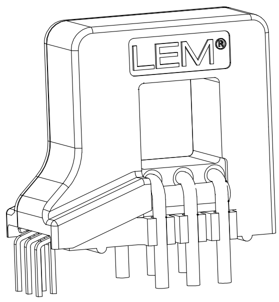
Current Transducer HO-P/SP33 SERIES

I_{PN} = 6, 10, 25 A

Ref: HO 6-P/SP33, HO 10-P/SP33, HO 25-P/SP33

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



Features

- Hall effect measuring principle
- Multirange current transducer through PCB pattern lay-out
- Galvanic separation between primary and secondary circuit
- Insulated test voltage 4300 V
- Low power consumption
- Extremely low profile 12 mm
- Fixed offset & sensitivity
- Overcurrent detection 2.63 x I_{PN} (peak value)
- Memory check.

Special feature

- Single power supply 3.3 V.

Advantages

- Small size and space saving
- Only one design for wide primary current range
- High immunity to external interference
- 8 mm creepage /clearance
- Fast response.

Applications

- AC variable speed drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications
- The solar inverter on DC side of the inverter (MPPT)
- Combiner box.

Standards

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

Application Domain

- Industrial.

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Absolute maximum ratings

Parameter	Symbol	Unit	Value
Supply voltage (not operating)	U_C	V	6.5
Primary conductor temperature	T_B	°C	125
ESD rating, Human Body Model (HBM)	$U_{ESD\ HDM}$	kV	2

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: 5

Standards

- CSA C22.2 NO. 14-10 INDUSTRIAL CONTROL EQUIPMENT - Edition 11 - Revision Date 2011/08/01
- UL 508 STANDARD FOR INDUSTRIAL CONTROL EQUIPMENT - Edition 17 - Revision Date 2010/04/15

Ratings

Parameter	Symbol	Unit	Value
Primary involved potential		V AC/DC	600
Max surrounding air temperature	T_A	°C	105
Primary current	I_P	A	According to series primary currents
Secondary supply voltage	U_C	V DC	3.3
Output voltage	U_{out}	V	0 ... 3.3

Conditions of acceptability

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

1 - *These devices have been evaluated for overvoltage category III and for use in pollution degree 2 environment.*

2 - *A suitable enclosure shall be provided in the end-use application.*

3 - *The terminals have not been evaluated for field wiring.*

4 - *These devices have been evaluated for use in 105°C maximum surrounding air temperature.*

5 - *The secondary (Sensing) circuit is intended to be supplied by a Isolated Secondary Circuit - Limited voltage circuit defined by UL 508 paragraph 32.5. The maximum open circuit voltage potential available to the circuit and overcurrent protection shall be evaluated in the end use application.*

6 - *These devices are intended to be mounted on a printed wiring board of end-use equipment. The suitability of the connections (including spacings) shall be determined in the end-use application.*

7 - *Any surface of polymeric housing have not been evaluated as insulating barrier.*

8 - *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).*

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.

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Insulation coordination

Parameter	Symbol	Unit	Value	Comment
RMS voltage for AC insulation test 50/60Hz/1 min [1)]	U_d	kV	4.3	
Impulse withstand voltage 1.2/50 µs	U_{Ni}	kV	8	
Partial discharge RMS test voltage (q_m < 10 pC)	U_t	V	1650	
Clearance (pri. - sec.)	d_{Cl}	mm	8	Shortest distance through air
Creepage distance (pri. - sec.)	d_{Cp}	mm	8	Shortest path along device body
Case material			V0	according to UL 94
Comparative tracking index	CTI	V	600	
Application example	-	V	600	Reinforced insulation, non uniform field according to EN 50178, CAT III PD2
Application example	-	V	300	Reinforced insulation, non uniform field according to IEC 61010, CAT III PD2
Application example	-	V	1000	Simple insulation, non uniform field according to EN 50178, IEC 61010, CAT III PD2

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−40		105	
Ambient storage temperature	$T_{A\ st}$	°C	−40		105	
Surrounding temperature according to UL 508		°C			105	
Mass	m	g		10		

Note: [1)] Voltage of Retention pins has to be consider. If it is same as primary electrical potential, insulation is no issue. If it is same as secondary electrical potental, insulation of primary bus bar has to be considered.

