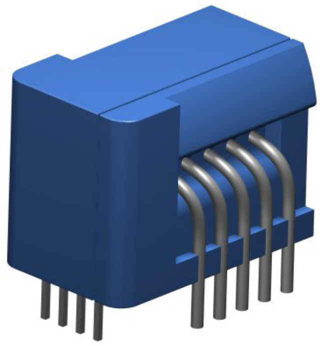
Current Transducer CKSR 75-NP

I_{PN} = 75 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

- Dedicated 5 primary conductors configuration.

Advantages

- Very low temperature coefficient of offset
- Very good du/dt immunity
- 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

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

Application Domain

- Industrial.

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Safety

Caution

If the device is used in a way that is not specified by the manufacturer, the protection provided by the device may be compromised.
Always inspect the electronics unit and connecting cable before using this product and do not use it if damaged.
Mounting assembly shall guarantee the maximum primary conductor temperature, fulfill clearance and creepage distance, minimize electric and magnetic coupling, and unless otherwise specified can be mounted in any orientation.

Caution, risk of electrical shock

This transducer must be used in limited-energy secondary circuits SELV according to IEC 61010-1, in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer's operating specifications.

Use caution during installation and use of this product; certain parts of the module can carry hazardous voltages and high currents (e.g. power supply, primary conductor).
Ignoring this warning can lead to injury and or/or cause serious damage.
De-energize all circuits and hazardous live parts before installing the product.
All installations, maintenance, servicing operations and use must be carried out by trained and qualified personnel practicing applicable safety precautions.

This transducer is a build-in device, whose hazardous live parts must be inaccessible after installation.
This transducer must be mounted in a suitable end-enclosure.
Besides make sure to have a distance of minimum 30 mm between the primary terminals of the transducer and other neighboring components.

Main supply must be able to be disconnected.
Never connect or disconnect the external power supply while the primary circuit is connected to live parts.
Never connect the output to any equipment with a common mode voltage to earth greater than 30 V.
Always wear protective clothing and gloves if hazardous live parts are present in the installation where the measurement is carried out.
This transducer is a built-in device, not intended to be cleaned with any product. Nevertheless if the user must implement cleaning or washing process, validation of the cleaning program has to be done by himself.
When defining soldering process, please use no cleaning process only.

ESD susceptibility
The product is susceptible to be damaged from an ESD event and the personnel should be grounded when handling it.

Do not dispose of this product as unsorted municipal waste. Contact a qualified recycler for disposal.
Although LEM applies utmost care to facilitate compliance of end products with applicable regulations during LEM product design, use of this part may need additional measures on the application side for compliance with regulations regarding EMC and protection against electric shock. Therefore LEM cannot be held liable for any potential hazards, damages, injuries or loss of life resulting from the use of this product.

c UL us

Underwriters Laboratory Inc. recognized component

Absolute maximum ratings

Parameter	Symbol	Unit	Value
Maximum supply voltage	$U_{\text{C max}}$	V	7
Maximum primary conductor temperature	$T_{\text{B max}}$	°C	110
Maximum primary current	$I_{\text{P max}}$	A	20 × $I_{\text{P N}}$
Maximum ESD rating, Human Body Model (HBM)	$U_{\text{ESD max}}$	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	75
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.

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

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

4 - 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).

5 - 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.

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Insulation coordination

Parameter	Symbol	Unit	Value	Comment
RMS voltage for AC insulation test, 50 Hz, 1 min	U_d	kV	4.1	
Impulse withstand voltage 1.2/50 µs	U_{Ni}	kV	7.5	
Partial discharge RMS test voltage (q_m< 10 pC)	U_t	V	1000	
Clearance (pri. - sec.)	d_{Cl}	mm	7.5	Shortest internal distance through air [1]
Creepage distance (pri. - sec.)	d_{Cp}	mm	7.5	Shortest internal path along device body [1]
Clearance (pri. - sec.)	d_{Cl}	mm	6.1	When mounted on PCB with recommended layout
Creepage distance (pri. - sec.)	d_{Cp}	mm	6.1	When mounted on PCB with recommended layout
Case material	-	-	V0	According to UL 94
Comparative tracking index	*CTI*		600	
Application example RMS voltage line-to-neutral	-	V	300	Reinforced insulation, according to IEC 61010-1 CAT III PD2
Application example RMS voltage line-to-neutral	-	V	600	Basic insulation, according to IEC 61010-1 CAT III PD2

Note: [1] Inside device enclosure providing protection IP5x.

Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	−40		105	[1]
Ambient storage temperature	$T_{A\,st}$	°C	−55		105	
Mass	m	g		9		

Note: [1] The working conditions have direct impact on the temperature of primary conductor. In any cases, the temperature of conductor must be below 110 °C according to absolute maximum ratings in page up.

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 definition of typ, Min, Max. paragraph in page 6).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal RMS current	I_{PN}	A		75		Apply derating according to Figure 1.
Primary current, measuring range	I_{PM}	A	−180		180	
Primary current, measuring range	I_{PM}	A	−182		182	With U_C = 4.75 V, T_A = 85 °C, R_L = 10 kΩ. For other conditions, see Figure 7.
Number of primary turns	N_P			1,2,3,4,5		
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 = 966 turns
Reference voltage @ I_P = 0 A	U_{ref}	V	2.495	2.5	2.505	Internal reference
External reference voltage	$U_{E\,ref}$	V	0		4	
Output voltage	U_{out}	V	U_{ref}−1.125		U_{ref}+1.125	@ I_{PM}
Output voltage @ I_P = 0 A	U_{out}	V		U_{ref}		
Electrical offset voltage	U_{OE}	mV	−0.725		0.725	100 % tested $U_{out} - U_{ref}$
Electrical offset current referred to primary	I_{OE}	mA	−116		116	100 % tested
Temperature coefficient of U_{ref}	TCU_{ref}	ppm/K	−50	±5	50	Internal reference
Temperature coefficient of U_{out} @ I_P = 0 A	TCU_{out}	ppm/K	−4		4	ppm/K of 2.5 V −40 °C … 105 °C (at ±6 Sigma)
Nominal sensitivity	S_N	mV/A		6.25		468.5 mV/I_{PN}
Sensitivity error	ε_S	%	−0.7		0.7	100 % tested
Temperature coefficient of S	TCS	ppm/K	−40		40	−40 °C … 105 °C
Linearity error	ε_L	% of I_{PN}	−0.1		0.1	
Magnetic offset current (10 × I_{PN}) referred to primary	I_{OM}	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	R_L = 1 kΩ
Delay time to 10 % to the final output value for I_{PN} step	$t_{D\,10}$	µs			0.3	R_L = 1 kΩ, di/dt = 68 A/µs
Delay time to 90 % to the final output value for I_{PN} step	$t_{D\,90}$	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_{PN}	−1.2		1.2	
Total error @ T_A = 105 °C	ε_{tot}	% of I_{PN}	−1.6		1.6	
Error	ε	% of I_{PN}	−1		1	
Error @ T_A = 105 °C	ε	% of I_{PN}	−1.4		1.4	

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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 the product.

