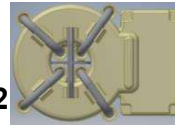


**Differential Current Sensor with tripping characteristic acc. to the partly combined standards IEC62955:2018 and UL2231-2 Ed.2**



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K-No.: 30733

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### Description

- Fluxgate current sensor with toroidal core
- PCB mounting

### Characteristics

- Excellent accuracy
- Switching open-collector outputs
- Compact design

### Applications

- Mainly used for stationary applications:
- Wallbox
  - Personnel Protection Systems for EV acc. to UL2231

Patents: EP2571128 / US9397494 / CN103001175 // EP2813856

### Electrical data – Ratings

		min.	typ.	max.	Unit
$I_P$	Primary nominal RMS current (1phase / 3phase)		32	40	A
$I_{\Delta N1}$	Rated residual fault current 1		6		mA DC
$I_{\Delta N2}$	Rated residual fault current 2		20		mA rms
$I_{\Delta N1, tolerance}$	Trip tolerance 1 (PIN X6-OUT)	4	5	6	mA DC
$I_{\Delta N2, tolerance}$	Trip tolerance 2 (PIN X20-OUT)	15		20 <sup>(1)</sup> / 70 <sup>(2)</sup>	mA rms
SPWM-OUT	Scaling factor of the DC component $I_{\Delta N1}$ <b>(for monitoring purpose only!)</b>		3.33		%/mA
$I_{\Delta RI, 1/2}$ (Fig.1)	Recovery current level for $I_{\Delta N1}/I_{\Delta N2}$ (absolute value DC/rms)		2.5 / 10		mA

(1) f = rated frequency (2) f = 2kHz

### Accuracy – Dynamic performance data

$I_{\Delta N, max}$	Measuring range (peak)	-300		+300	mA
X	Resolution (@ $I_{\Delta N}$ , $\Theta_A = 25^\circ C$ )		< 0.2		mA
$t_r$	Response times				According to IEC62955:2018 <sup>(3)</sup> According to UL2231-2 Ed.2
$f_{BW}$ (Fig.4)	Frequency range	DC		2	kHz

### General data

$\vartheta_A$	Ambient operation temperature	-40		85	°C
$\vartheta_{Storage}$	Ambient storage temperature <sup>(4)</sup>	-40		85	°C
m	Mass		32		g
$V_{CC}$	Supply voltage	4.8	5	5.2	V
$I_{CC}$	Supply current		33		mA rms
$S_{clear, pp}$	Clearance (primary to primary) <sup>(5)</sup>			4.22mm	
$S_{creep, pp}$	Creepage (primary to primary) <sup>(5)</sup>			5.65mm	
$S_{clear, ps}$	Clearance (primary to secondary) <sup>(6)</sup>			6.53mm	
$S_{creep, ps}$	Creepage (primary to secondary) <sup>(6)</sup>			7.75mm	
FIT	EN/IEC 61709 / SN 29500 <sup>(7)</sup>		<2200		fit

<sup>(3)</sup> Switching time of a standard relay (t = 20ms) is considered.

<sup>(4)</sup> see VAC M-sheet 3101; storage temperature inside cardboard packaging.

<sup>(5)</sup> Can only be achieved with the isolator; all values acc. to applied standards.

<sup>(6)</sup> Designed, manufactured and tested in accordance with IEC60664-1:2020. The isolation coordination is according to: Reinforced insulation, Insulation material group 1, Pollution degree 2, altitude ≤ 5500m and overvoltage category III.

<sup>(7)</sup> The results are valid under following conditions: 55°C mean component ambient temperature by continuous operation (8760h per year); Environment condition: ground mobile, no dust or harmful substances, according to IEC61709; Fit equals one failure per 10<sup>9</sup> component hours.

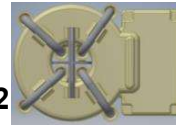
### General description of sensor function:

The Sensor is sensitive to AC and DC current and can be used for fault current detection in wallbox applications or personnel protection systems for EV. The Sensor detects DC fault current according to IEC62955:2018 and AC fault currents according to UL2231-2 Ed.2 In the event of a DC fault current, PIN 3 will change its state from a low level (GND) to high impedance state. In the event of an AC fault current, PIN 4 will change state from a low level (GND) to a high impedance state, see tab.1. Error conditions (e.g. an internal error) are signaled on PIN 1 (ERROR-OUT).

