Voltage transducer DVM 4000-DT/SP1
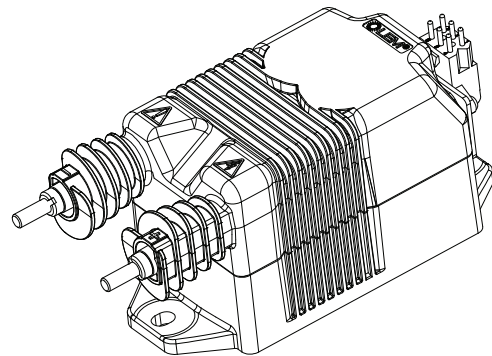
V_{PN} = 4000 V

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

Features

- Unipolar and insulated measurement up to 6000 V
- Unipolar supply voltage
- Voltage output
- Input connections with M5 studs
- Voltage threshold output
- SMS6GE6 Burndy connector is used for secondary connection.

Special feature

- Customer marking: DTR 0000440784.

Advantages

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

Applications

- Single or three phase inverters
- Propulsion and braking choppers
- Propulsion converters
- Auxiliary converters
- High power drives
- Substations.

Standards

- EN 50155: 2007
- EN 50121-3-2: 2015
- EN 50124-1: 2001
- IEC 61010-1: 2010
- IEC 61800-1: 1997
- IEC 61800-2: 2015
- IEC 61800-3: 2004
- IEC 61800-5-1: 2007
- IEC 62109-1: 2010
- UL 347 [1]: 2016
    [1] When used with UL 347 Isolator N° 92.24.06.420.0.

Application Domain

- Traction (trackside and onboard)
- Industrial.

N° 97.Q2.74.001.0

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Absolute maximum ratings

Parameter	Symbol	Value
Maximum supply voltage (V_P = 0 V, 0.1 s)	$U_{C\,max}$	34.6
Maximum supply voltage (working) (−40 … 85 °C)	$U_{C\,max}$	30
Maximum primary voltage (−40 … 85 °C)	$V_{P\,max}$	6000
Maximum steady state primary voltage (−40 … 85 °C)	$V_{P\,N\,max}$	4000

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.

UL 347: Ratings and assumptions of certification

File # E315896 Volume: 1 Section: 3

Standards

- CSA C22.2 No. 253 Medium-Voltage AC Contactors, Controllers, and Control Centers
- UL 347 Standards for Safety for Medium-Voltage AC Contactors, Controllers, and Control Centers.

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 - The terminals have not been evaluated for field wiring.
3 - The rated Basic Insulation Level (BIL) is 20 kV for this device, after performing Impulse Withstand Tests. Additional testing will be required if a higher BIL rating is desired.
4 - For products rated more than 2500 V, the specific kit model "UL 347 isolator" shall be mounted to the DVM.
5 - The products have been evaluated for a maximum surrounding air temperature of 85 °C..
6 - 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.
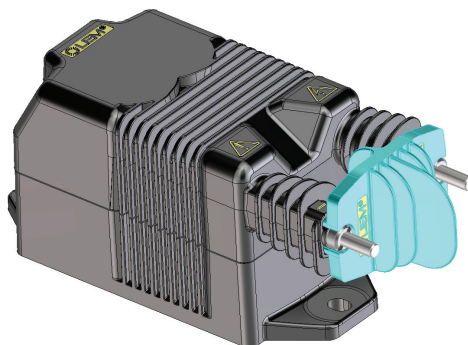
Assembly of UL 347 Isolator on primary studs.

UL 347 Isolator, reference number 92.24.06.420.0, to be ordered separately.

