<tr>
<td>Primary conductor temperature</td>
<td>$T_B$</td>
<td>°C</td>
<td>100</td>
</tr>
<tr>
<td>Maximum steady state primary current (−40 … 85 °C)</td>
<td>$I_{pn}$</td>
<td>A</td>
<td>500</td>
</tr>
</tbody>
</table>

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 terminals 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></td>
</tr>
<tr>
<td>Impulse withstand voltage 1.2/50 µs</td>
<td>$U_w$</td>
<td>kV</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>$R_{IS}$</td>
<td>MΩ</td>
<td>200</td>
<td>measured at 500 V DC</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>$CTI$</td>
<td></td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Application example</td>
<td></td>
<td></td>
<td>1000 V</td>
<td>Reinforced insulation, non uniform field according to EN 50178, IEC 61010</td>
</tr>
<tr>
<td>Application example</td>
<td></td>
<td></td>
<td>1000 V</td>
<td>Basic insulation, non uniform field according to EN 50178, IEC 61010</td>
</tr>
<tr>
<td>Case material</td>
<td>-</td>
<td>-</td>
<td>V0 according to UL 94</td>
<td></td>
</tr>
<tr>
<td>Clearance and creepage</td>
<td></td>
<td></td>
<td>See dimensions drawing on page 7</td>
<td></td>
</tr>
</tbody>
</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>−50</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>$m$</td>
<td>g</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Electrical data**

At $T_a = 25 \, ^\circ C$, $\pm U_c = \pm 24 \, V$, $R_{\text{m}} = 1 \, \Omega$, unless otherwise noted. Lines with an * in the conditions 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>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary nominal rms current</td>
<td>$I_{\text{PN}}$</td>
<td>A</td>
<td>500</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary current, measuring range</td>
<td>$I_{\text{PM}}$</td>
<td>A</td>
<td>$-800$</td>
<td>800</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Measuring resistance</td>
<td>$R_{\text{m}}$</td>
<td>$\Omega$</td>
<td>0</td>
<td>Max value of $R_{\text{m}}$ is given in figure 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary nominal rms current</td>
<td>$I_{\text{SN}}$</td>
<td>A</td>
<td>0.1</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance of secondary winding</td>
<td>$R_s$</td>
<td>$\Omega$</td>
<td>52.8</td>
<td></td>
<td>17.3</td>
<td>$R_s (T_a) = R_s \times (1 + 0.004 \times (T_a + \Delta temp - 25))$ Estimated temperature increase @ $I_{\text{PN}}$ is $\Delta temp = 15 , ^\circ C$</td>
</tr>
<tr>
<td>Secondary current</td>
<td>$I_s$</td>
<td>A</td>
<td>$-0.16$</td>
<td>0.16</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Number of secondary turns</td>
<td>$N_s$</td>
<td></td>
<td>5000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theoretical sensitivity</td>
<td>$G_{\text{th}}$</td>
<td>mA/A</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>$\pm U_c$</td>
<td>V</td>
<td>$\pm 14.25$</td>
<td>$\pm 25.2$</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Current consumption</td>
<td>$I_c$</td>
<td>mA</td>
<td>$44 + I_s$</td>
<td>$49 + I_s$</td>
<td></td>
<td>$\pm U_c = \pm 15 , V$ $\pm U_c = \pm 24 , V$</td>
</tr>
<tr>
<td>Offset current, referred to primary</td>
<td>$I_O$</td>
<td>A</td>
<td>$-1$</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature variation of $I_O$, referred to primary</td>
<td>$I_{OT}$</td>
<td>A</td>
<td>$-0.6$</td>
<td>0.6</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Magnetic offset current, referred to primary</td>
<td>$I_{OM}$</td>
<td>A</td>
<td>$\pm 0.7$</td>
<td></td>
<td>After $3 \times I_{PN}$</td>
<td></td>
</tr>
<tr>
<td>Sensitivity error</td>
<td>$\epsilon_g$</td>
<td>%</td>
<td>$-0.5$</td>
<td>0.5</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Linearity error</td>
<td>$\epsilon_l$</td>
<td>% of $I_{PN}$</td>
<td>$-0.1$</td>
<td>0.1</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Overall accuracy at $I_{PN}$</td>
<td>$X_{\text{G}}$</td>
<td>% of $I_{PN}$</td>
<td>$-0.5$</td>
<td>0.5</td>
<td>*</td>
<td>$25 \ldots 70 \ldots 85 , ^\circ C$ $-40 \ldots 85 , ^\circ C$</td>
</tr>
<tr>
<td>Output rms current noise referred to primary</td>
<td>$I_{no}$</td>
<td>mA</td>
<td>50</td>
<td></td>
<td>1 Hz to 20 kHz (see figure 4)</td>
<td></td>
</tr>
<tr>
<td>Reaction time @ 10 % of $I_{PN}$</td>
<td>$t_{ra}$</td>
<td>$\mu$s</td>
<td>$&lt; 0.5$</td>
<td>0 to 500 A, 200 A/$\mu$s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step response time to 90 % of $I_{PN}$</td>
<td>$t_s$</td>
<td>$\mu$s</td>
<td>$&lt; 0.5$</td>
<td>0 to 500 A, 200 A/$\mu$s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency bandwidth</td>
<td>$BW$</td>
<td>kHz</td>
<td>200</td>
<td>100</td>
<td>$-3 , \text{dB}$, small signal bandwidth $+3 , \text{dB}$ (see figure 5)</td>
<td></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 the product.
Typical performance characteristics