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Electrical data I_{PN} = 6 A

At T_A = 25 °C, U_C = + 3.3 V, N_P = 1 turn, R_L = 10 KΩ unless otherwise noted (see Min, Max, typ. definition paragraph in page 7).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal RMS current	I_{PN}	A		6		
Primary current, measuring range	I_{PM}	A	−20		20	
Number of primary turns	N_P			1, 2, 3		
Supply voltage	U_C	V	3.14	3.3	3.46	
Current consumption	I_C	mA			25	
Reference voltage	U_{ref}	V	1.636	1.65	1.664	Internal reference
External reference voltage	U_{ref}	V	0.5		1.85	@ U_C = 3.3 ≈ 3.46 V
			0.5		1.7	@ U_C = 3.14 ≈ 3.3 V
Output voltage range @ I_{PM}	$U_{out} - U_{ref}$	V	−1.15		1.15	
Output voltage @ I_P = 0 A	U_{out}	V		$U_{ref} + U_{OE}$		
Electrical offset voltage	U_{OE}	mV	−7		7	
Temperature coefficient of U_{ref}	TCU_{ref}	ppm/K			±170	−20 °C ... 85 °C Internal reference
					±190	−40 °C ... 105 °C Internal reference
Temperature coefficient of U_{OE}	TCU_{OE}	mV/K			±0.14	−40 °C ... 105 °C
Nominal sensitivity	S_N	mV/A		76.67		460 mV/ I_{PN} @ U_C = 3.3 V
Sensitivity error	ε_S	%			±0.85	Factory adjustement
Temperature coefficient of S	TCS	ppm/K			±250	
Linearity error 0 ... I_{PN}	ε_L	% of I_{PN}			±0.5	@ U_C = 3.3 V
Linearity error 0 ... I_{PM}	ε_L	% of I_{PM}			±0.8	@ U_C = 3.3 V
Sensitivity error with respect to U_C ±10 %	ε_S	%/%			±0.4	Sensitivity error per U_C drift
Magnetic offset voltage @ I_P = 0 after 2.5 x I_{PN}	U_{OM}	mV			±3	
Delay time to 10 % of the final output value I_{PN} step	$t_{D\,10}$	µs			2	di/dt = I_{PN}/µs
Delay time to 90 % of the final output value I_{PN} step	$t_{D\,90}$	µs			3.5	di/dt = I_{PN}/µs
Frequency bandwidth (−3 dB)	BW	kHz		250		
Noise voltage spectral density (DC ... 100 kHz)	u_{no}	µV/√Hz			18.9	
RMS noise voltage (DC ... 20 MHz)	U_{no}	mVpp		40		
Overcurrent detection		V	2.6 x I_{PN}	2.9 x I_{PN}	3.2 x I_{PN}	peak value
Sum of sensitivity and linearity error @ I_{PN}	ε_{SL}	% of I_{PN}			±1.35	$\varepsilon_S + \varepsilon_L$
Sum of sensitivity and linearity error @ I_{PN}, @ T_A = 85 °C	$\varepsilon_{SL\,85}$	% of I_{PN}			±4.68	See formula note 1)
Sum of sensitivity and linearity error @ I_{PN}, @ T_A = 105 °C	$\varepsilon_{SL\,105}$	% of I_{PN}			±5.79	See formula note 1)

Note: 1) Error @ I_P and $\varepsilon_{TA} = \pm[\varepsilon + (TCS/10000) \cdot (T_A - 25) + TCU_{OE} \cdot 100 \cdot (T_A - 25) / (S_N \cdot I_P)]$.