Insulation coordination

Parameter	Symbol	Unit	Value	Comment
RMS voltage for AC insulation test, 50 Hz, 1 min	U_d	kV	12	100 % tested in production
Impulse withstand voltage 1.2/50 µs	$\hat{U}_W$	kV	30	
Partial discharge extinction RMS voltage @ 10 pC	U_e	V	5000	
Insulation resistance	R_{INS}	MΩ	200	
Clearance (pri. - sec.)	d_{Cl}	mm	See dimensions drawing on page 10	Shortest distance through air
Creepage distance (pri. - sec.)	d_{Cp}	mm		Shortest path along device body
Case material	-	-	V0	According to UL 94
Comparative tracking index	CTI	V	600	
Maximum DC common mode voltage	$V_{HV+} + V_{HV-}$ and $|V_{HV+} - V_{HV-}|$	kV	≤ 6.3 $\leq V_{PM}$	

Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max
Ambient operating temperature	T_A	°C	−40		70
Ambient storage temperature	T_S	°C	−50		90
Mass	m	g		375	

Electrical threshold detection data

At T_A = 25 °C, $+U_C$ = +24 V, R_M = 2 kΩ, unless otherwise noted.
Lines with a * in the conditions column apply over the −40 … 70 °C ambient temperature range.

Parameter	Symbol	Unit	Min	Typ	Max	Conditions
Primary high threshold voltage	$U_{P\,H\,Th}$	V		500		±10 %
Primary low threshold voltage	$U_{P\,L\,Th}$	V		400		±10 %
Maximum secondary (output) voltage when threshold detection is active	$U_{S\,Th\,max}$	V			30	
Maximum secondary (output) current when threshold detection is active	$I_{S\,Th\,max}$	mA			100	No overcurrent protection
Minimum load resistance, threshold detection output	$R_{L\,Th\,min}$	Ω	300			
Response time of threshold output for high value	$t_{r\,H\,Th}$	ms		2		0 to $V_{P\,N}$ transition
Response time of threshold output for low value	$t_{r\,L\,Th}$	ms		700		$V_{P\,N}$ to 0 transition
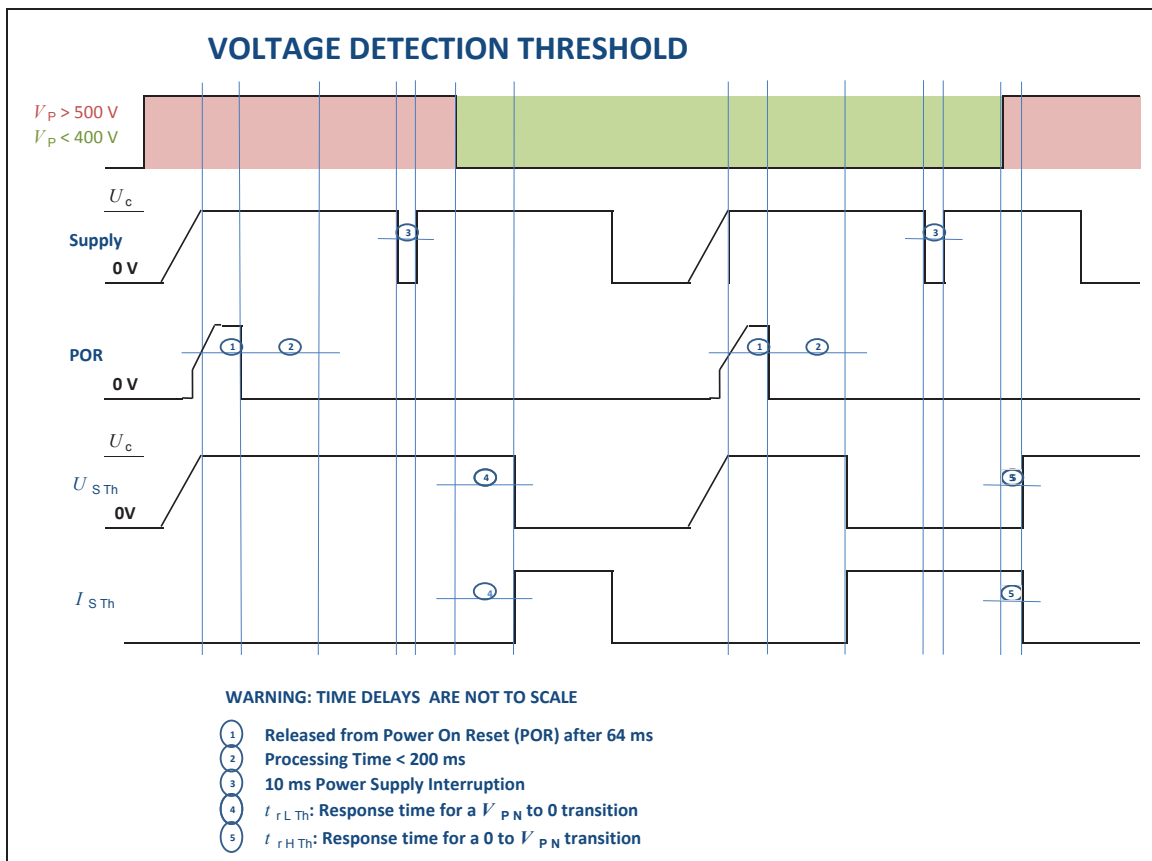
Figure 1: Voltage detection threshold timing diagram

