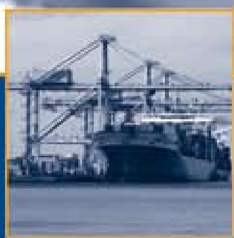
Technical Information

DV series Voltage Transducer
Insulated High Voltage measurements



LEM®

DV series Voltage Transducer
Insulated High Voltage measurements from 1200 to 4200 V_{RMS}
Now available for Traction and Industry applications

There are many applications requiring highly insulated, accurate and fast measurement of electrical parameters such as voltage, current, frequency and power in a high voltage environment for control and drive purposes or simply for monitoring purposes. Electrical drives for railway locomotives that are supplied with energy from networks up to 3000 V are one example of an application. In many of these applications, the measurement signal needs to be transmitted to electronic circuitry in a low voltage environment for control and/or display purposes. Certain applications need to power these sensors from a power supply located in the low voltage environment. The transmission of power and signals from a high voltage environment to a low voltage environment requires specific insulation features depending on the application. The DV fulfils the all necessary standards. In addition, a compact package was requested.

To achieve this goal, LEM has designed a new range of voltage transducers based on a technology different than the traditionally used Closed Loop Hall effect technology. The result is the DV series voltage transducers that covers nominal voltage measurements from 1200 to 4200 V_{RMS}.

To operate, they only need to be connected to the measuring voltage, without any additional resistors on the primary side to insert, and to a standard DC power supply range of +/- 13.5 to +/- 26.4 V.

The DV models have been specially designed for the railway environment and to respond to the technology evolution in converters requiring better performances such as:

- Low influence in common mode
- Low thermal drift
- Fast response time
- Large bandwidth
- Low noise

They are also well adapted for industrial applications for high and medium voltage measurements.

DV Transducer Technology: Insulating Digital Technology

To measure primary voltage V_P, the DV model uses only renowned electronic components. The measuring voltage, V_P, is applied directly to the transducer primary connections through a resistor network allowing the signal conditioning circuitry to feed an analogue to digital converter coupled with a Sigma-Delta modulator (to modulate the measurement signal).

The signal is then transmitted to the secondary side over an insulating transformer ensuring the insulation between the high voltage side (called "primary") and the low voltage side (called "secondary").

The signal is reshaped on the secondary side of the transformer, then decoded and filtered through a digital filter to feed a micro-controller using a Digital/Analogue (D/A) converter.

The analogue voltage signal at the output of the micro-controller and D/A converter is then transformed through a voltage-current converter protected against short circuits.

There may be other types of outputs such as voltage output, Pulse-Width Modulation (PWM) output, digital output or other known measurement signal output.

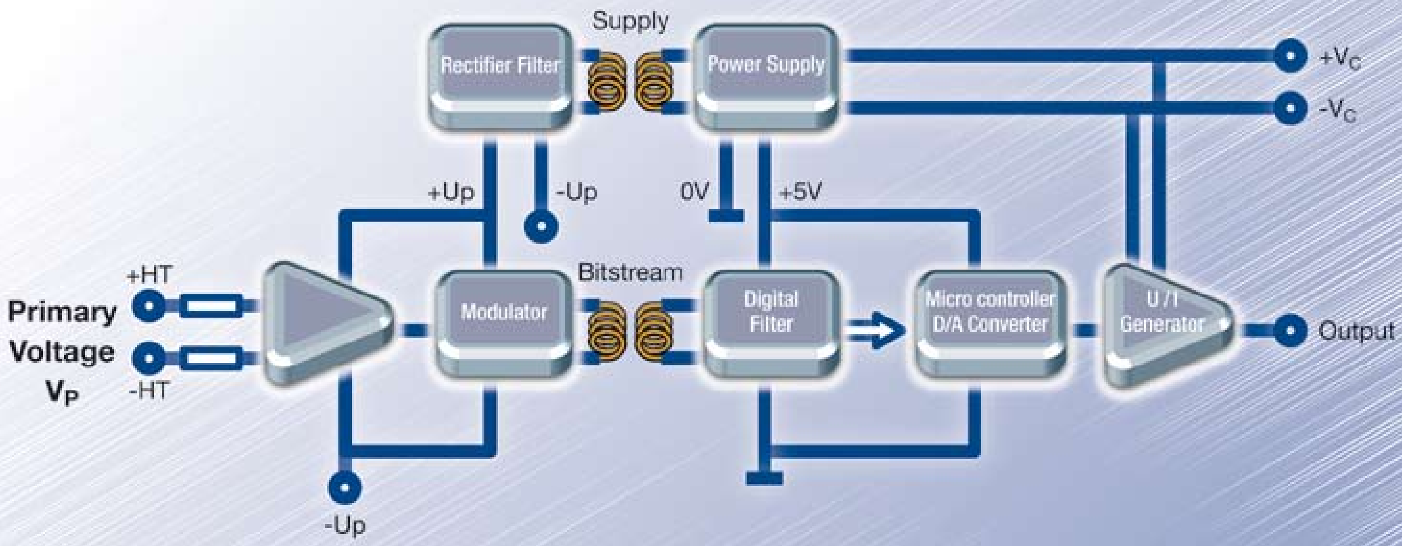
The recovered output signal is completely insulated against the primary (high voltage), and is an exact representation of the primary voltage.

A DC/DC converter connected to customer power supply provides different supply voltages for the secondary side of the transducer, primary side being supplied through another insulated transformer based on the same principle than the one used for the data transmission.

Insulating digital technology features

- Measurement of all types of signals: DC, AC, pulsed and complex
- Low volume technology: compact size
- High galvanic insulation between primary (high power) and secondary circuits (electronic circuit)
- Low consumption technology
- Very high accuracy
- Low temperature drift

Fig. 1. DV Technology



Dimensions

One of the main characteristics of the DV Voltage transducer is to provide medium/high voltage measurements in a very compact size compared to the existing Hall effect based or Fluxgate based voltage transducers.