Maximum continuous DC primary current

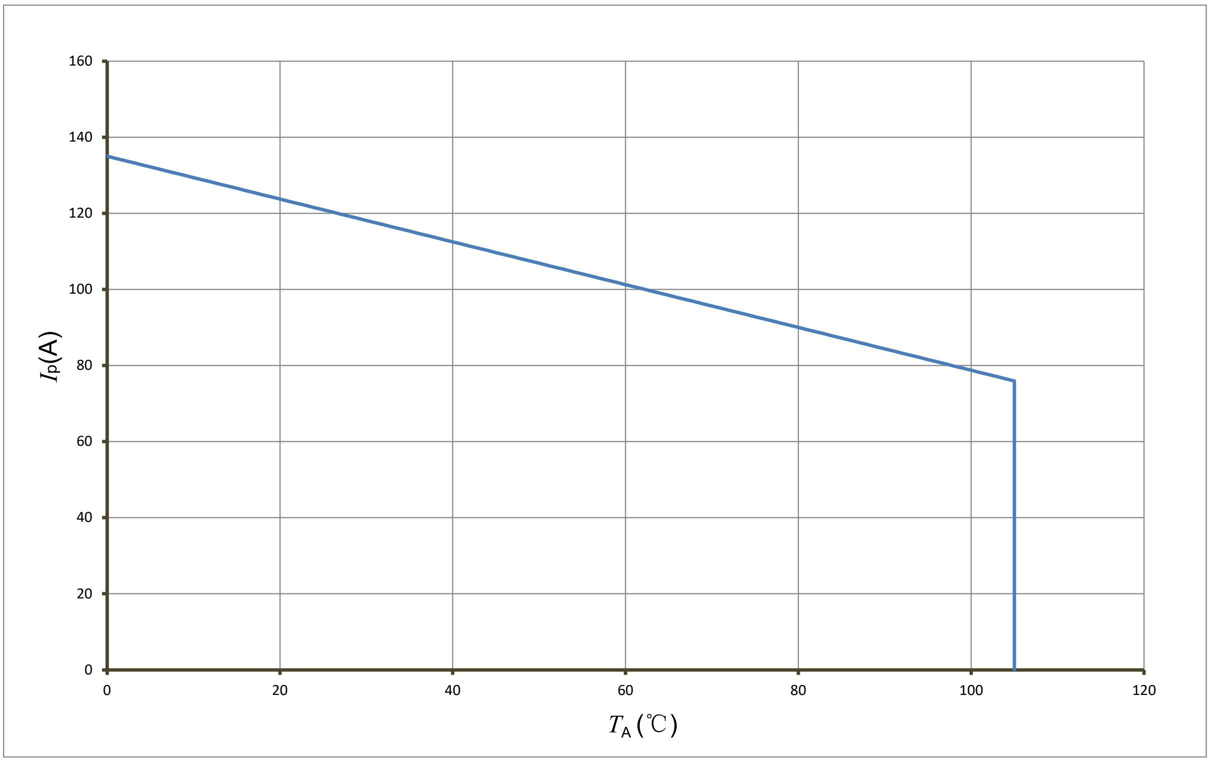

Figure 1: I_P vs T_A for CKSR 75-NP

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

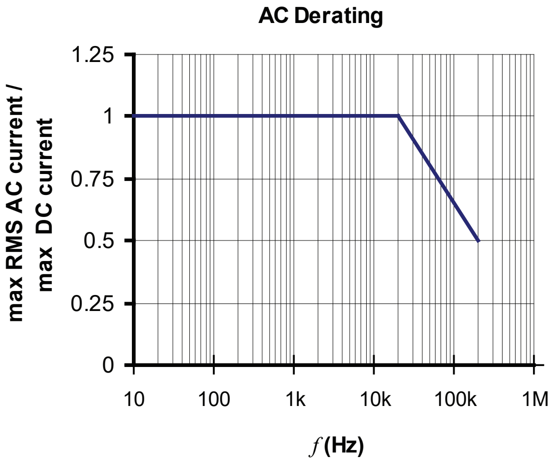

Figure 2: Maximum RMS AC primary current / maximum DC primary current vs frequency

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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.

Transducer simplified model

The static model of the transducer at temperature T_A is:
$U_{out} = S\,\Theta_P + \varepsilon$

In which ε =
$U_{O\,E} + U_{O\,T}(T_A) + \varepsilon_S \cdot \Theta_P \cdot S + \varepsilon_L(\Theta_{P\,max}) \cdot \Theta_{P\,max} \cdot S + TCS \cdot (T_A - 25) \cdot \Theta_P \cdot S$

With:

	$\Theta_P = N_P I_P$	:the input ampere-turns (At) Please read above warning.
	$\Theta_{P\,max}$	:the maxi input ampere-turns that have been applied to the transducer (At)
	U_{out}	:the secondary voltage (V)
	T_A	:the ambient temperature (°C)
	$U_{O\,E}$	:the electrical offset voltage (V)
	$U_{O\,T}(T_A)$	:the temperature variation of U_O at temperature T_A (V)
	S	:the sensitivity of the transducer (V/At)
	ε_S	:the sensitivity error
	$\varepsilon_L(\Theta_{P\,max})$	:the 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:

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

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 $\pm I_{P\,N}$.
The linearity error ε_L is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of $I_{P\,N}$.

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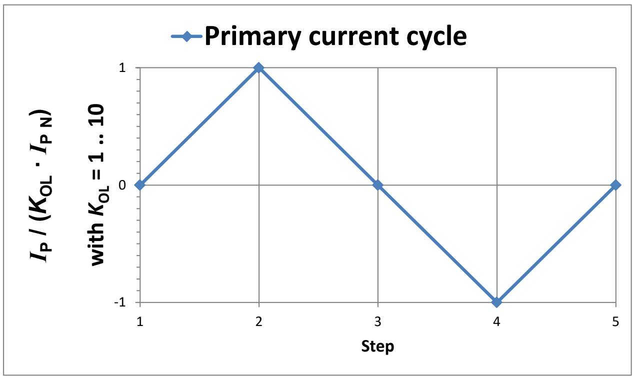
Magnetic offset referred to primary

The magnetic offset current $I_{O\,M}$ 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. $I_{O\,M}$ depends on the current value $I_P \geq I_{P\,N}$.