Electrical data

At T_A = 25 °C, +U_C = +24 V, R_M = 2 kΩ, unless otherwise noted.
Lines with a * in the conditions column apply over the −40 … 70 °C ambient temperature range.

Parameter	Symbol	Unit	Min	Typ	Max		Conditions
Primary nominal RMS voltage	V_{PN}	V			4000	*	
Primary voltage, measuring range	V_{PM}	V	−6000		6000	*	
Measuring resistance	R_M	Ω	2000			*	
Secondary nominal RMS voltage	V_{SN}	V		6.66		*	
Secondary voltage	V_S	V	−10		10	*	
Supply voltage	U_C	V	16.8		30	*	
Rise time of U_C (10-90 %)	t_{rise}	ms			100		
Current consumption @ U_C = +24 V at V_P = 0 V and $I_{S\,Th}$ = 0	I_C	mA		50			
Offset voltage	V_O	mV	−7		7		100 % tested in production
Temperature variation of V_O	V_{OT}	mV	−25 −30		25 30	*	−25 … 70 °C −40 … 70 °C
Sensitivity	G	mV/V		1.66			10 V for primary 6000 V
Sensitivity error	ε_G	%	−0.3		0.3		
Thermal drift of sensitivity	ε_{GT}	%	−0.5		0.5	*	
Linearity error	ε_L	% of V_{PM}	−0.5		0.5		±6000 V range
Overall accuracy	X_G	% of V_{PN}	−0.5 −1		0.5 1	 *	25 °C; 100 % tested in production; −40 … 70 °C
Output RMS noise voltage	V_{no}	mV		2.4			10 Hz to 100 kHz
Reaction time @ 10 % of V_{PN}	t_{ra}	µs		30			
Response time @ 90 % of V_{PN}	t_r	µs		50	60		0 to 4000 V step, 6 kV/µs
Frequency bandwidth	BW	kHz		14 8			−3 dB −1 dB
Start-up time	t_{start}	ms		190	250	*	
Resistance of primary (winding)	R_P	MΩ		25.1		*	
Total primary power loss @ V_{PN}	P_P	W		0.64		*	