Moreover, the same compact design is used to cover the complete voltage range from 1200 V to 4200 V_{RMS}.

The DV design is half of the size and weight of the LV 200-AW/2/Voltage transducer (Closed Loop Hall effect chip technology).

The large volume needed by the closed loop Hall effect chip and Fluxgate technologies can be attributed to the magnetic circuits necessary for operation.

The advantage of the electronic based DV technology is to eliminate the magnetic circuit and integrate only electronic components (amplifiers, resistors, capacitors, A/D & D/A converters, micro-controllers etc.), which saves about 50% in height compared to the LV 200-AW/2/Voltage models.

In addition to the reduction in height, the large heatsinks, usually installed on the Hall effect and Fluxgate based voltage transducers, have been removed as they are no longer needed.

For applications, this is a of great interest as the dedicated locations for the voltage and current transducers are consistently being reduced in size.

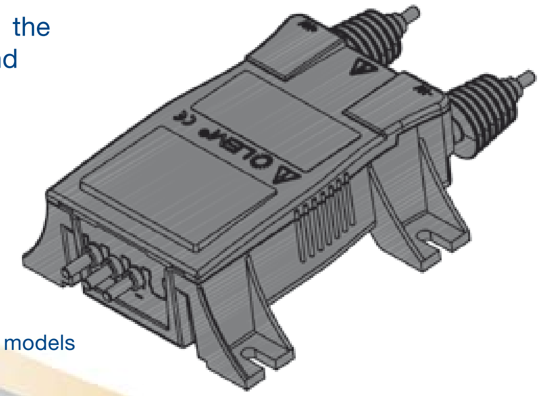
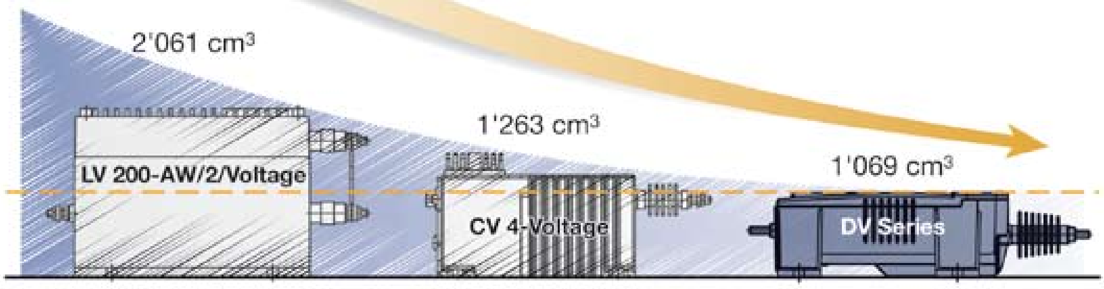
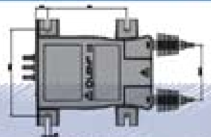
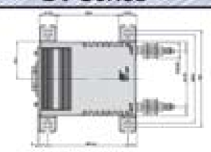
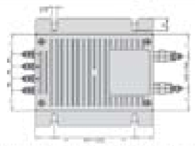


Fig. 2. 50% higher compared to the DV models



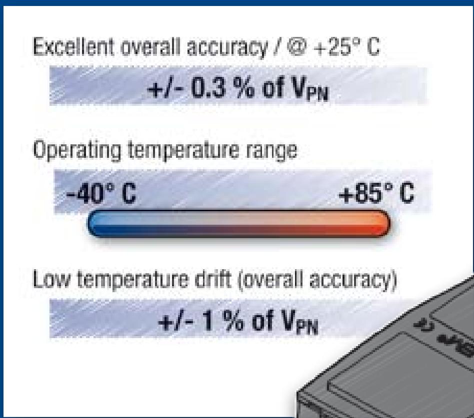
Transducers Dimensions

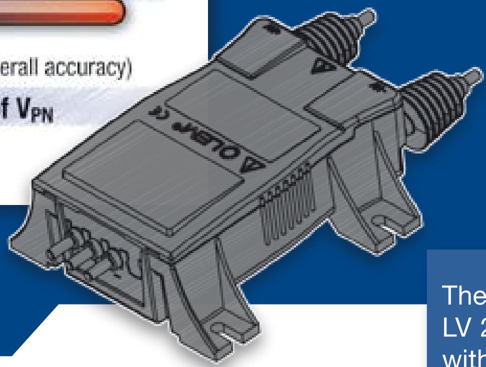
	Height	Length	Width
 DV Series	**54.22 mm**	**147.25 mm**	**134 mm**
 CV 4-Voltage	77.6 mm	121.5 mm	134 mm
 LV 200-AW/2/Voltage	105 mm	146.5 mm	134 mm

Electrical data

With zero primary voltage and with a power supply of +/- 24 V, the consumption is max 23 mA. With more than zero primary voltage, the transducer consumes 23 mA max + the output current (typically 50 mA at nominal value), when programmed with current output.

In comparison to the other ways to measure high voltages, this is a considerable energy savings (for instance, a Fluxgate based voltage transducer consumes between 35 to 50 mA with no primary voltage).





