Voltage transducer DVM 2000-B

\[ V_{PN} = 2000 \text{ V} \]

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 3000 V
- Voltage output
- Input connections with M5 threaded studs and output connections with M5 threaded inserts.

**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: 2017
- 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.
### Absolute maximum ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum supply voltage ($V_{P} = 0, \text{V}, 0.1, \text{s}$)</td>
<td>$\pm U_{C, \text{max}}$</td>
<td>$\pm 34$</td>
</tr>
<tr>
<td>Maximum supply voltage (working) ($-40, \ldots, 85, ^\circ, \text{C}$)</td>
<td>$\pm U_{C, \text{max}}$</td>
<td>$\pm 26.4$</td>
</tr>
<tr>
<td>Maximum primary voltage ($-40, \ldots, 85, ^\circ, \text{C}$)</td>
<td>$V_{P, \text{max}}$</td>
<td>3000</td>
</tr>
<tr>
<td>Maximum steady state primary voltage ($-40, \ldots, 85, ^\circ, \text{C}$)</td>
<td>$V_{P, \text{N, max}}$</td>
<td>2000</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS voltage for AC insulation test, 50 Hz, 1 min</td>
<td>( U_d )</td>
<td>kV</td>
<td>12</td>
<td>100 % tested in production</td>
</tr>
<tr>
<td>Impulse withstand voltage 1.2/50 µs</td>
<td>( U_w )</td>
<td>kV</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Partial discharge extinction RMS voltage @ 10 pC</td>
<td>( U_e )</td>
<td>V</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>( R_{ins} )</td>
<td>MΩ</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Clearance (pri. - sec.)</td>
<td>( d_{CI} )</td>
<td>mm</td>
<td>See dimensions drawing on page 9</td>
<td>Shortest distance through air</td>
</tr>
<tr>
<td>Creepage distance (pri. - sec.)</td>
<td>( d_{CP} )</td>
<td>mm</td>
<td>See dimensions drawing on page 9</td>
<td>Shortest path along device body</td>
</tr>
<tr>
<td>Case material</td>
<td>-</td>
<td>-</td>
<td>V0</td>
<td>According to UL 94</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>CTI</td>
<td>V</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Maximum DC common mode voltage</td>
<td>( V_{HV^+} + V_{HV^-} ) and (</td>
<td>V_{HV^+} - V_{HV^-}</td>
<td>) kV</td>
<td>( \leq 6.3 ) and ( \leq V_{PM} )</td>
</tr>
</tbody>
</table>

**Environmental and mechanical characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient operating temperature</td>
<td>( T_A )</td>
<td>°C</td>
<td>-40</td>
<td>85</td>
</tr>
<tr>
<td>Ambient storage temperature</td>
<td>( T_S )</td>
<td>°C</td>
<td>-50</td>
<td>90</td>
</tr>
<tr>
<td>Mass</td>
<td>( m )</td>
<td>g</td>
<td>375</td>
<td></td>
</tr>
</tbody>
</table>
Electrical data

