Voltage Transducer DVC 1000-P

U_{PN} = 1000 V

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

Features

- Bipolar and insulated measurement up to 1500 V
- Voltage output
- PCB mounting
- 8 pins
- 5 V unipolar power supply
- Ingress protection rating IP 20.

Advantages

- Low consumption and low losses
- Compact design
- Very low sensitivity to common mode voltage variations
- Excellent accuracy (offset, sensitivity, linearity)
- Fast delay time
- Low temperature drift
- High immunity to external interferences.

Applications

- AC variable speed and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Power supplies for welding applications
- Single or three phase inverters
- Auxiliary converters
- Substations.

Standards

- EN 50155: 2017
- EN 50121-3-2: 2016
- IEC 62497-1: 2018
- IEC 61000-6-2: 2016
- IEC 61000-6-3: 2016
- IEC 61800-3: 2005
- IEC 61010-1: 2010
- IEC 61800-5-1: 2007
- IEC 62109-1: 2010
- UL 508: 2018

Application Domain

- Industrial or Railway (fixed installations and onboard).

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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 before using this product and do not use it if damaged.
Care must be taken to maintain the clearance and creepage distances with the board design using proper PCB techniques.
This transducer must be mounted only on printed circuit board (PCB) with respect to applicable standards and safety requirements in accordanace with the manufacturer's operating instructions.

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.
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.

This transducer is not intended to be cleaned with any product. Nevertheless if the user must implement cleaning 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.

Underwriters Laboratory Inc. recognized component

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Absolute maximum ratings

Parameter	Symbol	Unit	Value
Maximum DC supply voltage ⎓ (U_P = 0 V, 0.1 s)	$U_{C\ max}$	V	6
Maximum DC supply voltage ⎓ (working) (− 40 … + 85 °C)	$U_{C\ max}$	V	5.25
Electrostatic discharge voltage (HBM - Human Body Model)	$U_{ESD\ HBM}$	kV	4
Maximum DC common mode voltage	$U_{HV+} + U_{HV-}$ and $\lvert U_{HV+} - U_{HV-}\rvert$	kV	≤ 1.5

Absolute maximum ratings apply at 25 °C unless otherwise noted.
Stresses above these ratings may cause permanent damage.
Exposure to absolute maximum ratings for extended periods may degrade reliability.

Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	-40		85	
Ambient storage temperature	$T_{A\ st}$	°C	-50		90	
Relative humidity	RH	%			95	Non condensing
Mass	m	g		22		
Ingress protection rating				IP20		IEC 60529 (Indoor use)
Altitude		m			2000 [1]	
Pollution degree					PD3 [2]	

Notes:
[1] Insulation coordination at 2000 m
[2] PD2 max accordingly to UL 508

UL 508: Rating and assumptions of certification

File # E189713 Volume: 2 Section: 16

Standards

- Canadian Standard for industrial Control Equipment CSA C22.2 No. 14-18
- US Standard for Industrial Control Equipement UL 508

Conditions of acceptability

When installed in the end-use equipment, consideration shall be given to the following:
1. These devices are intended to be mounted on a printed wiring board.
2. The secondary circuit pin terminals have not been evaluated for field wiring.
3. Low voltage control circuit shall be supplied by an isolating source (such as a transformer, optical isolator, limiting impedance or electro-mechanical relay).
4. These devices are intended to be mounted in an ultimate enclosure.
5. The products have been evaluated for a maximum surrounding air temperature of 85 °C.
6. These devices are intended to be installed in a pollution degree 2 max.