The sensor only fulfills the switch-off characteristic of the IEC62955 standard (monitoring the residual current). An additional driver-circuit must be used for driving RCBO, RCCB or circuit breaker as defined in IEC62955. The sensor's outputs are limited to max. 40V/50mA!

Datum	Name	Index	Änderung
11.12.2023	MB	82	Update of firmware. CN23-057
Editor.: MC-PD-CS    Designer: MB    MC-PM: BZ    Released by: SB			

**Differential Current Sensor with tripping characteristic acc. to the partly combined standards IEC62955:2018 and UL2231-2 Ed.2**



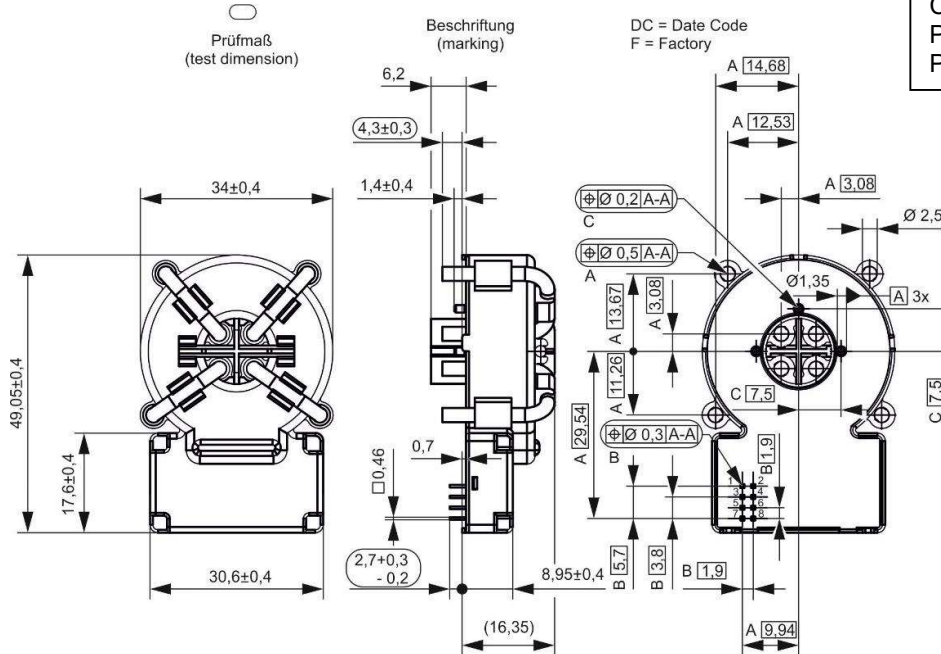
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**Mechanical outline (mm):** General tolerances DIN ISO 2768-c



Connections:  
PIN no. 1-8: 0.46mm x 0.46mm  
PIN no. 9-16:  $\varnothing = 2.5\text{mm}$