Details of the overall accuracy:

➔ Initial offset @ +25°C: 50 µA max with a max possible drift of +/- 100 µA over the operating temperature range

➔ Sensitivity error @ +25°C: +/- 0.2 % as max possible value with a max possible drift over the operating temperature range of +/- 0.8 %

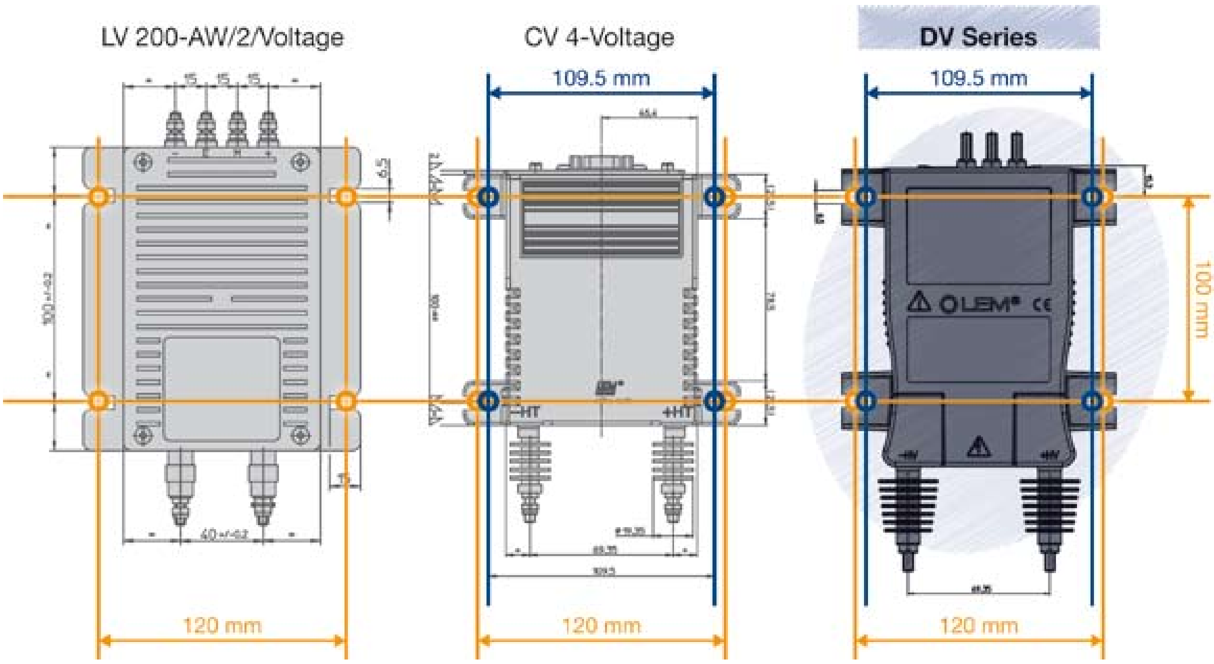
The micro-controller, used among other things for the Digital to Analogue conversion, is also useful for offset and gain adjustment during production, enabling these parameters.

Moreover, as opposed to the Closed Loop Hall effect chip technology, there are no large primary and secondary windings used causing more important sensitivity error.

➔ Linearity: only +/- 0.1 %

The DV models are 100 % compatible with the LV 200-AW/2/Voltage and CV 4-Voltage models with regards to the footprint mounting. This is highly desirable when retrofits are required on older installations.

Fig. 3. DV transducers can be mounted at the exact place of the previous Voltage transducers



Dynamic performances

DV transducer typical response times (Response time defined at 90 % of V_{PN}) against a voltage step at V_{PN} (ramp up defined at 6 kV/µs) will have a delay of 48 µs (Max 60 µs).

Other closed Loop Hall effect chip based voltage transducers have a response delay of several hundred of µs.

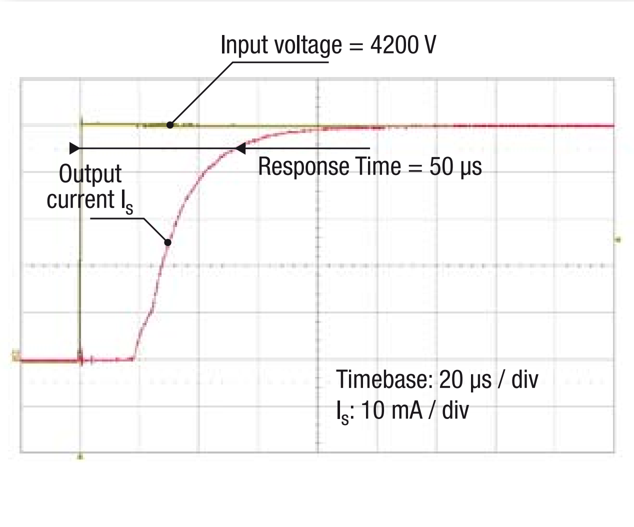


Fig. 4. Response time to a voltage step of 4200 V

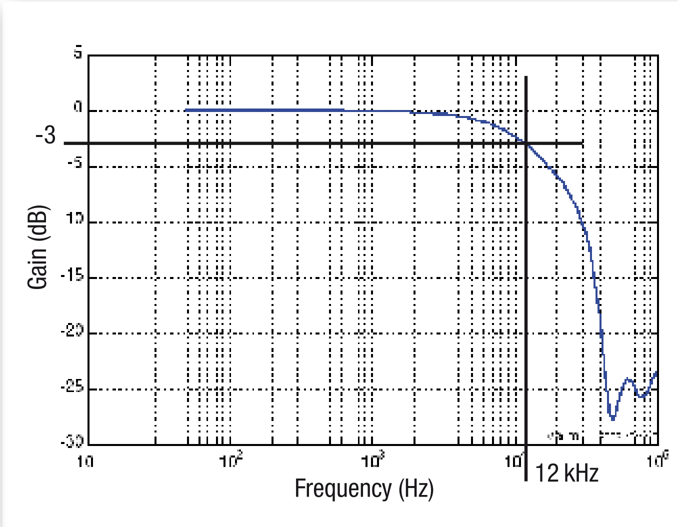


Fig. 5. Frequency response / DV 4200 model

As a result of the fast response time, a large bandwidth has been verified at 12 kHz @ 3 db (Fig. 5).

