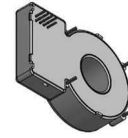**Differential Current Sensor with tripping characteristic acc. to the partly combined standards IEC62752:2016 and UL2231-2 Ed.2**

Date: 16.11.2022

K-No.:30560

Customer: Standard type

Description
- Fluxgate current sensor with toroidal core
- PCB mounting

Patents: EP2571128 / US9397494 / CN103001175 // EP2813856

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

Applications
Mainly used for stationary and mobile applications:
- IC-CPD acc. to IEC62752
- Personnel Protection Systems for EV acc. to UL2231

Electrical data – Ratings

		min.	typ.	max.	Unit
I_P	Primary rated current (1phase / 3phase)			80 / 40	A
$I_{\Delta N1}$	Rated residual fault current 1		6		mA dc
$I_{\Delta N2}$	Rated residual fault current 2		20		mA rms
$I_{\Delta N3}$	Rated residual fault current 3		30		mA rms
$I_{\Delta N1, tolerance}$	Trip tolerance 1 (PIN X6/30-OUT)	4		6	mA dc
$I_{\Delta N2, tolerance}$	Trip tolerance 2 (PIN X6/30-OUT)	20		30	mA rms
$I_{\Delta N3, tolerance}$	Trip tolerance 3 (PIN X20-OUT)	15		$20^{(1)}$ / $70^{(2)}$	mA rms
$S_{PWM-OUT}$	Scaling factor of the rms component **(for monitoring purpose only!)**		2		%/mA
$I_{\Delta RI,1/2}$ (Fig.1)	Recovery current level for $I_{\Delta N1}$ or $I_{\Delta N2/3}$ (absolute value dc/rms)		2.5 / 10		mA

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

Accuracy – Dynamic performance data

		min.	typ.	max.	Unit
$I_{\Delta N,max}$	Measuring range (peak)	-300		+300	mA
X	Resolution (@ $I_{\Delta N}$, Θ_A = 25°C)		< 0.2		mA
t_r	Response times		According to IEC62752:2016[3] According to UL2231-2 Ed.2		
f_{BW}	Frequency range	DC		2	kHz

General data

		min.	typ.	max.	Unit
ϑ_A	Ambient operation temperature	-40		85	°C
$\vartheta_{Storage}$	Ambient storage temperature[4]	-40		85	°C
m	Mass		21		g
V_{CC}	Supply voltage	4.8	5	5.2	V
I_{CC}	Supply current		33		mA rms
$S_{clear, ps}$	Clearance (primary to secondary)		not applicable if insulated cable is used[5]		
$S_{creep, ps}$	Creepage (primary to secondary)		not applicable if insulated cable is used[5]		
FIT	EN/IEC 61709 / SN 29500[6]		<2200		fit

[3] **Switching time of a standard relay (IEC: t = 20ms / UL: t = 10ms) is considered.**

[4] **see VAC M-sheet 3101; storage temperature inside cardboard packaging**

[5] **Constructed, manufactured and tested in accordance with IEC60664-1:2020 Isolated wires are preferred. If isolated primary conductors are used, the isolation coordination is according to: Reinforced insulation, Insulation material group 1, Pollution degree 2, and overvoltage category III.**

[6] **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 10^9 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 IC-CPD applications or personnel protection systems for EV. The Sensor detects DC & AC fault currents according to IEC62752:2016 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, PINs 4 and/or 3 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 by PIN 1 (ERROR-OUT) which changes state to high impedance.

Datum	Name	Index	Änderung
16.11.2022	SF	81	Change of typical application diagram. CN-22-157

| Editor.:R&D-PD-NPI D | Designer: SF | MC-PM: BZ | | Released by: SB |

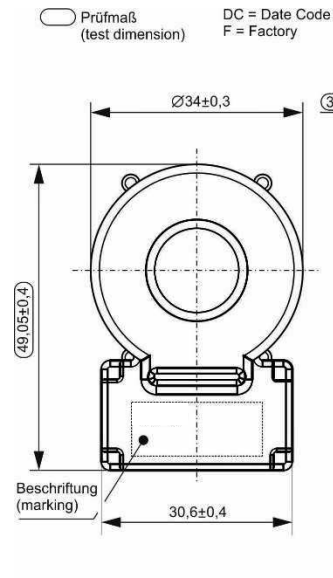|	**Specification**	**Item no.: T60404-N4641-X803**
VAC VACUUMSCHMELZE	**Differential Current Sensor with tripping characteristic acc. to the partly combined standards IEC62752:2016 and UL2231-2 Ed.2**	Date: 16.11.2022
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Mechanical outline (mm): General tolerances DIN ISO 2768-c

