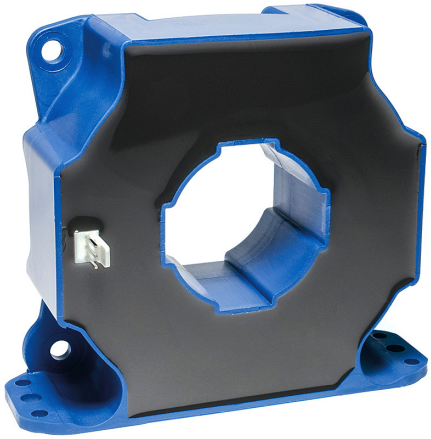
Current Transducer LF 1010-S

I_{PN} = 1000 A

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



Features

- Bipolar and insulated current measurement
- Current output
- Closed loop (compensated) current transducer
- Panel mounting.

Advantages

- High accuracy
- Very low offset drift over temperature.

Applications

- Windmill inverters
- Test and measurement
- AC variable speed and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications.

Standards

- EN 50121-3-2: 2016
- EN 61326-1: 2013
- EN 61000-6-2: 2005 / AC: 2005
- EN 61000-6-3: 2007 / A1: 2011 / AC: 2012
- EN 61010-1: 2010 / A1:2019
- EN 61800-5-1: 2007
- IEC 62109-1: 2010
- UL 508: 2013.

Application Domain

- Industrial.

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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 and connecting cable before using this product and do not use it if damaged.
Mounting assembly shall guarantee the maximum primary conductor temperature, fulfill clearance and creepage distance, minimize electric and magnetic coupling, and unless otherwise specified can be mounted in any orientation.

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.
De-energize all circuits and hazardous live parts before installing the product.
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.
Besides make sure to have a distance of minimum 30 mm between the primary terminals of the transducer and other neighboring components.

Main supply must be able to be disconnected.
Always inspect the current transducer for damage before using this product.
Never connect or disconnect the external power supply while the primary circuit is connected to live parts.
Never connect the output to any equipment with a common mode voltage to earth greater than 30 V.
Always wear protective clothing and gloves if hazardous live parts are present in the installation where the measurement is carried out.
Safe and trouble-free operation of this transducer can only be guaranteed if transport, storage and installation are carried out correctly and are carried out with care.
If not working, the current transducer shall be replaced by an equivalent device.
This transducer is a built-in device, not intended to be cleaned with any product. Nevertheless if the user must implement cleaning or washing process, validation of the cleaning program has to be done by himself.

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 supply voltage (working) (−40 … 85 °C)	$U_{C\,max}$	V	±25.2
Maximum primary conductor temperature	$T_{B\,max}$	°C	100
Maximum steady state primary nominal current (−40 … 85 °C)	$I_{P\,N\,max}$	A	1000

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	
Mass	m	g		503		
Relative humidity	RH	%	0		95	Non-condensing
Altitude		m			2000 [1)]	
Environmental conditions						Indoors
Cooling conditions						Natural convection

Note: [1)] Insulation coordination at 2000 m above sea level.

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UL 508: Ratings and assumptions of certification

File # E189713 Volume: 2 Section: 9

Standards

- USR indicates investigation to the Standard for Industrial Control Equipment UL 508.
- CNR indicates investigation to the Canadian standard for Industrial Control Equipment CSA C22.2 No. 14-13.

Ratings

Parameter	Symbol	Unit	Value
Primary potential involved		V AC/DC	1500
Maximum surrounding air temperature	$T_{A\,max}$	°C	85
Primary current	I_P	A	0 ... 1200
Secondary supply voltage	U_C	V DC	0 ... ±24
Secondary current	I_S	mA	0 ... 400

This is the Maximum UL rating table for the LF 1010 product family.

Conditions of acceptability

When installed in the end-use equipment, consideration shall be given to the following:

1 - These products must be mounted in a suitable end-use enclosure.

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 transformer, optical isolator, limiting impedance or electro-mechanical relay).

4 - Based on the temperature test performed on all Series, the primary bar or conductor shall not exceed 100 °C in the end use application.

5 - LF 1010-S shall be used in a pollution degree 2.

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.

