BENDER
The Power in Electrical Safety™

IR155 03/04 Series

Ground Fault Detector for Ungrounded AC/DC Drive Systems

For Electric Vehicles

Technical Bulletin

NAE1012830 / 07.2013

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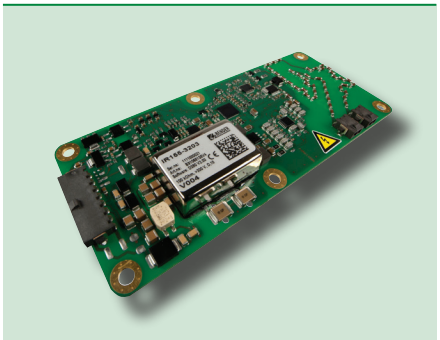
Ground fault detector for ungrounded AC/DC drive systems
For electric vehicles



IR155-3203

Features

- Designed specifically for elecric vehicles
- 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

Description

The IR155 03/04 series ground fault detectors monitor ungrounded DC drive systems onboard electric vehicles 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 low side (-03 models) or high-side (-04 models) 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 models of the -03 and -04 series are specifically designed for use in electric vehicles. See ordering information for available configurations. For IR155 models designed for electric vehicle charging systems (EVSE), refer to the IR155 10 series.

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
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

*** Standards exclusion**

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

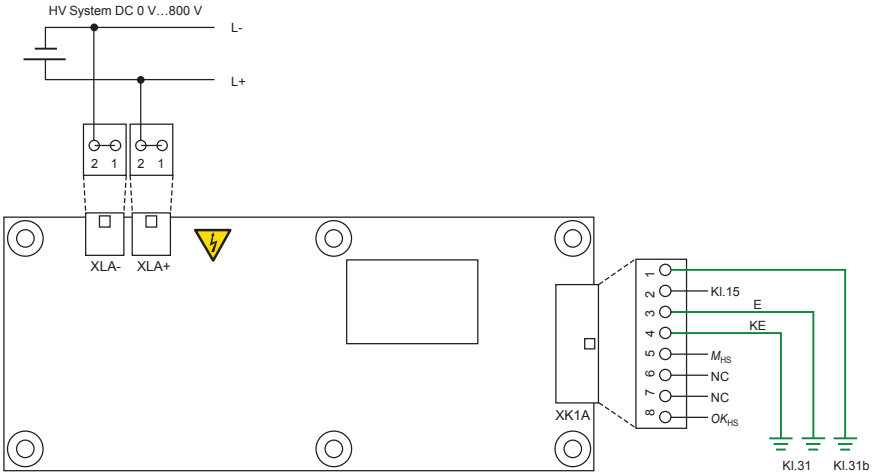
The standard IEC61557-8 will be fulfilled by creating the function for LED warning and test button at end user if necessary.

