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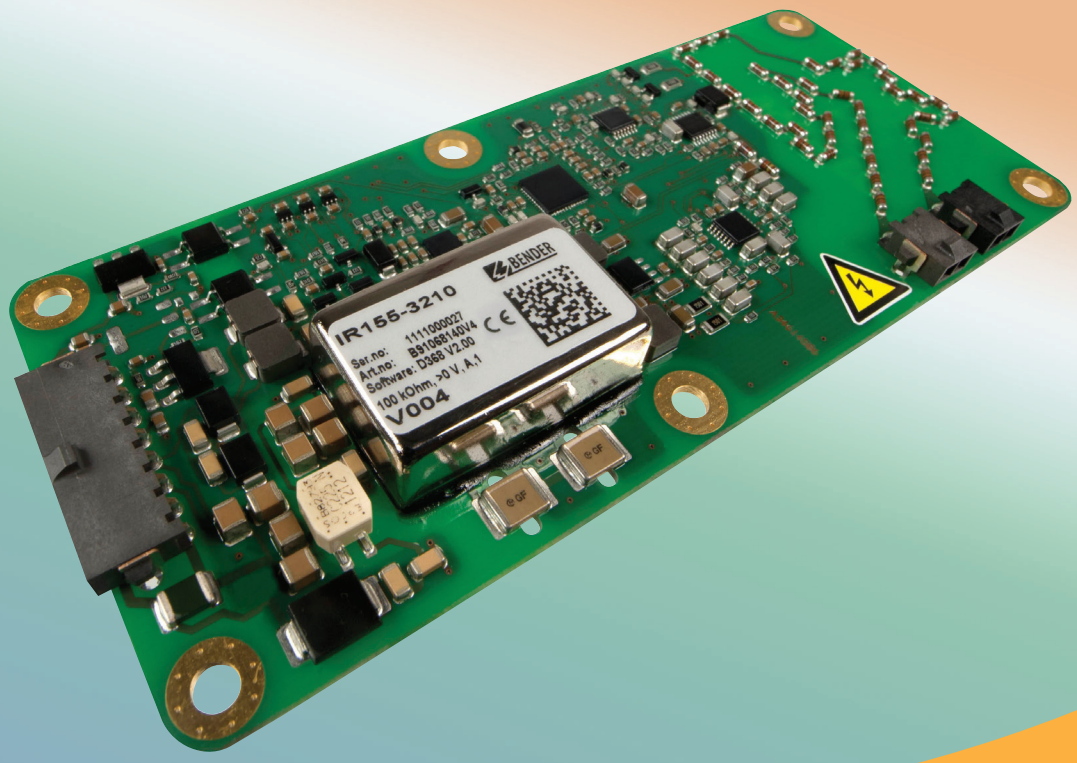
# IR155 10 Series

## Ground Fault Detector for Ungrounded AC/DC Systems

## For Level 3 Electric Vehicle Charging Systems (EVSE)




*Technical Bulletin*

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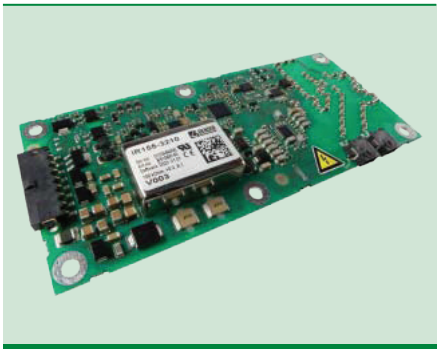
**For level 3 electric vehicle charging stations (EVSE)**