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.
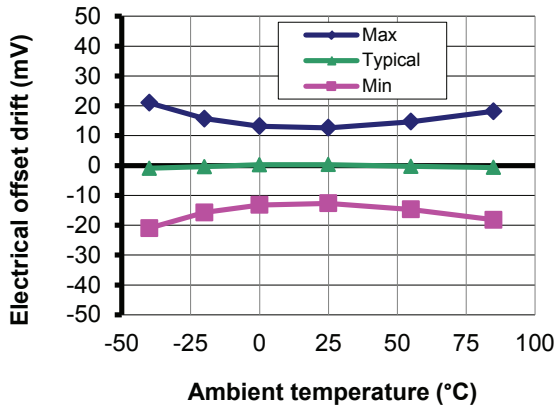
Typical performance characteristics
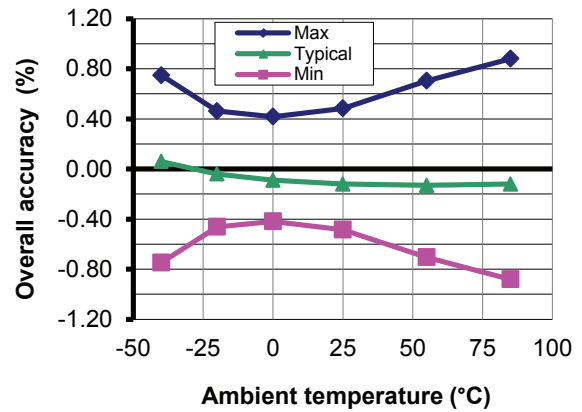

Figure 2: Electrical offset thermal drift

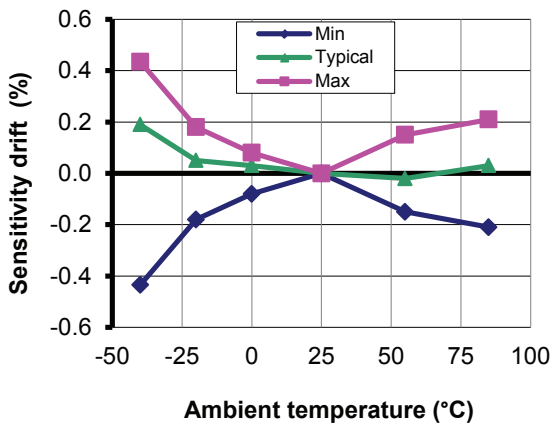Figure 3: Overall accuracy in temperature

Figure 4: Sensitivity thermal drift

Input V_P: 667.7 V/div
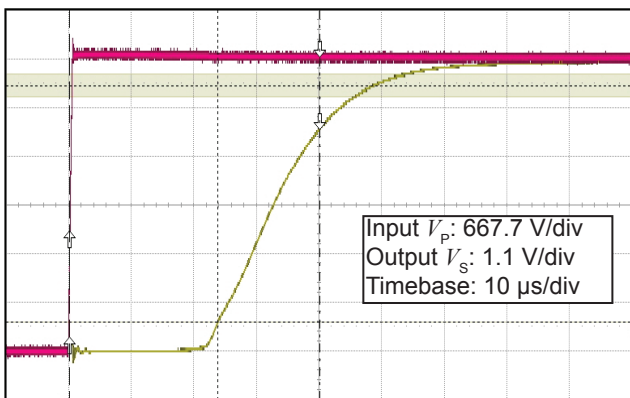Output V_S: 1.1 V/div
Timebase: 10 µs/div

Figure 5: Typical step response (0 to 4000 V)

Input V_P: 2100 V/div
Output V_S: 66.6 mV/div
Timebase: 20 µs/div
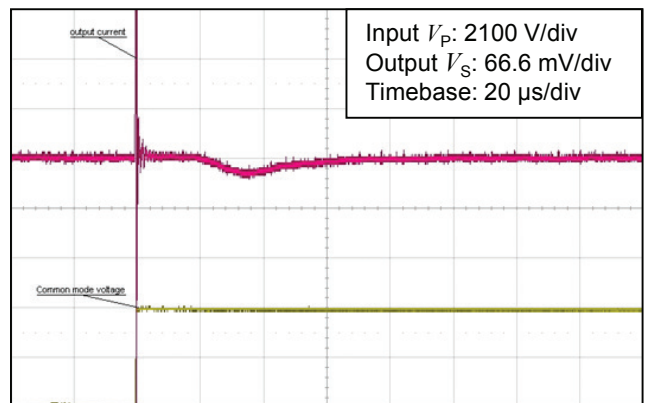
Figure 6:   Detail of typical common mode perturbation
(4200 V step with 6 kV/µs, R_M = 2 kΩ)