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

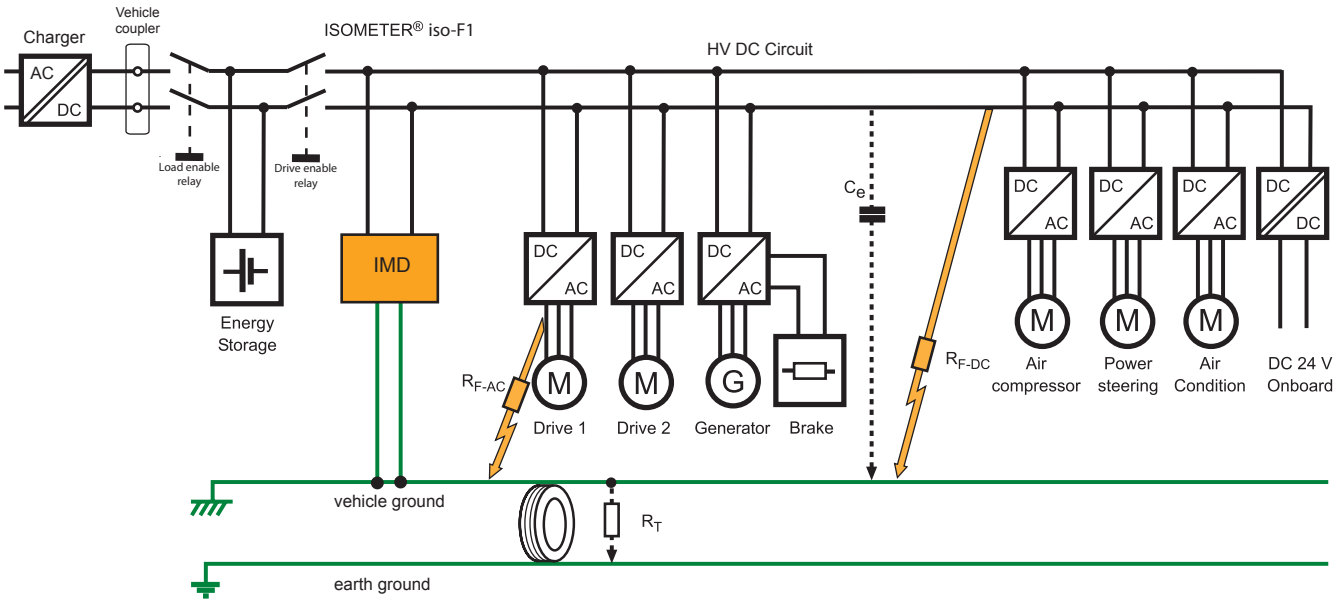
Connector XLA-

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	M_{LS}	Data out, PWM (low side)
Pin 7	No connection	
Pin 8	OK_{HS}	Status output (high side)

Sample application

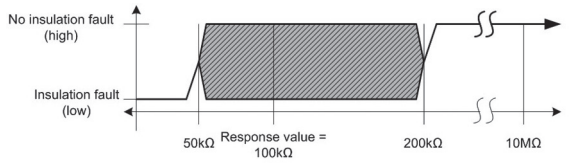


Technical data

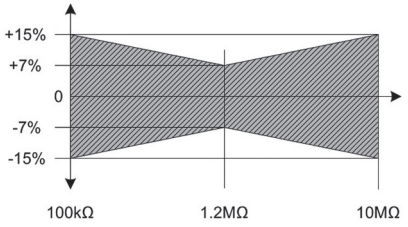
Supply voltage U_S	DC 10…36 V
Nominal supply voltage	DC 12 V / 24 V
Voltage range	10 V…36 V
Max. operational current I_S	150 mA
Max. current I_k	2 A
	6 A / 2 ms Rush-In current
Power dissipation P_S	< 2 W
Line L+ / L- Voltage U_n	AC 0 V…1000 V peak;
	0 V…660 V rms (10 Hz…1 kHz)
	DC 0 V…1000 V
Protective separation (reinforced insulation) between	
	(L+ / L-) – (KI.31, KI.15, E, KE, M_{HS}, M_{LS}, OK_{HS})
Voltage test	AC 3500 V / 1 min
Load dump protection	< 60 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 1 MΩ > 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 DCP technologie
Factor averaging	
F_{ave} (Output M)	1…10 (default: 10; EOL Bender)
Relative error at SST (≤ 2s)	Good > 2 * R_{an}; Bad < 0.5 * R_{an}
Relative error at DCP	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 (DCP)	25 %
Response value R_{an}	100 kΩ…1 MΩ
	▶ 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}; DCP)	
(Changeover R_F: 10 MΩ ▶ R_{an}/2; at C_e = 1 µF; U_n = 1000 V DC)	
	t_{an} ≤ 20 s (at F_{ave} = 10*)
	t_{an} ≤ 17.5 s (at F_{ave} = 9)
	t_{an} ≤ 17.5 s (at F_{ave} = 8)
	t_{an} ≤ 15 s (at F_{ave} = 7)
	t_{an} ≤ 12.5 s (at F_{ave} = 6)
	t_{an} ≤ 12.5 s (at F_{ave} = 5)
	t_{an} ≤ 10 s (at F_{ave} = 4)
	t_{an} ≤ 7.5 s (at F_{ave} = 3)
	t_{an} ≤ 7.5 s (at F_{ave} = 2)
	t_{an} ≤ 5 s (at F_{ave} = 1)
	during self test ▶ t_{an} + 10 s