**IR155-3210**

## Features

- Designed specifically for level 3 elecric vehicle chargers
- Suitable for 12 V and 24 V systems
- Automatic self-test
- Continuous measurement of insulation resistance up to 10 MΩ
- Response time < 2 s after power on for first estimated insulation resistance (SST)
- Response time < 10 s for measured insulation resistance
- Automatic adaptation to the existing system leakage capacitance up to 1 µF
- Detection of ground faults and lost ground connection
- Capability of low voltage detection for voltages below 500 V, configured at factory
- Models with Molex connectors or special automotive rated connector
- Short protected outputs for:
  - Fault detection (high side output)
  - Measurement value (PWM 5…95%) and status (f = 10…50 Hz) at high side driver
- Conformal coating (SL1301ECO-FLZ)
- Small footprint and lightweight
- UL2231 recognized (IR155-3210)

## Description

The IR155 10 series ground fault detectors monitor ungrounded AC/DC systems onboard level 3 electric vehicle chargers for ground faults. The devices monitor the system's insulation resistance between the system conductors ($U_n$ = DC 0…800 V) and chassis ground. The advanced measurement method monitors both the DC side as well as the AC motor side of the system, even through high system interference conditions caused by motor control processes. The IR155 has a very small footprint and is lightweight, and meets automotive requirements for environmental conditions.

Alarm messages are output via the integrated and galvanically isolated high side driver interface. The interface consists of a status output ($OK_{HS}$ output, gives a go-no go output) and a measurement output ($M_{HS}$ output, signals the insulation resistance reading). Base frequency encoded messages allow distinguishing between various alarm messages and measurement readings.

IR155-3210 and IR155-4210 models are specifically designed for use in level three electric vehicle chargers. See ordering information for available configurations. For IR155 models designed for use in electric vehicles, refer to the IR155 03/04 series.

Model IR155-3210 is UL2231 recognized for integration into electric vehicle chargers.

## Function

The IR155 generates a pulsed measuring voltage superimposed on the system via the terminals L+/L- and E/KE. The currently read insulation resistance value is output as a PWM signal at the terminal $M_{HS}$. The connection between the terminals E/KE is continuously monitored.

Once power is applied, the device performs an initial SST measurement. The device provides the first estimated insulation resistance reading within a maximum of 2 sec. The AMP measurement (continuous insulation resistance measurement) begins subsequently. Faults in the connection wires or functional faults will be automatically recognized and signaled.

## Standards

**Corresponding standards and regulations***

| | |
|---|---|
| IEC 61557-8 | 2007-01 |
| IEC 61010-1 | 2010-06 |
| IEC 60664-1 | 2004-04 |
| IEC 61326-2-4 | 2010-05 |
| ISO 6469-3 | 2001-11 |
| ISO 23273-3 | 2006-11 |
| ISO 16750-1 | 2006-08 |
| ISO 16750-2 | 2010-03 |
| ISO 16750-4 | 2010-04 |
| e1 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 |
| UL2231-1 | 2002 |
| UL2231-2 | 2002 |

*** Standards exclusion**

The device went through an automotive test procedure in combination of multi customer requirements reg. ISO16750-x.

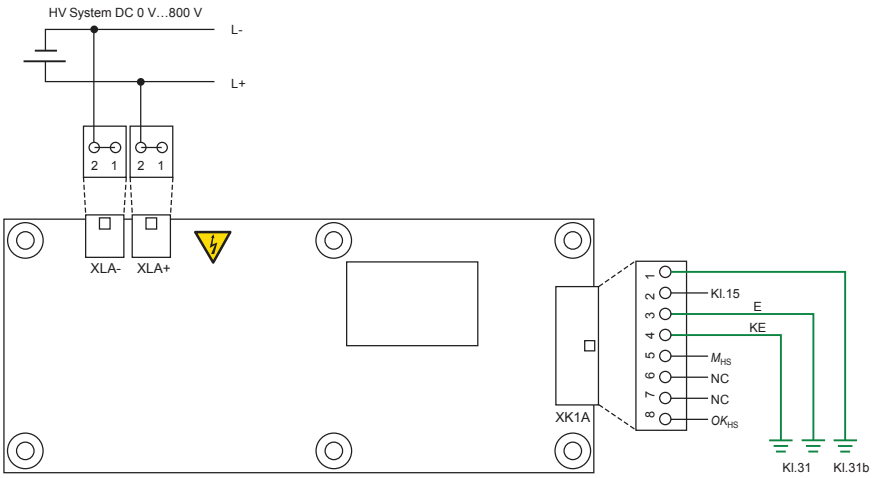
The standard IEC61557-8 will be fulfilled by creating the function for LED warning and test button at end user if necessary.

