Electric Vehicles

Electrical safety solutions for EV & EVSE

Design the future
of energy

BENDER

Index

Intelligent Electrical Safety for the Mobile Future

Since 1937, we have learned to think ahead in a strategic, future-oriented manner, creating today what the customer will need tomorrow. Innovative solutions and services, unique know-how, and global expertise when it comes to electrical safety provide a response to the mobile challenges of the future - from electrical installation to charging stations and bringing electrical safety into the vehicle.

Electric vehicles

Charging stations

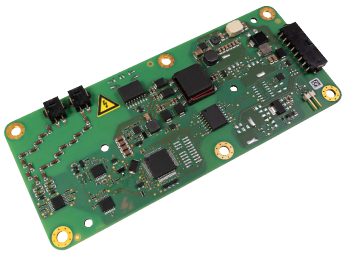
Energy log

Electrical Safety Applications

1 ISOMETER® iso175

Provides isolation detection in electrical vehicles

- Constant monitoring of the entire electrical system for loss of isolation
- Compatible with all electric vehicles currently present on the market
- Superior measurement for the entire circuit - from battery to the drivetrain
- Fully adaptive to varying Y-caps



2 CC613

Charge controller for level 2 chargers

- Combines electrical safety requirements of AC charging points with the vehicle charging requirements
- Compatible with all electric vehicles currently present on the market
- Fully functional interface and compliant with OCPP protocols
- Load management functionality
- Provides ability to create a fully functional charging network

3 ISOMETER® isoCHA-xx

Isolation monitor interrupter for DC fast chargers

- Fulfills UL, SAE, and Chademo requirements
- Provides electrical safety from shock hazards
- Fully compliant with local and international standards
- Accurate monitoring and interrupting of high-voltage circuits

4 RCMB121-xx

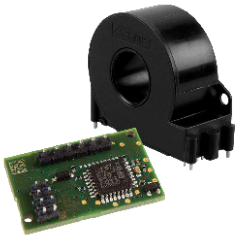
CCID5 & 20 ground fault functionality for fast interrupting

- Fulfills UL & IEC requirements
- Charge current interruption on ground faults
- AC & DC capable
- High accuracy over a wide temperature band
- Sensors incorporate all necessary electronic circuitry

5 RCMB104-xx

CCID5 & 20 ground fault functionality for fast interrupting

- Fulfills UL & IEC requirements for ground fault interruptions in EVSE
- Capable of accepting various larger current transformer sizes
- AC & DC capable
- High accuracy over a wide temperature band
- Sensors incorporate all necessary electronic circuitry
- Higher power levels and 3-phase capability



From inside the car to charging stations, Bender devices provide a complete solution for mitigating risks of electric shock, equipment failure, and fire damage. Our devices are designed specifically for integrating into electric vehicles, as well as level 2 and fast DC charging stations.

Designed in compliance with requirements such as UL 2231, NEC 625, and SAE standards (US), C22.2 NO.281-1 & NO.281.2 (Canada), and NMX-J-668/1-ANCE & NMX-J-668/2-ANCE (Mexico), our equipment provides a simple, integratable solution for your electrical safety requirements.

Insulation Monitoring

The power supply system in an electric vehicle is comprised of an HV battery, power distribution, and a drivetrain. This system is designed to be ungrounded (floating) against the vehicle's frame. One of the major challenges lies in detecting insulation faults early. Causes for insulation faults in normal operation can be, for example: contamination, salt, humidity, faulty connectors, mechanical influences, etc.

What are the requirements of the standard?

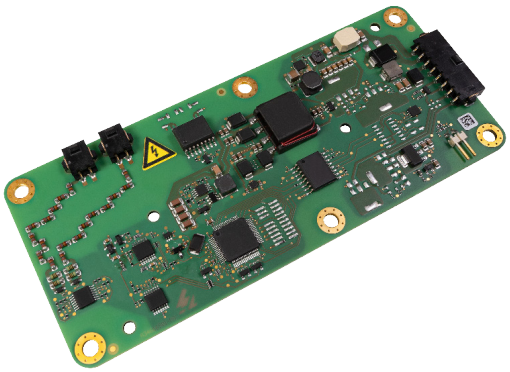
- ISO6469-3:2011
  Electrically propelled road vehicles – Safety specifications – Part 3: Protection of persons against electric shock
  "The minimum insulation resistance of the on-board network must be maintained throughout the service life and under all operating conditions".