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Insulation coordination

Parameter	Symbol	Unit	≤ Value	Comment
RMS voltage for AC insulation test, 50 Hz, 1 min (Type test)	U_d	kV	3.8	Between primary and secondary
RMS voltage for AC insulation test, 50 Hz, 2 sec (Routine test)	U_d	kV	3	Between primary and secondary
Impulse withstand voltage 1.2/50 µs	U_{Ni}	kV	15.6	
Clearance (pri. - sec.)	d_{Cl}	mm	19.0	Shortest distance through air
Creepage distance (pri. - sec.)	d_{Cp}	mm	20.1	Shortest path along device body
Case material	-	-	V0	According to UL 94
Comparative tracking index	CTI		600	
Application example RMS voltage line-to-neutral		V	1000	Reinforced insulation according to IEC 61010-1 CAT III, PD 2 (Table value)
Application example System voltage RMS		V	1000	Reinforced insulation according to IEC 61800-5-1 CAT III, PD 2
Application example System voltage DC		V	1500	Reinforced insulation according to IEC 612109-1 CAT III, PD 2

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Electrical data

At T_A = 25 °C, $\pm U_C$ = ±24 V, N_P = 1 turn, R_M = 1 Ω unless otherwise noted (see Min, Max, typ, definition paragraph in page 7).
Lines with a * in the conditions column apply over the −40 … 85 °C ambient temperature range.

Parameter	Symbol	Unit	Min	Typ	Max		Conditions
Primary nominal RMS current	I_{PN}	A			1000	*	
Primary current, measuring range	I_{PM}	A	−2700		2700	*	With U_C = ±22.8 V; T_A = +85 °C; R_M = 1 Ω For other conditions, see figure 1
Measuring resistance	R_M	Ω	0			*	Max value of R_M is given in figure 1
Secondary nominal RMS current	I_{SN}	A	−0.2		0.2	*	
Resistance of secondary winding	R_S	Ω			30.2		$R_S(T_A) = R_S \times (1 + 0.004 \times (T_A + \Delta\text{temp} - 25))$ Estimated temperature increase @ I_{PN} is Δtemp = 15 °C
Secondary current	I_S	A	−0.54		0.54	*	
Number of secondary turns	N_S			5000			
Nominal sensitivity	S_N	mA/A		0.2			
Supply voltage	$\pm U_C$	V	±14.25		±25.2	*	
Current consumption	I_C	mA		44 + I_S 49 + I_S			$\pm U_C$ = ±15 V $\pm U_C$ = ±24 V
Offset current, referred to primary	I_O	A	−1		1		
Temperature variation of I_O, referred to primary	I_{OT}	A	−0.6		0.6	*	
Magnetic offset current after 3 × I_{PN}, referred to primary	I_{OM}	A		±1			
Sensitivity error	ε_S	%		±0.15		*	
Linearity error	ε_L	% of I_{PN}	−0.15		0.15	*	
Total error at I_{PN}	ε_{tot}	% of I_{PN}	−0.2 −0.4		0.2 0.4	 *	25 ... 70 ... 85 °C −40 … 85 °C
RMS noise current, referred to primary	I_{no}	mA		50			1 Hz to 20 kHz (see figure 4)
Delay time to 10 % of the final output value for I_{PN}	t_{D10}	µs		< 0.5			0 to 1 kA, 200 A/µs
Delay time to 90 % of the final output value for I_{PN}	t_{D90}	µs		< 0.5			0 to 1 kA, 200 A/µs
Frequency bandwidth	BW	kHz		200			−3 dB, small signal bandwidth (see figure 5 and figure 6)

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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 a product.

