

# Voltage Transducer DVC 1000-P

$$U_{PN} = 1000 \text{ V}$$

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).

## 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 accordance 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/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

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

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	$T_s$	°C	-50		90	
Relative humidity	$RH$	%			95	Non condensing
Mass	$m$	g		22		
Ingress protection rating				IP20		IEC 60529 (Indoor use)
Altitude		m			2000 <sup>1)</sup>	
Pollution degree					PD3 <sup>2)</sup>	

#### Notes:

- <sup>1)</sup> Insulation coordination at 2000 m
- <sup>2)</sup> 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 $\mu$ s	$U_{Ni}$	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 <sup>1)</sup>			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:**

<sup>1)</sup> Electronic board limitation

**Electrical data**

At  $T_A = T_{Amin} \dots T_{Amax}$ ,  $U_C = +5\text{ V}$ ,  $R_L > 1\text{ M}\Omega$ , unless otherwise noted (see Min, Max, typ, definition paragraph in page 6).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal DC voltage (continuous)	$U_{PNDC}$	V		1000		
Primary nominal AC RMS voltage (continuous)	$U_{PNAC}$	V		1000		$f \leq 100\text{ Hz}$
Primary voltage, measuring range	$U_{PM}$	V	-1500		1500	
Load resistance	$R_L$	$\Omega$	2000			
Load capacitance	$C_L$	nF			1	
Secondary nominal RMS voltage	$U_{SN}$	V		3.833		
Secondary voltage	$U_S$	V	0.5		4.5	Full primary voltage range
DC supply voltage <sup>= 1)</sup>	$U_C$	V	4.75	5	5.25	
DC current consumption <sup>=</sup>	$I_C$	mA		29		$U_C = +5\text{ V}$ , $U_p = 0\text{ V}$ @ $25\text{ }^\circ\text{C}$
Reference voltage <sup>2)</sup>	$U_{ref}$	V	2.492	2.500	2.508	@ $25\text{ }^\circ\text{C}$
Power consumption $U_p = 0\text{ V}$ @ $U_C$	$P_C$	W		0.15		
Temperature variation of $U_{ref}$ <sup>2)</sup>	$U_{refT}$	mV	-4		4	
Rise time of $U_C$ (10 % ... 90 %)	$t_{rise}$	ms			100	
Total error	$\epsilon_{tot}$	%	-1.5		1.5	
Total error	$\epsilon_{tot}$	%	-1		1	@ $25\text{ }^\circ\text{C}$ , 100 % tested in prod.
Temperature variation of $U_o$ referred to primary	$U_{OT}$	V	-3.00		3.00	referred to $25\text{ }^\circ\text{C}$
Electrical offset voltage referred to primary	$U_{OE}$	V	-6.00		6.00	@ $25\text{ }^\circ\text{C}$ , 100 % tested in prod.
Sensitivity	$S$	mV/V		1.333		
Sensitivity error	$\epsilon_s$	%	-0.8		0.8	@ $25\text{ }^\circ\text{C}$
Temperature variation of sensitivity error	$\epsilon_{sT}$	%	-0.4		0.4	referred to $25\text{ }^\circ\text{C}$
Linearity error	$\epsilon_L$	% of $U_{PN}$	-0.2		0.2	@ $25\text{ }^\circ\text{C}$ , $\pm 1500\text{ V}$ range
RMS noise voltage 100 Hz ... 100 kHz referred to primary	$U_{no}$	mV		450		
Delay time @ 10 % of $U_{PN}$	$t_{D10}$	$\mu\text{s}$		1		
Delay time @ 90 % of $U_{PN}$	$t_{D90}$	$\mu\text{s}$		8		
Frequency bandwidth (-3 dB) (-1 dB)	$BW$	kHz		44 22		
Start-up time	$t_{start}$	ms		1		
Resistance of primary circuit	$R_p$	M $\Omega$		12.6		
Total primary power loss @ $U_{PN}$	$P_p$	W		0.08		
Reference output current <sup>2)</sup>	$I_{refout}$	$\mu\text{A}$			300	sourced
Reference input current <sup>2)</sup>	$I_{refin}$	$\mu\text{A}$			100	sinked

**Note(s):**

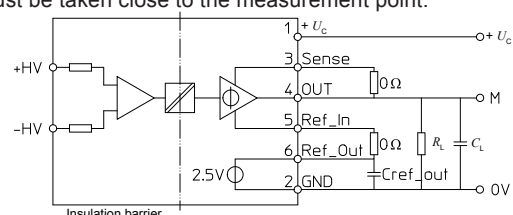
<sup>1)</sup> Interruption voltage supply class: S1 (EN 50155: 2017)

<sup>2)</sup> 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  $\pm 2\text{ V}$  swing output around  $U_{refin}$ . For instance, with  $U_{refin} = 2\text{ V}$ , the product can measure from only  $-1125\text{ V}$  (output = 0.5 V) to  $+1500\text{ V}$  (output = 4 V).