Options

Electrical Output

The DV series models deliver a standard analogue current output of 50 mA for nominal voltage defined value (75 mA full scale = for the possible max range).

The current provided at the output is the exact representation of the measured voltage.

Voltage output is also possible on request such as 10 V for nominal voltage defined value.

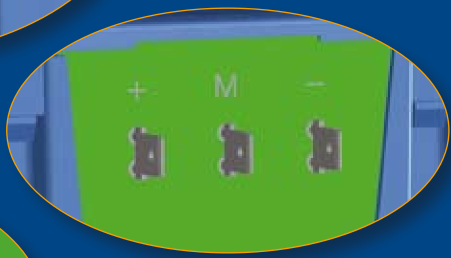
The transducer can be easily adapted for different ranges by modifying the gain programmed by the micro-controller. This does not require changes in the design of the transformer cores or in the design of the assembly of the circuit boards and transformer core parts in the housing.

Flexibility with modular connections

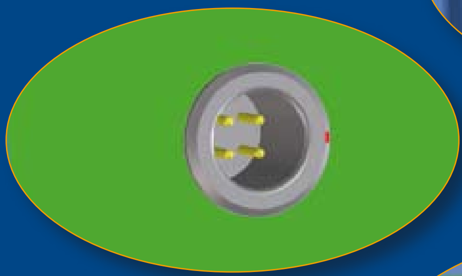
The DV product modular approach allows easy adaptation with various connections available for the primary side, e.g. terminals or isolated cable, and any kind of connection for the secondary side like connectors, shielded cables, terminals (threaded studs, M4, M5, UNC etc.) according to customer specifications.

Various options for secondary connections

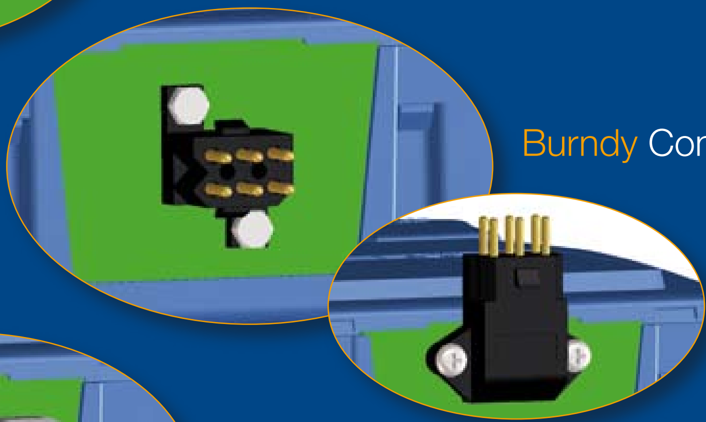
Threaded Studs, M4, M5, UNC...



...or Faston

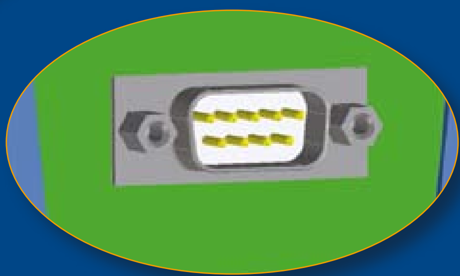


LEMO Connectors

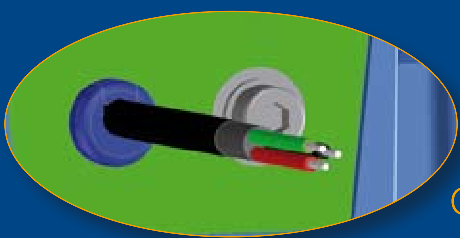


Burndy Connectors

AMP Connectors



Sub-D Connectors



Cables, Shielded Cables...

But also Wago, Phoenix, Souriau ... connectors

The DV models have been designed and tested according to latest recognized worldwide standards for traction applications:

- Higher insulation and partial discharge levels in order to guarantee safety
- Better immunity against external electrical, magnetic and electromagnetic fields for EMC protection
- Low level of emission
- Excellent accuracy to suit to high demanding applications such as energy metering
- Protection against fire and smoke, mandatory in railway applications

The EN 50155 standard dedicated to “Electronic Equipment used on Rolling stock” in railway applications is our standard of reference for electrical, environmental and mechanical parameters.

It guarantees the overall performances of our products in railway environments.

Our main production centres for traction transducers are IRIS certified, a must for companies supplying the railway market.

IRIS Certification

DV products are CE marked as a guarantee of the product compliance to the European EMC directive 89/336/EEC and low voltage directive. They also comply to the derived local EMC regulations (EMC: Electro-Magnetic Compatibility).

CE

RoHS COMPLIANT 2002/95/EC

The transducer complies to the EN 50121-3-2 standard (railway EMC standard) in its latest update, with EMC constraints higher than that of the typical industrial application standards.

The updates have been:

1. Immunity to lightning strokes: the standard refers to EN 61000-4-5 with 2 levels according to the points of injection
2. Immunity to conducted radio frequency fields (equivalent in Industry to IEC 61000-4-6 standard): the level changed from 3 V_{RMS} to 10 V_{RMS} when it is already done at 10 V_{RMS} for industry and traction transducers in LEM
3. The main new requirements have been the levels and frequencies of the radiated electromagnetic field immunity tests according to EN 61000-4-3:
    - 20 V/m from 80 MHz to 1 GHz (instead of 10V/m previously),
    - 10 V/m from 1.4 GHz to 2.1 GHz (nothing specified previously),
    - 5 V/m from 2.1 GHz to 2.5 GHz (nothing specified previously).