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Electrical data $I_{P N}$ = 10 A

At T_A = 25 °C, U_C = + 3.3 V, N_P = 1 turn, R_L = 10 KΩ 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		10		
Primary current, measuring range	$I_{P M}$	A	−25		25	
Number of primary turns	N_P			1, 2, 3		
Supply voltage	U_C	V	3.14	3.3	3.46	
Current consumption	I_C	mA			25	
Reference voltage	U_{ref}	V	1.636	1.65	1.664	Internal reference
External reference voltage	U_{ref}	V	0.5		1.85	@ U_C = 3.3 ≈ 3.46 V
			0.5		1.7	@ U_C = 3.14 ≈ 3.3 V
Output voltage range @ $I_{P M}$	U_{out} - U_{ref}	V	−1.15		1.15	
Output voltage @ I_P = 0 A	U_{out}	V		U_{ref} + $U_{O E}$		
Electrical offset voltage	$U_{O E}$	mV	−5		5	
Temperature coefficient of U_{ref}	TCU_{ref}	ppm/K			±170	−20 °C ... 85 °C Internal reference
					±190	−40 °C ... 105 °C Internal reference
Temperature coefficient of $U_{O E}$	$TCU_{O E}$	mV/K			±0.080	−40 °C ... 105 °C
Nominal sensitivity	S_N	mV/A		46		460 mV/ $I_{P N}$, @ U_C = 3.3 V
Sensitivity error	ε_S	%			±0.85	Factory adjustement
Temperature coefficient of S	TCS	ppm/K			±250	
Linearity error 0 ... $I_{P N}$	ε_L	% of $I_{P N}$			±0.5	@ U_C = 3.3 V
Linearity error 0 ... $I_{P M}$	ε_L	% of $I_{P M}$			±0.8	@ U_C = 3.3 V
Sensitivity error with respect to U_C ±10 %	ε_S	%/%			±0.4	Sensitivity error per U_C drift
Magnetic offset voltage @ I_P = 0 after 2.5 x $I_{P N}$	$U_{O M}$	mV			±3	
Delay time to 10 % of the final output value $I_{P N}$ step	$t_{D 10}$	µs			2	di/dt = $I_{P N}$/µs
Delay time to 90 % of the final output value $I_{P N}$ step	$t_{D 90}$	µs			3.5	di/dt = $I_{P N}$/µs
Frequency bandwidth (−3 dB)	BW	kHz		250		
Noise voltage spectral density (DC ... 100 kHz)	u_{no}	µV/√Hz			10.15	
RMS noise voltage (DC ... 20 MHz)	U_{no}	mVpp		30		
Overcurrent detection		V	2.6 x $I_{P N}$	2.9 x $I_{P N}$	3.2 x $I_{P N}$	peak value
Sum of sensitivity and linearity error @ $I_{P N}$	$\varepsilon_{S L}$	% of $I_{P N}$			±1.35	ε_S + ε_L
Sum of sensitivity and linearity error @ $I_{P N}$, @ T_A = 85 °C	$\varepsilon_{S L 85}$	% of $I_{P N}$			±3.9	See formula note [1]
Sum of sensitivity and linearity error @ $I_{P N}$, @ T_A = 105 °C	$\varepsilon_{S L 105}$	% of $I_{P N}$			±4.75	See formula note [1]

Note: [1] Error @ I_P and $\varepsilon_{TA} = \pm[\varepsilon + (TCS/10000) \cdot (T_A - 25) + TCU_{O E} \cdot 100 \cdot (T_A - 25) / (S_N \cdot I_P)]$.

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Electrical data I_{PN} = 25 A

