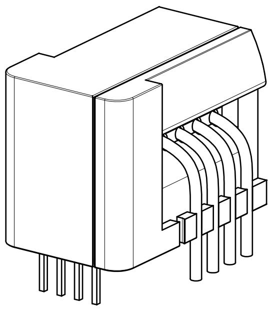
Current Transducer CKSR 25-NP/SP3

I_{PN} = 25 A

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
- Voltage output
- Single supply
- Compact design for PCB mounting.

Special feature

- Customer dedicated.

Advantages

- Very low temperature coefficient of offset
- Very good dv/dt immunity
- Higher creepage distance/clearance
- Reduced height
- Reference pin with two modes: Ref IN and Ref OUT
- Extended measuring range for unipolar measurement.

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
- Solar inverters.

Standards

- EN 50178: 1997
- IEC 60950-1: 2006
- IEC 61010-1: 2010
- IEC 61326-1: 2012
- UL 508: 2010.

Application Domain

- Industrial.

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

Absolute maximum ratings

Parameter	Symbol	Unit	Value
Maximum supply voltage	$U_{C\ max}$	V	7
Maximum primary conductor temperature	$T_{B\ max}$	°C	110
Maximum primary current	$I_{P\ max}$	A	$20 \times I_{P\ N}$
Maximum ESD rating, Human Body Model (HBM)	$U_{ESD\ max}$	kV	4

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

Parameter	Symbol	Unit	Value
Primary involved potential		V AC/DC	1000
Max surrounding air temperature	T_A	°C	105
Primary current	I_P	A	25
Secondary supply voltage	U_C	V DC	5
Output voltage	U_{out}	V	0 to 5

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.

4 - CKSR series intended to be mounted on the printed circuit wiring board of the end-use equipment (with a minimum CTI of 100).

5 - CKSR series shall be used in a pollution degree 2.

8 - 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).

11 - CKSR series: based on results of temperature tests, in the end-use application, a maximum of 100 °C cannot be exceeded at soldering joint between primary coil pin and soldering point (corrected to the appropriate evaluated max. surrounding air).

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

Parameter	Symbol	Unit	Value	Comment
RMS voltage for AC insulation test, 50 Hz, 1 min	U_d	kV	4.3	
Impulse withstand voltage 1.2/50 μs	U_{Ni}	kV	8	
Partial discharge extinction RMS voltage @ 10 pC	U_e	V	1000	
Clearance (pri. - sec.)	d_{Cl}	mm	8.2	Shortest distance through air
Creepage distance (pri. - sec.)	d_{Cp}	mm	8.2	Shortest internal path along device body
Case material	-	-	V0	According to UL 94
Comparative tracking index	CTI		600	
Application example	-	-	300 V	Reinforced insulation, non uniform field according to IEC 61010-1 CAT III PD2
Application example	-	-	600 V	Reinforced insulation, non uniform field according to EN 50178 CAT III PD2
Application example	-	-	1000 V	Simple insulation, non uniform field according to EN 50178 CAT III PD2

Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−40		105	
Ambient storage temperature	T_S	°C	−55		105	
Mass	m	g		9		