The perfect solution:

- Permanent monitoring of insulation resistance and isolation with ISOMETER® iso175

ISOMETER®

Product	ISOMETER® iso175
Main voltage	DC 0...1000 V
Supply voltage	DC 10-36 V
Y-caps Ce	10
Response value R	100 kΩ - 2MΩ
Automotive grade housing	none/PCB
Communication	CAN
Solid alarm out	✓ (High side driver)
Automated self-test	✓
Article number	B91068201 (iso175C-32-SS) B91068202 (iso175C-42-SS) B91068203 (iso175C-32-SB) B91068204 (iso175C-42-SB) B91068205 (iso175P-32-S) B91068206 (iso175P-42-S)



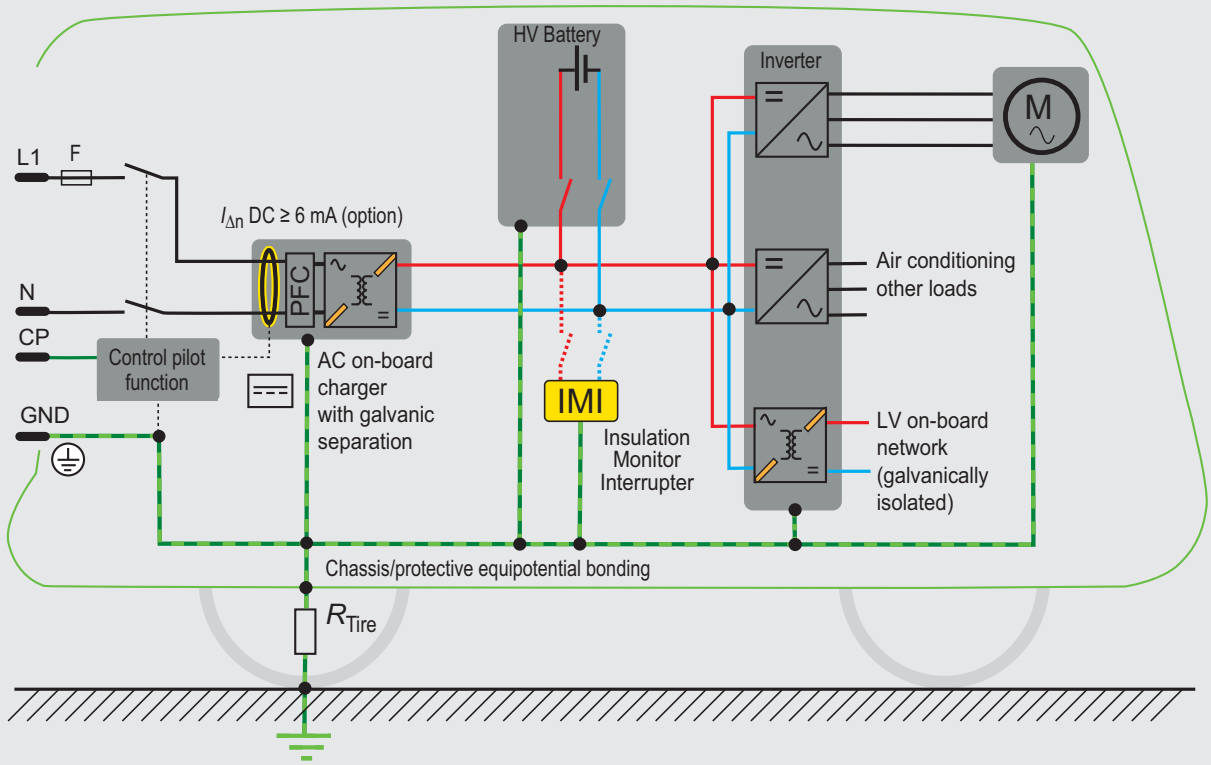


Figure 1: Outline of equipment

Insulation monitoring in an electric vehicle (EV) with an AC on-board charger with galvanic separation