At T_A = 25 °C, U_C = + 3.3 V, N_P = 1 turn, R_L = 10 KΩ unless otherwise noted (see Min, Max, typ. definition paragraph in page 7).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal RMS current	I_{PN}	A		25		
Primary current, measuring range	I_{PM}	A	−62.5		62.5	
Number of primary turns	N_P			1,2,3		
Supply voltage	U_C	V	3.14	3.3	3.46	
Current consumption	I_C	mA			25	
Reference voltage	U_{ref}	V	1.636	1.65	1.664	Internal reference
External reference voltage	U_{ref}	V	0.5		1.85	@ U_C = 3.3 ≈ 3.46 V
			0.5		1.7	@ U_C = 3.14 ≈ 3.3 V
Output voltage range @ I_{PM}	$U_{out} - U_{ref}$	V	−1.15		1.15	
Output voltage @ I_P = 0 A	U_{out}	V		$U_{ref} + U_{OE}$		
Electrical offset voltage	U_{OE}	mV	-6		6	
Temperature coefficient of U_{ref}	TCU_{ref}	ppm/K			±170	−20 °C ... 85 °C Internal reference
					±190	−40 °C ... 105 °C Internal reference
Temperature coefficient of U_{OE}	TCU_{OE}	mV/K			±0.075	−40 °C ... 105 °C
Nominal sensitivity	S_N	mV/A		18.4		460 mV/ I_{PN} @ U_C = 3.3 V
Sensitivity error	ε_S	%			±0.85	Factory adjustement
Temperature coefficient of S	TCS	ppm/K			±250	
Linearity error 0 ... I_{PN}	ε_L	% of I_{PN}			±0.5	@ U_C = 3.3 V
Linearity error 0 ... I_{PM}	ε_L	% of I_{PM}			±0.8	@ U_C = 3.3 V
Sensitivity error with respect to U_C ±10 %	ε_S	%/%			±0.4	Sensitivity error per U_C drift
Magnetic offset voltage @ I_P = 0 after 2.5 x I_{PN}	U_{OM}	mV			±4	
Delay time to 10 % of the final output value I_{PN} step	$t_{D\,10}$	µs			2	di/dt = I_{PN}/µs
Delay time to 90 % of the final output value I_{PN} step	$t_{D\,90}$	µs			3.5	di/dt = I_{PN}/µs
Frequency bandwidth (−3 dB)	BW	kHz		250		
Noise voltage spectral density (DC ... 100 kHz)	u_{no}	µV/√Hz			6.13	
RMS noise voltage (DC ... 20 MHz)	U_{no}	mVpp		20		
Overcurrent detection		V	2.6 x I_{PN}	2.9 x I_{PN}	3.2 x I_{PN}	peak value
Sum of sensitivity and linearity error @ I_{PN}	ε_{SL}	% of I_{PN}			±1.35	$\varepsilon_S + \varepsilon_L$
Sum of sensitivity and linearity error @ I_{PN}, @ T_A = 85 °C	$\varepsilon_{SL\,85}$	% of I_{PN}			±3.83	See formula note [1]
Sum of sensitivity and linearity error @ I_{PN}, @ T_A = 105 °C	$\varepsilon_{SL\,105}$	% of I_{PN}			±4.66	See formula note [1]

Note: [1] Error @ I_P and $\varepsilon_{TA} = \pm[\varepsilon + (TCS/10000) \cdot (T_A - 25) + TCU_{OE} \cdot 100 \cdot (T_A - 25) / (S_N \cdot I_P)]$.

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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.

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Maximum continuous DC primary current