* F_{ave} = 10 is recommended for electric vehicles

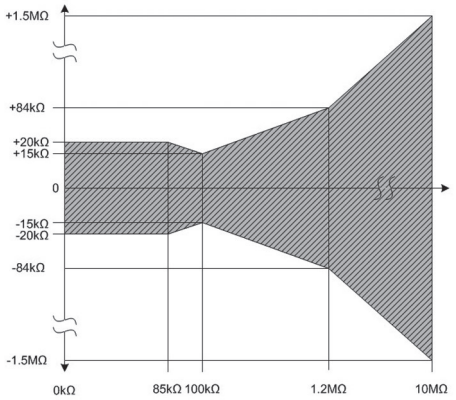
Switch-off time t_{ab} (OK_{HS}; DCP)	
(Changeover R_F: $R_{an/2}$ ▶ 10 MΩ; at C_e =1 µF; U_n = 1000V DC)	
	t_{ab} ≤ 40 s (at F_{ave} = 10)
	t_{ab} ≤ 40 s (at F_{ave} = 9)
	t_{ab} ≤ 33 s (at F_{ave} = 8)
	t_{ab} ≤ 33 s (at F_{ave} = 7)
	t_{ab} ≤ 33 s (at F_{ave} = 6)
	t_{ab} ≤ 26 s (at F_{ave} = 5)
	t_{ab} ≤ 26 s (at F_{ave} = 4)
	t_{ab} ≤ 26 s (at F_{ave} = 3)
	t_{ab} ≤ 20 s (at F_{ave} = 2)
	t_{ab} ≤ 20 s (at F_{ave} = 1)
	during self test ▶ t_{ab} + 10 s
Self test time	10 s
	(every 5 minutes; has to be added to t_{an} / t_{ab})
Relative error (SST)	"Good-Value" ≥ 2 * R_{an}
	"Bad-Value" ≤ 0.5 * R_{an}



Relative error (DCP)	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 (DCP)	0 Ω…85 kΩ ▶ +/-20 kΩ



Measurement Output (M)

M_{HS} switches to U_S – 2 V (4204)
(external load to ground necessary 2.2 kΩ)

M_{LS} switches to KI.31 +2 V (4203)
(external load to U_b necessary 2.2 kΩ)

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

10 Hz ▶ Normal Condition
Insulation measuring DCP;
starts 2 s after Power-On;
first successful insulation measurement at ≤ 17.5 s
PWM active 5 %…95 %

20 Hz ▶ Under voltage condition
Insulation measuring DCP (correct measurement);
starts 2 s after Power-On;
PWM active 5 %…95 %
first successful insulation measurement at ≤ 17.5 s
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 (KI. 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)

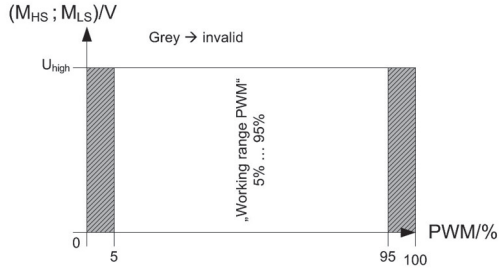
Operating principle PWM- driver

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

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

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

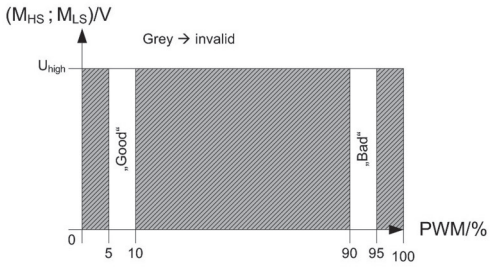
dc_{meas} = measured duty cycle (5 %…95 %)



Operating principle: PWM driver

- Condition “SST” (30Hz)

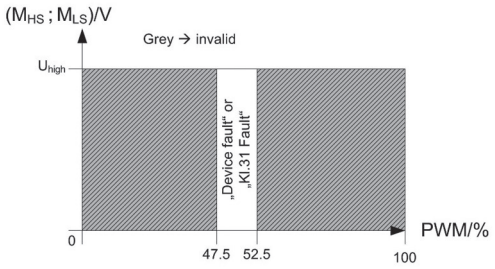
Duty cycle ▶ 5 %…10 % (“Good”)
90 % … 95 % (“Bad”)