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Typical performance characteristics

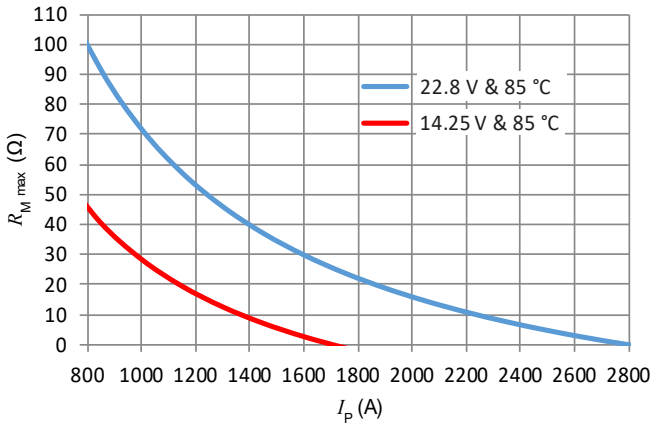

Figure 1: Maximum measuring resistance

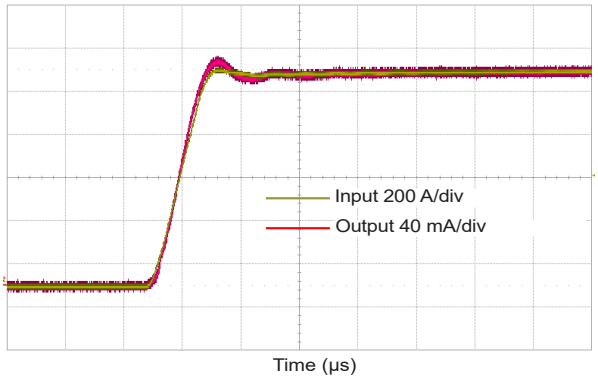

Figure 2: Typical delay time (0 to 1 kA, 200 A/µs)

$$R_{M\,max} = N_S \times \frac{U_{C\,min} - 0.5\ V}{I_P} - R_{S\,max} - 0.93\ \Omega$$

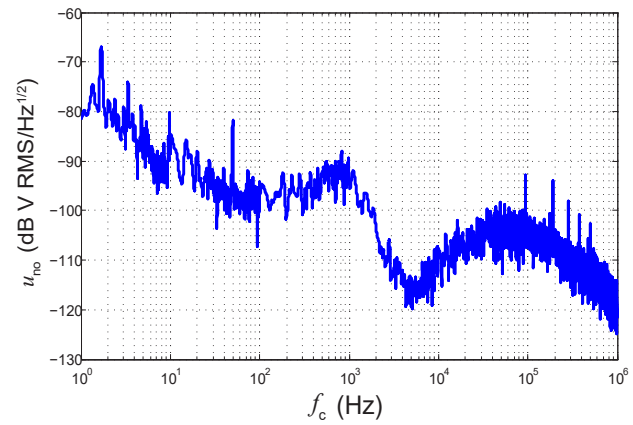

Figure 3: Typical noise voltage spectral density referred to primary u_{no} with R_M = 100 Ω

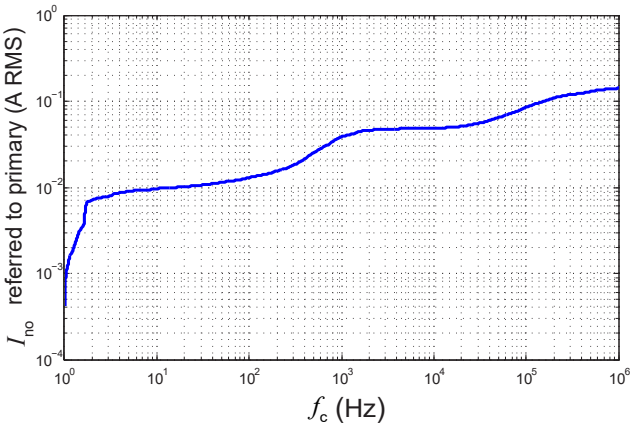

Figure 4: Typical total RMS noise current referred to primary I_{no} with R_M = 100 Ω

To calculate the noise in a frequency band f_1 to f_2, the formula is:

$$I_{no}\,(f_1 \cdots f_2) = \sqrt{I_{no}\,(f_2)^2 - I_{no}\,(f_1)^2}$$

with $I_{no}\,(f)$ read from figure 4 (typical, RMS value).

Example:
What is the noise from 1 to 10^6 Hz?
Figure 4 gives I_{no} (1 Hz) = 0.5 mA and I_{no} (10^6 Hz) = 199 mA.
The output RMS noise current is therefore:

$\sqrt{(199 \times 10^{-3})^2 - (0.5 \times 10^{-3})^2}$ = 199 mA referred to primary.