**Marking:**

benvac  
4641-X827  
F DC

Content of Data-Matrix-Code is: benvac, 4641-X827, F, DC

Datecode  
Format: [YWW]  
Example: J04:  
2017, Week 4

**PIN description:**

PIN no.	Description
PIN 1 → ERROR-OUT (open collector output)	If no system fault is detected, the output PIN 1 is a low level (GND). If a system fault is detected, PIN 1 is high impedance. In this case, PINs 3 and 4 will be set to a high impedance state (see tab. 1).
PIN 2 → TEST-IN (refer to Fig. 2)	A function test including an offset measurement (this value is stored in EEPROM for further calculation) is activated if this PIN is connected to GND for a period of 40ms to 1.2s. If the PIN is set to GND less than 40ms or more than 1.2s, no function test will be performed. <b>Attention:</b> During the functional test and offset measurement, no differential current shall flow. <b>To ensure high accuracy of the sensor this test shall be activated at regular intervals (e.g. at startup, before measuring...).</b> If a push-pull switch is used, the voltage range must be 0V...5V.
PIN 3 → X6-OUT (open collector output)	If the residual current is below DC 6mA and no system fault occurs the output on PIN 3 is a low level (GND). In any other case output PIN 3 is in a high impedance state (see tab. 1).
PIN 4 → X20-OUT (open collector output)	If the residual current is below the 20mA rms and no system fault occurs the output on PIN 4 is a low level (GND). In any other case PIN 4 is in a high impedance state (see tab. 1).
PIN 5 → GND	Ground connection
PIN 6 → VCC	Positive supply voltage
PIN 7 → PWM-OUT	Acc. to the DC component of residual current a duty-cycle with $f=8\text{kHz}$ is generated. This is for monitoring purposes only and is not safety function! Refer to $S_{\text{PWM-OUT}} = 3.33\%/mA$
PIN 8 → N.C.	Not connected
PIN 9 – 16	For primary wires connection

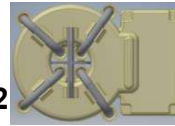
Editor.: MC-PD-CS

Designer: MB

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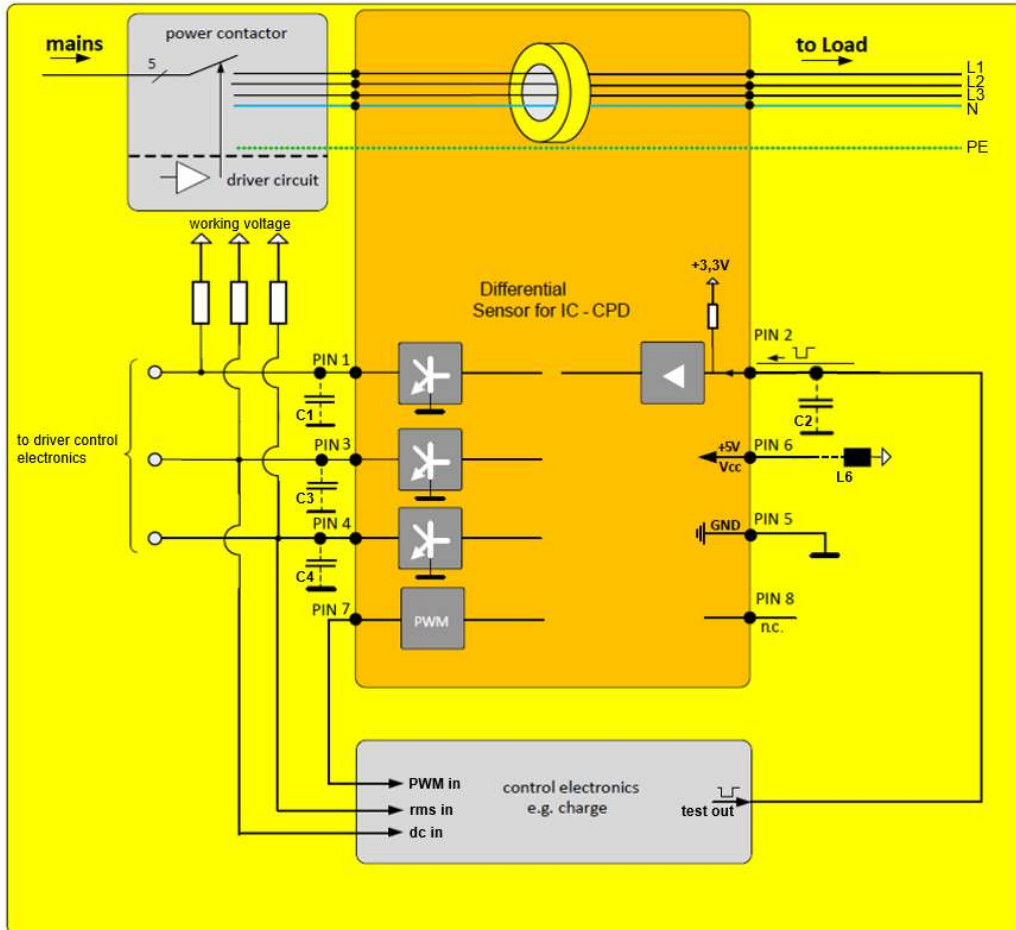
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**Typical application diagram:**