IMI = Insulation Monitoring Interrupter
PFC = Power Factor Correction

Overview of important standards

ISO 6469-3:2011-12	ISO 23273-3:2006-11	UL 2231-1:2002-05	IEC 61557-8:2007-01
Electric propelled road vehicles – Safety inspections Part 3: Protection of persons against electric shock	Fuel cell road vehicles – Safety inspections Part 3 – Protection of persons against electric shock	Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General requirements	Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. – Equipment for testing measuring or monitoring protective measures – Part 8: Insulation monitoring devices for grounded systems

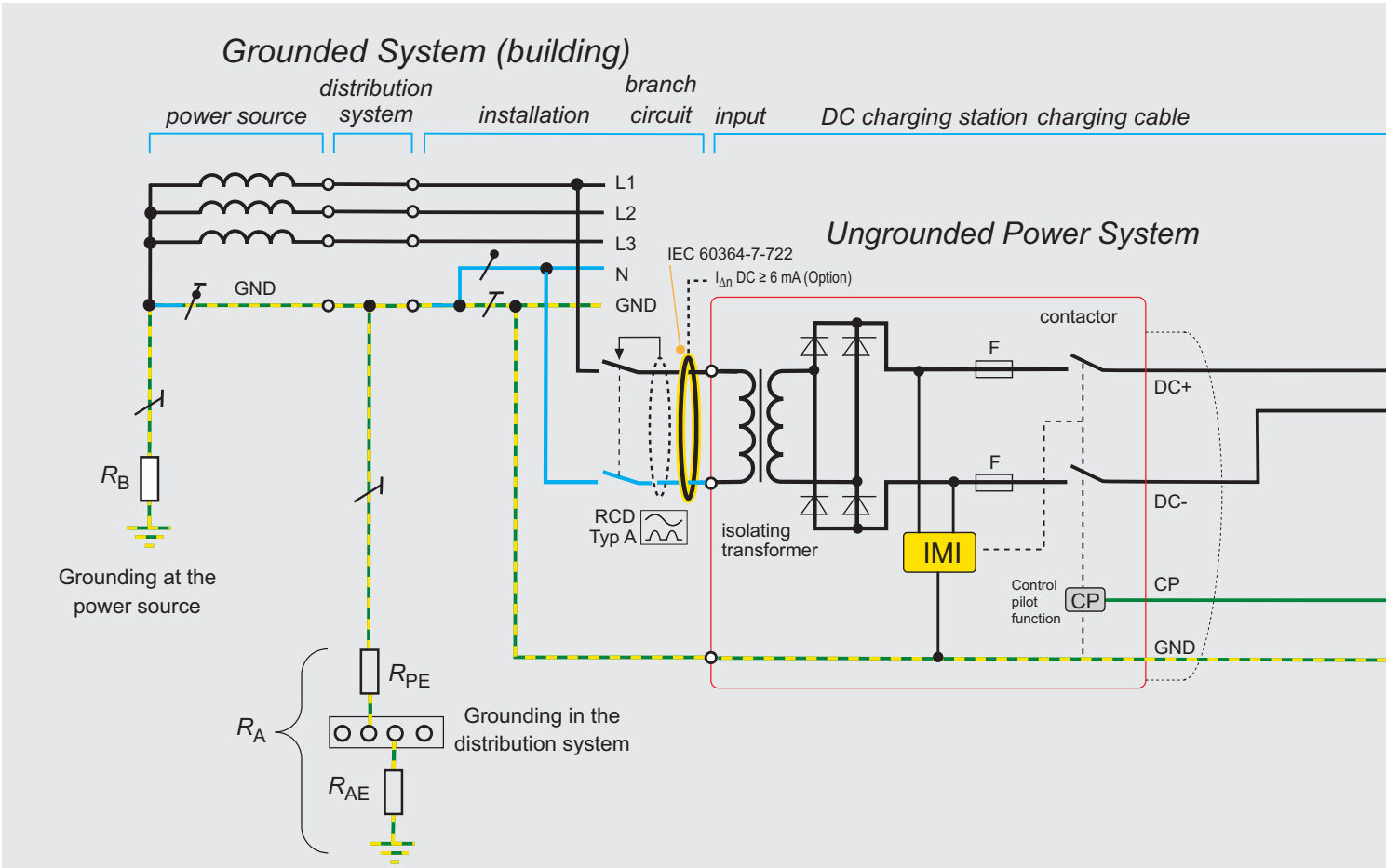
Ground Continuity Monitor

Product	LINETRAXX® GM420
Supply voltage	DC 9.6-94 V (GM420-D-1) AC 16-72 V (GM420-D-1) AC/DC 70-300 V (GM420-D-2)
Main function	Ground continuity monitoring
Response value R	0-100 Ω
Extraneous voltage	0...50 V
Industrial housing	✓
Solid alarm out	2X SPDT
Automated self-test	✓
Article number	B93082001 (GM420-D-1) B93082002 (GM420-D-2)

