Current Transducer LTSP 25-P

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

Features
- Closed loop (compensated) multi-range current transducer using the Hall effect
- Current output
- Unipolar supply voltage
- Insulated plastic case recognized according to UL 94-V0
- Compact design for PCB mounting
- Voltage reference readout access.

Advantages
- Excellent accuracy
- Very good linearity
- Very low temperature drift
- Optimized response time
- Wide frequency bandwidth
- No insertion losses
- High immunity to external interference
- Current overload capability.

Applications
- AC variable speed and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications
- Renewable Energy (Solar and Wind).

Standards
- EN 50178: 1997
- IEC 61010-1: 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</td>
<td>$U_{C\ max}$</td>
<td>V</td>
<td>7</td>
</tr>
<tr>
<td>Maximum primary conductor temperature</td>
<td>$T_{B\ max}$</td>
<td>°C</td>
<td>100</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: 1

Standards
- CSA C22.2 NO. 14-10 INDUSTRIAL CONTROL EQUIPMENT - Edition 11
- UL 508 STANDARD FOR INDUSTRIAL CONTROL EQUIPMENT - Edition 17

Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary involved potential</td>
<td>$T_A$</td>
<td>°C</td>
<td>85</td>
</tr>
<tr>
<td>Max surrounding air temperature</td>
<td>$I_p$</td>
<td>A</td>
<td>According to series primary currents</td>
</tr>
<tr>
<td>Output voltage</td>
<td>$V_{out}$</td>
<td>V</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

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 - The LTS, LTSR, LTSP Series are intended to be mounted on the printed wiring board of the end-use equipment (with a minimum CTI of 100).
4 - The LTS, LTSR, LTSP Series shall be used in a pollution degree 2 environment.
5 - Low voltage circuits are intended to be powered by a circuit derived from an isolating source (such as a 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).
6 - The LTS, LTSR, LTSP Series: based on results of temperature tests, in the end-use application, a maximum of 100°C cannot be exceeded at soldering point between primary coil pin and soldering point or on primary bus bar (corrected to the appropriate evaluated max, surrounding air).
7 - For LTS, LTSR, LTSP Series, the secondary sensing circuit was evaluated as the circuit intended to be supplied from a Limited Voltage/Current circuit defined in UL 508 standard.

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>$U_{ds}$</td>
<td>kV</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Impulse withstand voltage 1.2/50 μs</td>
<td>$U_{iw}$</td>
<td>kV</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Partial discharge extinction RMS voltage @ 10 pC</td>
<td>$U_{es}$</td>
<td>kV</td>
<td>&gt; 1.5</td>
<td></td>
</tr>
<tr>
<td>Clearance (pri. - sec.)</td>
<td>$d_{CI}$</td>
<td>mm</td>
<td>6.2</td>
<td>Shortest distance through air</td>
</tr>
<tr>
<td>Creepage distance (pri. - sec.)</td>
<td>$d_{CP}$</td>
<td>mm</td>
<td>15.35</td>
<td>Shortest path along device body</td>
</tr>
<tr>
<td>Case material</td>
<td>-</td>
<td>-</td>
<td>V0 according to UL 94</td>
<td></td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>$CTI$</td>
<td></td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Application example</td>
<td>V</td>
<td></td>
<td>300</td>
<td>Reinforced insulation, CAT OV III,PD 2 non uniform field according to EN 50178, IEC 61010-1</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>-40</td>
<td>+90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>$m$</td>
<td>g</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
At $T_A = 25\ ^\circ C$, $U_C = +5\ V$ and $R_M = 24.3\ \Omega$, $N_P = 1$ turn unless otherwise noted (see Definition of typical paragraph page 8).