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

Electrical data

At T_A = 25 °C, U_C = +5 V, N_P = 1 turn, R_L = 10 kΩ internal reference unless otherwise noted (see Min, Max, typ. definition paragraph in page 7).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal RMS current	$I_{P N}$	A		25		Apply derating according to fig. 7
Primary current, measuring range	$I_{P M}$	A	−85		85	
Number of primary turns	N_P			1,2,3,4		
Supply voltage	U_C	V	4.75	5	5.25	
Current consumption	I_C	mA		$15 + \frac{I_P\text{ (mA)}}{N_S}$	$20 + \frac{I_P\text{ (mA)}}{N_S}$	N_S = 1731 turns
Reference voltage @ I_P = 0 A	U_{ref}	V	2.495	2.5	2.505	Internal reference
External reference voltage	U_{ref}	V	0		4	
Output voltage	U_{out}	V	0.375		4.625	
Output voltage @ I_P = 0 A	U_{out}	V		U_{ref}		
Electrical offset voltage	$U_{O E}$	mV	−1.35		1.35	100 % tested $U_{out} - U_{ref}$
Electrical offset current	$I_{O E}$	mA	−54		54	100 % tested
Temperature coefficient of U_{ref}	TCU_{ref}	ppm/K		±5	±50	Internal reference
Temperature coefficient of U_{out} @ I_P = 0 A	TCU_{out}	ppm/K		±1.4	±4	ppm/K of 2.5 V −40 °C … 105 °C (at ±6 Sigma)
Nominal sensitivity	S_N	mV/A		25		625 mV/$I_{P N}$
Sensitivity error	ε_S	%	−0.7		0.7	100 % tested
Temperature coefficient of S	TCS	ppm/K			±40	−40 °C … 105 °C
Linearity error	ε_L	% of $I_{P N}$	−0.1		0.1	
Magnetic offset current (10 × $I_{P N}$) referred to primary	$I_{O M}$	A	−0.1		0.1	
RMS noise current (spectral density) 100 Hz … 100 kHz referred to primary	I_{no}	µA/Hz½		20		R_L = 1 kΩ
Peak-peak output ripple at oscillator frequency f = 450 kHz (typ.)	-	mV		10	40	R_L = 1 kΩ
Delay time @ 10 % of $I_{P N}$	$t_{D 10}$	µs			0.3	R_L = 1 kΩ, di/dt = 68 A/µs
Delay time to 90 % of $I_{P N}$	$t_{D 90}$	µs			0.3	R_L = 1 kΩ, di/dt = 68 A/µs
Frequency bandwidth (±1 dB)	BW	kHz	200			R_L = 1 kΩ
Frequency bandwidth (±3 dB)	BW	kHz	300			R_L = 1 kΩ
Total error	ε_{tot}	% of $I_{P N}$			1	
Total error @ T_A = 85 °C (105 °C)	ε_{tot}	% of $I_{P N}$			1.35 (1.45)	
Error	ε	% of $I_{P N}$			0.8	
Error @ T_A = 85 °C (105 °C)	ε	% of $I_{P N}$			1.15 (1.25)	