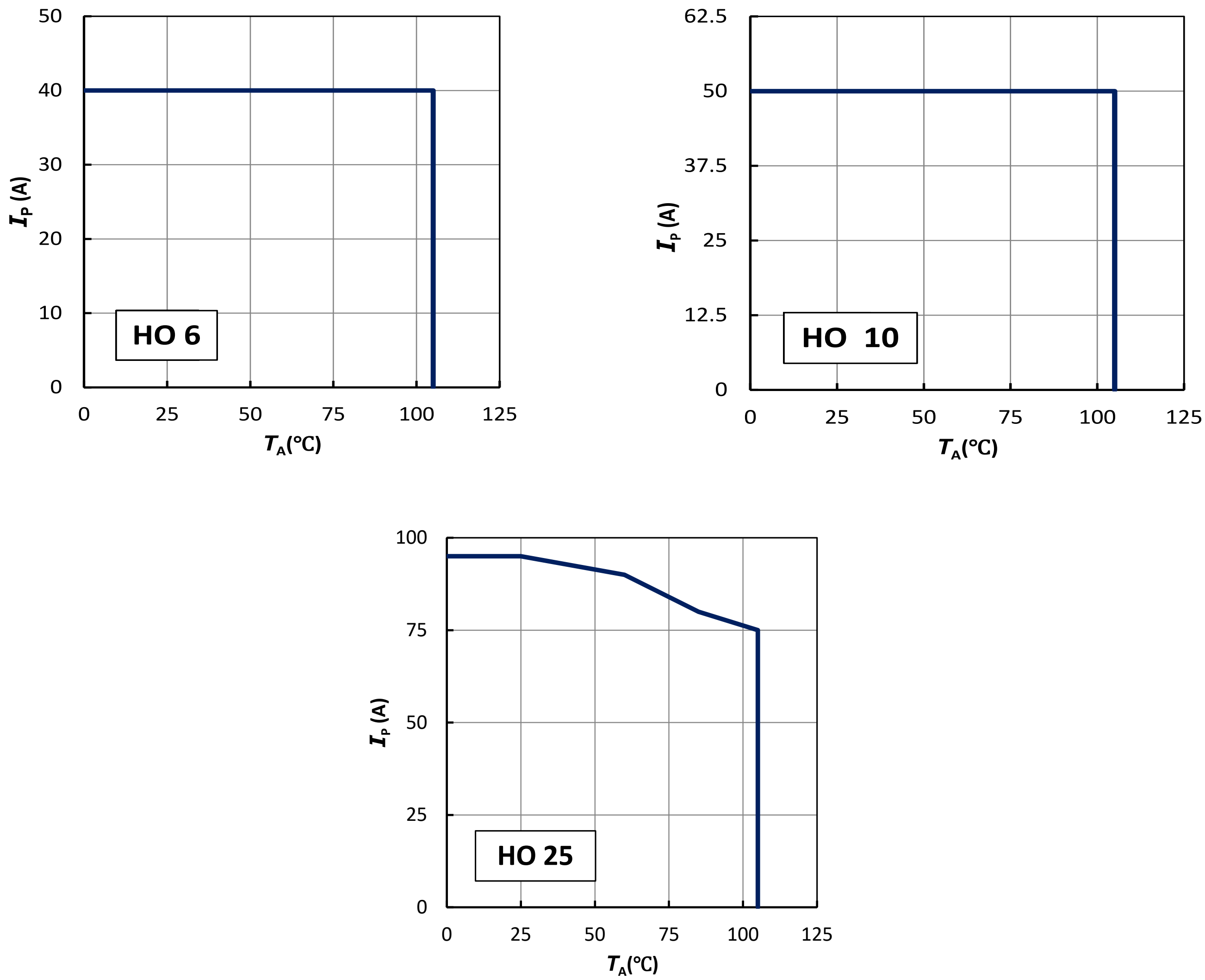

Figure 1: I_P vs T_A for HO series

<u>Important notice</u>: whatever the usage and/or application, the primary conductor temperature shall not go above the maximum rating of 125 °C as stated in page 2 of this datasheet.

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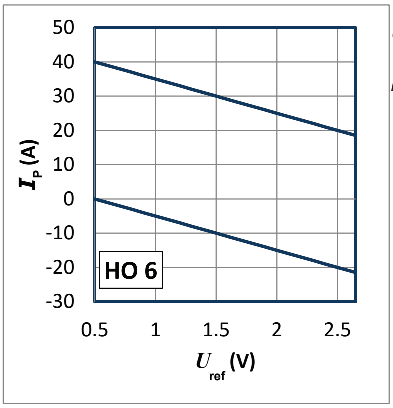
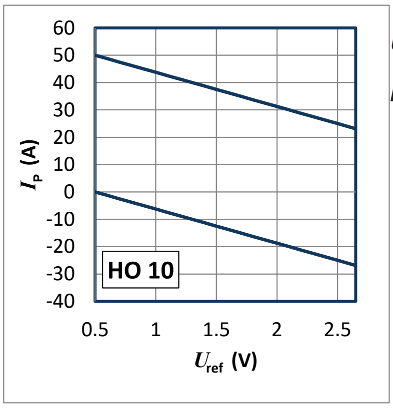
Measuring range with external reference voltage