The device includes no surge and load dump protection above 60 V. Additional central protection is necessary.

## Abbreviations

| | |
|---|---|
| DCP | Direct Current Pulse |
| SST | Speed Start Measuring |

## Wiring




**Connector XLA+**

| | | |
|---|---|---|
| Pin 1+2 | L+ | Line voltage, positive |

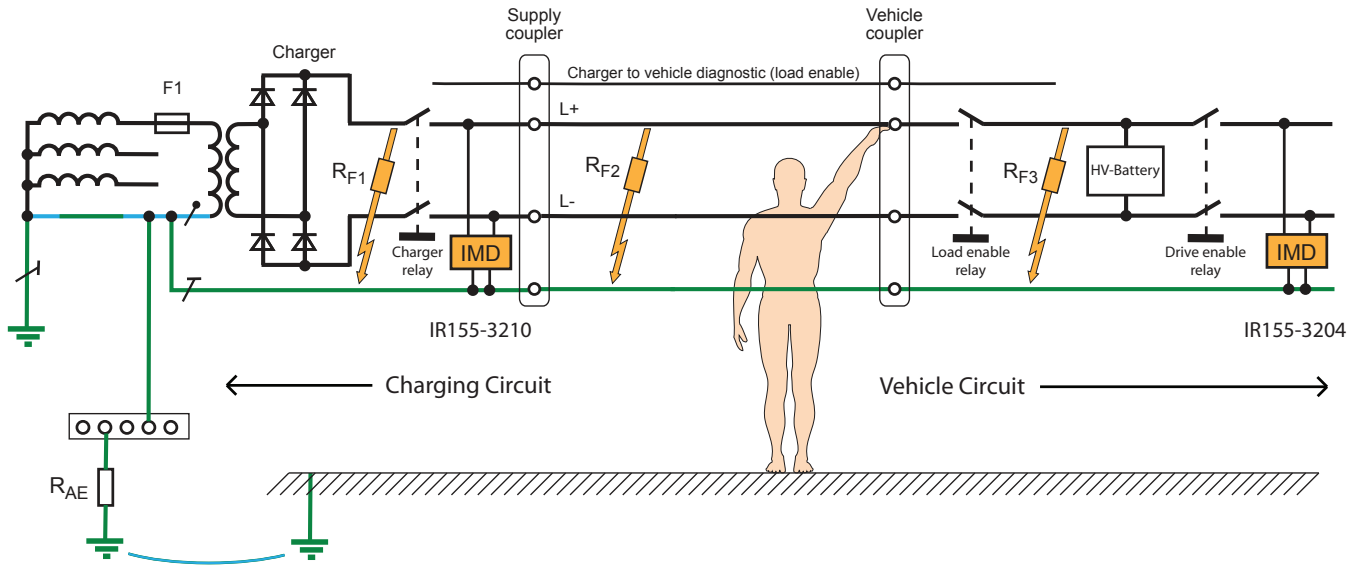
**Connector XLA-**

| | | |
|---|---|---|
| Pin 1+2 | L- | Line voltage, negative |

**Connector XK1A**

| | | |
|---|---|---|
| Pin 1 | KI.31b | Chassis ground |
| Pin 2 | KI.15 | Supply voltage |
| Pin 3 | KI.31 | Chassis ground |
| Pin 4 | KI.31 | Chassis ground |
| Pin 5 | $M_{HS}$ | Data out, PWM (high side) |
| Pin 6 | No connection | |
| Pin 7 | No connection | |
| Pin 8 | $OK_{HS}$ | Status output (high side) |