K_{OL}: Overload factor

Figure 3: Current cycle used to measure magnetic and electrical offset (transducer supplied)

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

Electrical offset referred to primary

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

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

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

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

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

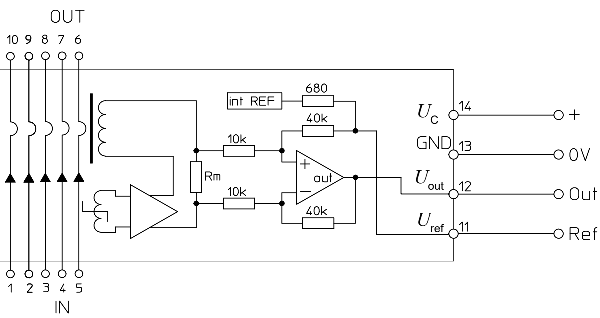


Figure 4: Test connection

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.

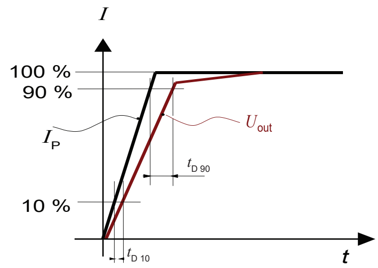


Figure 5: $t_{D\,10}$ (delay time @ 10 %) and $t_{D\,90}$ (delay time @ 90 %).

Total error referred to primary

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

- the electrical offset $I_{O\,E}$
- the magnetic offset $I_{O\,M}$
- the sensitivity error ε_S
- the linearity error ε_L (to $I_{P\,N}$).

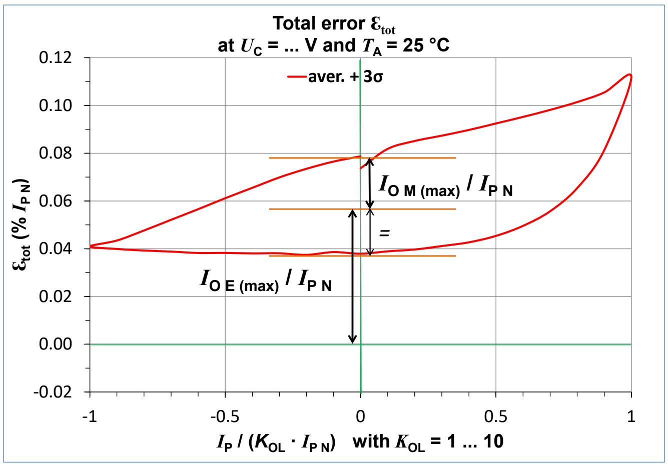


Figure 6: Total error ε_{tot}

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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	0.144	10 9 8 7 6 out in 1 2 3 4 5
2	0.6	10 9 8 7 6 out in 1 2 3 4 5
5	3.6	10 9 8 7 6 out in 1 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.

Measurement range

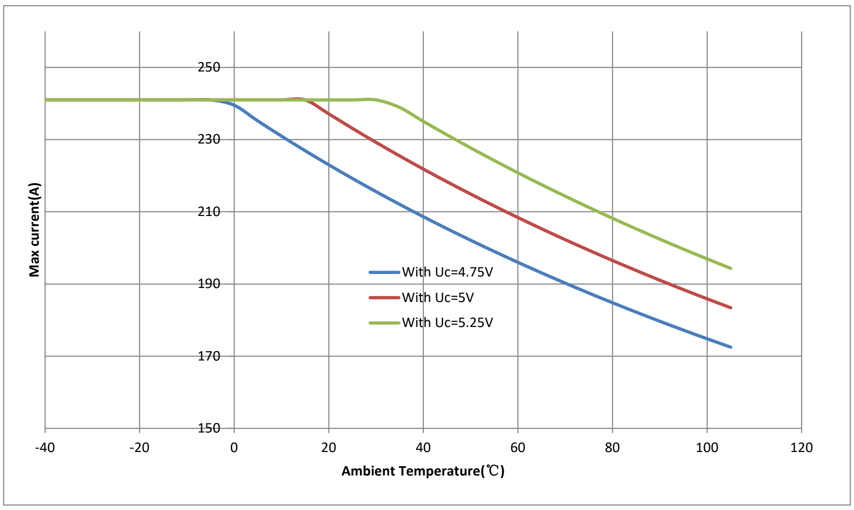

Figure 7: The measurement range vs. temperature

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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.

