

# ISOMETER® IR155-3203/IR155-3204

Insulation monitoring device (IMD) for unearthed DC drive systems (IT systems) in electric vehicles

**Version V004**



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Insulation monitoring device (IMD) for unearthed DC drive systems (IT systems) in electric vehicles



ISOMETER® IR155-3204

## Device features

- Suitable for 12 V and 24 V systems
- Automatic device self test
- Continuous measurement of the insulation resistance 0...10 MΩ
  - Response time for the first measurement of the system state (SST) is < 2 s after switching the supply voltage on
  - Response time < 20 s for insulation resistance measurement (DCP)
- Automatic adaptation to the existing system leakage capacitance ( $\leq 1 \mu\text{F}$ )
- Detection of earth faults and interruption of the earth connection
- Insulation monitoring of AC and DC insulation faults for unearthed systems (IT systems) 0...1000 V
- Undervoltage detection for voltages below 500 V (adjustable at factory by Bender)
- Short-circuit proof outputs for:
  - Fault detection (high-side output)
  - Measured value (PWM 5...95 %) and status ( $f = 10...50 \text{ Hz}$ ) at high or inverted low-side driver ( $M_{HS}/M_{LS}$  output)
- Protective coating (SL 1301ECO-FLZ)

## Approvals



### ATTENTION



Observe precautions for handling electrostatic sensitive devices.  
Handle only at safe work stations.

### ATTENTION



The device is monitoring HIGH VOLTAGE.  
Be aware of HIGH VOLTAGE near to the device.

## Product description

The ISOMETER® IR155-3203/-3204 monitors the insulation resistance between the insulated and active HV-conductors of an electrical drive system ( $U_n = \text{DC } 0 \text{ V} \dots 1000 \text{ V}$ ) and the reference earth (chassis ground ▶ Kl.31). The patented measurement technology is used to monitor the condition of the insulation on the DC side as well as on the AC motor side of the electrical drive system. Existing insulation faults will be signalled reliably, even under high system interferences, which can be caused by motor control processes, accelerating, energy recovering etc.

Due to its space-saving design and optimised measurement technology, the device is optimised for use in hybrid or fully electric vehicles. The device meets the increased automotive requirements with regard to the environmental conditions (e.g. temperatures and vibration, EMC...).

The fault messages (insulation fault at the HV-system, connection or device error of the IMD) will be provided at the integrated and galvanic isolated interface (high- or low-side driver). The interface consists of a status output ( $OK_{HS}$  output) and a measurement output ( $M_{HS}/M_{LS}$  output). The status output signals errors or that the system is error free, i.e. the "good" condition as shown by the "Operating principle PWM driver" diagram on page 5. The measurement output signals the actual insulation resistance. Furthermore, it is possible to distinguish between different fault messages and device conditions, which are base frequency encoded.

## Function

The ISOMETER® iso-F1 IR155-3203/-3204 generates a pulsed measuring voltage, which is superimposed on the IT system via terminals L+/L- and E/KE. The latest measured insulation condition is available as a pulse-width-modulated (PWM) signal at terminals  $M_{HS}$  (for IR155-3204) or  $M_{LS}$  (for IR155-3203). The connection between the terminals E/KE and the chassis ground (▶ Kl.31) is continuously monitored. Therefore it is necessary to install two separated conductors from the terminals E or KE to chassis ground.



Connection monitoring of the earth terminals E/KE is specified for  $R_F \leq 4 \text{ M}\Omega$  if the ISOMETER® is connected as shown in the application diagram on page 3.

Once power is switched on, the device performs an initialisation and starts the system state (SST) measurement. The ISOMETER® provides the first estimated insulation resistance during a maximum time of 2 seconds. The DCP measurement (▶ continuous measurement method) starts subsequently. Faults in the connecting wires or functional faults will be automatically recognised and signalled.

During operation, a self test is carried out automatically every five minutes. The interfaces will not be influenced by these self tests.



Connection monitoring of the earth terminals E/KE may not work as intended when  $R_F > 4 \text{ M}\Omega$  if the supply terminals (Kl.15/Kl.31) are not galvanically isolated from the chassis earth (Kl.31).