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 at 50 Hz	U_d	kV	4.26	Type test: 1mn Routine test: 10s (100 % tested in prod.) Both tests according to IEC 62497-1
Impulse withstand voltage 1.2/50 µs	U_{Ni}	kV	7.84	According to IEC 62497-1
Partial discharge RMS test voltage (q_m < 10 pC)	U_t	V	1650	According to 61800-5-1
Case material	-	-	V0	According to UL 94
Comparative tracking index	CTI		600	

Between primary and secondary

Maximum RMS insulation voltage [1]			1000 600 300	CAT I & II CAT III CAT IV
Clearance	d_{Cl}	mm	9.0	Shortest distance through air
Creepage distance	d_{Cp}	mm	9.0	Shortest path along device body
Application example RMS voltage line-to-neutral		V	600	Basic insulation according to IEC 61010-1 CAT III, PD2
Application example RMS voltage line-to-neutral		V	300	Reinforced insulation according to IEC 61010-1 CAT III, PD2
Application example System voltage RMS		V	600	Basic insulation according to IEC 61800-5-1, IEC 62109-1 CAT III, PD2
Application example System voltage RMS		V	600	Reinforced insulation according to IEC 61800-5-1, IEC 62109-1 CAT III, PD2
Application example Rated insulation RMS voltage	U_{Nm}	V	600	Basic insulation according to IEC 62497-1 CAT III, PD2
Application example Rated insulation RMS voltage	U_{Nm}	V	500	Reinforced insulation according to IEC 62497-1 CAT III, PD2
Operating voltage		V	1000	Insulation according to UL 508 CAT II, PD2

Note:
[1] Electronic board limitation

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Electrical data

At $T_A = T_{A\,min} \dots T_{A\,max}$, U_C = + 5 V, R_L > 1 MΩ, unless otherwise noted (see Min, Max, typ, definition paragraph in page 6).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal DC voltage (continuous)	$U_{P\,N\,DC}$	V		1000		
Primary nominal AC RMS voltage (continuous)	$U_{P\,N\,AC}$	V		1000		f ≤ 100 Hz
Primary voltage, measuring range	$U_{P\,M}$	V	-1500		1500	
Load resistance	R_L	Ω	2000			
Load capacitance	C_L	nF			1	
Secondary nominal RMS voltage	$U_{S\,N}$	V		3.833		
Secondary voltage	U_S	V	0.5		4.5	Full primary voltage range
DC supply voltage ⎓ [1]	U_C	V	4.75	5	5.25	
DC current consumption ⎓	I_C	mA		29		U_C = +5 V, U_P = 0 V@ 25 °C
Reference voltage [2]	U_{ref}	V	2.492	2.500	2.508	@ 25 °C
Power consumption U_P= 0 V @ U_C	P_C	W		0.15		
Temperature variation of U_{ref} [2]	$U_{ref\,T}$	mV	-4		4	
Rise time of U_C (10 % ... 90 %)	t_{rise}	ms			100	
Total error	ε_{tot}	%	-1.5		1.5	
Total error	ε_{tot}	%	-1		1	@ 25 °C, 100 % tested in prod.
Temperature variation of U_O referred to primary	$U_{O\,T}$	V	-3.00		3.00	referred to 25 °C
Electrical offset voltage referred to primary	$U_{O\,E}$	V	-6.00		6.00	@ 25 °C, 100 % tested in prod.
Sensitivity	S	mV/V		1.333		
Sensitivity error	ε_S	%	-0.8		0.8	@ 25 °C
Temperature variation of sensitivity error	$\varepsilon_{S\,T}$	%	-0.4		0.4	referred to 25 °C
Linearity error	ε_L	% of $U_{P\,N}$	-0.2		0.2	@ 25 °C, ±1500 V range
RMS noise voltage 100 Hz … 100 kHz referred to primary	U_{no}	mV		450		
Delay time to 10 % of the final output value for $U_{P\,N}$ step	$t_{D\,10}$	µs		1		
Delay time to 90 % of the final output value for $U_{P\,N}$ step	$t_{D\,90}$	µs		8		
Frequency bandwidth (−3 dB) (−1 dB)	BW	kHz		44 22		
Start-up time	t_{start}	ms		1		
Resistance of primary circuit	R_P	MΩ		12.6		
Total primary power loss @ $U_{P\,N}$	P_P	W		0.08		
Reference output current [2]	$I_{ref\,out}$	µA			300	sourced
Reference input current [2]	$I_{ref\,in}$	µA			100	sinked

Note(s):