**Remark(s):**

Decoupling capacitors may be added (not mandatory) on OUT, Ref\_Out and  $+U_C$  pins, but may modify dynamic behavior. External  $0\text{ }\Omega$  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  $0\text{ }\Omega$  shunt between Ref\_Out and Ref\_In pins connected only if internal 2.5 V reference used.



## 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  $-\text{sigma}$  and  $+\text{sigma}$  for a normal distribution.

Typical, maximal and minimal values are determined during the initial characterization of the product.

Typical performance characteristics

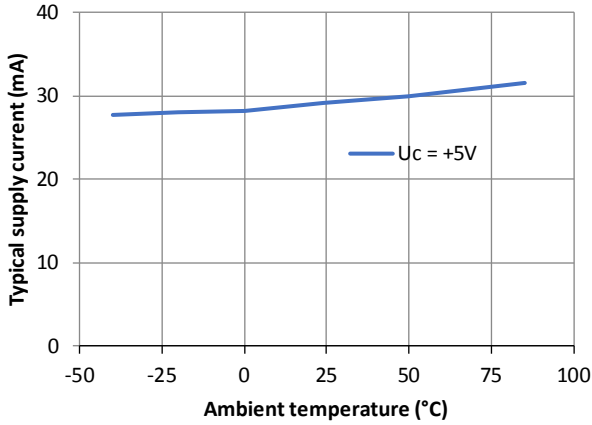


Figure 1: Supply current function of temperature

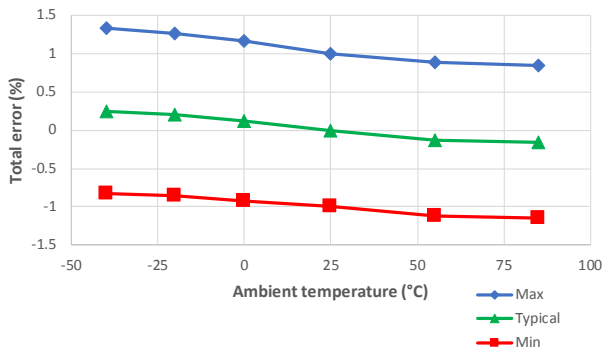


Figure 2: Total error in temperature

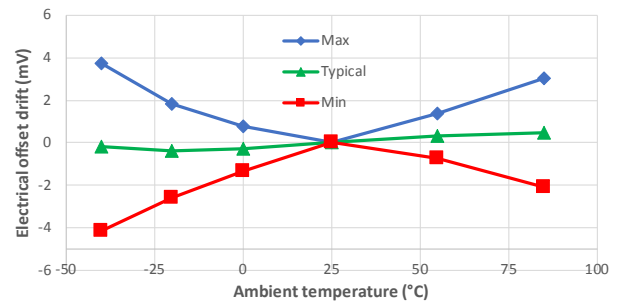


Figure 3: Electrical offset thermal drift