## Standards

### Corresponding standards and regulations\*

IEC 61557-8	2014-12
IEC 61010-1	2010-06
IEC 60664-1	2004-04
ISO 6469-3	2011-12
ISO 23273-3	2006-11
ISO 16750-1	2006-08
ISO 16750-2	2010-03
ISO 16750-4	2010-04
E1 (ECE regulation No. 10 revision 5)	
acc. 72/245/EWG/EEC	2009/19/EG/EC
DIN EN 60068-2-38	Z/AD:2010
DIN EN 60068-2-30	Db:2006
DIN EN 60068-2-14	Nb:2010
DIN EN 60068-2-64	Fh:2009
DIN EN 60068-2-27	Ea:2010

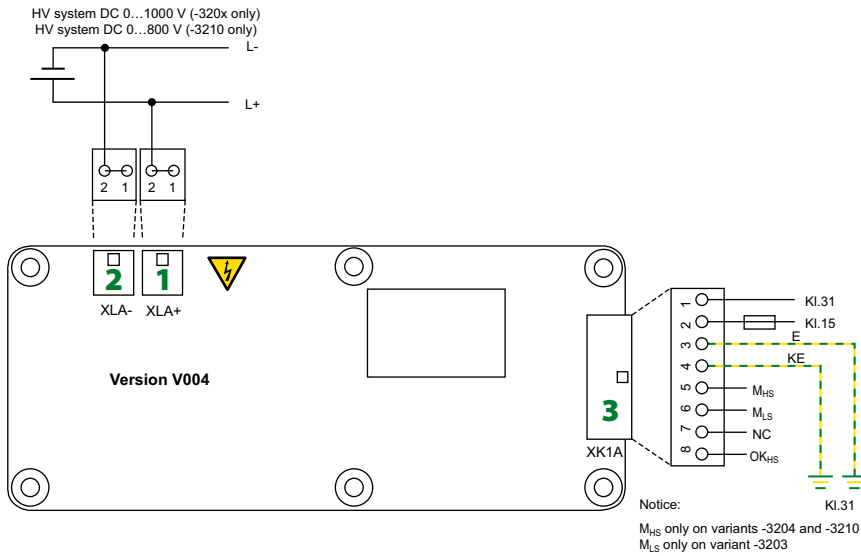
### \* Normative exclusion

The device went through an automotive test procedure in combination with multi customer requirements reg. ISO16750-x.  
The standard IEC61557-8 will be fulfilled by creating the function for LED warning and test button at the customer site if necessary.  
The device includes no surge and load dump protection above 60 V. An additional central protection is necessary.

## Abbreviations

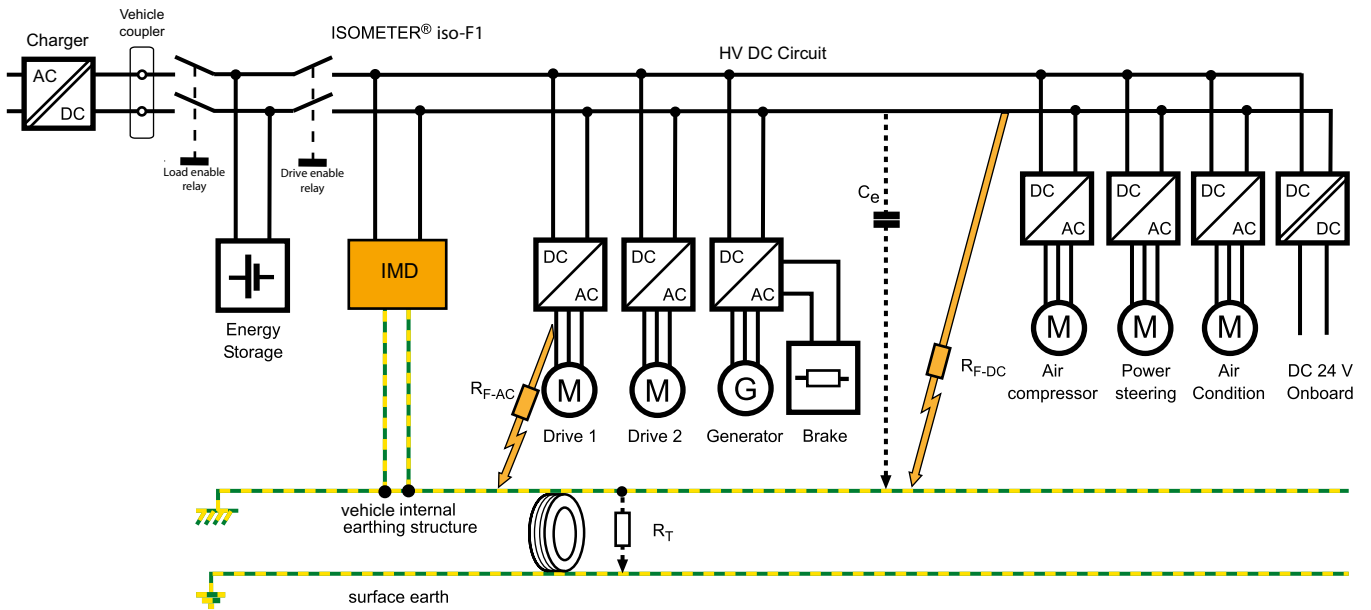
DCP	Direct Current Pulse
SST	Speed Start Measuring