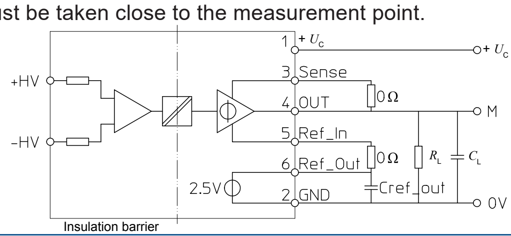
[1] Interruption voltage supply class: S1 (EN 50155: 2017)

[2] It is recommended to short-circuit externally Ref_Out with Ref_In. However, if an external precise reference is needed, that one has to be connected to Ref_In (external short-circuit removed). In any case, output voltage range is limited to [0.5 V, 4.5 V] with ±2 V swing output around $U_{ref\,in}$. For instance, with $U_{ref\,in}$ = 2 V, the product can measure from only −1125 V (output = 0.5 V) to +1500 V (output = 4 V).

Remark(s):

Decoupling capacitors may be added (not mandatory) on OUT, Ref_Out and + U_C pins, but may modifiy dynamic behavior.
External 0 Ω shunt between Sense and OUT pins always present. If the line to the measurement point is too long, a significant voltage difference along may appear. So in such case the "sense" information must be taken close to the measurement point.

External 0 Ω shunt between Ref_Out and Ref_In pins connected only if internal 2.5 V reference used.



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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.

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Typical performance characteristics