At \( T_a = 25 \, ^\circ\text{C}, +U_C = \pm 24 \, \text{V}, \, R_M = 2 \, \text{k}\Omega \), unless otherwise noted.
Lines with a * in the conditions column apply over the −40 ... 85 °C ambient temperature range.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary nominal RMS voltage</td>
<td>( V_{PN} )</td>
<td>( -2000 )</td>
<td>( 2000 )</td>
</tr>
<tr>
<td>Primary voltage, measuring range</td>
<td>( U_{PM} )</td>
<td>( -3000 )</td>
<td>( 3000 )</td>
</tr>
<tr>
<td>Measuring resistance</td>
<td>( R_M )</td>
<td>( \Omega )</td>
<td>( 2000 )</td>
</tr>
<tr>
<td>Secondary nominal RMS voltage</td>
<td>( V_{SN} )</td>
<td>( )</td>
<td>( 6.66 )</td>
</tr>
<tr>
<td>Secondary voltage</td>
<td>( U_S )</td>
<td>( -10 )</td>
<td>( +10 )</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>( \pm U_C )</td>
<td>( \pm 13.5 )</td>
<td>( \pm 24 )</td>
</tr>
<tr>
<td>Rise time of ( U_C ) (10-90 %)</td>
<td>( t_{rise} )</td>
<td>ms</td>
<td>( 100 )</td>
</tr>
<tr>
<td>Current consumption at ( U_C = +24 , \text{V at} , U_P = 0 , \text{V} )</td>
<td>( I_C )</td>
<td>mA</td>
<td>27</td>
</tr>
<tr>
<td>Offset voltage</td>
<td>( V_O )</td>
<td>mV</td>
<td>7</td>
</tr>
<tr>
<td>Temperature variation of ( V_O )</td>
<td>( V_{OT} )</td>
<td>mV</td>
<td>( 25 )</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>( G )</td>
<td>mV/V</td>
<td>( 3.33 )</td>
</tr>
<tr>
<td>Sensitivity error</td>
<td>( \varepsilon_G )</td>
<td>%</td>
<td>( -0.3 )</td>
</tr>
<tr>
<td>Thermal drift of sensitivity</td>
<td>( \varepsilon_{GT} )</td>
<td>%</td>
<td>( -0.5 )</td>
</tr>
<tr>
<td>Linearity error</td>
<td>( \varepsilon_L )</td>
<td>% of ( V_{PM} )</td>
<td>( -0.5 )</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>( X_G )</td>
<td>% of ( V_{PN} )</td>
<td>( -1 )</td>
</tr>
<tr>
<td>Output RMS noise voltage</td>
<td>( V_{no} )</td>
<td>mV</td>
<td>( 2.4 )</td>
</tr>
<tr>
<td>Reaction time @ 10 % of ( V_{PN} )</td>
<td>( t_{ra} )</td>
<td>( \mu s )</td>
<td>( 30 )</td>
</tr>
<tr>
<td>Response time @ 90 % of ( V_{PN} )</td>
<td>( t_f )</td>
<td>( \mu s )</td>
<td>( 50 )</td>
</tr>
<tr>
<td>Frequency bandwidth</td>
<td>( BW )</td>
<td>kHz</td>
<td>( 14 )</td>
</tr>
<tr>
<td>Start-up time</td>
<td>( t_{start} )</td>
<td>ms</td>
<td>( 190 )</td>
</tr>
<tr>
<td>Resistance of primary (winding)</td>
<td>( R_P )</td>
<td>M\Omega</td>
<td>25.1</td>
</tr>
<tr>
<td>Total primary power loss @ ( V_{PN} )</td>
<td>( P_P )</td>
<td>W</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**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 1: Electrical offset thermal drift**

**Figure 2: Overall accuracy in temperature**

**Figure 3: Sensitivity thermal drift**

**Figure 4: Typical step response (0 to 2000 V)**

**Figure 5: Detail of typical common mode perturbation**

(4200 V step with 6 kV/µs, $R_M = 2\, \text{kΩ}$)
Typical performance characteristics continued

![Supply current function of supply voltage](image1)

*Figure 6: Supply current function of supply voltage*

![Supply current function of temperature](image2)

*Figure 7: Supply current function of temperature*

![Typical frequency and phase response](image3)

*Figure 8: Typical frequency and phase response*

![Typical frequency and phase response (detail)](image4)

*Figure 9: Typical frequency and phase response (detail)*
Figure 10 (output RMS noise voltage spectral density) shows that there are no significant discrete frequencies in the output. Figure 11 confirms the absence of steps in the total output voltage noise that would indicate discrete frequencies. To calculate the noise in a frequency band \(f_1\) to \(f_2\), the formula is:

\[
V_{no}(f_1 \text{ to } f_2) = \sqrt{V_{no}(2)^2 - V_{no}(1)^2}
\]

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

Example:
What is the noise from 10 to 1 kHz?
Figure 11 gives \(V_{no}(10 \text{ Hz}) = 33 \mu V\) and \(V_{no}(1 \text{ kHz}) = 336 \mu V\).
The output RMS voltage noise is therefore.

\[
\sqrt{(336 \times 10^{-6})^2 - (33 \times 10^{-6})^2} = 334 \mu V
\]
**Sensitivity and linearity**

To measure sensitivity and linearity, the primary voltage (DC) is cycled from 0 to \(V_{PM}\), then to \(-V_{PM}\) and 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 \(\varepsilon_L\) 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 \(V_{OT}(T_A)\) 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 13: response time \(t_r\) and reaction time \(t_{ra}\)](image-url)
**Mechanical characteristics**

- **General tolerance**: ±1 mm
- **Transducer fastening**: 2 holes Ø 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**: 4 M5 threaded inserts (max screw length is 12 mm)
  - Recommended fastening torque: 2.2 N·m

**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](https://www.lem.com).
- 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.