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Typical performance characteristics continued

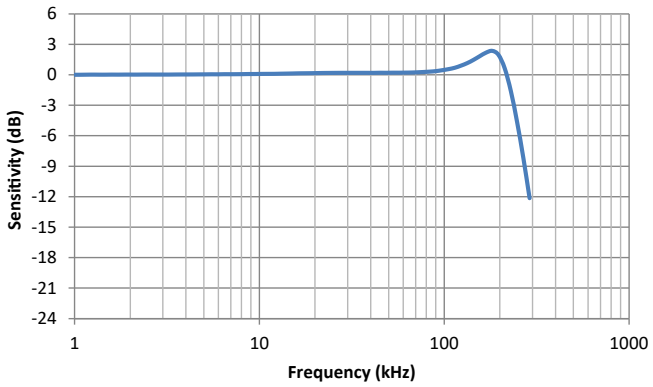

Figure 5: Typical frequency response, small signal bandwidth

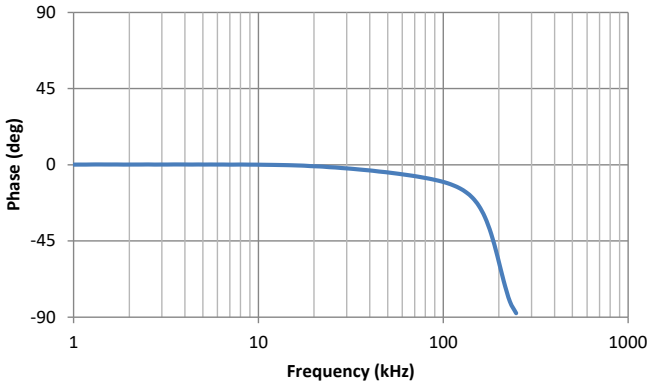

Figure 6: Typical phase shift, small signal bandwidth

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Terms and definitions

Ampere-turns and amperes

The transducer is sensitive to the primary current linkage Θ_P (also called ampere-turns).

$$\Theta_P = N_P \cdot I_P$$

Where N_P is the number of primary turn (depending on the connection of the primary jumpers).
Caution: As most applications will use the transducer with only one single primary turn (N_P = 1), much of this datasheet is written in terms of primary current instead of current linkages. However, the ampere-turns (A) unit is used to emphasis that current linkages are intended and applicable.

Simplified transducer model

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

$$I_S = S \cdot \Theta_P \cdot (1 + \varepsilon)$$

In which (referred to primary):

$$\varepsilon \cdot \Theta_P = I_O + I_{O\,T} + \varepsilon_S \cdot \Theta_P + \varepsilon_L(\Theta_{P\,max}) \cdot \Theta_{P\,max}$$

$\Theta_P = N_P \cdot I_P$: primary current linkage (A)
$\Theta_{P\,max}$: maximum primary current linkage applied to the transducer
I_S : secondary current (A)
S : sensitivity of the transducer (A/A)
T_A : ambient operating temperature (°C)
I_O : offset current (A)
$I_{O\,T}$: temperature variation of I_O (A)
ε_S : sensitivity error at 25 °C
$\varepsilon_L(\Theta_{P\,max})$: linearity error for $\Theta_{P\,max}$

This model is valid for primary ampere-turns Θ_P between $-\Theta_{P\,max}$ and $+\Theta_{P\,max}$ 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 $\pm I_{P\,N}$, relative to the rated value $I_{P\,N}$.
It includes all errors mentioned above:

- the electrical offset $I_{O\,E}$
- the magnetic offset $I_{O\,M}$
- the sensitivity error ε_S
- the linearity error ε_L (to $I_{P\,N}$).