<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 nominal RMS current</td>
<td>$I_{PN}$</td>
<td>At</td>
<td>25</td>
<td></td>
<td></td>
<td>Apply derating according to figure 1</td>
</tr>
<tr>
<td>Primary current, measuring range</td>
<td>$I_{PM}$</td>
<td>At</td>
<td>50</td>
<td></td>
<td></td>
<td>At $T_A = 85\ ^\circ C$, $U_C = +5V\pm5\ %$</td>
</tr>
<tr>
<td>Measuring resistance</td>
<td>$R_M$</td>
<td>$\Omega$</td>
<td>0</td>
<td></td>
<td>150</td>
<td>$I_{PM} = 71.7\ At$, $T_A = 85\ ^\circ C$, $U_C = +5V\pm5\ %$ see figure 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$I_{PM} = 19.4\ At$, $T_A = 85\ ^\circ C$, $U_C = +5V\pm5\ %$ see figure 5</td>
</tr>
<tr>
<td>Secondary nominal RMS current</td>
<td>$I_{SN}$</td>
<td>mA</td>
<td>12.5</td>
<td></td>
<td></td>
<td>At $I_{PN}$</td>
</tr>
<tr>
<td>Current consumption</td>
<td>$I_C$</td>
<td>mA</td>
<td>20 + $I_s$</td>
<td>28 + $I_s$</td>
<td></td>
<td>See figure 6</td>
</tr>
<tr>
<td>Reference voltage</td>
<td>$V_{ref}$</td>
<td>V</td>
<td>2.475</td>
<td>2.5</td>
<td>2.525</td>
<td>See figure 6</td>
</tr>
<tr>
<td>Capacitive loading on $V_{ref}$</td>
<td>$C_L$</td>
<td>pF</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>$U_C$</td>
<td>V</td>
<td>4.75</td>
<td>5.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical offset current</td>
<td>$I_{OE}$</td>
<td>$\mu A$</td>
<td>$-200$</td>
<td>0</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Magnetic offset current</td>
<td>$I_{OM}$</td>
<td>$\mu A$</td>
<td>44</td>
<td>After a cycle to 75 A, (see figure 7)</td>
<td>60</td>
<td>After a cycle to 125 A, (see figure 7)</td>
</tr>
<tr>
<td>Temperature variation of $I_{OE}$</td>
<td>$I_{OET}$</td>
<td>$\mu A$</td>
<td>$\pm100$</td>
<td>$+25\ ^\circ C ... +85\ ^\circ C$</td>
<td>$\pm125$</td>
<td>$-40\ ^\circ C ... +25\ ^\circ C$</td>
</tr>
<tr>
<td>Temperature coefficient of $V_{ref}$</td>
<td>$TCV_{ref}$</td>
<td>ppm/K</td>
<td>50</td>
<td>$+25\ ^\circ C ... +85\ ^\circ C$</td>
<td>100</td>
<td>$-40\ ^\circ C ... +25\ ^\circ C$</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>$G$</td>
<td>mA/At</td>
<td>0.5</td>
<td></td>
<td></td>
<td>For $K_N$, see transducer simplified model page 6</td>
</tr>
<tr>
<td>Primary turns</td>
<td>$N_P$</td>
<td></td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity error</td>
<td>$\varepsilon_I$</td>
<td>%</td>
<td>$-1$</td>
<td>1</td>
<td>$\pm25\ A\ range$</td>
<td></td>
</tr>
<tr>
<td>Linearity error</td>
<td>$\varepsilon_L$</td>
<td>% of $I_{PN}$</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>$X_G$</td>
<td>%</td>
<td>$-2.7$</td>
<td>2.7</td>
<td></td>
<td>$= I_{OE} + \varepsilon_I + \varepsilon_L$</td>
</tr>
<tr>
<td>Output RMS noise current</td>
<td>$I_{no}$</td>
<td>$\mu A$</td>
<td>72</td>
<td>$0.1\ Hz &lt; f &lt; 50\ Hz$, $I_p = 0$</td>
<td>1.9</td>
<td>$50\ Hz &lt; f &lt; 1\ kHz$, $I_p = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td>$1\ kHz &lt; f &lt; 100\ kHz$, $I_p = 0$</td>
</tr>
<tr>
<td>Reaction time @ 10 % of $I_{PN}$</td>
<td>$t_{ra}$</td>
<td>ns</td>
<td>200</td>
<td></td>
<td></td>
<td>$I_p = 50\ At$, $di/dt = 100/\mu A/s$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150</td>
<td></td>
<td>$I_p = 50\ At$, $di/dt = 100/\mu A/s$</td>
</tr>
<tr>
<td>Step response time to 90 % of $I_{PN}$</td>
<td>$t_s$</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
<td>$I_p = 50\ At$, $di/dt = 100/\mu A/s$</td>
</tr>
<tr>
<td>Secondary coil resistance</td>
<td>$R_S$</td>
<td>$\Omega$</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency bandwidth at 25 At</td>
<td>$BW$</td>
<td>kHz</td>
<td>$&gt;300$</td>
<td>$N_P = 1$ turn, $I_p = 25\ A$, $-1\ dB$</td>
<td>$&gt;300$</td>
<td>$N_P = 2$ turns, $I_p = 12.5\ A$, $-1\ dB$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$&gt;300$</td>
<td></td>
<td>$N_P = 3$ turns, $I_p = 8.3\ A$, $-1\ dB$</td>
</tr>
</tbody>
</table>
Typical performance characteristics

Figure 1: Frequency derating

Figure 2: Temperature variation of $I_{OE}(I_{OET})$

Figure 3: Typical frequency response

Figure 4: Typical $di/dt$ follow-up

Figure 5: Measuring resistance
Performance parameters definition

Schematic used to measure all electrical parameters
(C = 100 nF, R_m = 24.3 Ω unless otherwise noted):

Ampere-turns and amperes
The transducer is sensitive to the primary current linkage \( \theta_p \) (also called ampere-turns).

\[ \theta_p = N_p \cdot I_p \, (\text{At}) \]

Where \( N_p \) is the number of primary turn (depending on the connection of the primary jumpers)

Caution: As most applications will use the transducer with only one single primary turn \( (N_p = 1) \), much of this datasheet is written in terms of primary current instead of current linkages. However, the ampere-turns (At) unit is used to emphasis that current linkages are intended and applicable.