Figure 1: Maximum measuring resistance

\[ R_{\text{max}} = N_S \frac{U_{\text{Cmin}} - 0.5}{I_P} - R_{\text{Smax}} - 1.1 \, \Omega \]

Figure 2: Typical step response (0 to 500 A, 100 A/μs \( R_{\text{m}} = 1 \, \Omega \))

Figure 3: Typical noise voltage density \( e_{\text{no}} \)

with \( R_{\text{m}} = 100 \, \Omega \)

Figure 4: Typical total output current noise with \( R_{\text{m}} = 100 \, \Omega \) (primary referred, rms)

To calculate the noise in a frequency band \( f_1 \) to \( f_2 \), the formula is:

\[ I_{\text{no}} (f_1 \ldots f_2) = \sqrt{I_{\text{no}} (f_1)^2 - I_{\text{no}} (f_2)^2} \]

with \( I_{\text{no}} (f) \) read from figure 4 (typical, rms value).

Example:

What is the noise from 1 to \( 10^6 \) Hz?

Figure 4 gives \( I_{\text{no}} (1 \, \text{Hz}) = 0.4 \, \text{mA} \) and \( I_{\text{no}} (10^6 \, \text{Hz}) = 145 \, \text{mA} \).

The output current noise (rms) is therefore:

\[ \sqrt{(145 \times 10^{-3})^2 - (0.4 \times 10^{-3})^2} = 145 \, \text{mA referred to primary} \]
Performance parameters definition

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 $±I_{PM}$.
The linearity error $\varepsilon_L$ 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
The magnetic offset $I_{OM}$ is the change of offset after a given current has been applied to the input. It is included in the linearity error as long as the transducer remains in its measuring range.

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

Overall accuracy
The overall accuracy $X_G$ is the error at $±I_{PM}$ relative to the rated value $I_{PN}$.
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.

Figure 5: Typical frequency response, small signal bandwidth

Figure 6: Response time $t_r$ and reaction time $t_{ra}$
Dimensions (in mm)

**Mechanical characteristics**
- General tolerance: ±0.5 mm
- Transducer fastening
  - Vertical position: 6 holes ø 4.3 mm, 6 M4 steel screws, recommended fastening torque 2.1 N·m (±10 %)
  - Primary through-hole: ø 30 mm, 30 mm × 10 mm
- Transducer fastening
  - Horizontal position: 4 holes ø 4.3 mm, 4 M4 steel screws, recommended fastening torque 2.1 N·m (±10 %)
- Connection of secondary: MOLEX 6410

**Remarks**
- $I_S$ is positive when $I_P$ flows in the direction of arrow.
- The secondary cables also have to be routed together all the way.
- Installation of the transducer is to be done without primary current or secondary voltage present.
- Maximum temperature of primary conductor: see page 2.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements...), please contact us.

**Connection**

**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 (eg. 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.