Wiring diagrams



- 1 - Connector XLA+**  
 Pin 1+2 L+ Line Voltage
- 2 - Connector XLA-**  
 Pin 1+2 L- Line Voltage
- 3 - Connector XK1A**
  - Pin 1 KI.31 Chassis ground/  
 electronic ground
  - Pin 2 KI.15 Supply voltage
  - Pin 3 KI.31 Chassis ground
  - Pin 4 KI.31 Chassis ground  
 (separate line)
  - Pin 5 M<sub>HS</sub> Data Out, PWM  
 (high side)
  - Pin 6 M<sub>LS</sub> Data Out, PWM  
 (low side)
  - Pin 7 n.c.
  - Pin 8 OK<sub>HS</sub> Status Output  
 (high side)

Typical application



**Technical data**

**Insulation coordination acc. to IEC 60664-1**

Protective separation (reinforced insulation)  
between (L+/L-) – (Kl. 31, Kl. 15, E, KE,  $M_{HS}$ ,  $M_{LS}$ ,  $OK_{HS}$ )

Voltage test AC 3500 V/1 min

**Supply/IT system being monitored**

Supply voltage $U_S$	DC 10...36 V
Max. operating current $I_S$	150 mA
Max. current $I_k$	2 A
	6 A/2 ms inrush current
HV voltage range (L+/L-) $U_N$	AC 0...1000 V (peak value) 0...660 V r.m.s. (10 Hz...1 kHz) DC 0...1000 V
Power consumption	< 2 W

**Response values**

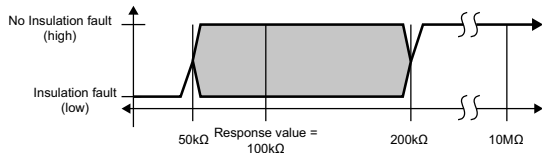
Response value hysteresis (DCP)	25 %
Response value $R_{an}$	100 k $\Omega$ ...1 M $\Omega$
Undervoltage detection	0...500 V

**Measuring range**

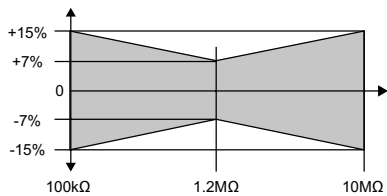
Measuring range	0...10 M $\Omega$
Undervoltage detection	0...500 V default setting: 0 V (inactive)
Relative uncertainty	
SST ( $\leq 2$ s)	good $> 2^* R_{an}$ ; bad $< 0.5^* R_{an}$
Relative uncertainty DCP	0...85 k $\Omega$ $\blacktriangleright$ $\pm 20$ k $\Omega$
(default setting 100 k $\Omega$ )	100 k $\Omega$ ...10 M $\Omega$ $\blacktriangleright$ $\pm 15$ %
Relative uncertainty output M (fundamental frequency)	$\pm 5$ % at each frequency (10 Hz; 20 Hz; 30 Hz; 40 Hz; 50 Hz)

Relative uncertainty undervoltage detection  $U_N \geq 100$  V  $\blacktriangleright$   $\pm 10$  %; at  $U_N \geq 300$  V  $\blacktriangleright$   $\pm 5$  %

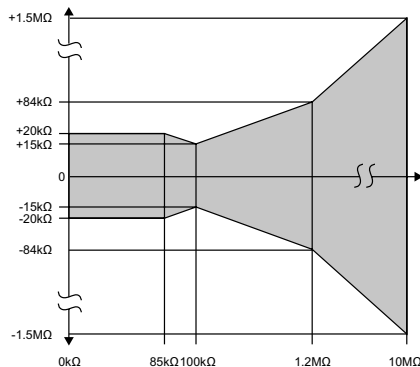
Relative uncertainty (SST)  
"Good condition"  $\geq 2^* R_{an}$   
"Bad condition"  $\leq 0.5^* R_{an}$