Recommended: C1, C3, C4 with 100nF to ground and C2 with 10nF to ground as optional EMC improvement. (Components have to be placed close to the device pins)

L6 is not longer recommended for new designs, in existing layouts component L6 should be used with the following parameters:

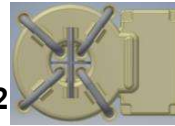
L6: Inductance  $\leq 220 \mu\text{H}$ ; DC Resistance 1 to 5  $\Omega$

**Absolute maximum ratings<sup>(8)</sup>:**

		Min	Typ.	Max	Unit
$V_{CE}$	Collector-Emitter voltage (PINs 1, 3 and 4)			40	V
$I_C$	Collector current (PINs 1, 3 and 4)			50	mA
$V_{CC}$	Maximum supply voltage (without function)	-0.3		6	V
$U_{MAX}$	Maximum rated voltage of primary conductors			440	V
$V_{TEST-IN, high}$	TEST-IN Input Voltage, high level	0		0.6	V
$V_{TEST-IN, low}$	TEST-IN Input Voltage, low level	2.5		5	V

<sup>(8)</sup> Stresses above these ratings may cause permanent damage. Exposure to these conditions for extended periods may degrade device reliability. Functional operation of the device at these or any other conditions beyond those specified is not supported.

**Differential Current Sensor with tripping characteristic acc. to the partly combined standards IEC62955:2018 and UL2231-2 Ed.2**



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**Final Tests:** (Measurements after temperature balance of the samples at room temperature, SC=significant characteristic)

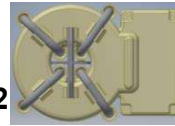
		Min.	Max.	Unit
Vcc	Supply voltage	4.9	5.1	V
Icc	Supply current	16	28	mA
TEST-IN	TEST-IN voltage	2.8	3.4	V
X6-OUT (normal)	X6-OUT voltage	0	0.6	V
X20-OUT (normal)	X20-OUT voltage	0	0.6	V
ERROR-OUT (normal)	ERROR-OUT voltage	0	0.6	V
X6-OUT (activated)	X6-OUT voltage activated @5V, 1kΩ (pull-up)*	4.9	5.1	V
X20-OUT (activated)	X20-OUT voltage activated @5V, 1kΩ (pull-up)*	4.9	5.1	V
ERROR-OUT (activated)	ERROR-OUT voltage activated @5V, 1kΩ (pull-up)*	4.9	5.1	V
TC1 (SC)	Trip current 1 – X6	4.5	5.4	mA
TC2 (SC)	Trip current 2 – X6	-5.4	-4.5	mA
TC3 (SC)	Trip current 3 – X20@60Hz	14	20	mA
PWM-OUT (frequency)	PWM-OUT frequency	7.8	8.2	kHz
PWM-OUT (duty-cycle)	PWM-OUT duty-cycle @6mA DC	18	22	%
LV1 (SC)	Limit values of break time - X6-OUT@6mA DC	0	700	ms
LV2 (SC)	Limit values of break time – X20-OUT@20mA, 60Hz	0	1000	ms
NTC1	X6-OUT & X30-OUT@50mA,50Hz	0	0,6	V

\* the maximum values of collector-emitter voltage and current see “Absolute maximum ratings”

**Product Tests:** The EMC product standards can only be fulfilled in the complete application system (more EMC test's can be shown if required).

	Acc. to VAC sheet M3238	passed
	Following tests differ from M3238:	
	4.5a: Damp heat, steady state. Duration: 1000h	
ESD	Air- and contact discharge; U=±2000V, R=1500Ω, C=100pF Acc. to Human Body Model JESD22-A114	±2.0 kV

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**Requalification Tests:** (replicated every year, Precondition acc. to M3238)