## Sample application




## Additional requirements per UL 2231

A product employing a manual test feature shall be marked:

"Test Before Each Use"

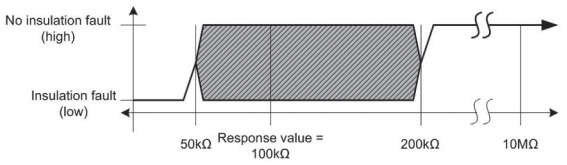
The instructions related to perfoming the test and interpreting the results must be included. These instructions are to state that a device that produces an unacceptable test result shall not be used.

**Example:**

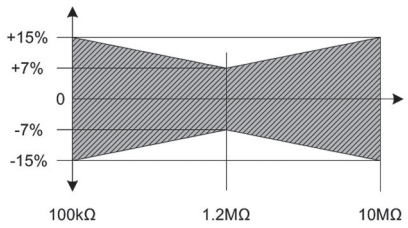
During normal operation, the device must respond within 10 seconds if the insulation resistance of the system falls below the set response value. A possible test implentation may include switching a test resistor into the system between the conductors and ground and a simultaneous measurement of the response time. A device which takes longer than 10 seconds to respond shall be considered a failed device and must not be used.

## Technical data

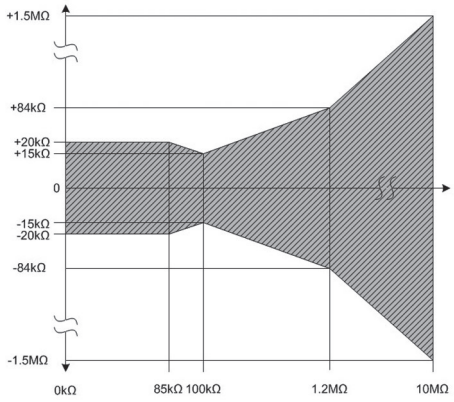
| | |
|---|---|
| Supply voltage $U_S$ | DC 10…36 V |
| Nominal supply voltage | DC 12 V / 24 V |
| Voltage range | 10 V…36 V |
| Max. operational current $I_S$ | 150 mA |
| Max. current $I_k$ | 2 A |
| | 6 A / 2 ms Rush-In current |
| Power dissipation $P_S$ | <2 W |
| Line L+ / L- Voltage $U_n$ | AC 0 V…800 V peak; |
| | 0 V…560 V rms (10 Hz…1 kHz) |
| | DC 0 V…800 V |
| Protective separation (reinforced insulation) between | |
| | (L+ / L-) – (Kl.31, Kl.15, E, KE, $M_{HS}$, $OK_{HS}$) |
| Voltage test | AC 3500 V / 1 min |
| Load dump protection | < 40 V |
| Under voltage detection | 0 V…500 V; Default: 0 V (inactive) |
| System leakage capacity $C_e$ | ≤ 1 µF |
| Reduced measuring range and increased measuring time at $C_e$ | > 1µF |
| (E.g. max. range 1 MΩ @ 3 µF, $t_{an}$ = 68 s @ change over $R_F$ 1MΩ > $R_{an}$/2) | |
| Measuring voltage $U_m$ | +/- 40 V |
| Measuring current $I_m$ at $R_F$ = 0 | +/- 33 µA |
| Impedance $Z_i$ at 50 Hz | ≥ 1.2 MΩ |
| Internal resistance $R_i$ | ≥ 1.2 MΩ |
| Measurement range | 0…10 MΩ |
| Measurement method | Bender AMP Technologie |
| Relative error at SST (≤ 2 s) | Good > 2 * $R_{an}$; Bad < 0.5 * $R_{an}$ |
| Relative error at AMP | 0…85 kΩ ▶ +/-20 kΩ |
| | 100 kΩ…10 MΩ ▶ +/-15 % |
| Relative error Output – M (base frequencies) | +/- 5 % at each frequency |
| | (10 Hz; 20 Hz; 30 Hz; 40 Hz; 50 Hz) |
| Relative error under voltage detection | $U_n$ ≥ 100 V ▶ +/-10 %; |
| | at $U_n$ ≥ 300 V ▶ +/-5 % |
| Response value hysteresis (AMP) | 25 % |
| Response value $R_{an}$ | 100 kΩ…200 kΩ |
| | ▶ higher tolerances at $R_{an}$ < 85 kΩ; (Default: 100 kΩ) |
| Response time $t_{an}$ ($OK_{HS}$; SST) | $t_{an}$ ≤ 2 s (typ. < 1 s at $U_n$ > 100 V) |
| Response time $t_{an}$ ($OK_{HS}$; AMP) | $t_{an}$ ≤ 10 s |
| Switch-off time $t_{ab}$ ($OK_{HS}$; AMP) | $t_{ab}$ ≤ 26 s |
| Self test time | 10 s |
| | (only at power on) |
| Relative error (SST) | "Good-Value" ≥ 2 * $R_{an}$ |
| | "Bad-Value" ≤ 0.5 * $R_{an}$ |