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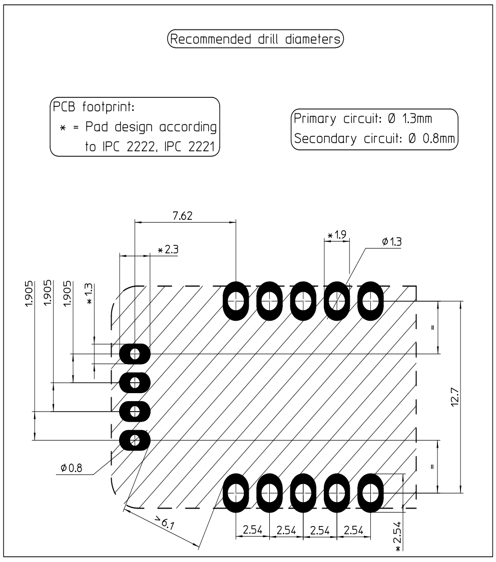
PCB footprint



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

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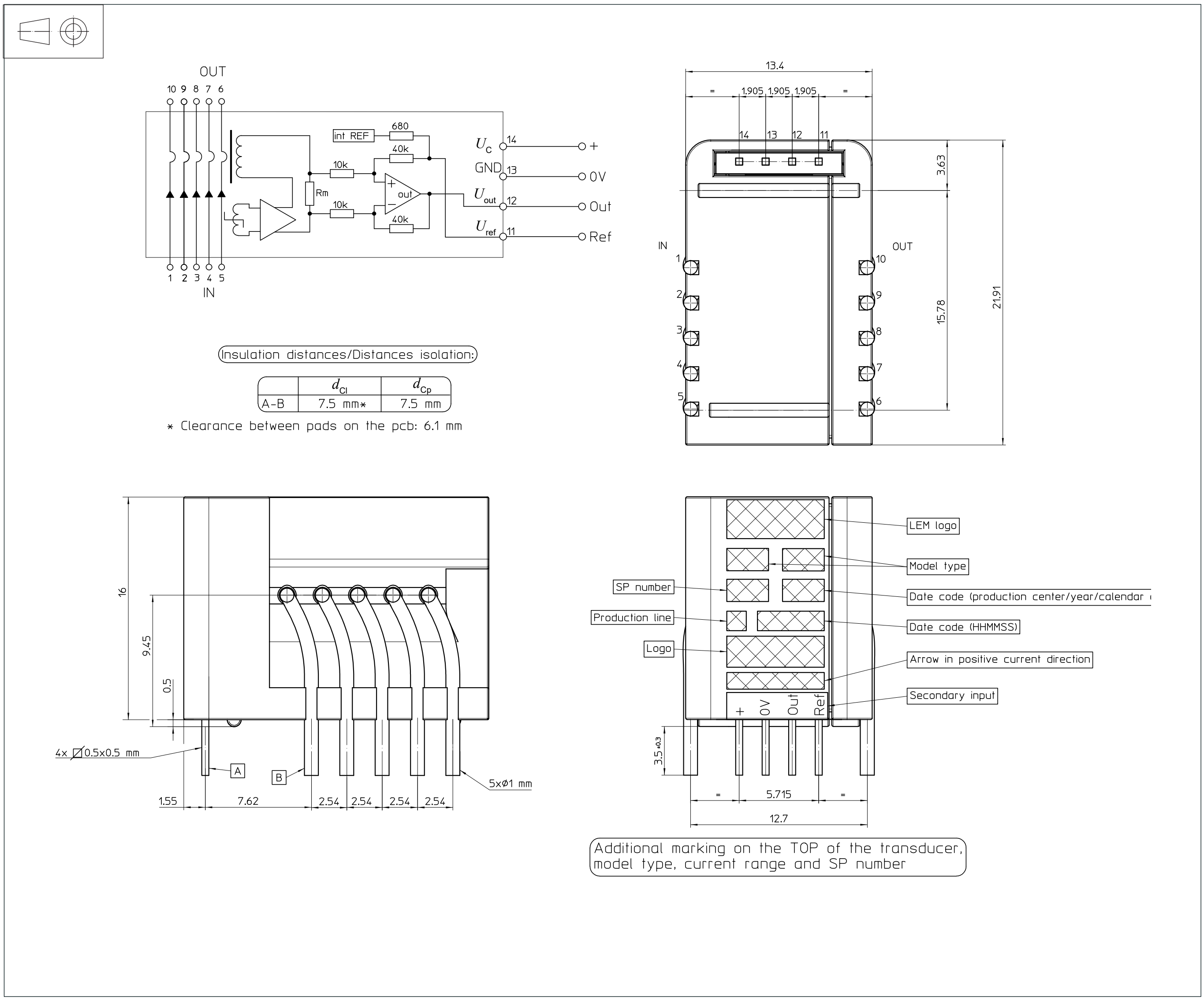
Dimensions (in mm, general linear tolerance ±0.25 mm)



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