EVSE standards

IEC 61851-1 (General)
IEC 61851-3 (LEV)
IEC 61851-22 (AC)
IEC 61851-23 (DC)
IEC 61851-23-1 (ACD)
IEC 61851-21-2 (CEM)
IEC 62752 (Cordon Mode 2)
SAE J1772
GB/T 18487
UL2231-1 & UL2231-2
C22.2 NO.281-1 & NO.281.2
NMX-J-668/1-ANCE & NMX-J-668/2-ANCE

Application examples



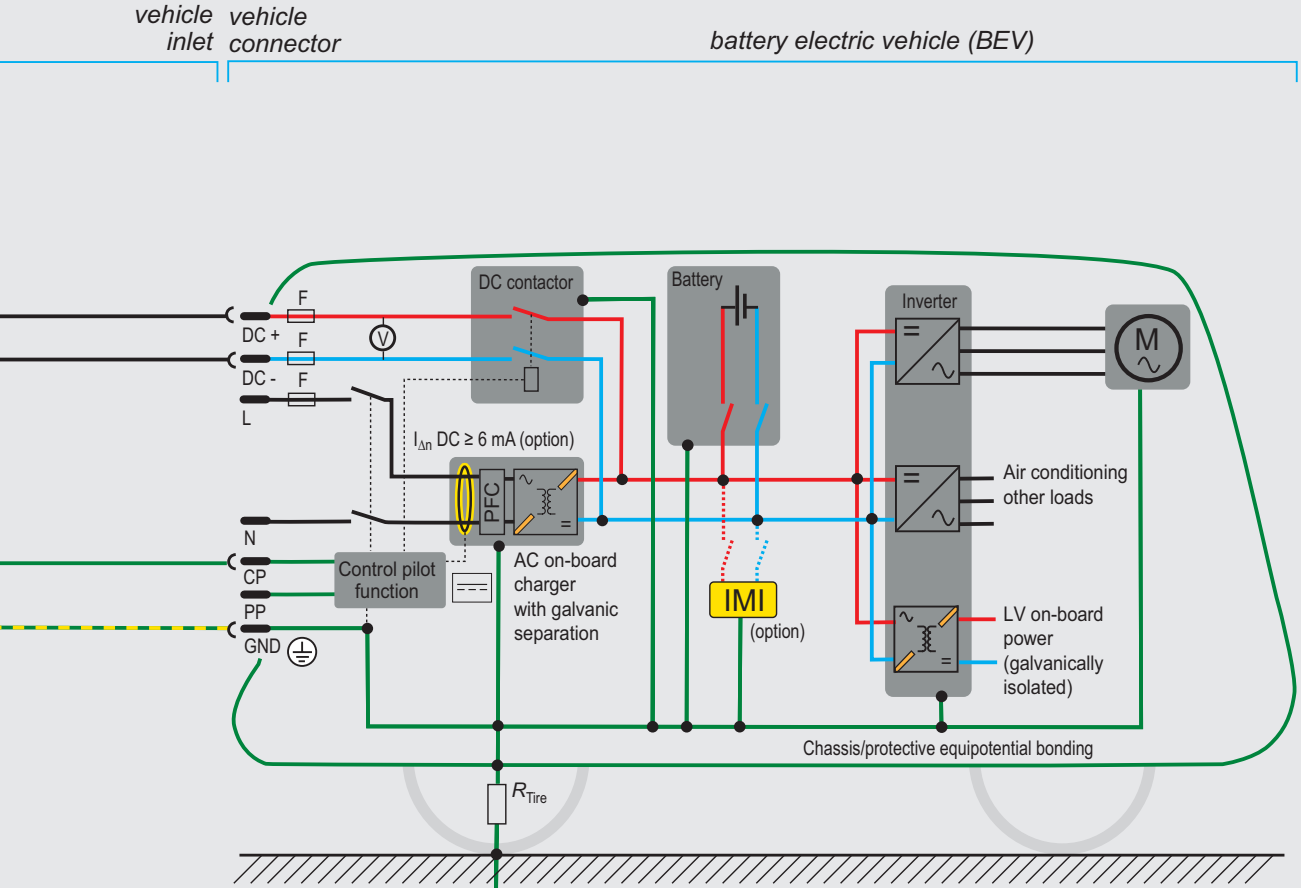
DC Fast Charging Stations

DC charging stations are the means of choice for charging electrical vehicles quickly. In order to guarantee the electrical safety of the charging circuit, it is set up as an ungrounded/ floating DC power supply system with insulation monitoring. During the charging process, the insulation monitoring device (IMI) monitors the entire charging circuit from the charging station to the electric vehicle. This requires coordination with the insulation monitoring device in the vehicle. The IMI in the vehicle needs to be disabled during the charging process to avoid interference.

isoCHA425HV-D4-4+AGH420-1

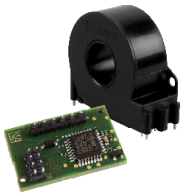
The perfect solution:

Monitoring of the HVDC charging circuit using ISOMETER® isoCHA425HV and AGH420-1 coupling device (for voltages of up to DC 1000V).



RCMB Matrix

	Dimensions	Supply voltage	Standards	Switching threshold		Bender Article Number
Variant 4-N4641-				X6	X30	Bender article
X900 RCMB121-1	49.45 mm (Length) 34.3 mm (Width) 13.95 mm (Height)	DC 5 V +/- 0.1	V IEC62752	6mADC+ 30mArms	30m Arms (info)	B94042490
X901 RCMB121-2			UL2231	5mArms (CCID5)	20mArms (CCID20)	B94042491