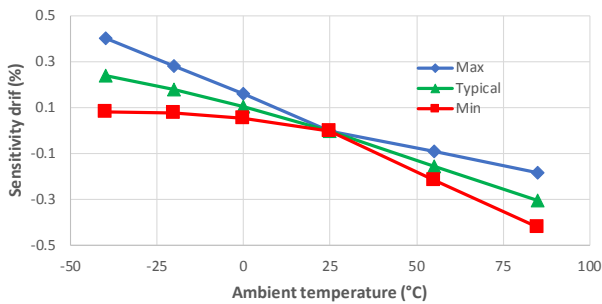


Figure 4: Sensitivity thermal drift

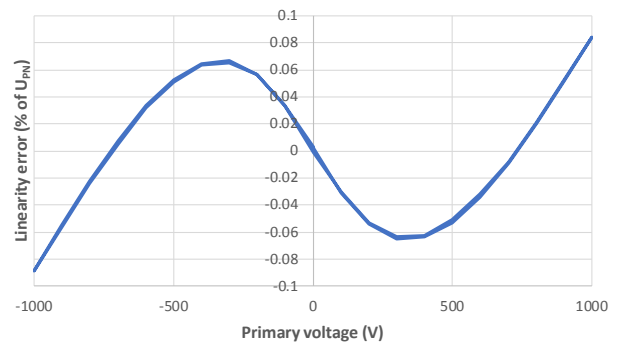


Figure 5: Typical linearity error at 25 °C

Typical performance characteristics

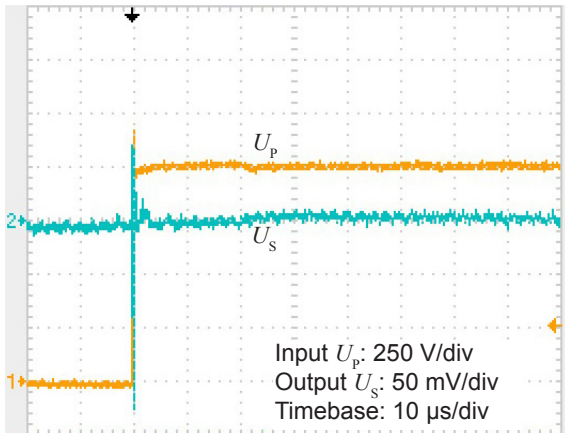


Figure 6: Detail of typical common mode perturbation (1000 V step with 6 kV/μs,  $R_M = 2 \text{ k}\Omega$ )

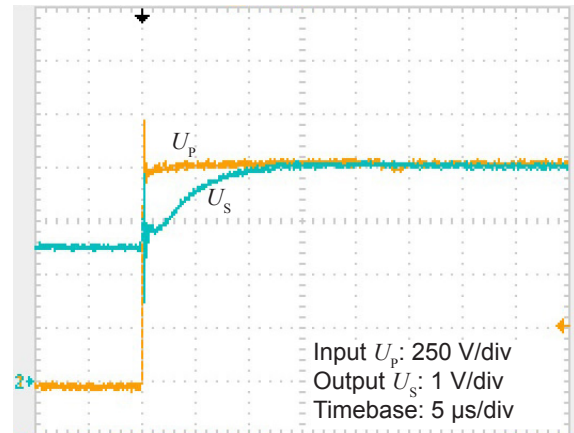


Figure 7: Typical step response (0 to 1000 V)

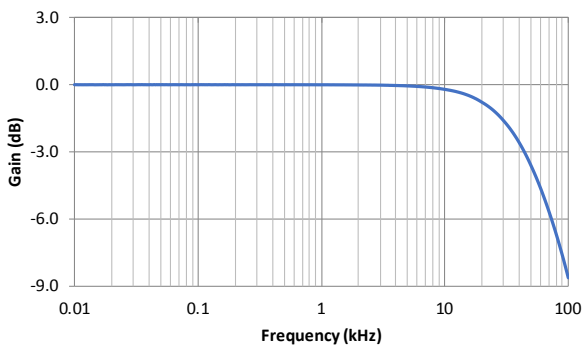


Figure 8: Gain function of frequency

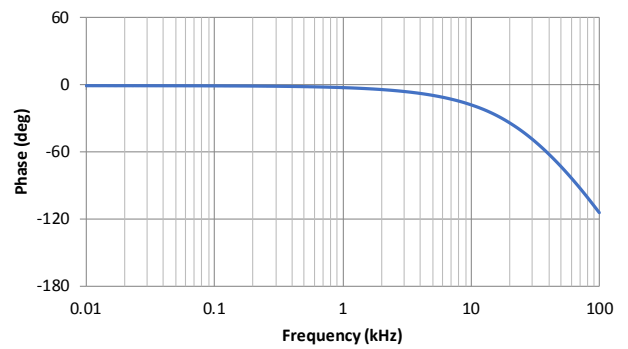


Figure 9: Phase shift function of frequency



Typical performance characteristics

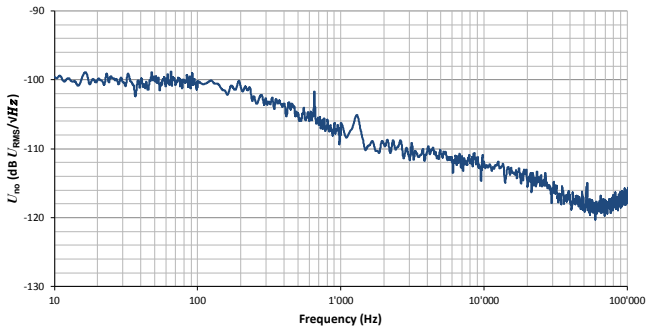


Figure 10: Typical output noise voltage spectral density  $U_{no}$  referred to secondary with  $R_M = 2 \text{ k}\Omega$