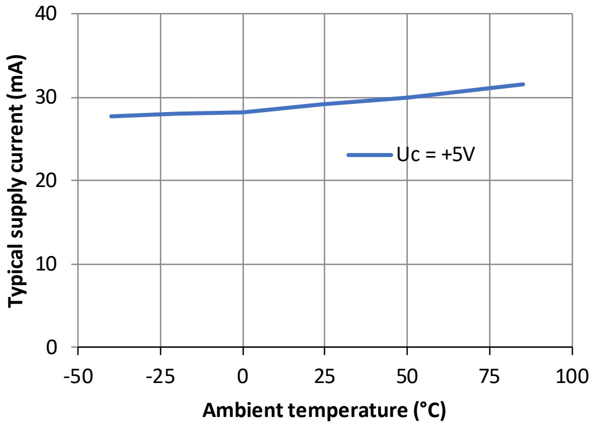

Figure 1: Supply current function of temperature

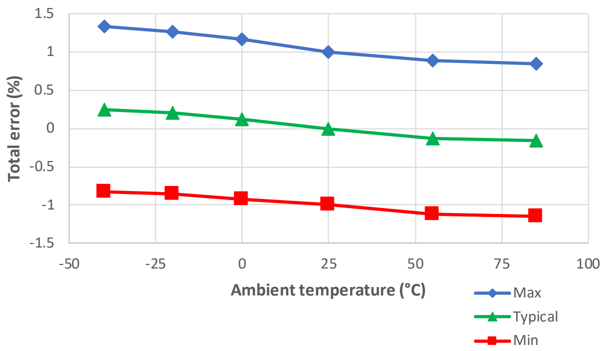

Figure 2: Total error in temperature

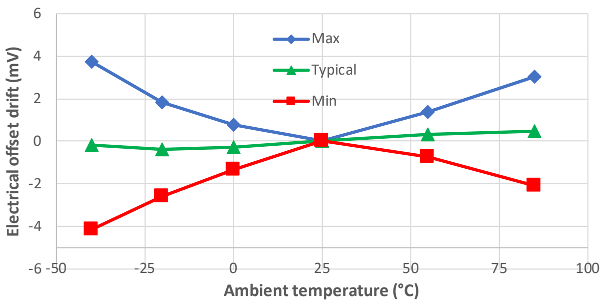

Figure 3: Electrical offset thermal drift

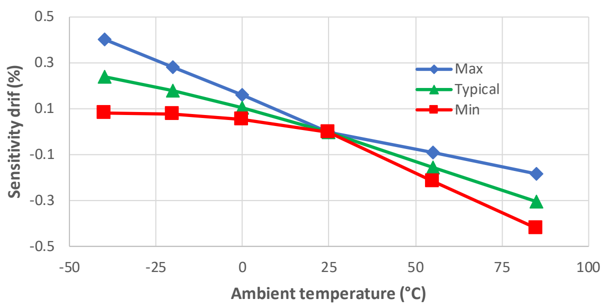

Figure 4: Sensitivity thermal drift

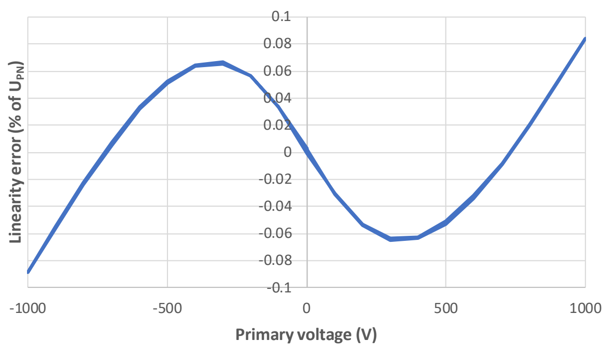

Figure 5: Typical linearity error at 25 °C

LEM reserves the right to carry out modifications on its transducers, in order to improve them, without prior notice

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Typical performance characteristics

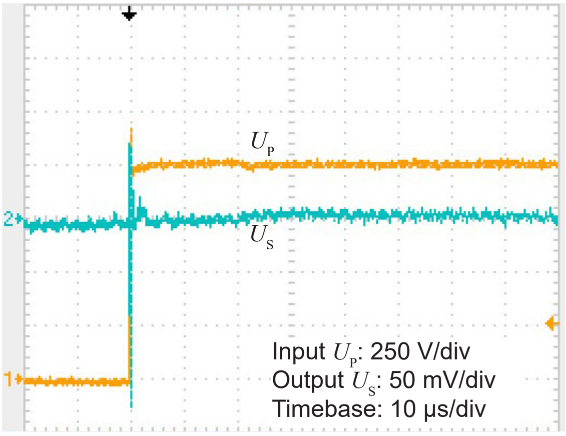

Figure 6: Detail of typical common mode perturbation (1000 V step with 6 kV/µs, R_M = 2 kΩ)

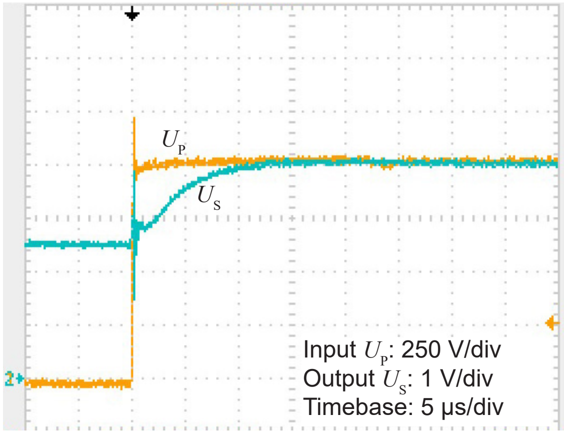

Figure 7: Typical step response (0 to 1000 V)