From these three evolutions, only the radiated electromagnetic field immunity tests (point n°: 3) and the conducted radio frequency fields tests (point n°: 2) are mandatory for transducers because they are not directly fed by the battery and therefore not subject to lightning strokes (point n°: 1).

Insulation and safety

The EN 50124-1 (“Basic requirements - clearances and creepage distances for all electrical and electronic equipment”) standard has been used as a reference to design the creepage and clearance distances for the DV transducers versus the required insulation levels (rated insulation voltage) and the conditions of use.

For the highest possible rated insulation voltage, the DV products have been designed with the following data:

Creepage distance (as represented below):
236 mm (Internal dimensions)

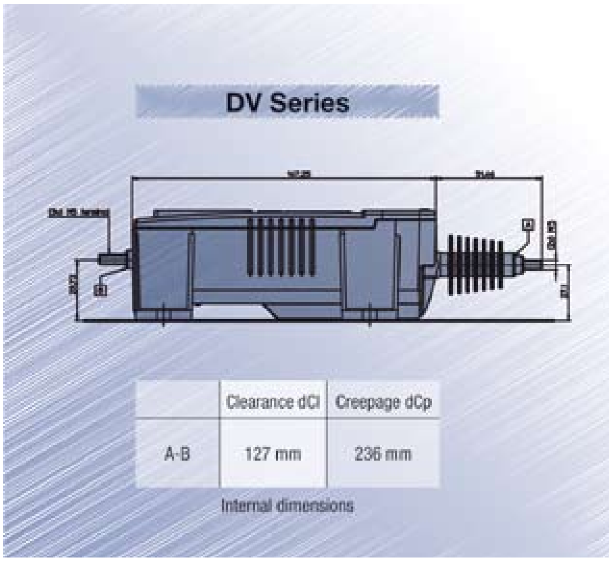
Clearance distance (as represented below):
127 mm (Internal dimensions)

CTI (Comparative Tracking Index): 600 V (group I)

A few reminders

- Clearance distance (the shortest distance in air between two conductive parts)
- Creepage distance (the shortest distance along the surface of the insulating material between two conductive parts)
- Pollution degree (application specific - this is a way to classify the micro-environmental conditions having an effect on the insulation)

Fig. 6. Creepage and clearance distances on DV model



- Overvoltage category (application specific - characterizes the exposure of the equipment to overvoltages)
- Comparative Tracking Index (CTI linked to the kind of material used for the insulated material) leading to a classification over different Insulating Material groups
- Simple (Basic) or Reinforced insulation need or rated insulation voltage (U_{Nm}): an RMS withstand voltage value assigned by the manufacturer to the equipment or a part of it, characterizing the specified permanent (over five minutes) withstand capability of its insulation.
- Partial Discharges: PD: a partial discharge (PD) is the dissipation of energy caused by the buildup of localized electric field intensity; electric discharges partially bridge the insulation.

  Failure is by gradual erosion or treeing leading to puncture or surface flashover.

  The PD behavior is influenced by the frequency of the applied voltage.

  The partial discharge test is to verify that no partial discharges are maintained in the solid insulation:

  – at the highest steady-state voltage

  – at the long-term temporary overvoltage

  – at the recurring peak voltage

  The higher the extinction partial discharges voltage level is, the better, as no discharges happen during the normal defined function. The partial discharges level is defined at 10 pC.

These parameters are used to define the performances in the following conditions of use.

The conditions of use truly determine the ability of the transducer to support a certain insulation level.

In the following example, the DV voltage transducer is supposed to be placed in a propulsion inverter mounted into a train. The following conditions of use are then assumed:

- Overvoltage category: III (Definition: Same as OV IV defined as “circuits which are not protected against external or internal overvoltages (e.g. directly connected to the contact or outside lines) and which may be endangered by lightning or switching overvoltages” but with less harsh overvoltage conditions and/or lower requirements concerning safety and reliability).

  Examples: power distribution systems in installations or lines outside of buildings protected by additional provisions for protection.

- Pollution Degree: 3 (definition:
  dust deposit ➔ low conductivity
  (caused by condensation);
  humidity ➔ frequent condensation).

Basic or Single insulation

According to EN 50124-1 standard: with clearance distance of 127 mm and PD3, U_{Ni} (rated impulse voltage) = 75 kV.

With U_{Ni} = 75 kV & OV III, the rated insulation voltage (AC or DC) called “U_{Nm}” can be 17.25 kV.

This is valid only for rolling stock applications. For fixed installations, the data is different.

With a creepage distance of 236 mm and PD3 and CTI of 600 V (group I), it is allowed to have 12.5 mm/kV, leading to a possible rated insulation voltage U_{Nm} of 18.8 kV.

In conclusion, the possible rated insulation voltage, U_{Nm}, in these conditions of use, is 17.25 kV (the lowest value given by the both results from the creepage and clearance distances).

Reinforced insulation

Let’s examine reinforced insulation for the same creepage and clearance distances as previously defined:

When dimensioning reinforced insulation, from the clearance distance point of view, the rated impulse voltage, U_{Ni}, shall be 160 % of the rated impulse voltage required for basic insulation.

The clearance distance of 127 mm is already designed and then, we look for the reinforced insulation with this distance.

Reinforced U_{Ni} = 75 kV obtained with the clearance distance of 127 mm.

Basic U_{Ni} = Reinforced U_{Ni} / 1.6 = 46.87 kV.

Reinforced U_{Nm}: From 4.8 to 6.5 kV, according to the clearance distance.

From the creepage distance point of view, when dimensioning reinforced insulation, the rated insulation voltage U_{Nm} shall be two times the rated insulation voltage required for the basic insulation.