X903 RCMB121-3			EC62752 or UL2231	6mADC+ 30mArms	20mArms	B94042492
X904 RDC121-4			IEC62955	6mADC	6mADC (Info)	B94042493
X920 RCMB123-1			IEC62752	6mADC+30mArms	30m Arms (info)	B94042470
X922 RDC123-4			IEC62955	6mADC	6mADC (Info)	B94042473
Variante 4-N4641-				IEC	UL	Bender article description
X803 RCMB121-3S	49.45 mm (Length) 34.3 mm (Width) 13.95 mm (Height)	DC 5 V +/- 0.1	IEC62752 UL2231	6mADC+30mArms	20mArms (CCID20)	B94042449
X804 RDC121-5S			IEC62955 UL2231	6mADC	20mArms	B94042448
X836 RDC125-5S	Not finalized	DC 5 V +/- 0.1*	IEC62955 UL2231*	6mADC*	20mArms (CCID20)	B94042450 *Preliminary
X825 RDC123-5S	49.45 mm (Length) 34.3 mm (Width) 13.95 mm (Height)	DC 5 V +/- 0.1	IEC62955 UL2231	6mArms	20mArms (CCID20)	B94042478
X820 RCMB123-1S			IEC62752	6mADC+30mArms	30mArms (Info)	B94042475
PCB Solution				Switch 2	Switch 1	
RCMB104-1	PCB 28.00 mm (Length) 17.41 mm (Width) 6.5 mm (Height) CT 52.7 (Length) 20.8 mm (Width) 43.5 mm (Height)	DC 5 V +/- 5 %	IEC62752	6mADC+30mArms	30mArms (Info)	B94042480
RCMB104-2			UL2231	5mArms (CCID5)	20mArms (CCID20)	B94042481
RDC104-4			IEC62955	6mADC	6mADC (Info)	B94042483
RCMB104-3M			IEC62752 UL2231-2	6mADC+30mArms	20mArms (CCID20)	B94042484
RDC104-5M			IEC62955 UL2231-2	6mADC	20mArms (CCID20)	B94042487



Electrical safety for AC
Charging level 1 & 2

Application example:
The RCBM121-1, 2, 3 are PCB mounted CCID5 and 20 sensors recognized to UL2231. IEC versions are also available.

RDC104 provides the same functionality but enable the use of larger current transformers.