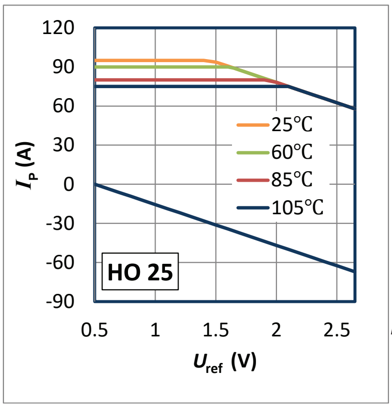
Upper limit: $I_P = -10 \times U_{ref} + 45$ (U_{ref} = 0.5 ... 2.65 V)

Lower limit: $I_P = -10 \times U_{ref} + 5$ (U_{ref} = 0.5 ... 2.65 V)



Upper limit: $I_P = -12.5 \times U_{ref} + 56.25$ (U_{ref} = 0.5 ... 2.65 V)

Lower limit: $I_P = -12.5 \times U_{ref} + 6.25$ (U_{ref} = 0.5 ... 2.65 V)



Upper limit:

T_A = 105° C: $I_P = 75$ (U_{ref} = 0.5 ..2.1 V); $I_P = 31.25 \times U_{ref} + 140.63$ (U_{ref} = 2.1 ... 2.65 V)

T_A = 85° C: $I_P = 80$ (U_{ref} = 0.5 ..1.94 V); $I_P = 31.25 \times U_{ref} + 140.63$ (U_{ref} = 1.94 ... 2.65 V)

T_A = 60° C: $I_P = 90$ (U_{ref} = 0.5 ..1.62 V); $I_P = 31.25 \times U_{ref} + 140.63$ (U_{ref} = 1.62 ... 2.65 V)

T_A = 25° C: $I_P = 95$ (U_{ref} = 0.5 ..1.46 V); $I_P = 31.25 \times U_{ref} + 140.63$ (U_{ref} = 1.46 ... 2.65 V)

Lower limit: $I_P = -31.25 \times U_{ref} + 15.63$ (U_{ref} = 0.5 ... 2.65 V)

Example with U_{ref} = 0.5 V:

- The 6 A version has a measuring range from 0 A to 40 A
- The 10 A version has a measuring range from 0 A to 50 A
- The 25 A version has a measuring range from 0 A to 75 A at T_A = 105° C

Example with U_{ref} = 1.5 V:

- The 6 A version has a measuring range from −10 A to 30 A
- The 10 A version has a measuring range from −18.7 A to +56.3 A
- The 25 A version has a measuring range from −31.2 A to +80 A at T_A = 85° C

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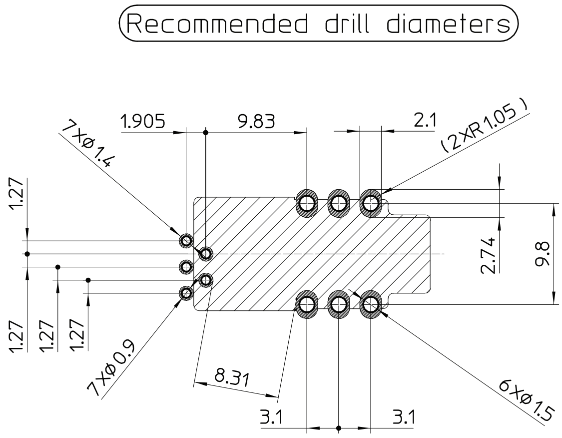
PCB Footprint



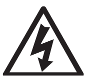
Assembly on PCB

- Recommended PCB hole diameter — 1.5 mm for retention pin; 0.9 mm for secondary pin
- Maximum PCB thickness — 2.4 mm
- Wave soldering profile — maximum 260 °C, 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 (e.g. primary bus bar, 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.