Typical performance characteristics continued
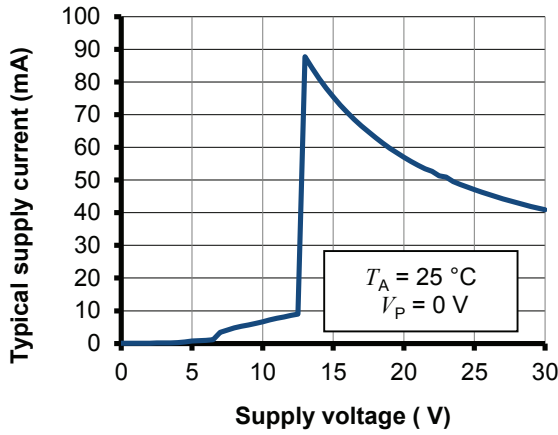
Figure 7: Supply current function of supply voltage
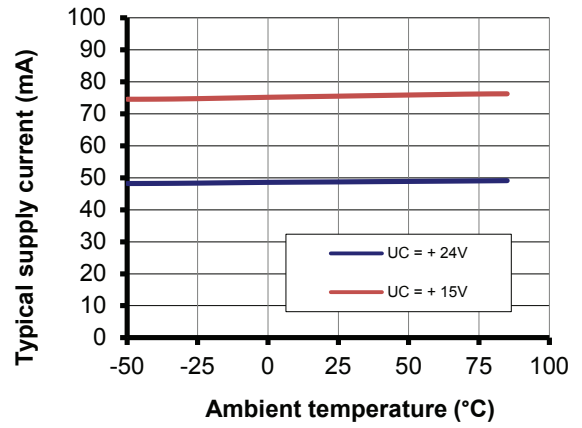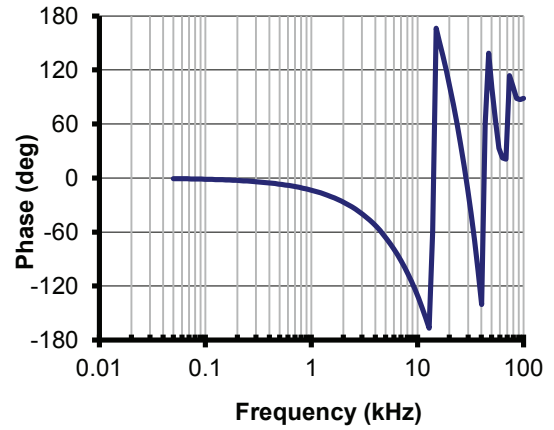

Figure 8: Supply current function of temperature
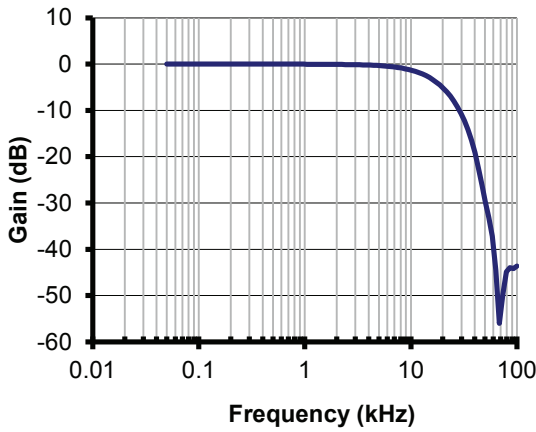