| | |
|---|---|
| Relative error (AMP) | 100 kΩ ▶ +/-15% |
| | 100 kΩ…1.2 MΩ ▶ +/-15% to +/-7% |
| | 1.2 MΩ ▶ +/-7% |
| | 1.2 MΩ…10 MΩ ▶ +/-7% to +/-15% |
| | 10 MΩ ▶ +/-15% |




| | |
|---|---|
| Absolute error (AMP) | 0 Ω…85 kΩ ▶ +/-20 kΩ |




### Measurement Output (M)

***$M_{HS}$* switches to *$U_S$* – 2V (3210)**

(external load to ground necessary 2.2 kΩ)

**0 Hz** ▶ Hi > short to $U_b$+ (Kl.15); Low > IMD off or short to Kl.31

**10 Hz** ▶ Normal Condition
Insulation measuring AMP; starts 10 s after Power-On; PWM active 5 %…95 %

**20 Hz** ▶ Under voltage condition
Insulation measuring AMP (correct measurement) starts 10 s after Power-On; PWM active 5 %…95 %
Under voltage detection 0 V…500 V (EOL Bender configurable).

**30 Hz** ▶ Speed Start
Insulation measuring (only good/bad estimation); Starts directly after Power-On; response time ≤ 2 s; PWM 5 %…10 % (good) and 90 %…95 % (bad)

**40 Hz** ▶ IMD Error
IMD error detected; PWM 47.5%…52.5%

**50 Hz** ▶ Ground error
Error on measurement ground line (Kl. 31) detected PWM 47.5%…52.5%

### Status Output ($OK_{HS}$)

***$OK_{HS}$* switches to *$U_S$* – 2 V**

(external load to ground necessary 2.2 kΩ)

High ▶ No fault; $R_F$ > response value

Low ▶ Insulation resistance ≤ response value detected; IMD error; ground error, under voltage detected or IMD off (ext. pull-down resistor required)

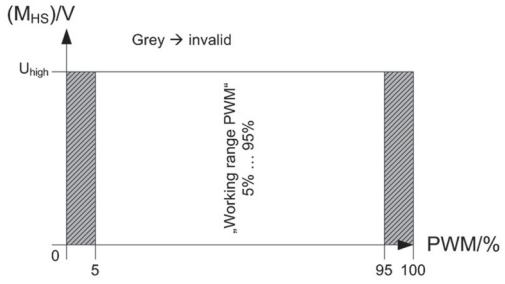
### Operating principle PWM- driver

- Condition “Normal” and “Under voltage detected” (10Hz; 20Hz)

Duty cycle ▸ 5 % = >50 MΩ (∞)
Duty cycle ▸ 50 % = 1200 kΩ
Duty cycle ▸ 95 % = 0 kΩ