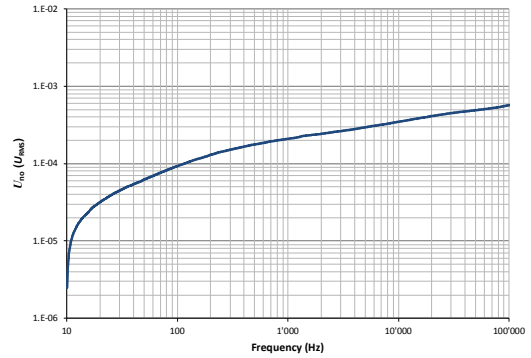


Figure 11: Typical total output RMS noise voltage  $U_{no}$  referred to secondary with  $R_M = 2 \text{ k}\Omega$

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  $f_1$  to  $f_2$ , 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  $U_{no}(100 \text{ Hz}) = 100 \text{ }\mu\text{V}$  and  $U_{no}(1 \text{ kHz}) = 200 \text{ }\mu\text{V}$ . Therefore, the total output RMS noise current is  $173 \text{ }\mu\text{V}$ .

## 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):

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

- $U_P$  : primary voltage (V)
- $U_{Pmax}$  : 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)
- $\varepsilon_S$  : sensitivity error at 25 °C
- $\varepsilon_{ST}$  : thermal drift of  $S$
- $\varepsilon_L(U_{Pmax})$  : linearity error for  $U_{Pmax}$

This model is valid for primary voltage  $U_P$  between  $-U_{Pmax}$  and  $+U_{Pmax}$  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  $\varepsilon_{tot}$  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  $\varepsilon_S$
- the linearity error  $\varepsilon_L$  (to  $U_{PN}$ ).

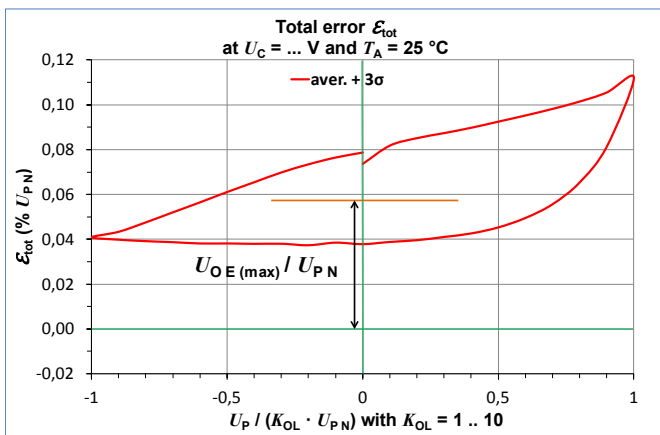
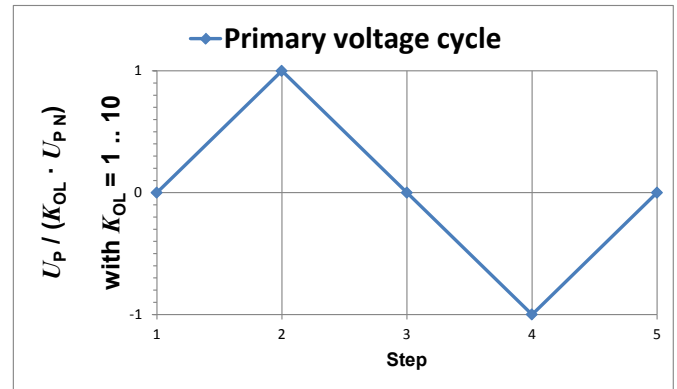


Figure 12: Total error  $\varepsilon_{tot}$

### 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.

$$U_{OT}(T) = U_{OE}(T) - U_{OE}(25^\circ\text{C})$$

### 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  $\varepsilon_L$  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  $t_{D10}$  @ 10 % and the delay time  $t_{D90}$  @ 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.