Figure 9: Typical frequency and phase response
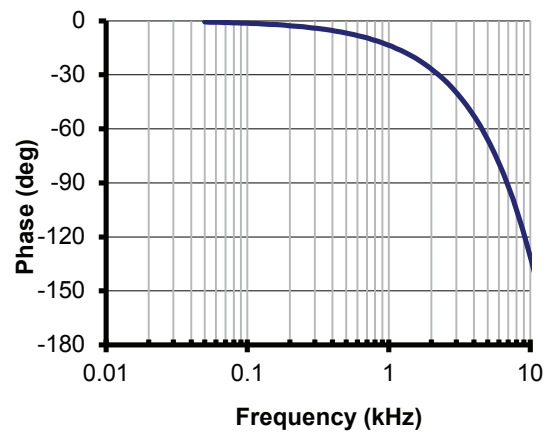
Figure 10: Typical frequency and phase response (detail)
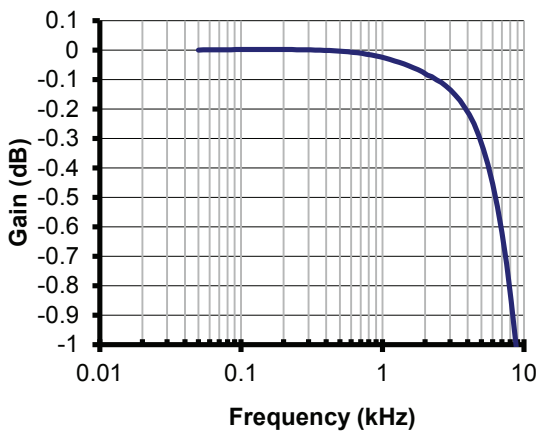
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Typical performance characteristics

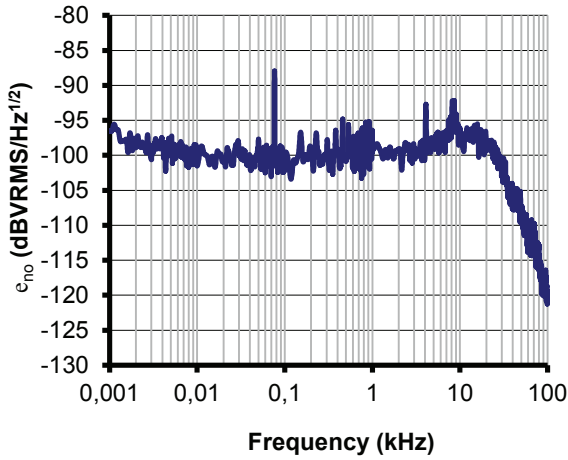
Figure 11:   Typical total output RMS noise voltage spectral density e_{no} with R_M = 2 kΩ

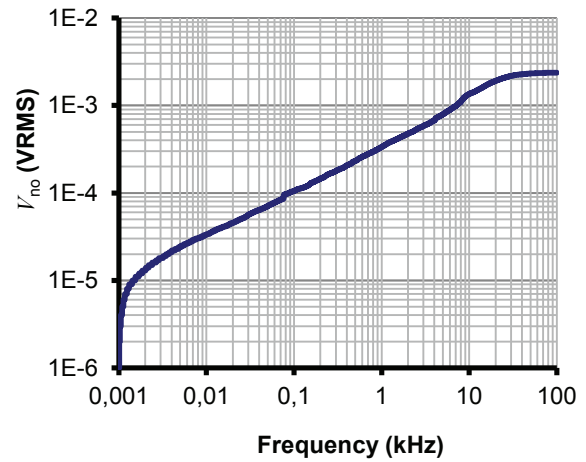
Figure 12:   Typical total output RMS noise voltage spectral density V_{no} with R_M = 2 kΩ

Figure 11 (noise voltage spectral density) shows that there are no significant discrete frequencies in the output.
Figure 12 confirms the absence of steps in the total output voltage noise that would indicate discrete frequencies.
To calculate the noise in a frequency band $f1$ to $f2$, the formula is:

$$V_{no}(f1 \text{ to } f2) = \sqrt{V_{no}(f2)^2 - V_{no}(f1)^2}$$

with $V_{no}(f)$ read from figure 12 (typical, RMS value).