Prüfmaß (test dimension)
DC = Date Code
F = Factory

Ø34±0,3   (3,5±0,5)   □0,7
49,05±0,4
□0,46   0,7
Beschriftung (marking)
30,6±0,4   8,95±0,3   3,8   1,9
(13,65±0,3)

21,13   Ø13,5±0,3   27,9   43,49   5,7
4x ⊕0,3
8x ⊕0,4
1,9   18,6

Connections:

PIN no. 1-8: 0.46mm x 0.46mm
PIN no. 9-12: 0.7mm x 0.7mm
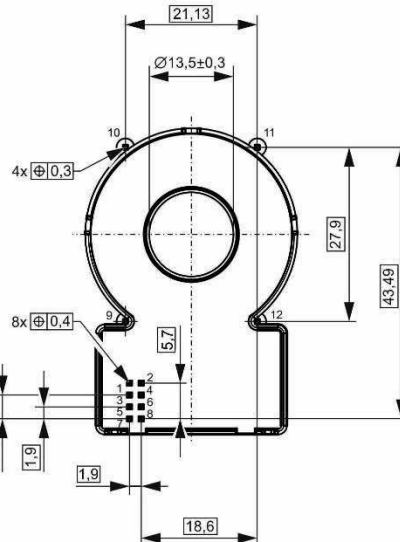
Marking:

benvac
4641-X803
F   DC

Content of Data-Matrix-Code is: benvac, 4641-X803, 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 at low level (GND). If a system fault is detected, PIN is at high impedance state. In this case, PINs 3 and 4 will be set to a high impedance state too (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. **Attention:** During the functional test and offset measurement, no differential current shall flow. **To ensure high accuracy of the sensor this test shall be activated at regular intervals (e.g. at startup, before measuring…).** If a push-pull switch is used, the voltage range must be 0V…5V.
PIN 3 → X6/30-OUT (open collector output)	If the residual current is below 6mA dc and no system fault occurs the output on PIN 3 is a low level (GND). If the residual current is below the 30mA rms and no system fault occurs the output on PIN 3 is also 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 PINs 4 are 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=8kHz is generated. This is for monitoring purposes only and shall not be used to switch the power relay. Refer to $S_{PWM\text{-}OUT} = 2\%/mA$
PIN 8 → N.C.	Not connected