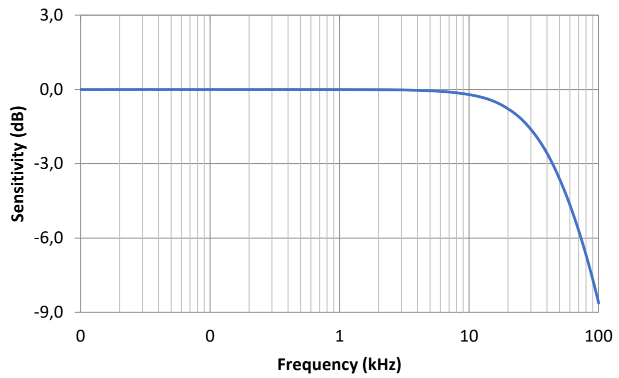

Figure 8: Gain function of frequency

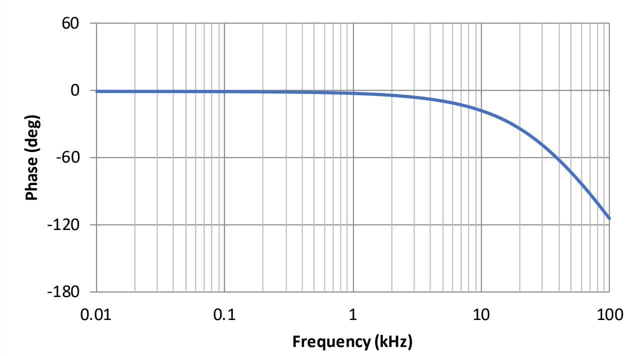

Figure 9: Phase shift function of frequency

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Typical performance characteristics

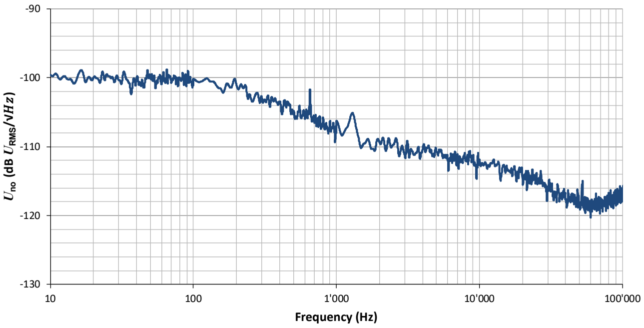

Figure 10: Typical output noise voltage spectral density U_{no} referred to secondary with R_M = 2 kΩ

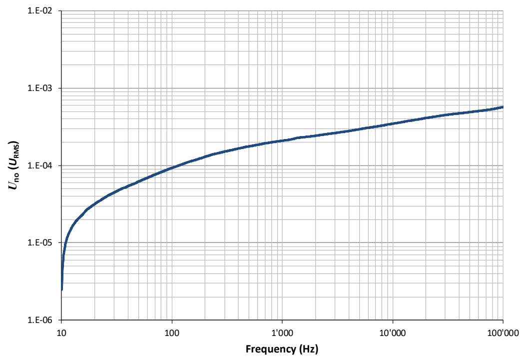

Figure 11: Typical total output RMS noise voltage U_{no} referred to secondary with R_M = 2 kΩ

Figure 10 shows that there are no significant discrete frequencies in the output.
Figure 11 confirms the absence of steps in the total output RMS noise current that would indicate discrete frequencies.
To calculate the total output RMS noise in a frequency band $f1$ to $f2$, the formula is:

$$U_{no}(f_1 \text{ to } f_2) = \sqrt{U_{no}(f_2)^2 - U_{no}(f_1)^2}$$

with U_{no}(f) read from figure 11 (typical, RMS value).

Example:
What is the total output RMS noise from 100 to 1 kHz?
Figure 11 gives U_{no}(100 Hz) = 100 µV and U_{no}(1 kHz) = 200 µV.
Therefore, the total output RMS noise current is 173 µV.

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Terms and definitions

Simplified transducer model

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

$U_S = S \cdot U_P \cdot (1 + \varepsilon)$

In which (referred to primary):

$\varepsilon \cdot U_P = U_{OE} + U_{OT} + \varepsilon_S \cdot U_P + \varepsilon_{ST} \cdot U_P + \varepsilon_L(U_{P\,max}) \cdot U_{P\,max}$

U_P	: primary voltage (V)
$U_{P\,max}$	: maximum primary voltage applied to the transducer (V)
U_S	: secondary voltage (V)
S	: sensitivity of the transducer
TCS	: temperature coefficient of S
T_A	: ambient operating temperature (°C)
U_{OE}	: electrical offset voltage (V)
U_{OT}	: temperature variation of U_{OE} (V)
ε_S	: sensitivity error at 25 °C
ε_{ST}	: thermal drift of S
$\varepsilon_L(U_{P\,max})$	: linearity error for $U_{P\,max}$

This model is valid for primary voltage U_P between $-U_P$ max and $+U_P$ 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 $\pm U_{PN}$, relative to the rated value U_{PN}.