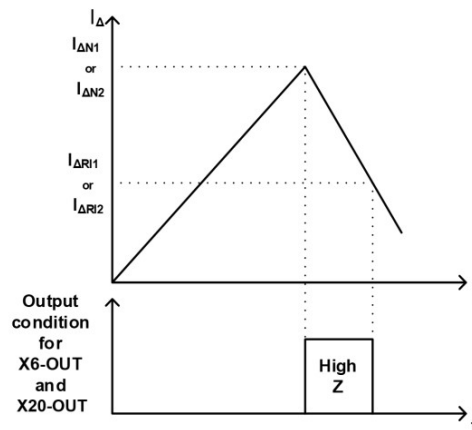
$\hat{U}_{W, \text{prim-sec}}$	M3064	Impulse test (1.2 $\mu$ s/50 $\mu$ s waveform) PIN 1-8 vs. PIN 9-14 5 pulse $\rightarrow$ polarity +, 5 pulse $\rightarrow$ polarity -	5.5	kV rms
$\hat{U}_{W, \text{prim-prim}}$	M3064	Impulse test (1.2 $\mu$ s/50 $\mu$ s waveform) PIN 9 vs. PIN 11, PIN 11 vs. PIN 13, PIN 13 vs. PIN 15, PIN 15 vs. PIN 9 5 pulse $\rightarrow$ polarity +, 5 pulse $\rightarrow$ polarity -	4.0	kV rms
$U_d$	M3014	Test voltage, 60s PIN 1-8 vs. PIN 9-14	1.5	kV rms
$U_{d, \text{prim-prim}}$	M3014	Test voltage between primary conductors, 5s PIN 9 vs. PIN 11, PIN 11 vs. PIN 13, PIN 13 vs. PIN 15, PIN 15 vs. PIN 9	1.5	kV rms
$U_{PDE}$	M3024	Partial discharge voltage (extinction) PIN 1-8 vs. GND *acc. to table 24	1.2	kV rms
$U_{PD} \times 1.875$	M3024	Partial discharge voltage (extinction) PIN 1-8 vs. GND *acc. to table 24	1.5	kV rms

\* IEC 61800-5-1:2007

**Other instructions:**

- Temperature of the primary conductor should not exceed 105°C.
- Vcc during Test-IN function test must be in rated range.
- Housing and bobbin material UL-listed, flammability class 94V-0.
- Fall- and rise-time of Vcc:  $t > 20\mu\text{s/V}$
- UL certification is still pending
- Further standards UL 2231 E file No. 488116, category FFUQ2 / FFUQ8

**Figures:**



**Fig. 1: Meaning of switching recovery level**

If the trip-level  $I_{\Delta N1}/I_{\Delta N2}$  is accomplished the outputs X6-OUT/X20-OUT will change their state from low-level (GND) to high impedance. Depending on the existence of the residual current  $I_{\Delta}$ , the outputs X6-OUT/X20-OUT will remain in this state until  $I_{\Delta}$  falls below the threshold  $I_{\Delta R11}/I_{\Delta R12}$ .

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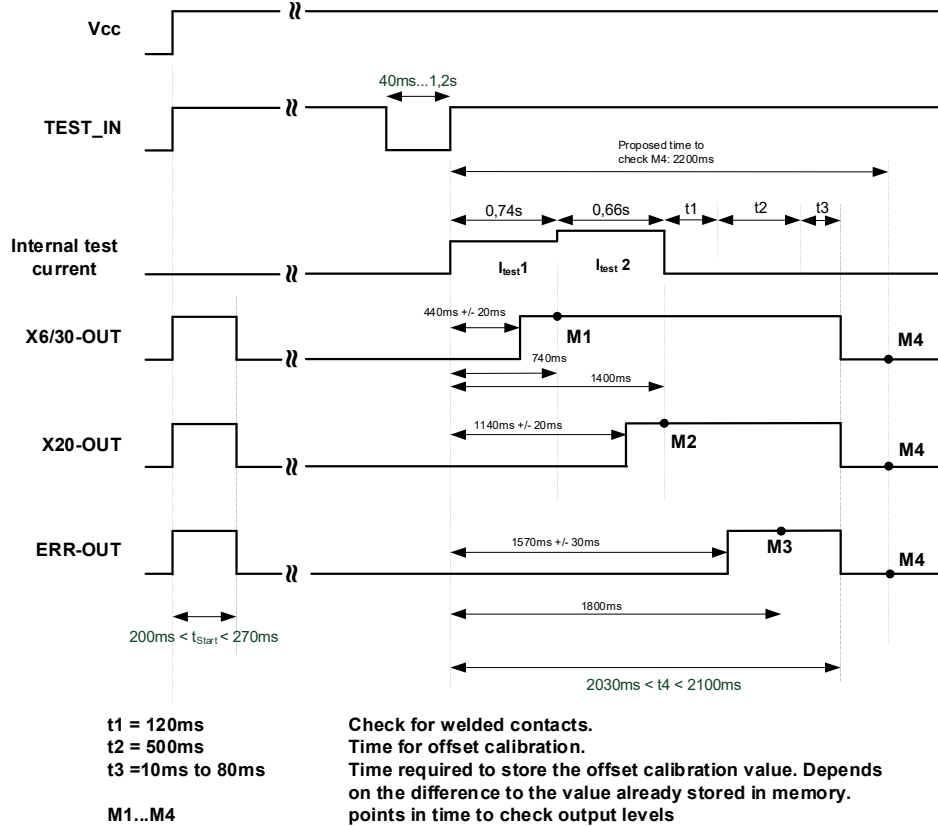