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

Typical performance characteristics

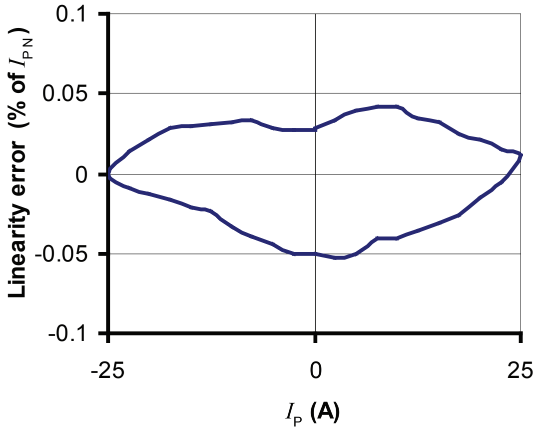


Figure 1: Linearity error

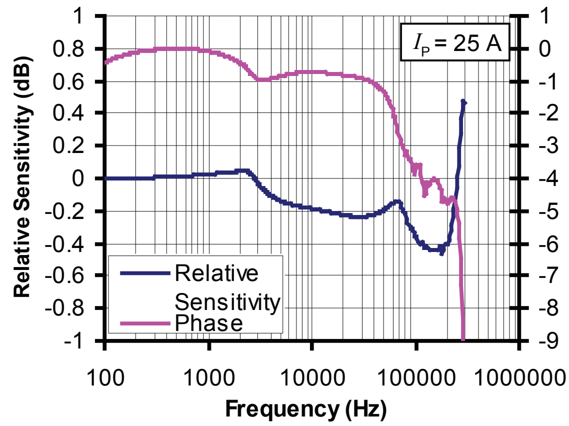


Figure 2: Frequency response

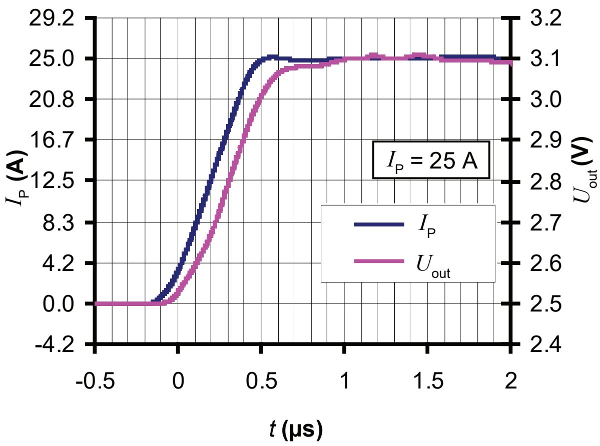


Figure 3: Delay time

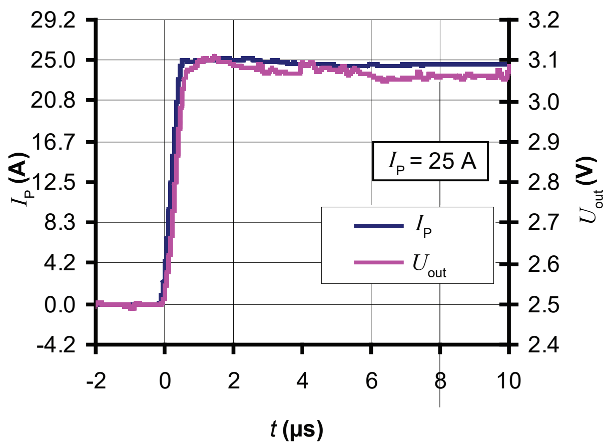


Figure 4: Delay time

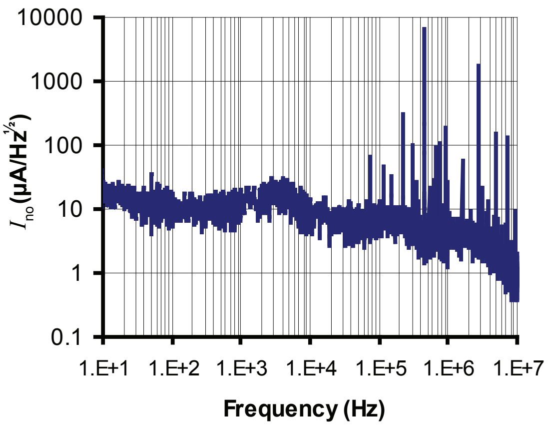


Figure 5: RMS noise current (spectral density) *referred to primary*

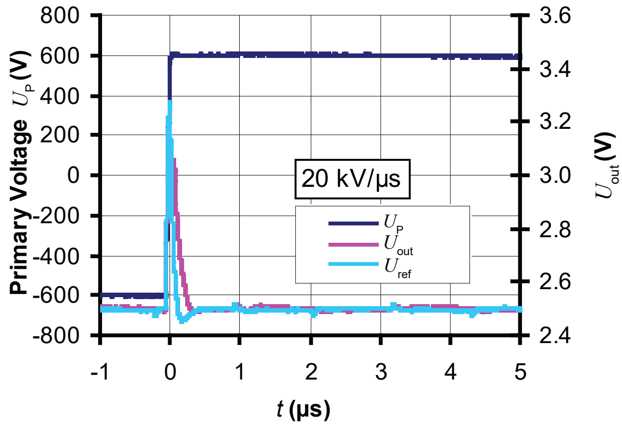


Figure 6: dv/dt

Maximum continuous DC primary current

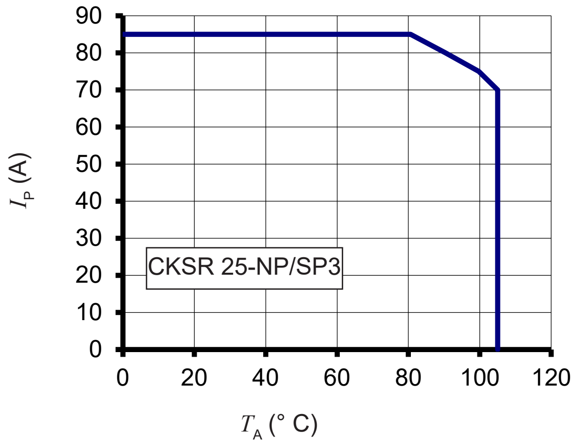


Figure 7: I_P vs T_A for CKSR 25-NP/SP3

The maximum continuous DC primary current plot shows the boundary of the area for which all the following conditions are true:

- $I_P < I_{PM}$
- Junction temperature T_J < 125 °C
- Primary conductor temperature < 110 °C
- Resistor power dissipation < 0.5 × rated power