With a creepage distance of 236 mm and PD3 and CTI of 600 V (group I), it is then allowed to have 25 mm/kV (2 x 12.5) vs. 12.5 mm/kV previously (for basic insulation), leading to a possible reinforced rated insulation voltage U_{Nm} of 9.44 kV.

In conclusion, the possible reinforced rated insulation voltage U_{Nm}, in these conditions of use, is of from 4.8 to 6.5 kV (the lowest value given by the both results from the creepage and clearance distances).

Fire and smoke

Materials used for the DV models comply with the NFF 16101/2 standards for fire and smoke classification (tests report for materials available on request) and are UL94V0 (as long as they are relevant).

Reliability

Of course, reliability and lifetime are guaranteed by the quality in design and process. Accelerated tests have been performed to estimate failure rate (temperature cycles and/or humidity test and complete characterization of the product according to standards).

The technology of the DV is innovative while using renowned components and by respecting the guidelines for high reliability applications such as the railway environment. These efforts make it possible to guarantee excellent reliability.

Partial discharges, test insulation and common mode behavior

Thanks to an innovative design using the insulation transformer, the DV models guarantee insulation and partial discharge levels for high voltage applications up to 6000 Vpk.

RMS voltage for partial discharge extinction @ 10 pC is of 5 kV, certainly the highest-performance voltage transducer in its category on the market for this parameter.

Not less than 18.5 kV as RMS voltage for AC insulation test 50/60 Hz / 1 min thanks to a successful highly studied design.

These 2 features make the DV models unique on the market.

Due to their low parasitic capacitance, the effect of dynamic common mode is reduced (Fig. 7).

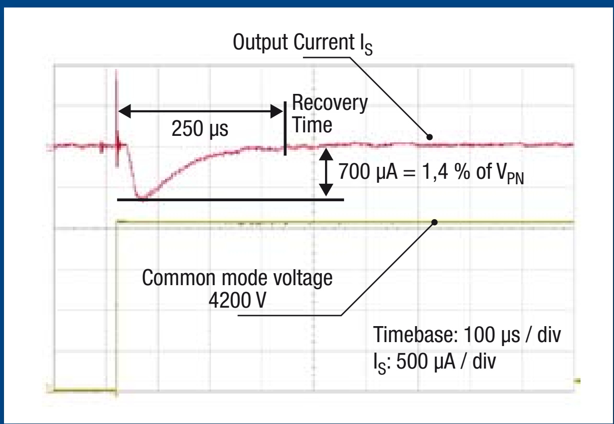


Fig. 7. Typical common mode behavior (4200 V applied with dv/dt = 6 kV/µs), only 1,4 % of V_{PN} as error during the dv/dt with a recovery time of less than 250 µs.

Measuring resistor R_M

The DV series supplies a current as an output in its standard version (provided by an internal voltage-current conversion). Voltage outputs can be easily provided on request or the output current can be transformed into a voltage by simply adding a load resistor called measuring resistor R_M at the output.

The value for R_M is indicated in each data sheet and is limited to a max value called R_{MMAX} and to a min value called R_{MMIN} and are given as per the graphs Fig. 8 and 9.

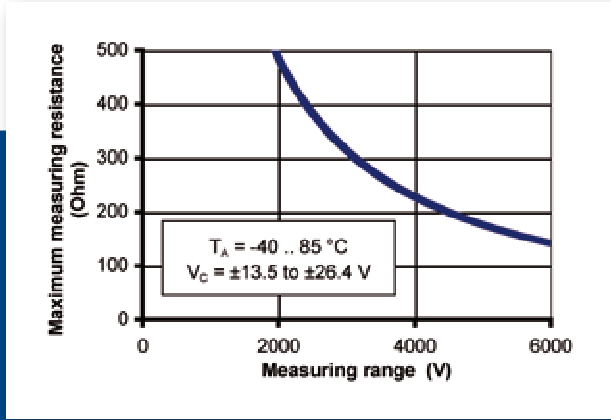


Fig. 8. Maximum measuring resistor (DV 4200 model)

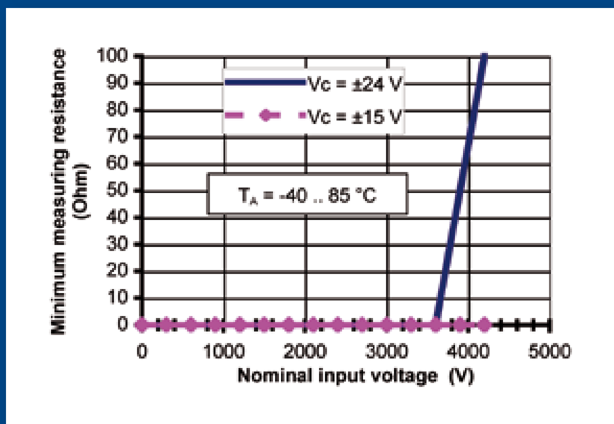


Fig. 9. Minimum measuring resistor (DV 4200 model)

DV series performances vs existing voltage measurement solutions performances

Voltage transducer	LV 200-AW/2/6400	CV 4-6000/SP7	Competition	DV 4200
Overall accuracy (in the operating temperature range)	1.75 % @ V_{PN}	1.43 % @ V_{PN}	1.7 % @ V_{PN}	**1 %** @ V_{PN}
Response time @ 90% of V_{PN} (typical value)	400 µs	50 µs	50 µs	**48 µs**
Common mode perturbation level (typical value)	30 % of V_{PN}	4 % of V_{PN}	8 % of V_{PN}	**1,4 %** of V_{PN}
Bandwidth (+/-3 dB) (typical value)	950 Hz	8 kHz	13 kHz	**12 kHz**
Insulation voltage level (minimum value)	12 kV_{RMS}/50 Hz/1 min	13.4 kV_{RMS}/50 Hz/1 min	12 kV_{RMS}/50 Hz/1 min	**18.5** kV_{RMS}/50 Hz/1 min
Partial discharges: Extinction voltage @ 10 pC (minimum value)	5.2 kV @ 50 pC	4.6 kV	4.3 kV	**5 kV**
Operating temperature range	-25°C to +70°C	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C