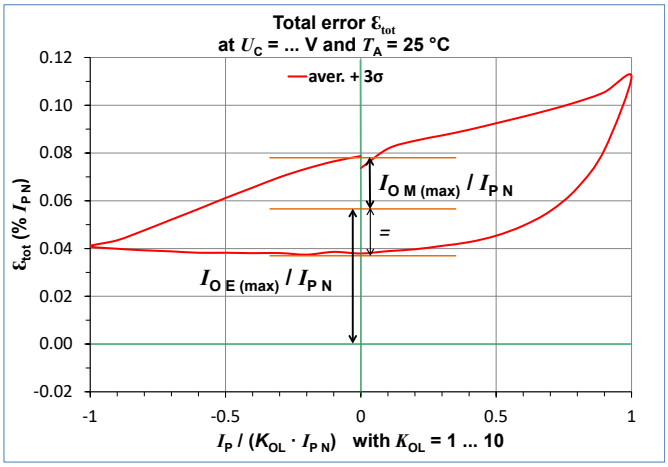

Figure 7: Total error ε_{tot}

Electrical offset referred to primary

Using the current cycle shown in figure 8, the electrical offset current $I_{O\,E}$ is the residual output referred to primary when the input current is zero.

$$I_{O\,E} = \frac{I_{S\,(3)} + I_{S\,(5)}}{2}$$

The temperature variation $I_{O\,T}$ of the electrical offset current $I_{O\,E}$ is the variation of the electrical offset from 25 °C to the considered temperature.

$$I_{O\,T}(T) = I_{O\,E}(T) - I_{O\,E}(25\ °C)$$

Magnetic offset referred to primary

The magnetic offset current $I_{O\,M}$ is the consequence of a current on the primary side (“memory effect” of the transducer’s ferro-magnetic parts). It is measured using the following primary current cycle. $I_{O\,M}$ depends on the current value $I_P \geq I_{P\,N}$.
K_{OL}: Overload factor

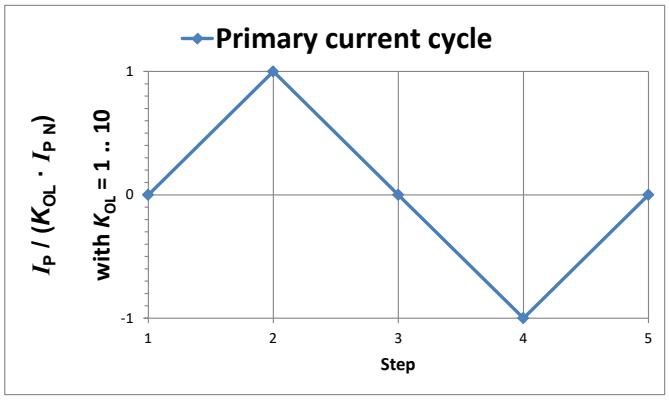

Figure 8: Current cycle used to measure magnetic and electrical offset (transducer supplied)

$$I_{O\,M} = \frac{I_{S\,(3)} - I_{S\,(5)}}{2}$$

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Performance parameters definition

Sensitivity and linearity

To measure sensitivity and linearity, the primary current (DC) is cycled from 0 to I_P, then to $-I_P$ and back to 0 (equally spaced $I_P/10$ steps). The sensitivity S is defined as the slope of the linear regression line for a cycle between $\pm I_{PN}$.
The linearity error ε_L is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of I_{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 current di/dt.
They are measured at nominal current.

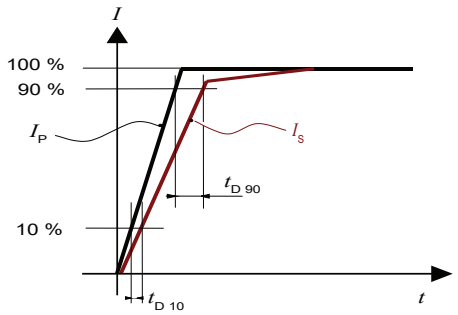

Figure 9: t_{D10} (delay time @ 10 %) and t_{D90} (delay time @ 90 %)