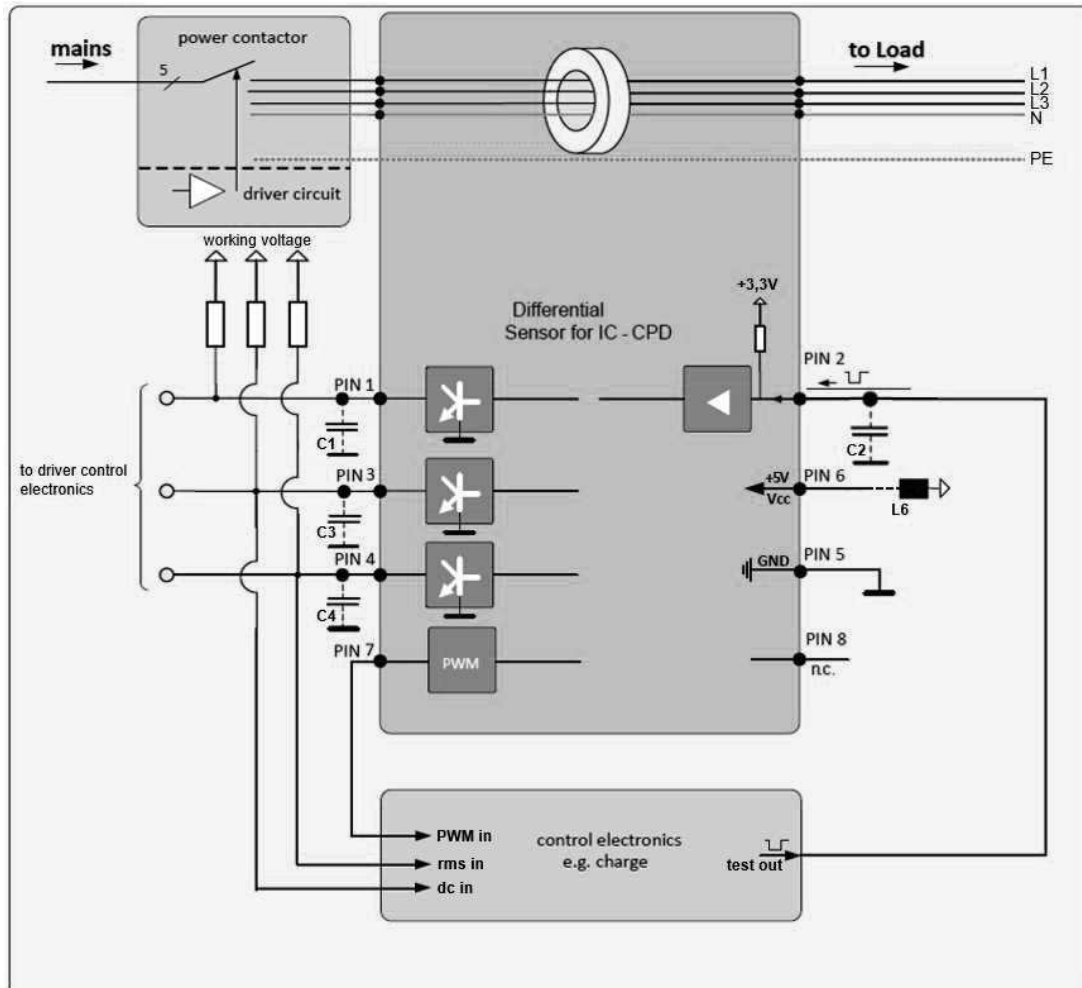| VAC VACUUMSCHMELZE	**Specification**	**Item no.:** **T60404-N4641-X803**
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Typical application diagram:

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 ≤220 µH; DC Resistance 1 to 5 Ω

Absolute maximung ratings[6]:

		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 (AC rms)			250	V
$V_{TEST-IN, low}$	TEST-IN Input Voltage, low level	0		0.6	V
$V_{TEST-IN, high}$	TEST-IN Input Voltage, high level	2.5		5	V

[6]**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.

Editor.:R&D-PD-NPI D	Designer: SF		MC-PM: BZ			Released by: SB

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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	16.0	28.0	mA
TEST-IN	TEST-IN voltage	2.8	3.4	V
X6/30-OUT (normal)	X6/30-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
X6/30-OUT (activated)	X6/30-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 – X6/30	4.5	5.4	mA
TC2 (SC)	Trip current 2 – X6/30	-5.4	-4.5	mA
TC3 (SC)	Trip current 3 – X30@50Hz	20	30	mA
TC4 (SC)	Trip current 4 – X20@60Hz	14	20	mA
TC5 (SC)	Trip current 5 – X30@1000Hz	105	149	mA
PWM-OUT (frequency)	PWM-OUT frequency	7.8	8.2	kHz
PWM-OUT (duty-cycle)	PWM-OUT duty-cycle @6mA, 60Hz	11	13	%
LV1 (SC)	Limit values of break time - X6/30-OUT@6mA DC	0	700	ms
LV2 (SC)	Limit values of break time - X6/30-OUT@30mA, 50 Hz	0	300	ms
LV3 (SC)	Limit values of break time – X20-OUT@20mA, 60Hz	0	1000	ms

* 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 Following tests differ from M3238: 4.5a: Damp heat, steady state. Duration: 1000h	passed	
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)