Relative uncertainty DCP	100 k $\Omega$ ...10 M $\Omega$ $\pm 15$ %
	100 k $\Omega$ ...1.2 M $\Omega$ $\blacktriangleright$ $\pm 15$ % to $\pm 7$ %
	1.2 M $\Omega$ $\blacktriangleright$ $\pm 7$ %
	1.2...10 M $\Omega$ $\blacktriangleright$ $\pm 7$ % to $\pm 15$ %
	10 M $\Omega$ $\blacktriangleright$ $\pm 15$ %



Absolute uncertainty 0...85 k $\Omega$   $\blacktriangleright$   $\pm 20$  k $\Omega$



**Time response**

Response time  $t_{an}$  ( $OK_{HS}$ ; SST)  $t_{an} \leq 2$  s (typ.  $< 1$  s at  $U_N > 100$  V)  
Response time  $t_{an}$  ( $OK_{HS}$ ; DCP)

(when changing over from  $R_F = 10$  M $\Omega$  to  $R_{an}/2$ ; at  $C_e = 1$   $\mu$ F;  $U_N = DC 1000$  V)  
 $t_{an} \leq 20$  s (at  $F_{ave} = 10^*$ )  
 $t_{an} \leq 17.5$  s (at  $F_{ave} = 9$ )  
 $t_{an} \leq 17.5$  s (at  $F_{ave} = 8$ )  
 $t_{an} \leq 15$  s (at  $F_{ave} = 7$ )  
 $t_{an} \leq 12.5$  s (at  $F_{ave} = 6$ )  
 $t_{an} \leq 12.5$  s (at  $F_{ave} = 5$ )  
 $t_{an} \leq 10$  s (at  $F_{ave} = 4$ )  
 $t_{an} \leq 7.5$  s (at  $F_{ave} = 3$ )  
 $t_{an} \leq 7.5$  s (at  $F_{ave} = 2$ )  
 $t_{an} \leq 5$  s (at  $F_{ave} = 1$ )  
during the self test  $t_{an} + 10$  s

Switch-off time  $t_{ab}$  ( $OK_{HS}$ ; DCP)  
(when changing over from  $R_{an}/2$  to  $R_F = 10$  M $\Omega$ ; at  $C_e = 1$   $\mu$ F;  $U_N = DC 1000$  V)

$t_{ab} \leq 40$  s (at  $F_{ave} = 10$ )  
 $t_{ab} \leq 40$  s (at  $F_{ave} = 9$ )  
 $t_{ab} \leq 33$  s (at  $F_{ave} = 8$ )  
 $t_{ab} \leq 33$  s (at  $F_{ave} = 7$ )  
 $t_{ab} \leq 33$  s (at  $F_{ave} = 6$ )  
 $t_{ab} \leq 26$  s (at  $F_{ave} = 5$ )  
 $t_{ab} \leq 26$  s (at  $F_{ave} = 4$ )  
 $t_{ab} \leq 26$  s (at  $F_{ave} = 3$ )  
 $t_{ab} \leq 20$  s (at  $F_{ave} = 2$ )  
 $t_{ab} \leq 20$  s (at  $F_{ave} = 1$ )  
during a self test  $t_{ab} + 10$  s

Duration of the self test 10 s  
(every five minutes; should be added to  $t_{an}/t_{ab}$ )

**Measuring circuit**

System leakage capacitance $C_e$	$\leq 1$ $\mu$ F
Smaller measurement range and increased measuring time at $C_e$	$> 1$ $\mu$ F (e.g. max. range 1 M $\Omega$ @ 3 $\mu$ F, $t_{an} = 68$ s when changing over from $R_F$ 1 M $\Omega$ to $R_{an}/2$ )
Measuring voltage $U_M$	$\pm 40$ V
Measuring current $I_M$ at $R_F = 0$	$\pm 33$ $\mu$ A
Impedance $Z_i$ at 50 Hz	$\geq 1.2$ M $\Omega$
Internal DC resistance $R_i$	$\geq 1.2$ M $\Omega$

\*  $F_{ave} = 10$  is recommended for electric and hybrid vehicles

**Output**

**Measurement output (M)**

**M<sub>HS</sub> switches to U<sub>S</sub> – 2 V (3204)**

(external pull-down resistor to Kl. 31 necessary 2.2 kΩ)