Example:
What is the noise from 10 to 1 kHz?
Figure 12 gives $V_{no}(10 \text{ Hz})$ = 33 µV and $V_{no}(1 \text{ kHz})$ = 336 µV. The output RMS voltage noise is therefore.

$$\sqrt{(336 \times 10^{-6})^2 - (33 \times 10^{-6})^2} = 334 \text{ µV}$$

Performance parameters definition

The schematic used to measure all electrical parameters are:

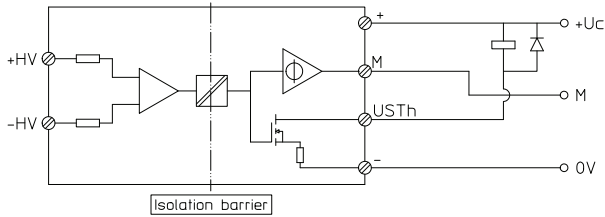Figure 13: Standard characterization schematics for voltage output transducers (R_M = 2 kΩ unless otherwise noted)

Transducer simplified model

The static model of the transducer at temperature T_A is:
$$V_S = G \cdot V_P + \varepsilon$$
In which
$$\varepsilon = I_{OE} + I_{OT}(T_A) + \varepsilon_G \cdot G \cdot V_P + \varepsilon_{GT}(T_A) \cdot G \cdot V_P + \varepsilon_L \cdot G \cdot V_{PM}$$

V_S : secondary voltage (V)
G : sensitivity of the transducer (V/V)
V_P : primary voltage (V)
V_{PM} : primary voltage, measuring range (V)
T_A : ambient operating temperature (°C)
V_{OE} : electrical offset voltage (V)
$V_{OT}(T_A)$: temperature variation of V_O at temperature T_A (V)
ε_G : sensitivity error at 25 °C
$\varepsilon_{GT}(T_A)$: thermal drift of sensitivity at temperature T_A
ε_L : linearity error

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 voltage (DC) is cycled from 0 to V_{PM}, then back to 0 (equally spaced $V_{PM}/10$ steps).
The sensitivity G is defined as the slope of the linear regression line for a cycle between V_{PM}.
The linearity error ε_L is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of the maximum measured value.

Electrical offset

The electrical offset voltage V_{OE} is the residual output voltage when the input voltage is zero.
The temperature variation V_{OT} of the electrical offset voltage V_{OE} is the variation of the electrical offset from 25 °C to the considered temperature.

Overall accuracy

The overall accuracy X_G is the error at V_{PN}, relative to the rated value V_{PN}.
It includes all errors mentioned above.