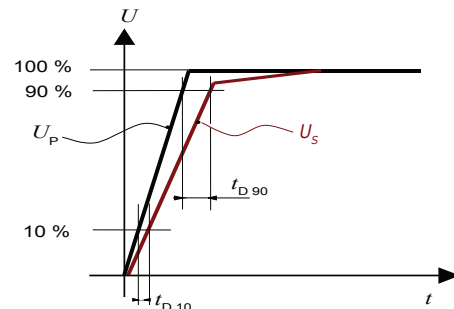
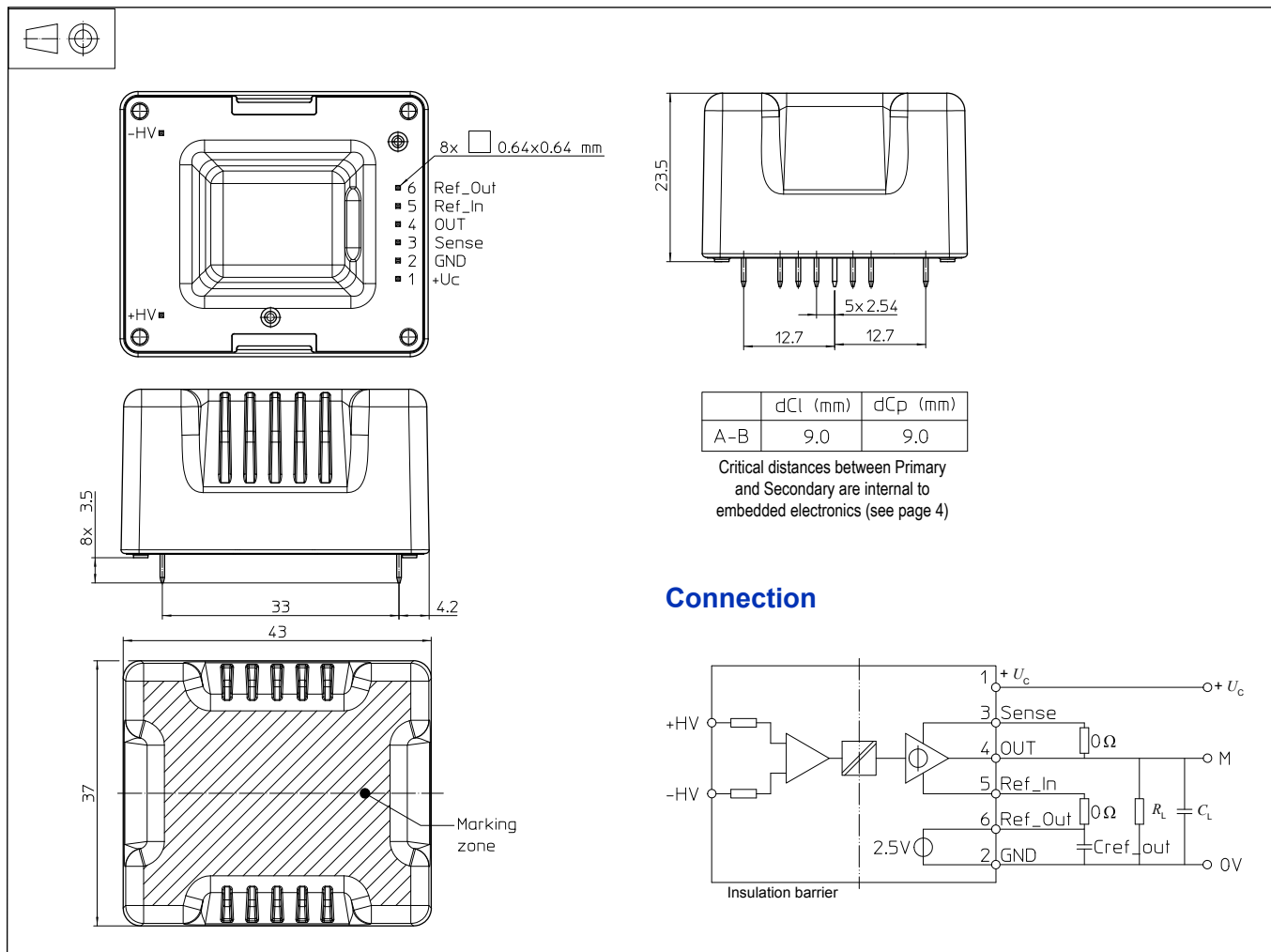


Figure 14: delay time  $t_{D10}$  @ 10 % and delay time  $t_{D90}$  @ 90 %.



**Dimensions (in mm)**



**Mechanical characteristics**

- General tolerance  $\pm 0.5$  mm
- Transducer fastening 8 holes  $\varnothing 0.64$  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/>