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

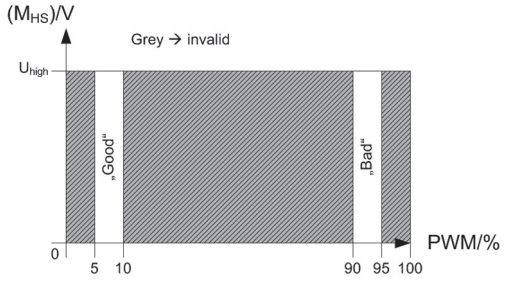
$dc_{meas}$ = measured duty cycle (5 %…95 %)




### Operating principle PWM- driver

- Condition “SST” (30Hz)

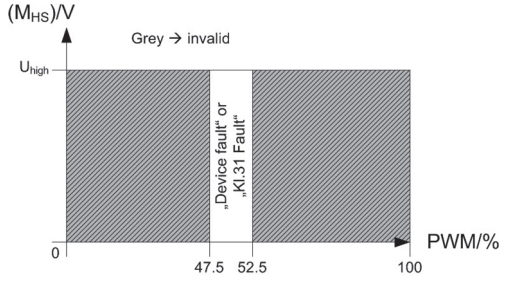
Duty cycle ▸ 5 %…10 % („Good“)
90 % … 95 % („Bad“)




### Operating principle PWM- driver

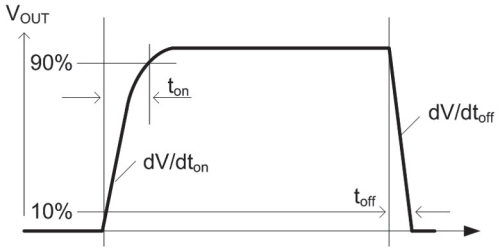
- Condition “Device error” and “Kl.31 fault” (40Hz; 50Hz)

Duty cycle ▸ 47.5% … 52.5 %




| | |
|---|---|
| Load current $I_L$ | 80 mA |
| Turn-on time ▸ to 90 % $V_{OUT}$ | Max. 125 µs |
| Turn-off time ▸ to 10 % $V_{OUT}$ | Max. 175 µs |
| Slew rate on ▸ 10 to 30 % $V_{OUT}$ | Max. 6 V/µs |
| Slew rate off ▸ 70 to 40 % $V_{OUT}$ | Max. 8 V/µs |

Timing 3210



### Connectors - IR155-32xx

| | |
|---|---|
| Connectors | TYCO-MICRO MATE-N-LOK<br>1 x 2-1445088-8<br>(Kl.31, Kl.15, E, KE, $M_{HS}$, $M_{LS}$, $OK_{HS}$)<br>2 x 2-1445088-2 (L+, L-) |
| Crimp contacts | TYCO MICRO MATE-N-LOK Gold<br>14x 1-794606-1<br>Wire size: AWG 20…24 |
| Necessary crimp tongs (TYCO) | 91501-1 |
| Operating mode / mounting | Continuous operation / any position |
| Temperature range | -40 °C…+105 °C |
| Voltage dropout | ≤ 2 ms |
| Fire protection class acc. UL94 | V 0 |

### Connectors - IR155-42xx

| | |
|---|---|
| Connectors | Samtec Mini Mate Housing, IPD1-08-S-K<br>(Kl. 31B, Kl.15, KE, E, $M_{HS}$, $M_{LS}$, $OK_{HS}$)<br>Molex Mini Fit Jr. Housing, 39-01-2025, (L+, L-) |
| Crimp contacts | Samtec Mini Mate Gold, CC79R2024-01-L, AWG 20…24<br>Molex Mini Fit Jr. Gold, 39-00-0089, AWG 16 |
| Operating mode / mounting | Continuous operation / any position |
| Temperature range | -40 °C…+105 °C |
| Voltage dropout | ≤ 2 ms |
| Fire protection class acc. UL94 | V 0 |

### ESD protection

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

### Mounting

Screw mounting: M4 metal screws with locking washers between screw head and PCB.