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Terms and definitions

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 voltage output at temperature T_A is:

$$U_{out} = S \cdot \Theta_P (1 + \varepsilon)$$

In which:

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

$\Theta_P = N_P \cdot I_P$: primary current linkage (A)
$\Theta_{P\,max}$: maximum primary current linkage applied to the transducer
I_S : secondary current (A)
U_{out} : output voltage (V)
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:

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

Total error referred to primary

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

- the electrical offset I_{OE}
- the magnetic offset I_{OM}
- the sensitivity error ε_S
- the linearity error ε_L (to I_{PN}).

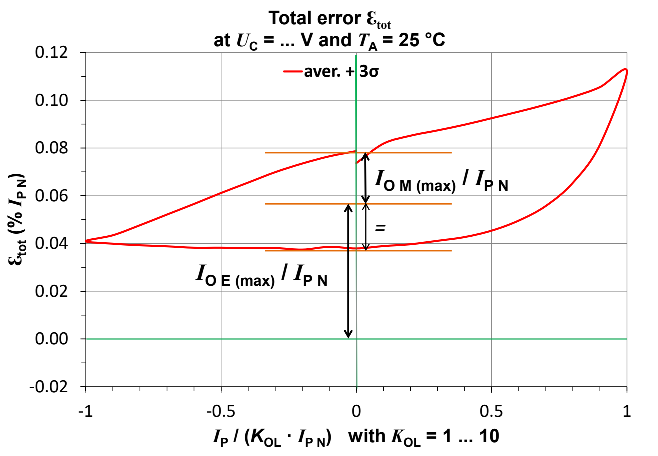

Figure 1: Total error ε_{tot}

Electrical offset referred to primary

Using the current cycle shown in figure 1, the electrical offset current I_{OE} is the residual output referred to primary when the input current is zero.

$$I_{OE} = \frac{I_{P(3)} + I_{P(5)}}{2}$$

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.

$$I_{OT}(T) = I_{OE}(T) - I_{OE}(25°C)$$

Magnetic offset referred to primary

The magnetic offset current I_{OM} 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_{OM} depends on the current value $I_P \geq I_{PN}$.
K_{OL}: Overload factor

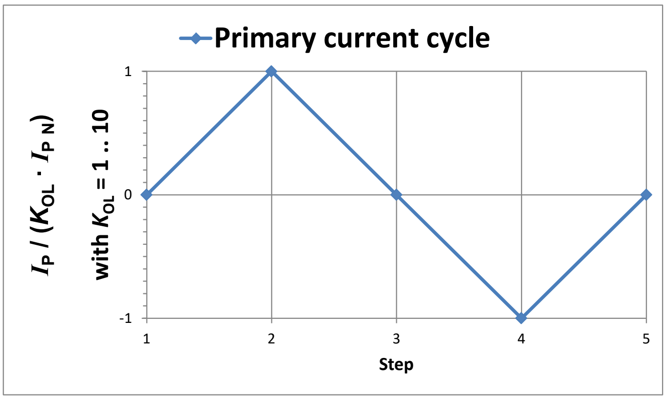

Figure 2: Current cycle used to measure magnetic and electrical offset (transducer supplied)

$$I_{OM} = \frac{I_{P(3)} - I_{P(5)}}{2}$$

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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}.

Delay times

The delay time $t_{D\,10}$ @ 10 % and the delay time $t_{D\,90}$ @ 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.

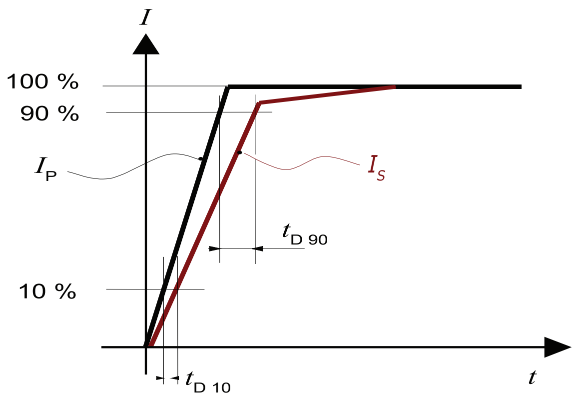

Figure 3: $t_{D\,10}$ (delay time @ 10 %) and $t_{D\,90}$ (delay time @ 90 %).