Frequency derating

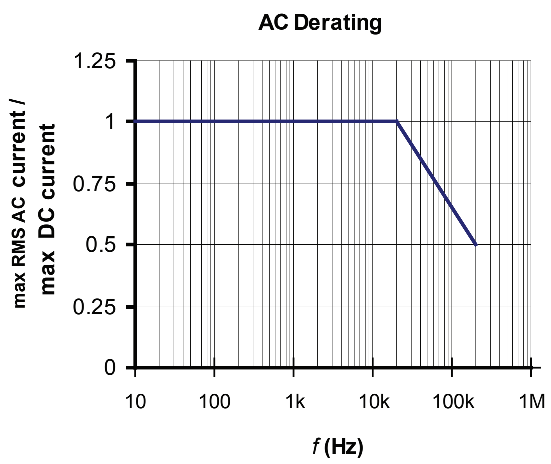


Figure 8: Maximum RMS AC primary current / maximum DC primary current vs frequency

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

Performance parameters definition

Ampere-turns and amperes

The transducer is sensitive to the primary current linkage Θ_P (also called ampere-turns).

$$\Theta_P = N_P \cdot I_P$$

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 (A) unit is used to emphasis that current linkages are intended and applicable.

Simplified transducer model

The static model of the transducer with current output at temperature T_A is:

$$I_s = S \cdot \Theta_P \cdot (1 + \varepsilon)$$

In which (referred to primary):

$$\varepsilon \cdot \Theta_P = I_{OE} + I_{OT} + \varepsilon_S \cdot \Theta_P + \varepsilon_{ST} \cdot \Theta_P + \varepsilon_L(\Theta_{P\,max}) \cdot \Theta_{P\,max} + I_{OM}$$

With: $\Theta_P = N_P \cdot I_P$: primary current link
age (A)

$\Theta_{P\,max}$: maximum primary current linkage applied to the transduer
I_S : secondary current (A)
S : sensitivity of the transducer
T_A : ambient operating temperature (°C)
I_{OE} : electrical offset current (A)
I_{OM} : magnetic offset current (A)
I_{OT} : temperature variation of I_{OE} (A)
ε_S : sensitivity error at 25 °C
ε_{ST} : thermal drift of S
$\varepsilon_L(\Theta_{P\,max})$: linearity error for $\Theta_{P\,max}$

This model is valid for primary ampere-turns Θ_P between $-\Theta_{P\,max}$ and $+\Theta_{P\,max}$ only.
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:

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

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, minimum and maximum values are determined during the initial characterization of the product.

Sensitivity and linearity

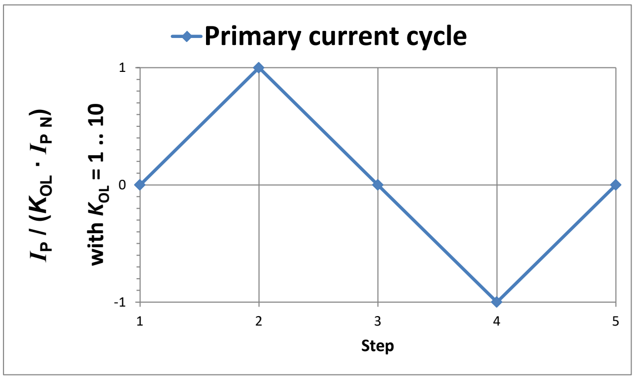
To measure sensitivity and linearity, the primary current (DC) is cycled from 0 to I_P, then to $-I_P$ and back to 0 (equally spaced I_P/10 steps). The sensitivity S is defined as the slope of the linear regression line for a cycle between $\pm I_{PN}$.
The linearity error ε_L is the maximum positive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

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

Performance parameters definition (continued)

Magnetic offset referred to primary

The magnetic offset current $I_{\text{O M}}$ is the consequence of a current on the primary side ("memory effect" of the transducer's ferro-magnetic parts). It is measured using the following primary current cycle. $I_{\text{O M}}$ depends on the current value $I_{\text{P}} \geq I_{\text{P N}}$.