Trip Levels:

- RCMB121-1 (5mA DC, 30mA AC)
- RCMB121-2 (5mA AC, 20mA AC)
- RCMB121-3 (5mA DC, 20mA AC)
- RDC104-4 (5mA DC, 30mA AC)
- RCMB420EC (5mA DC, 30 mA AC)

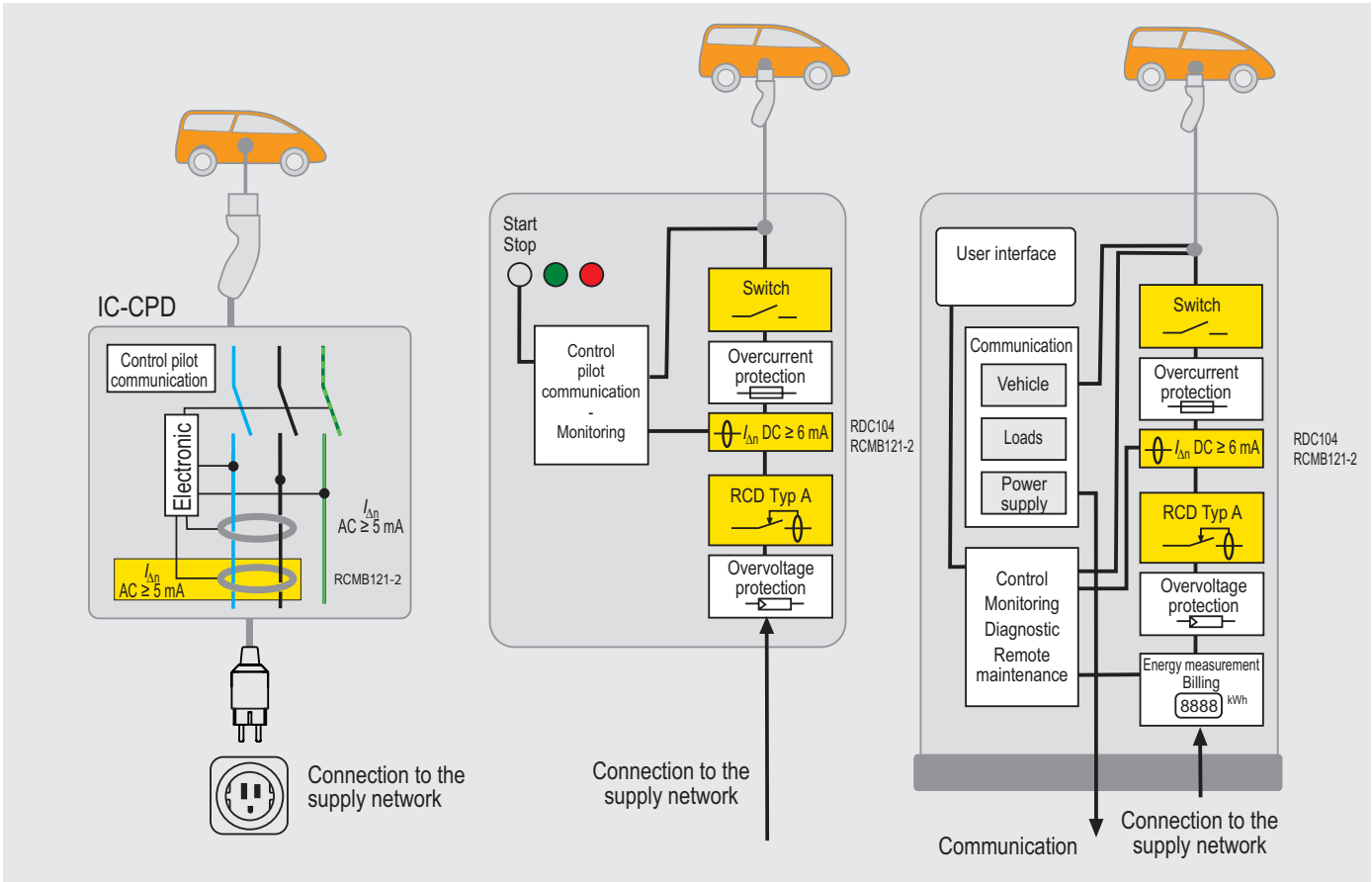
Ground fault current module RCMB121

CTBC17 ground fault current sensor

Charging Mode Level 1
Charging from sockets

Charging Mode Level 2
e.g. private charging station

Charging Mode Level 2
e.g. public charging station



* IC-CPD = In-Cable Control and Protective Device

The Challenges of EV

Electrical safety from the charging station to the electric vehicle

Electrical safety both in the electric vehicle itself and in the charging infrastructure is of key importance in the use of electric vehicles (EV). As in all areas of everyday life, protecting people from the hazards caused by electrical current is top priority here too.