Transducer simplified model
The static model of the transducer at temperature \( T_A \) is:

\[ I_s = G \cdot \theta_p + \varepsilon \]

In which \( \varepsilon = \frac{I_{OE} + I_{OE1}(T_A) + \varepsilon_G \cdot G + \varepsilon_T \cdot \theta_{P\max} \cdot \theta_{P\max}}{2} \)

With:
- \( \theta_p = N_p \cdot I_p \) : primary current linkage (At)
- \( \theta_{P\max} \) : max primary current linkage applied to the transducer (At)
- \( I_s \) : secondary current (A)
- \( T_A \) : ambient operating temperature (°C)
- \( I_{OE} \) : electrical offset current (A)
- \( I_{OE1}(T_A) \) : temperature variation of \( I_{OE} \) from 25 °C at temperature \( T_A \) (°C)
- \( G \) : sensitivity of the transducer (A/At)
- \( \varepsilon_G \) : sensitivity error
- \( \varepsilon_T(\theta_{P\max}) \) : linearity error for \( \theta_{P\max} \)

This model is valid for primary ampere-turns \( \theta_p \) between \(-\theta_{P\max}\) and \(+\theta_{P\max}\) only.

Sensitivity and linearity
To measure sensitivity and linearity, the primary current (DC) is cycled from 0 to \( I_p \), then to \(-I_p\) and back to 0 (equally spaced \( I_p/10 \) steps). The sensitivity \( G \) is defined as the slope of the linear regression line for a cycle between \( \pm I_{P\max} \).
The linearity error \( \varepsilon_T \) is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of \( I_{P\max} \).

Magnetic offset
The magnetic offset current \( I_{OM} \) is the consequence of a current on the primary side ("memory effect" of the transducer’s ferromagnetic parts). It is measured using the following primary current cycle, \( I_{OM} \) depends on the current value \( I_{p1} \, (I_{p1} > I_{pM}) \).

\[ I_{OM} = \frac{I_s(t_1) - I_s(t_2)}{2} \cdot \frac{1}{G_{th}} \]

Figure 7: Current cycle used to measure magnetic and electrical offset (transducer supplied)
Performance parameters definition

Electrical offset

The electrical offset current $I_{OE}$ can either be measured when the ferro-magnetic parts of the transducer are:

- completely demagnetized, which is difficult to realize,
- or in a known magnetization state, like in the current cycle shown in figure number.

Using the current cycle shown in figure 7, the electrical offset is:

$$I_{OE} = \frac{I_k(t_1) + I_k(t_2)}{2}$$

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

$$I_{OE,T}(T) = I_{OE}(T) - I_{OE}(25^\circ C)$$

Note: the transducer has to be demagnetized prior to the application of the current cycle (for example with a demagnetization tunnel).

Overall accuracy

The overall accuracy at 25 °C $X_g$ is the error in the $-I_{PN} ... +I_{PN}$ range, relative to the rated value $I_{PN}$.

It includes:

- the electrical offset $I_{OE}$
- the sensitivity error $\varepsilon_G$
- the linearity error $\varepsilon_L$ (to $I_{PN}$)

Response and reaction times

The response time $t_r$ and the reaction time $t_{ra}$ are shown in figure 8.

Both depend on the primary current $di/dt$. They are measured at nominal ampere-turns.

![Figure 8: Response time $t_r$ and reaction time $t_{ra}$](image)

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- the sensitivity error $\varepsilon_G$
- the linearity error $\varepsilon_L$ (to $I_{PN}$)
Application data

The LTSP 25-NP has been designed to be used at nominal currents from 8.3 to 25 A. The 3 primary jumpers allow the adaptation of the number of primary turns $N_p$ to the application so as to achieve the best compromise between nominal current, measuring range and secondary current.

<table>
<thead>
<tr>
<th>Number of primary turns</th>
<th>Primary nominal RMS current</th>
<th>Secondary nominal current $I_s$</th>
<th>Primary resistance $R_p$ [mΩ]</th>
<th>Primary insertion inductance $L_p$ [µH]</th>
<th>Recommended connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>12.5</td>
<td>0.18</td>
<td>0.013</td>
<td>6 5 4 IN OUT 1 2 3</td>
</tr>
<tr>
<td>2</td>
<td>12.5</td>
<td>12.5</td>
<td>0.81</td>
<td>0.05</td>
<td>6 5 4 IN OUT 1 2 3</td>
</tr>
<tr>
<td>3</td>
<td>8.33</td>
<td>12.5</td>
<td>1.62</td>
<td>0.12</td>
<td>6 5 4 IN OUT 1 2 3</td>
</tr>
</tbody>
</table>

See also the paragraph "Performance parameters definition; transducer simplified model" for more details about ampere-turns and output current.

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.
Assembly on PCB

- **Recommended PCB hole diameter:**
  - Ø 1.3 mm for primary pins
  - 0.8 mm for secondary pins
- **Maximum PCB thickness:**
  - 1.6 mm
- **Solder temperature:**
  - Maximum 270 °C for 15 s

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.**
Remark

$I_p$ is positive (sourcing) when $I_p$ flows in the direction of the arrow.