It includes all errors mentioned above

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

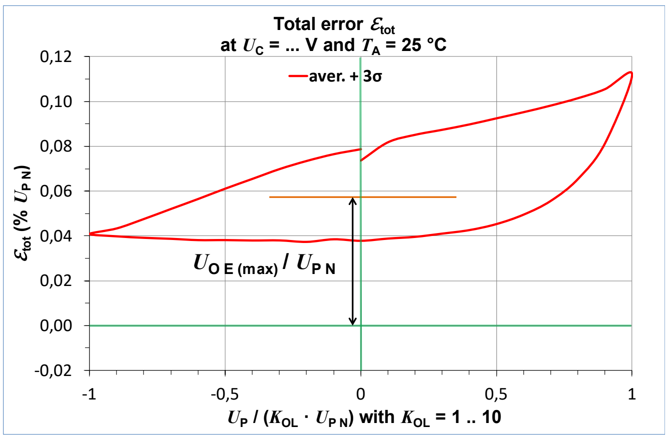
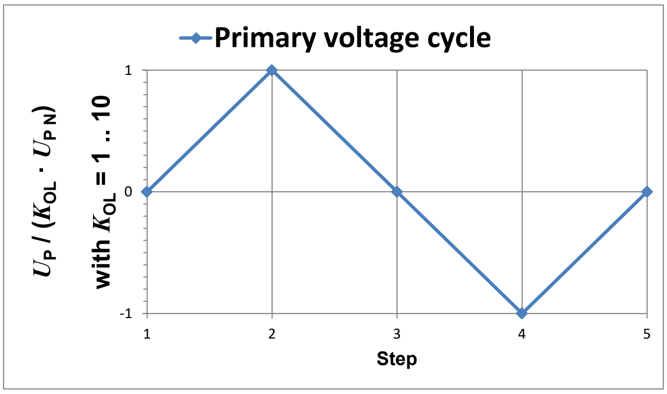


Figure 12: Total error ε_{tot}

Electrical offset referred to primary



K_{OL}: Overload factor

Figure 13: voltage cycle used to measure the electrical offset (transducer supplied)

Using the voltage cycle shown in previous figure, the electrical offset voltage U_{OE} is the residual output referred to primary when the input voltage is zero.

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

The temperature variation U_{OT} of the electrical offset voltage U_{OE} is the variation of the electrical offset from 25 °C to the considered temperature.

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

Sensitivity and linearity

To measure sensitivity and linearity, the primary voltage (DC) is cycled from 0 to U_P, then to $-U_P$ and back to 0 (equally spaced U_P/10 steps). The sensitivity S is defined as the slope of the linear regression line for a cycle between $\pm U_{PN}$.

The linearity error ε_L is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of U_{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 voltage dv/dt.

They are measured at nominal voltage.

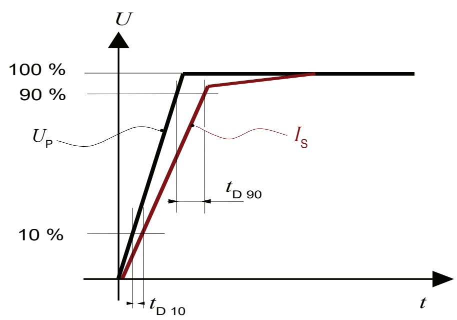


Figure 14: delay time $t_{D\,10}$ @ 10 % and delay time $t_{D\,90}$ @ 90 %.