Typical applications & conclusion

Mainly designed for medium and high voltages on-board railway applications like propulsion or auxiliary converter, DV transducers are designed and built for any kind of rugged environments, requiring:

- Good performances (accuracy, gain, linearity, low initial offset, low thermal drift etc.)
- High immunity to external interferences (generated by adjacent currents or external perturbations for example) and high immunity against high voltage variations
- Reduced size: DV is the smallest voltage transducer in its category (up to nominal voltage of 4200 V_{RMS})
- High flexibility and modularity for specific customer application (wide choice of primary and secondary connections, current or voltage output with different possible levels, pulse-width modulation (PWM) output, digital output etc.)
- High level of RMS voltage (5 kV) for partial discharges extinction @ 10 pC
- High level of insulation test voltage (18.5 kV_{RMS}/50-60 Hz/1 min)
- Excellent reliability

The DV is the first DC class accuracy voltage transducer on the market due to its outstanding performances over a large voltage and temperature range. It can be used for energy monitoring and billing purposes.

Medium and high voltages in railway applications are:

- Catenaries with the different voltage networks to be checked at the entrance of the locomotive (for the Eurostar for example)
- On-board energy meters needing voltage transducers to feed their voltage input channels designed to receive any traction network. Typically, they are located at the circuit breaker level or catenaries, where high accuracy is required
- Substations where voltage transducers monitor the DC voltages supplied to the catenaries at the DC switchgear (rectifier output).

The DV has been designed to minimize current consumption (maximum 23 mA when supplied with +/- 24 V, Vp = 0) on the secondary side. LEM is proud to be able to contribute to **energy savings** and is certified ISO 14001 for environmental management standards.

Absolute maximum ratings

Parameter	Symbol	Value
Maximum supply voltage for current output DVs (terminal $+V_C$ to $-V_C$, no input voltage, 0.1 s)		68 V
Maximum supply voltage for voltage output DVs (terminal 0V to $\pm V_C$, no input voltage, 0.1 s)		±34 V
Maximum supply voltage (working) (-40..85°C)	$\pm V_C$	±26.4 V
Maximum input voltage (1.2/50µs exponential shape)		10 kV
Maximum input voltage (DC) (-40..85°C)		V_{PM} (6 kV for DV 4200)
Maximum steady state input voltage (-40..85°C)		V_{PN} Fig 9 (4200 V for DV 4200)
Output short circuit for output current DVs (terminal M to supply mid-point)		10 min at ±26.4 V and 85°C For continuous short circuit, use Fig 9
ESD rating, Human Body Model (HBM)		4 kV

Absolute maximum ratings apply at 25°C unless otherwise noted.

Stresses above these ratings may cause permanent damage.
This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this data sheet is not implied.

Exposure to absolute maximum ratings for extended periods may degrade reliability.

Insulation characteristics

Parameter	Symbol	Unit	Min	Comment
RMS voltage for AC insulation test 50/60 Hz /1 min	V_d	kV	18.5	100% tested
Insulation resistance	R_{IS}	M Ω	200	Measured at 500 V
RMS voltage for partial discharge extinction @ 10 pC	V_e	V	5	
Clearance distance (pri. - sec.) A-B	dCl	mm	127	Shortest distance through air
Creepage distance (pri. - sec.) A-B	dCp	mm	236	Shortest path along device body
CTI of case material	CTI	-	600	

Environmental and mechanical characteristics

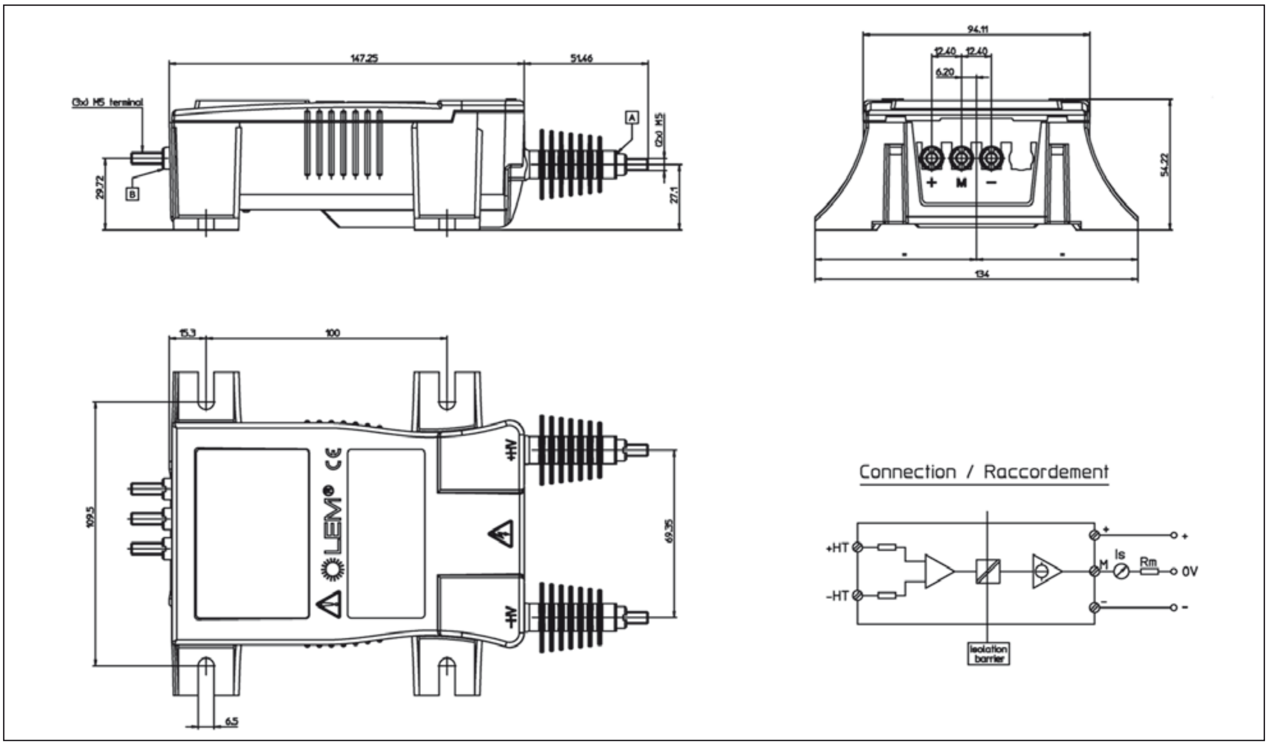
Parameter	Symbol	Unit	Min	Typ	Max
Ambient operating temperature	T_A	°C	-40		85
Ambient storage temperature	T_S	°C	-50		90
Mass	m	g		620	