K_{OL}: Overload factor

Figure 9: Current cycle used to measure magnetic and electrical offset (transducer supplied)

$$I_{\text{O M}} = \frac{I_{\text{P (3)}} - I_{\text{P (5)}}}{2}$$

Electrical offset referred to primary

Using the current cycle shown in figure 3, the electrical offset current $I_{\text{O E}}$ is the residual output referred to primary when the input current is zero.

$$I_{\text{O E}} = \frac{I_{\text{P (3)}} + I_{\text{P (5)}}}{2}$$

The temperature variation $I_{\text{O}\,T}$ of the electrical offset current $I_{\text{O E}}$ is the variation of the electrical offset from 25 °C to the considered temperature.

$$I_{\text{O}\,T}(T) = I_{\text{O E}}(T) - I_{\text{O E}}(25°\text{C})$$

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

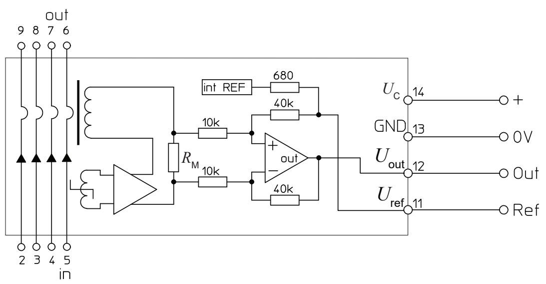


Figure 10: Test connection

Delay times

The delay time $t_{\text{D 10}}$ @ 10 % and the delay time $t_{\text{D 90}}$ @ 90 % with respect to the primary are shown in the next figure.
Both slightly depend on the primary current di/dt.
They are measured at nominal current.

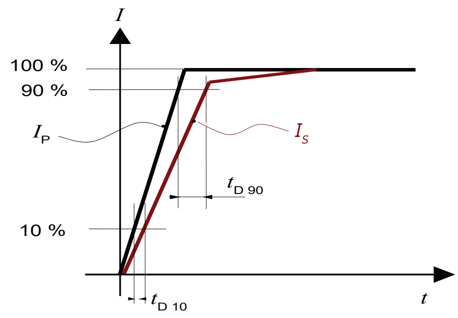


Figure 11: $t_{\text{D 10}}$ (delay time @ 10 %) and $t_{\text{D 90}}$ (delay time @ 90 %).

Total error referred to primary

The total error ε_{tot} is the error at $\pm I_{\text{P N}}$, relative to the rated value $I_{\text{P N}}$.
It includes all errors mentioned above

- the electrical offset $I_{\text{O E}}$
- the magnetic offset $I_{\text{O M}}$
- the sensitivity error ε_{S}
- the linearity error ε_{L} (to $I_{\text{P N}}$).

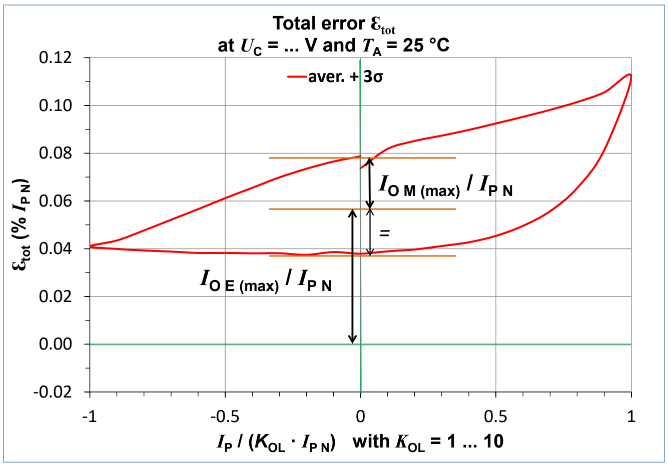


Figure 12: Total error ε_{tot}

Application information

Filtering and decoupling

Supply voltage U_C

The fluxgate oscillator draws current pulses of up to 30 mA at a rate of ca. 900 kHz. Significant 900 kHz voltage ripple on U_C can indicate a power supply with high impedance. At these frequencies the power supply rejection ratio is low, and the ripple may appear on the transducer output U_{out} and reference U_{ref}. The transducer has internal decoupling capacitors, but in the case of a power supply with high impedance, it is advised to provide local decoupling (100 nF or more, located close to the transducer).

Output U_{out}

The output U_{out} has a very low output impedance of typically 2 Ohms; it can drive 100 pF directly. Adding series Rf = 100 Ohms allows much larger capacitive loads. Empirical evaluation may be necessary to obtain optimum results. The minimum load resistance on U_{out} is 1 kOhm.