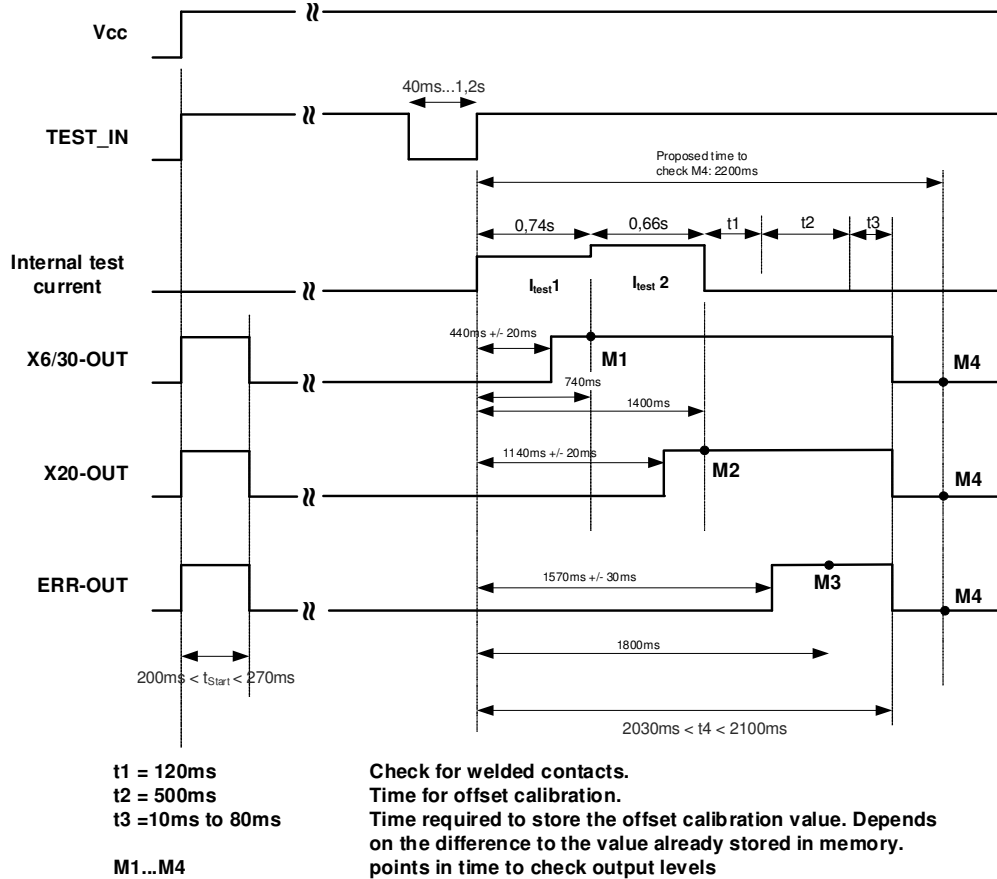|				
$\hat{U}_{W,\,prim\text{-}sec}$	M3064	Impulse test (1.2µs/50µs waveform) PIN 1-8 vs. insulated primary wire 5 pulse ➔ polarity +, 5 pulse ➔ polarity -	5.5	kV
U_d	M3014	Test voltage, 60s PIN 1-8 vs. insulated primary wire	1.5	kV rms
U_{PDE}	M3024	Partial discharge voltage (extinction) PIN 1-8 vs. insulated primary wire *acc. to table 24	1.2	kV rms
U_{PD} x 1.875	M3024	Partial discharge voltage (extinction) PIN 1-8 vs. insulated primary wire *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 > 20µs/V
- UL certification is still pending
- ~~Further standards UL 2231 E-file No. 488116, category FFUQ2 / FFUQ8~~