Operating principle: PWM driver

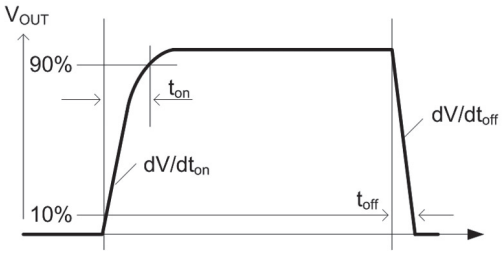
- Condition “Device error” and “KI.31 fault” (40Hz; 50Hz)

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 3204 (inverse of 3203)



Connectors - IR155-32xx

Connectors	TYCO-MICRO MATE-N-LOK 1 x 2-1445088-8 (Kl.31, Kl.15, E, KE, M_{HS}, M_{LS}, OK_{HS}) 2 x 2-1445088-2 (L+, L-)
Crimp contacts	TYCO MICRO MATE-N-LOK Gold 14x 1-794606-1 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 (Kl. 31B, Kl.15, KE, E, M_{HS}, M_{LS}, OK_{HS}) Molex Mini Fit Jr. Housing, 39-01-2025, (L+, L-)
Crimp contacts	Samtec Mini Mate Gold, CC79R2024-01-L, AWG 20…24 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.

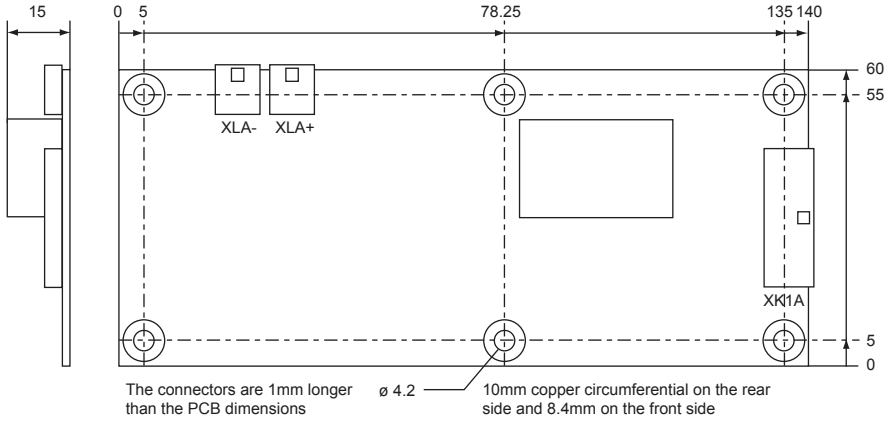
Torx, T20 with a max. tightening torque of 4 Nm for the screws. Furthermore max. 10 Nm pressure to the PCB at the mounting points.

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
IR155-3203	Electric vehicles	Default* See note 1	Low side driver	Tyco MICRO MATE-N-LOCK automotive rated connector	B 9106 8138V4
IR155-3203	Electric vehicles	Customized at factory** See note 2	Low side driver	Tyco MICRO MATE-N-LOCK automotive rated connector	B 9106 8138CV4
IR155-4203	Electric vehicles	Default* See note 1	Low side driver	Samtec / Molex connectors	B 9106 8141
IR155-4203	Electric vehicles	Customized at factory** See note 2	Low side driver	Samtec / Molex connectors	B 9106 8141C
IR155-3204	Electric vehicles	Default* See note 1	High side driver	Tyco MICRO MATE-N-LOCK automotive rated connector	B 9106 8139V4
IR155-3204	Electric vehicles	Customized at factory** See note 2	High side driver	Tyco MICRO MATE-N-LOCK automotive rated connector	B 9106 8139CV4
IR155-4204	Electric vehicles	Default* See note 1	High side driver	Samtec / Molex connectors	B 9106 8142
IR155-4204	Electric vehicles	Customized at factory** See note 2	High side driver	Samtec / Molex connectors	B 9106 8142C

Note 1 - Models with default parameters

Models with default parameters include the following settings:

- Alarm level (R_{an}): 100 kΩ
- Undervoltage alarm level: 300 V
- Factor averaging (F_{ave}): 10

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 kΩ - 1 MΩ
- 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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