Response and reaction times

The response time t_r and the reaction time t_{ra} are shown in the next figure.
Both depend on the primary voltage dv/dt. They are measured at nominal voltage.
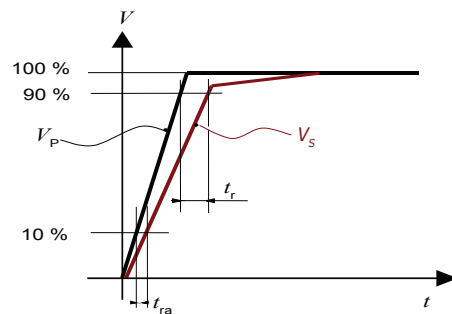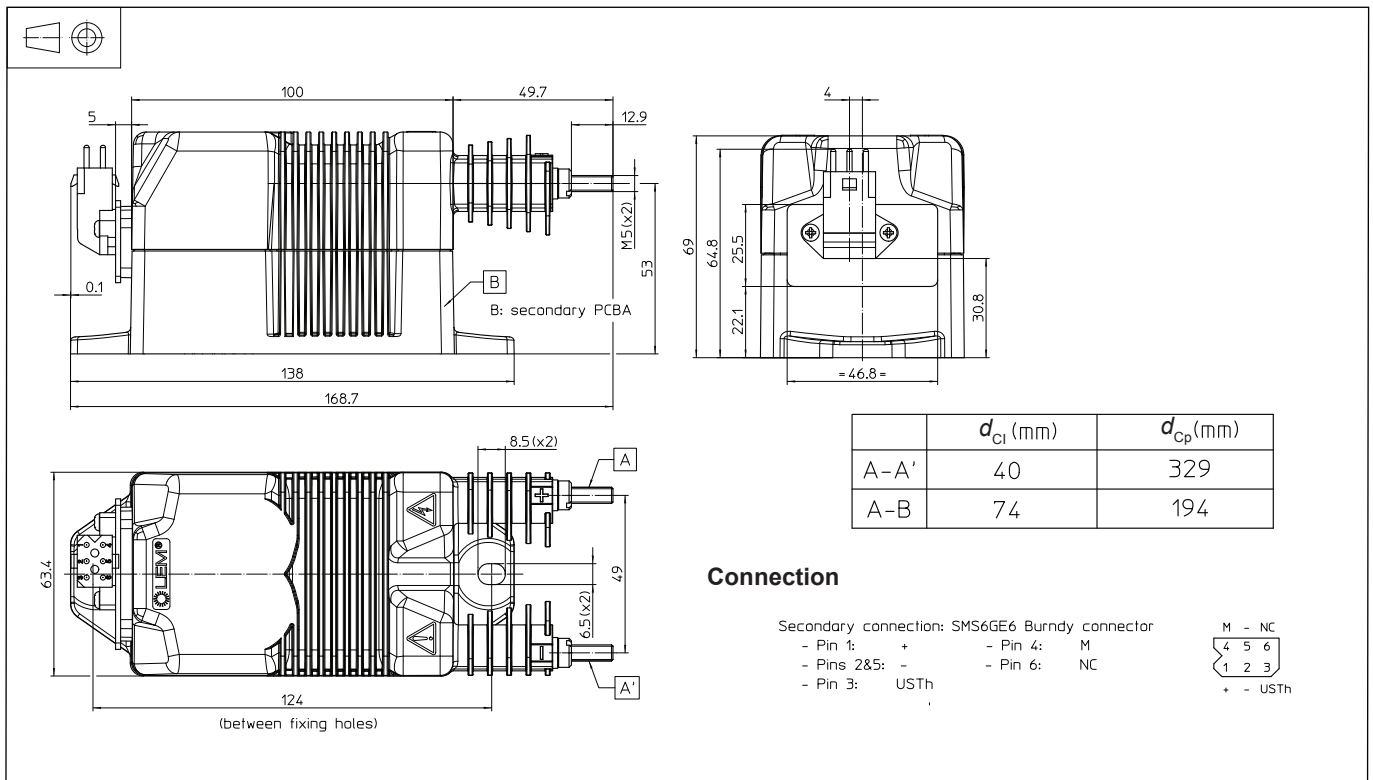

Figure 14: *response time t_r and reaction time t_{ra}*

Dimensions (in mm)

	d_{Cl} (mm)	d_{Cp} (mm)
A–A'	40	329
A–B	74	194

Connection

Secondary connection: SMS6GE6 Burndy connector
- Pin 1: +
- Pins 2&5: -
- Pin 3: USTh
- Pin 4: M
- Pin 6: NC

Mechanical characteristics

- General tolerance — ±1 mm
- Transducer fastening — 2 holes ⌀ 6.5 mm
  - 2 M6 steel screws
  - Recommended fastening torque — 5 N·m
- Connection of primary — 2 M5 threaded studs
  - Recommended fastening torque — 2.2 N·m
- Connection of secondary — SMS6GE6 Burndy

Remarks

- I_S is positive when a positive voltage is applied on +HV.
- The transducer is directly connected to the primary voltage.
- The primary cables have to be routed together all the way.
- The secondary cables also have to be routed together all the way.
- Installation of the transducer is to be done without 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: **Products/Product Documentation.**
- This is a standard model. For different versions (supply voltages, sensitivity, unidirectional measurements...), please contact us.

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 connections, 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.