Total Primary Resistance

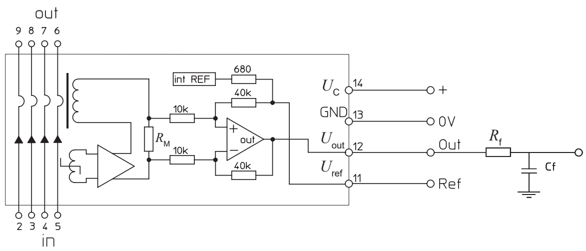
The primary resistance is 0.72 mΩ per conductor.

In the following table, examples of primary resistance according to the number of primary turns.

Number of primary turns	Primary resistance R_P [mΩ]	Recommended connections
1	0.18	9 8 7 6 out / in 2 3 4 5
2	0.72	9 8 7 6 out / in 2 3 4 5
4	2.88	9 8 7 6 out / in 2 3 4 5

Reference U_{ref}

Ripple present on the reference output can be filtered with a low value of capacitance because of the internal 680 Ohm series resistance. The maximum filter capacitance value is 1 µF.



8October2018/version 4

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

External reference voltage

If the Ref pin of the transducer is not used it could be either left unconnected or filtered according to the previous paragraph "Reference U_{ref}".

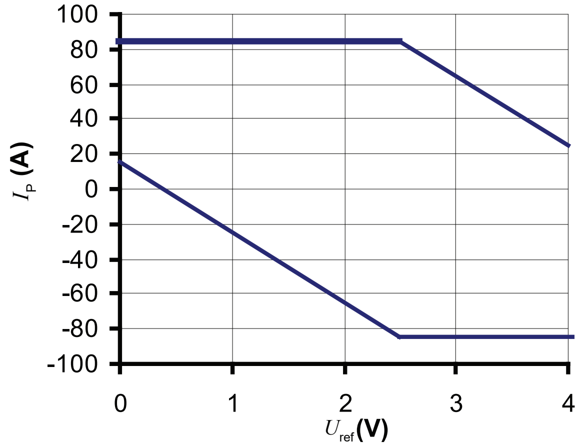
The Ref pin has two modes Ref IN and Ref OUT:

- In the Ref OUT mode the 2.5 V internal precision reference is used by the transducer as the reference point for bipolar measurements; this internal reference is connected to the Ref pin of the transducer through a 680 Ohms resistor. it tolerates sink or source currents up to ±5 mA, but the 680 Ohms resistor prevents this current to exceed these limits.
- In the Ref IN mode, an external reference voltage is connected to the Ref pin; this voltage is specified in the range 0 to 4 V and is directly used by the transducer as the reference point for measurements.
  The external reference voltage U_{ref} must be able:

- either to source a typical current of $\frac{U_{ref} - 2.5}{680}$, the maximum value will be 2.2 mA typ. when U_{ref} = 4 V.

- or to sink a typical current of $\frac{2.5 - U_{ref}}{680}$, the maximum value will be 3.68 mA typ. when U_{ref} = 0 V.

The following graphs show how the measuring range of each transducer version depends on the external reference voltage value U_{ref}.



Upper limit: $I_P = -40 * U_{ref} + 185$ (U_{ref} = 2.5 … 4 V)
Upper limit: $I_P = 85$ (U_{ref} = 0 … 2.5 V)
Lower limit: $I_P = -40 * U_{ref} + 15$ (U_{ref} = 0 … 2.5 V)
Lower limit: $I_P = -85$ (U_{ref} = 2.5 … 4 V)

Example with U_{ref} = 1.65 V:

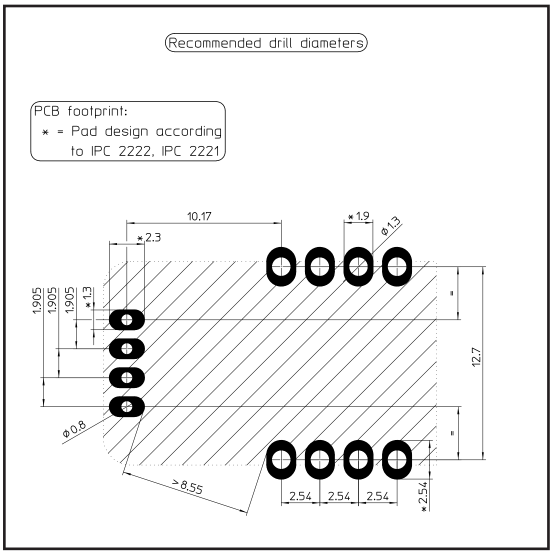
- The 25 A version has a measuring range from −51 A to +85 A