Electrical data DV 4200 (as example)

At T_A = 25 °C, V_C = ± 24 V, R_M = 100 Ω, unless otherwise noted.
Parameters with a * in the conditions column apply over the -40.. 85° C ambient temperature range.

Parameter		Unit	Min	Typ	Max	Conditions	
Primary nominal voltage, $_{RMS}$	V_{PN}	V			4200	*	
Primary voltage, measuring range	V_{PM}	V	-6000		6000	*	
Measuring resistance	R_M	Ω	0		140	*	
Secondary nominal current, $_{RMS}$	I_{SN}	mA	-50		50	*	
Output range	I_S	mA	-71.4		71.4	*	
Supply voltage	$\pm V_C$	V	±13.5	±24	±26.4	*	
Current consumption @ V_C = ±24 V	I_C	mA		19 + I_S	23 + I_S		
Offset current	I_O	µA	-50	0	50		100% tested
Offset drift	I_{OT}	µA	-80 -80 -100		80 80 100	*	-25 .. 70°C -25 .. 85°C -40 .. 85°C; 100% tested
Sensitivity	G	µA/V		11.9048			50 mA for 4200 V
Sensitivity error	ε_G	%	-0.2	0	0.2		
Thermal drift of sensitivity		%	-0.5 -0.8 -0.8		0.5 0.8 0.8	*	-25 .. 70°C -25 .. 85°C -40 .. 85°C
Linearity error	ε_L	%	-0.1		0.1	*	±6000 V range
Overall accuracy	X_G	% of V_{PN}	-0.3 -0.7 -1 -1		0.3 0.7 1 1	*	25°C; 100% tested -25.. 70°C -25 .. 85°C -40 .. 85°C
Output current noise	i_{no}	μA_{RMS}		10			1 Hz to 100 kHz
Reaction time @ 10 % of V_{PN}	t_{ra}	µs		21			
Response time @ 90 % of V_{PN}	t_r	µs		48	60		0 to 4200 V step, 6kV/µs
Frequency bandwidth	BW	kHz		12 6.5 1.6			3 dB 1 dB 0.1 dB
Start-up time		ms		190	250	*	
Primary resistance	R_1	MΩ		23		*	
Total primary power loss @ V_{PN}	P	W		0.77		*	

DV series - Dimensions



Dimensions in mm. 1 mm = 0.0394 inches

Mechanical characteristics

General tolerance	± 0.5 mm
Fastening of transducer	4 notches 6.5 mm
	4 steel screws M6 + washer ext. dia. 18 mm
Recommended fastening torque	5.00 Nm or 3.70 Lb. -Ft.
Connection of primary	M5 threaded studs
Connection of secondary	M5 threaded studs
Recommended fastening torque	2.5 Nm or 1.85 Lb. -Ft.

Remark

I_S is positive when V_P is applied on terminal +HT.

Safety

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 (eg. primary busbar, power supply).

Ignoring this warning can lead to injury and/or cause serious damage.

This transducer is a built-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.

5 Year Warranty
on LEM Transducers

LEM designs and manufactures high quality and high reliability products for its customers over the entire world. Since 1972, we have delivered several million current and voltage transducers which are, for most of them, still in operation on traction vehicles, industrial motor drives, UPS systems and many other applications requiring high quality standards.

Our 5 year warranty applies on all LEM transducers and is valid in addition to the legal warranty. The warranty granted on our Transducers is for a period of 5 years (60 months) from the date of their delivery.

During this period we shall replace or repair at our cost all defective parts (provided the defect is due to defective material or workmanship).

Further claims as well as claims for the compensation of damages, which do not occur on the delivered material itself, are not covered by this warranty.

All defects must be notified to us immediately and faulty material must be returned to the factory along with a description of the defect.

Warranty repairs and or replacements are carried out at our discretion. The customer bears the transport costs. An extension of the warranty period following repairs undertaken under warranty cannot be granted.

The warranty will be invalidated if the buyer has modified or repaired, or has had repaired by a third party the material without LEM's written consent.

The warranty does not cover any damage caused by incorrect conditions of use and cases of force majeure.

No responsibility will apply except legal requirements regarding product liability.

The warranty explicitly excludes all claims exceeding the above conditions.

LEM International, April 1. 2008

Paul Van Iseghem
President & CEO LEM

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