Figures:
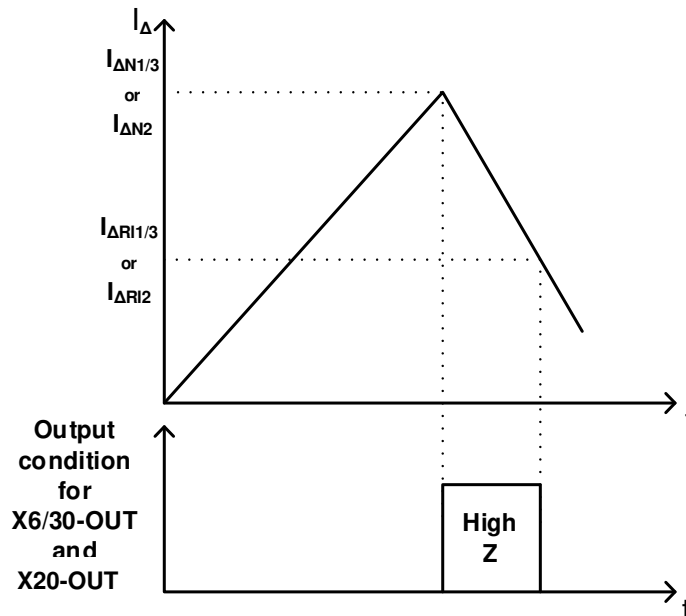
Fig. 1: Meaning of switching recovery level

If the trip-level $I_{\Delta N1/3}$/$I_{\Delta N2}$ is accomplished the corresponding output X6/30-OUT/X20-OUT will change its state from low-level (GND) to high impedance. Depending on the existence of the differential curent I_Δ, the outputs X6/30-OUT/X20-OUT will remain in their states until I_Δ is below the recovery threshold $I_{\Delta RI1/3}$/$I_{\Delta RI2}$.

Editor.:R&D-PD-NPI D	Designer: SF		MC-PM: BZ			Released by: SB

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t1 = 120ms   Check for welded contacts.
t2 = 500ms   Time for offset calibration.
t3 =10ms to 80ms   Time required to store the offset calibration value. Depends on the difference to the value already stored in memory.
M1...M4   points in time to check output levels

Fig. 2: Power-Up timing diagram
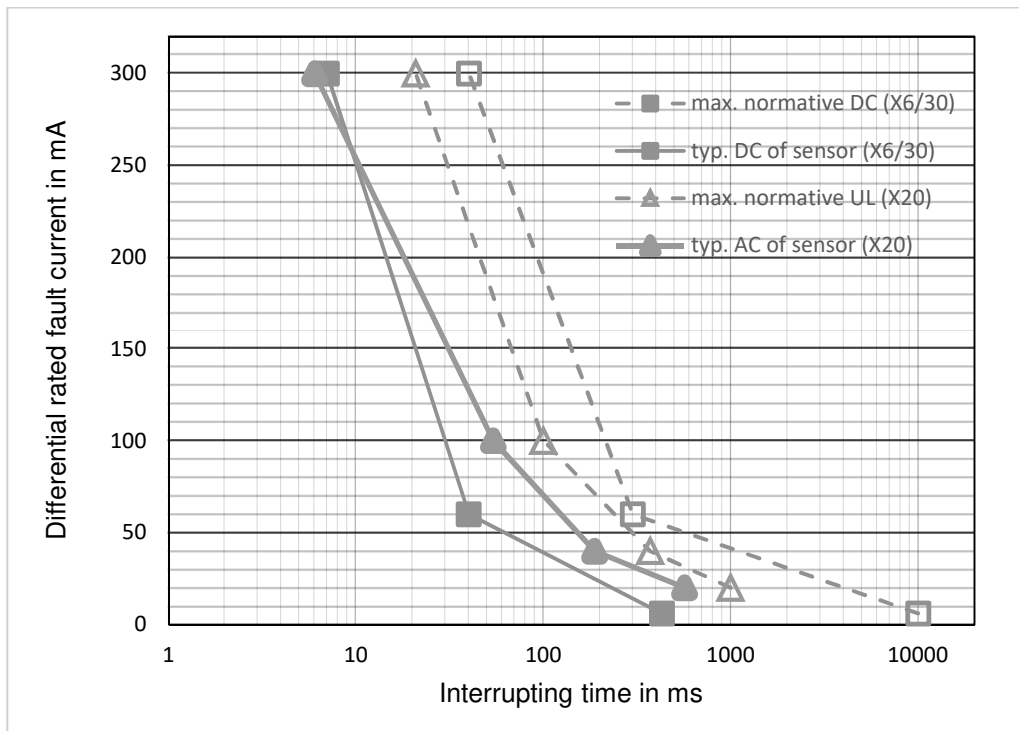
Fig. 3: Interrupting Time according to IEC62752 (E)-1:2016, UL2231-2 Ed.2 and typical values of sensor