Example with U_{ref} = 0 V:

- The 25 A version has a measuring range from +15 A to +85 A

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

PCB footprint



Assembly on PCB

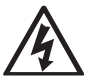
- Recommended PCB hole diameter — 1.3 mm for primary pin; 0.8 mm for secondary pin
- Maximum PCB thickness — 2.4 mm
- Wave soldering profile — maximum 260 °C for 10 s

  No clean process only

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.



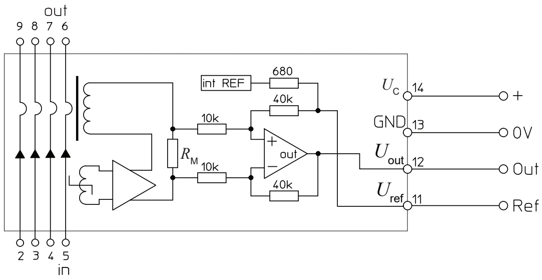
Caution, risk of electrical shock

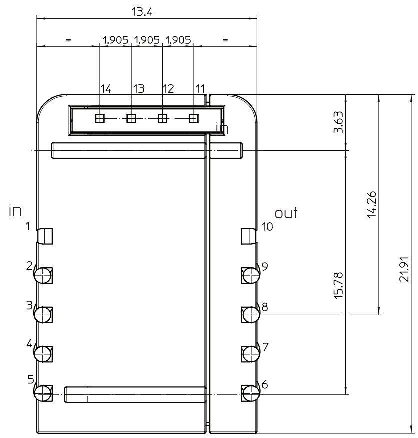
When operating the transducer, certain parts of the module can carry hazardous voltage (eg. primary busbar, power supply).
Ignoring this warning can lead to injury and/or cause serious damage.
This transducer is a build-in device, whose conducting parts must be inaccessible after installation.
A protective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

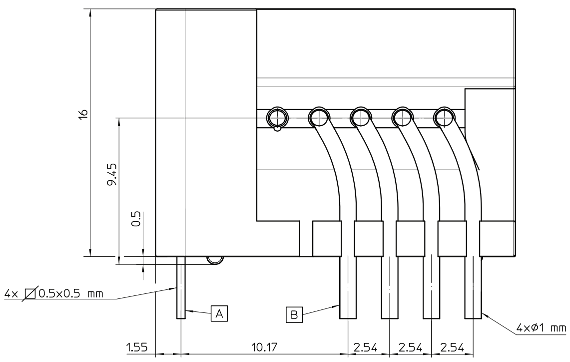
LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com

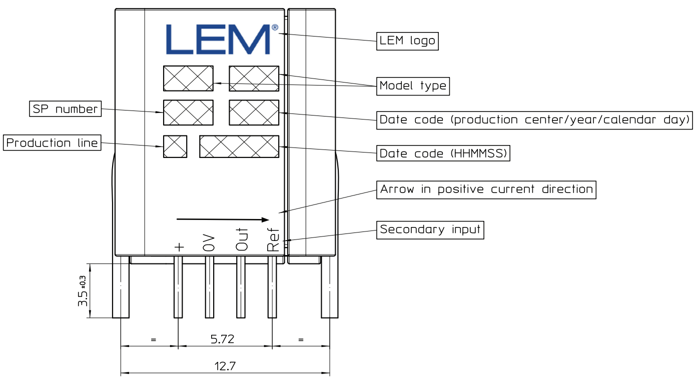
Dimensions (in mm, general linear tolerance ±0.25 mm)

Connection









	d_{Cl}	d_{Cp}
A-B	8.2 mm*	8.2 mm

* Clearance between pads on the pcb: 8.55 mm

Additional marking on the TOP of the transducer, model type, current range and SP number

8October2018/version 4

LEM International SA
Chemin des Aulx 8
1228 PLAN-LES-OUATES Switzerland
www.lem.com