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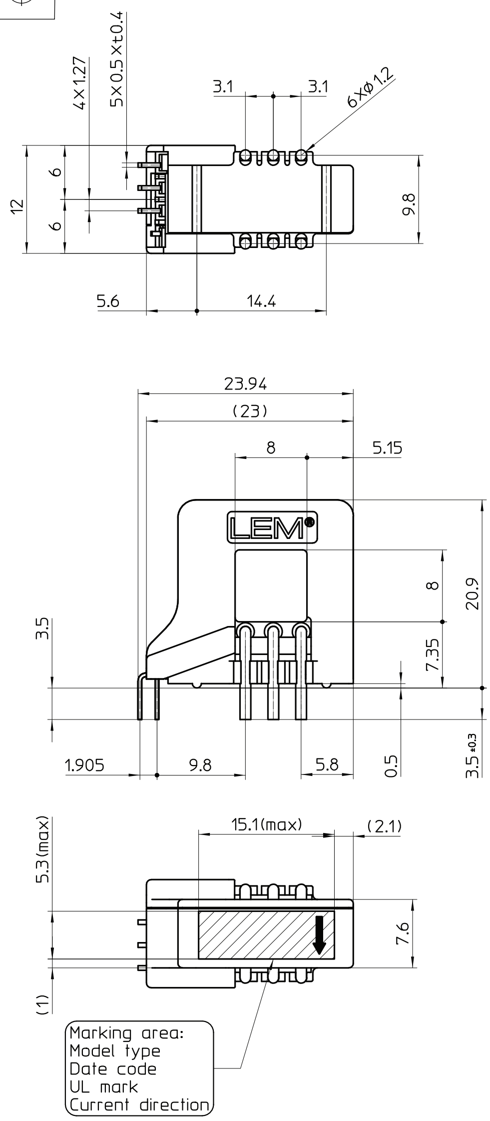
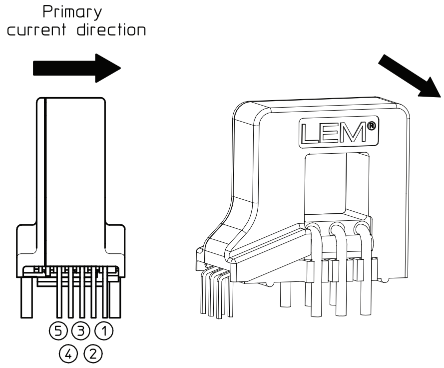
Dimensions HO 6-P/SP33, HO 10-P/SP33, HO 25-P/SP33 (±0.5 mm)



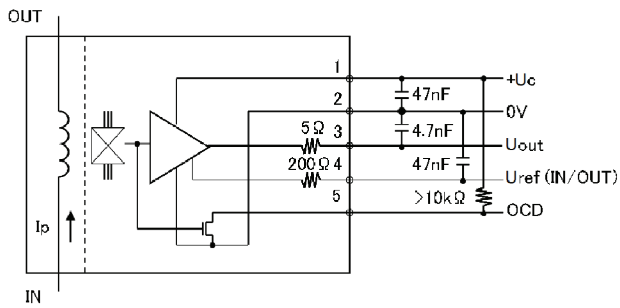


① : $+U_C$
② : 0V
③ : U_{out}
④ : U_{ref} (IN/OUT)
⑤ : OCD

	dCl (mm)	dCp (mm)
note1)	8.0	8.0

1) Minimum distance from the primary to the core

Connection



Remarks

·There are 6 retention pins which have to be used only for retention as well as into the section called “Assembly on PCB”.
·The pimary conductor to be measured should go through the aperture 8 x 8 mm.

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