**M<sub>LS</sub> switches to Kl. 31 + 2 V (3203)**

(external pull-up resistor to Kl. 15 required 2.2 kΩ)

**0 Hz** ▶ Hi > short-circuit to U<sub>b</sub> + (Kl. 15); Low > IMD off or short-circuit to Kl. 31

**10 Hz** ▶ Normal condition  
Insulation measurement DCP;  
starts two seconds after power on;  
First successful insulation measurement at ≤ 17.5 s  
PWM active 5...95 %

**20 Hz** ▶ undervoltage condition  
Insulation measurement DCP (continuous measurement);  
starts two seconds after power on;  
PWM active 5...95 %  
First successful insulation measurement at ≤ 17.5 s  
Undervoltage detection 0...500 V  
(Bender configurable)

**30 Hz** ▶ Speed start measurement  
Insulation measurement (only good/bad evaluation)  
starts directly after power on ≤ 2 s;  
PWM 5...10 % (good) and 90...95 % (bad)

**40 Hz** ▶ Device error  
Device error detected; PWM 47.5...52.5 %

**50 Hz** ▶ Connection fault earth  
Fault detected on the earth connection (Kl. 31)  
PWM 47.5...52.5 %

**Status output (OK<sub>HS</sub>)**

OK<sub>HS</sub> switches to U<sub>S</sub> – 2 V

(external pull-down resistor to Kl. 31 required 2.2 kΩ)

High ▶ No fault; R<sub>F</sub> > response value  
Low ▶ Insulation resistance ≤ response value detected;  
Device error; Fault in the earth connection  
Undervoltage detected or device switched off

**Operating principle PWM driver**

- Condition "Normal" and "Undervoltage detected" (10 Hz; 20 Hz)

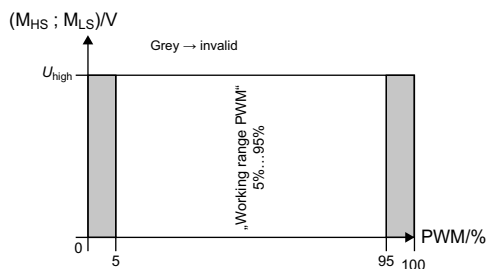
Duty cycle 5 % => 50 MΩ (∞)

Duty cycle 50 % = 1200 kΩ

Duty cycle 95 % = 0 kΩ

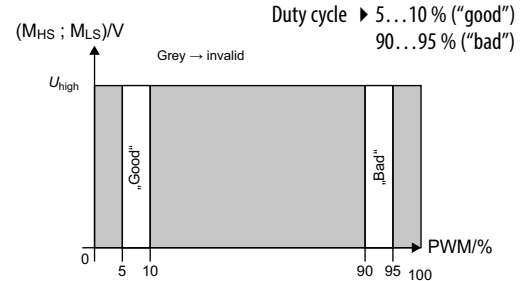
$$R_F = \frac{90\% \times 1200\text{ k}\Omega}{dC_{\text{meas}} - 5\%} - 1200\text{ k}\Omega$$

dC<sub>meas</sub> = measured duty cycle (5 %...95 %)



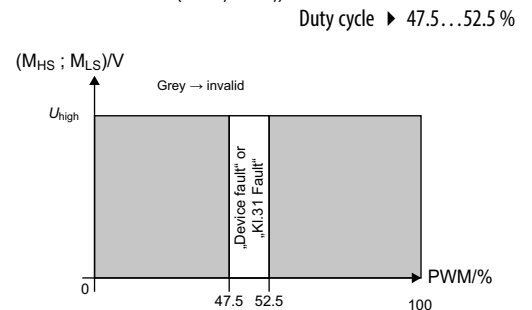
**Operating principle PWM driver**

- Condition "SST" (30 Hz)

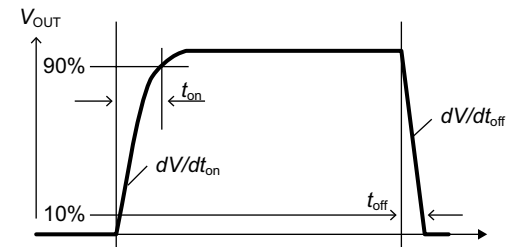


**Operating principle PWM driver**

- Condition "Device error" and "Kl.31 fault" (40 Hz; 50 Hz);