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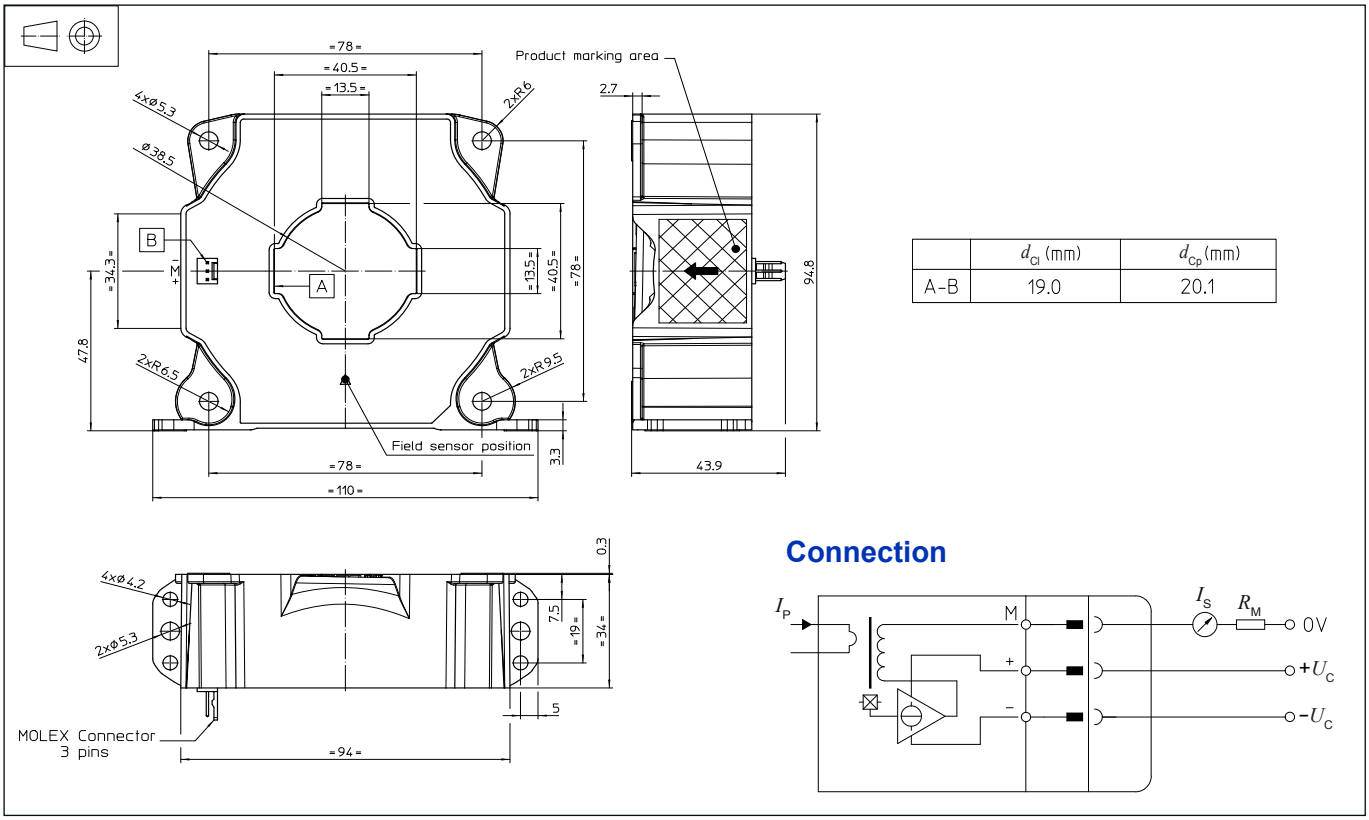
Dimensions (in mm)



	d_{Cl} (mm)	d_{Cp} (mm)
A-B	19.0	20.1

Connection

Mechanical characteristics

• General tolerance	±0.5 mm
• Transducer fastening Vertical position	2 holes Ø 5.3 mm 2 M5 steel screws
Recommended fastening torque	3.2 N·m (±10 %)
Or	4 holes Ø 4.2 mm 4 M4 steel screws
Recommended fastening torque	2.1 N·m (±10 %)
• Primary through-hole	Ø 38 mm
Or	40 mm × 13 mm
• Transducer fastening Horizontal position	4 holes Ø 5.3 mm 4 M5 steel screws
Recommended fastening torque	3.2 N·m (±10 %)
• Connection of secondary	Molex 6410

Remarks

- I_S is positive when I_P flows in the direction of arrow.
- The secondary cables also have to be routed together all the way.
- Installation of the transducer is to be done without primary current or secondary voltage present.
- Maximum temperature of primary conductor: see page 3.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements...), please contact us.
- 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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