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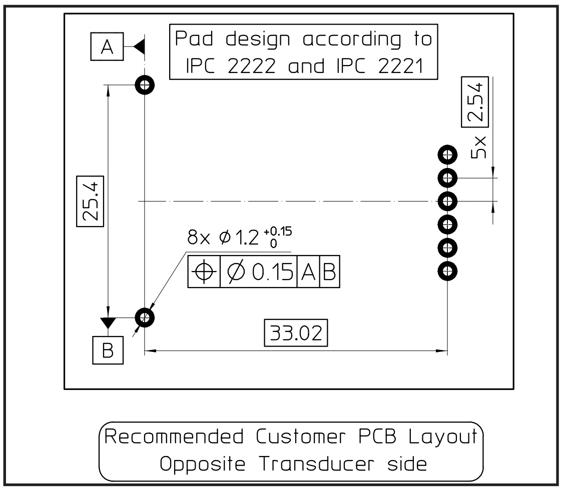
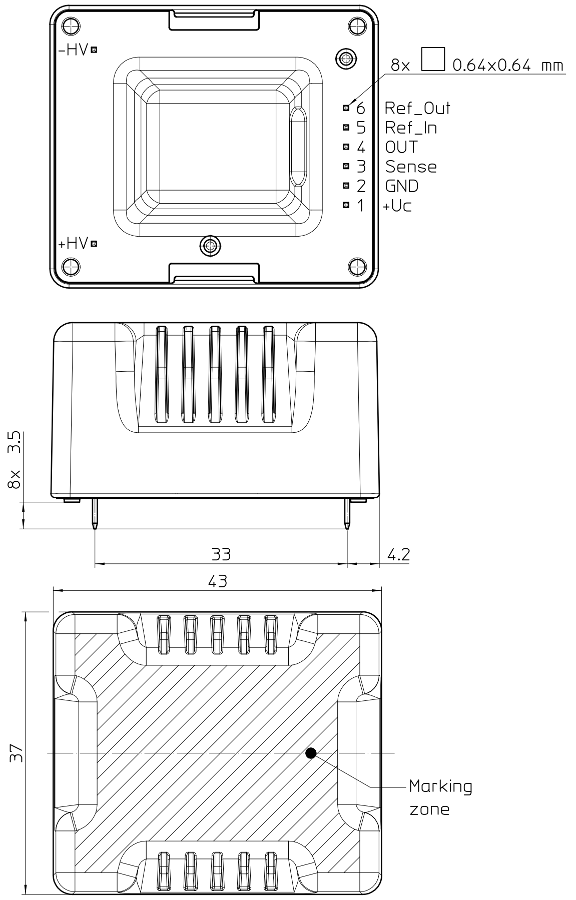
PCB footprint according to the product

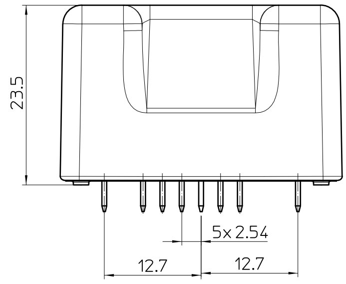


Assembly on PCB

- Recommended PCB hole diameter 1.2 mm for primary pin
  1.2 mm for secondary pin
- Maximum PCB thickness 2.4 mm
- Not suitable for reflow soldering process but others allowed
- Not suitable for washing process
- $Cu(Sn)_6$ pins with 1 to 2 µm copper finition and 4 to 6 µm pure tin finition

Dimensions (in mm)

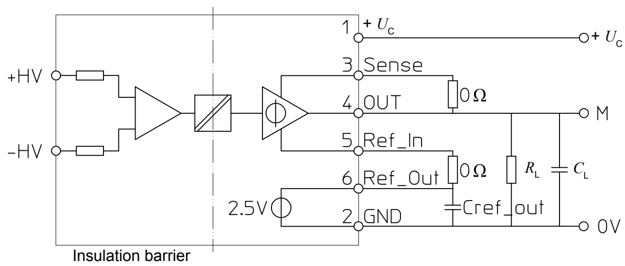




	dCl (mm)	dCp (mm)
A-B	9.0	9.0

Critical distances between Primary and Secondary are internal to embedded electronics (see page 4)

Connection



Mechanical characteristics

- General tolerance ±0.5 mm
- Transducer fastening 8 holes ∅ 0.64 mm
- Maximum pushing force on the pins 30 N

Remarks

- The transducer is directly connected to the primary voltage
- Installation of the transducer is to be done with out primary or secondary voltage present
- 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: https://www.lem.com/en/file/3137/download/

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