Load current I <sub>L</sub>	80 mA
Turn-on time ▶ to 90 % V <sub>out</sub>	max. 125 μs
Turn-off time ▶ to 10 % V <sub>out</sub>	max. 175 μs
Slew rate on ▶ to 10...30 % V <sub>out</sub>	max. 6 V/μs
Slew rate off ▶ to 70...40 % V <sub>out</sub>	max. 8 V/μs
Timing 3204 (inverse to 3203)	



**EMC**

Load dump protection	< 60 V
Measurement method	Bender-DCP technology
Factor averaging	
F <sub>ave</sub> (output M)	1...10 (factory set: 10)

**ESD protection**

Contact discharge – directly to terminals	≤ 10 kV
Contact discharge – indirectly to environment	≤ 25 kV
Air discharge – handling of the PCB	≤ 6 kV

**Connection**

On-board connectors	TYCO-MICRO MATE-N-LOK 1 x 2-1445088-8 (Kl. 31, Kl.15, E, KE, M <sub>HS</sub> , M <sub>LS</sub> , OK <sub>HS</sub> ) 2 x 2-1445088-2 (L+, L-); The connection between the respective connecting pins at L+ or L- may only be used as redundancy. Cannot be used for looping through!
Crimp contacts	TYCO-MICRO MATE-N-LOK Gold 14 x 1-794606-1 Conductor cross section: AWG 20...24
Enclosure for crimp contacts	TYCO-MICRO MATE-N-LOK receptor HSG single R -1445022-8 TYCO-MICRO MATE-N-LOK receptor HSG single R -1445022-2

## General data

Necessary crimp tongs (TYCO)	91501-1
Operating mode/mounting	continuous operation/any position
Temperature range	-40...+105 °C
Voltage failure	≤ 2 ms
Flammability class acc. to	UL 94 V-0

## Mounting

M4 metal screws with locking washers between screw head and PCB. Torx, T20 with a maximum tightening torque of 4 Nm for the screws. Furthermore, a maximum of 10 Nm tightening torque to the PCB at the mounting points.

**Mounting and connector kits are not included in delivery, but are available as accessories.** The maximum diameter of the mounting points is 10 mm.

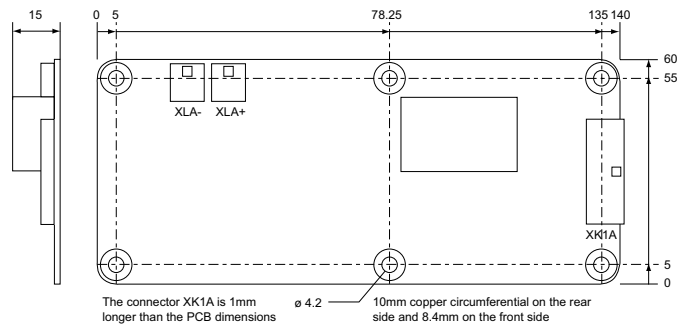
Before mounting the device, ensure sufficient insulation between the device and the vehicle or the mounting points (min. 11.4 mm to other parts). If the device is mounted on a metal or conductive subsurface, this subsurface has to be at earth potential (Kl.31; vehicle mass).

Deflection	max. 1 % of the length or width of the PCB
Coating	thick-film lacquer
Weight	52 g ± 2 g

## Dimension diagram

Dimensions in mm

PCB dimensions (L x W x H) 140 mm x 60 mm x 15 mm



## Ordering information

Parameters	Response value $R_{an}$	$F_{ave}$	Undervoltage detection	Measured value output	Type	Art. No.
Continuously set value	100 kΩ	10	300 V	Low side	IR155-3203	B 9106 8138V4
			0 V (inactive)	High side	IR155-3204	B 9106 8139 V4
Customer-specific setting	100 kΩ... 1 MΩ	1... 10	0 V... 500 V	Low side	IR155-3203	B 9106 8138CV4
				High side	IR155-3204	B 9106 8139CV4

## Accessories

Type designation	Art. No.
Fastening set	B 9106 8500
Connector set IR155-32xx	B 9106 8501

## Example for ordering

IR155-3204-100kΩ-0V + B 9106 8139V4  
 IR155-3204-200kΩ-100V + B 9106 8139CV4

The parameters, i.e. the response value and undervoltage protection value must be included in the order.

# optec

energie ist messbar

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