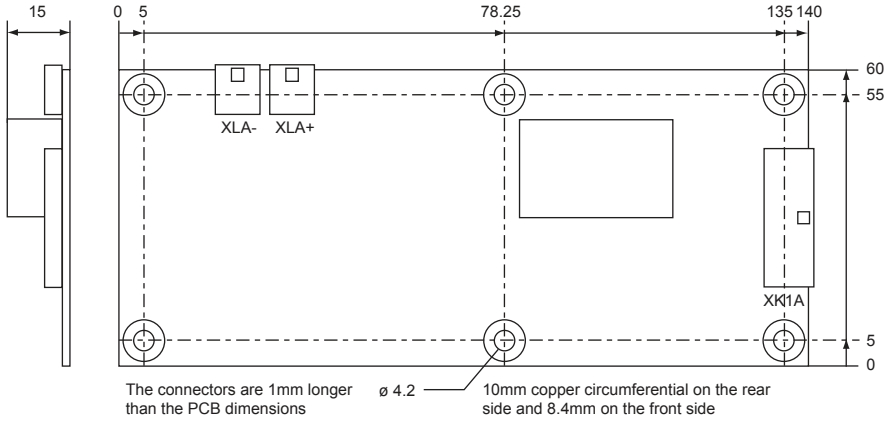
Torx, T20 with a max. tightening torque of 4 Nm for the screws. Furthermore max. 10 Nm pressure to the PCB at the mounting points.

**Mounting and connector kits are separately ordered accessories and are not included with the device.** The max. diameter of the mounting points is 10 mm.
Before mounting the device, ensure sufficient insulation between the device and the vehicle resp. the mounting points (min. 11.4 mm to other parts). If the IMD is mounted on a metal or conductive subsurface, this subsurface has to get ground potential (Kl.31; vehicle mass).

| | |
|---|---|
| Deflection | max. 1 % of the length resp. width of the PCB |
| Conformal coating | Thick-Film-Lacquer |
| Weight | 52 g +/-2 g |

## Dimensions

Dimensions in mm



| Ordering information | | | | | |
|---|---|---|---|---|---|
| **Type** | **Application** | **Parameters** | **Measurement Output Type** | **Connector Type** | **Ordering Number** |
| IR155-3210 | Level 3 electric vehicle chargers | Default*<br>See note 1 | Low side driver | Samtec / Molex connectors | B 9106 8140V4 |
| IR155-3210 | Level 3 electric vehicle chargers | Customized at factory**<br>See note 2 | Low side driver | Samtec / Molex connectors | B 9106 8140CV4 |
| IR155-4210 | Level 3 electric vehicle chargers | Default*<br>See note 1 | Low side driver | Tyco MICRO MATE-N-LOCK automotive rated connector | B 9106 8143 |
| IR155-4210 | Level 3 electric vehicle chargers | Customized at factory**<br>See note 2 | Low side driver | Tyco MICRO MATE-N-LOCK automotive rated connector | B 9106 8143C |

### Note 1 - Models with default parameters

Models with default parameters include the following settings:

- Alarm level ($R_{an}$): 100 kΩ
- Undervoltage alarm level: 0 V (inactive)

### Note 2 - Customizable settings

Models with "C" in the ordering number may have customized fixed alarm levels, configured at the factory (not field-adjustable):

- Alarm level ($R_{an}$): Fixed value within range of 100 - 200 kΩ
- Undervoltage alarm level: Fixed value within range of 0 - 500 V
- Factor averaging ($F_{ave}$): Fixed value within range of 1 - 10

Any customized settings must be specified in the part description.

### Accessories

| | |
|---|---|
| Mounting kit | B 9106 8500 |
| Connection kit, IR155-32xx | B 9106 8501 |
| Connection kit, IR155-42xx | B 9106 8502 |

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