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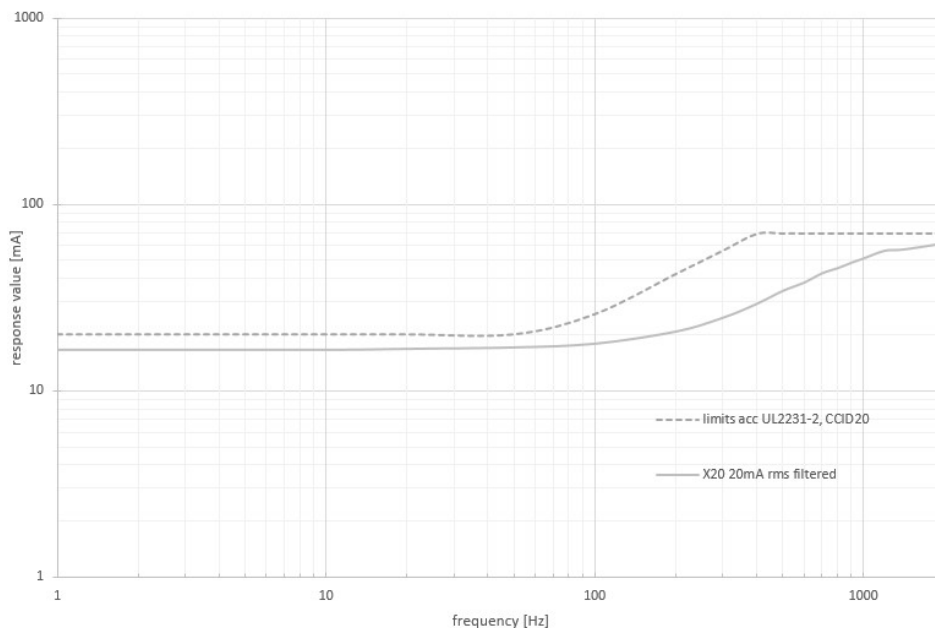
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**Fig. 2: Power-Up timing diagram**



**Fig. 3: UL2231 response value over frequency**

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X6-OUT	X20-OUT	ERROR-OUT	State
GND	GND	GND	Normal condition
High impedance	GND	GND	$I_{\Delta} \geq 6mA_{DC}$
GND	High impedance	GND	$I_{\Delta N2} \geq 20mA_{rms}$
High impedance	High impedance	GND	$I_{\Delta} \geq 6mA_{DC}$ AND $I_{\Delta N2} \geq 20mA_{rms}$
High impedance	High impedance	High impedance	Error, system fault

All other conditions not mentioned in the table are not possible. If these conditions occur, the sensor is in unknown state and describes an Error.

**Table 1: Possible output states**

	6mA	60mA	200mA
Standard values acc. to IEC62955:2018	10s	0.3s	0.1s
Typical values of sensor	0.45s	0.06s	0.035s

**Table 2: Maximum and typical values of break time for residual direct currents**