Editor.:R&D-PD-NPI D	Designer: SF	MC-PM: BZ		Released by: SB

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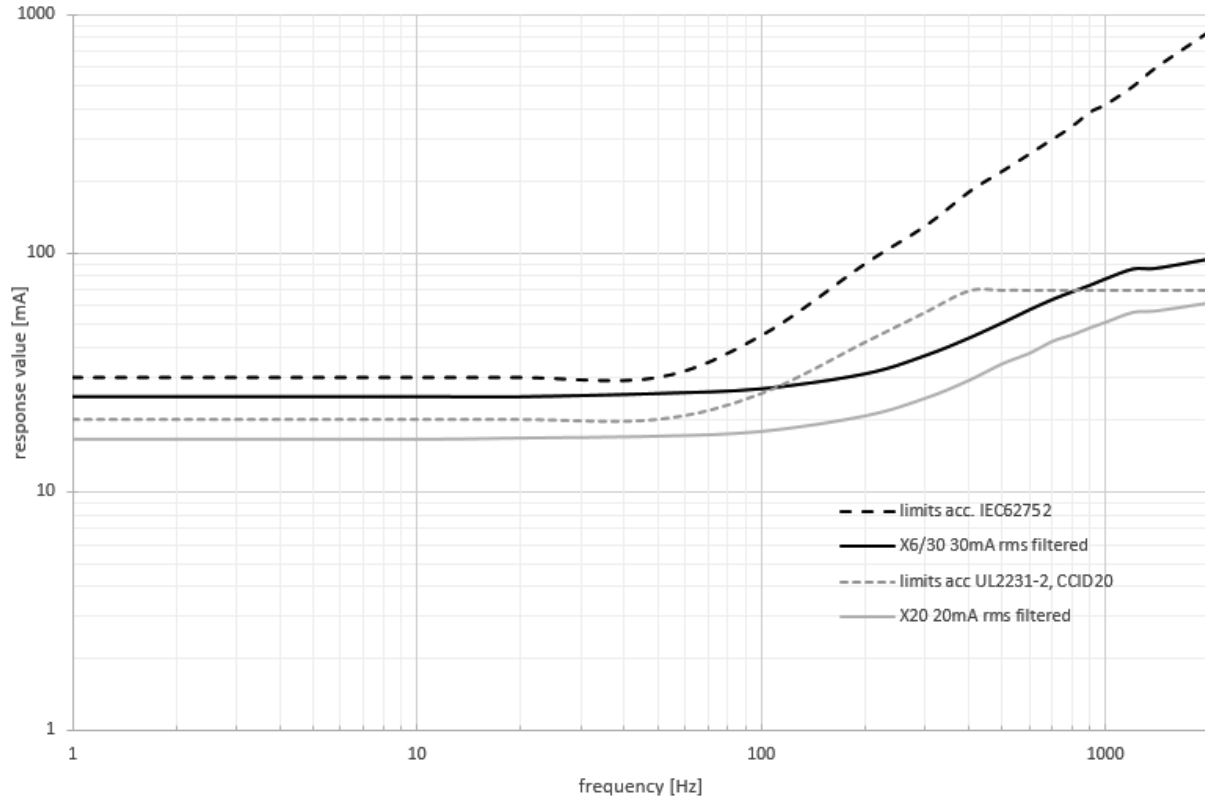
Fig. 4:IEC62752 and UL2231 response value over frequency

X6/30-OUT	X20-OUT	ERROR-OUT	State
GND	GND	GND	Normal condition
High impedance	GND	GND	$I_{\Delta N1} \geq 6mA_{DC}$
GND	High impedance	GND	$I_{\Delta N2} \geq 20mA_{rms} - 30mA_{rms}$
High impedance	High impedance	GND	$I_{\Delta N3} \geq 30mA_{rms}$
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 an unknown state and describes an Error.			

Table 1: Possible output states