In the electric vehicle (EV)

In the vehicle, there are various power systems which require careful coordination of protective measures to guard them. Insulation faults in the high voltage system (on-board network) caused by contamination, humidity, faulty connections, etc. must be avoided or detected and remedied.

At the charging station

The basic aim is to be able to charge electric vehicles from a variety of charging stations. This means different networks and protective measures can come together during the charging process. This requires careful coordination and implementation of all measures in order to guarantee comprehensive electrical safety for the user.

In building installations

The requirements for electrical safety in buildings are defined in detail in the NEC (National Electrical Code) in the US, and in the CEC (Canadian Electrical Code) in Canada. To make sure that electric vehicles (EV) can be charged safely and reliably, both the necessary protective measures required for the building and those required for new installations must be complied with and the system set up in accordance with the normative requirements for the charging process.

AC Charging

The Charge Controller CC613 combines the electrical safety requirements of AC charging points with the vehicle charging requirements.

Due to its compact structure and size (114.5 mm x 22.5 mm x 99 mm), the Charge Controller makes intelligent, small, and cost-effective charging stations possible. To communicate with the Charge Controller, a back-end system together with a well-known and reliable communication protocol is required. Since most of the back-end device manufacturers use the OCPP communication protocol, the Charge Controller is compatible with OCPP-1.5 and with all electric vehicles currently present on the market.

Integration tests with the back-end implementations of providers such as Vattenfall, Bosch, NTT, and DRIIVZ have been successfully carried out. The Charge Controller can be operated in an "Always-on system", which is always connected to a mobile network.

The controller supports 2.5G Edge and 3G UMTS mobile networks. For connection to online operation, a SIM card is required. User interaction is facilitated using an optional RFID module, which consists of an RFID card reader and LEDs. Charging is initiated by either holding a valid RFID card close to the reader or remotely by the backend system via OCPP. In offline operation, the charge controller can optionally allow charging without authorisation or it can authorise users based on RFID and a local whitelist of authorized RFID cards.

CC613
charge controller

CC Matrix

	ELM4PR-M	ELPR-M	ELM4PR	ELPR	HEM-X2	HB
DC fault current detection (>6 mA)	✓	✓	✓	✓	✓	✓
Weld check	✓	✓	✓	✓	✓	✓
PE monitoring	✓	✓	✓	✓	✓	✓
PLC acc. to ISO 15118	✓	✓	✓	✓	✓	✗
DLM	✓	✓	✓	✓	✓	✗
Emergency opener	✓	✓	✓	✓	✓	✗
OCPP 1.5 & 1.6 (JSON & SOAP)	✓	✓	✓	✓	✗	✗
Additional I/O	✓	✓	✓	✓	✗	✗
4G modern	✓	✗	✓	✗	✗	✗
Interface: 1x USB config	✓	✓	✓	✓	✓	✓
Interface: 2x USB host	✓	✓	✓	✓	✓	✗
Interface: Modbus energy meter	✓	✓	✓	✓	✓	✗
Interface: Ethernet	✓	✓	✓	✓	✓	✗
Interface: RFID card reader	✓	✓	✓	✓	✗	✗
Interface: External Modbus	✓	✓	✗	✗	✗	✗
Charge Case: C (fixed cable)	✓	✓	✓	✓	✓	✓
Charge Case: B (socket outlet)	✓	✓	✓	✓	✓	✗
Article No.	B94060020	B94060021	B94060026	B94060027	B94060028	B94060024

Monitoring of direct fault currents

$I_{\Delta n}$ DC ≥ 6 mA

Type A residual current device (RCD) are provided in accordance with IEC 61008-1/IEC 61009-1 to trigger for the following fault currents $I_{\Delta n}$:

- For sinusoidal alternating fault currents
- For pulsating direct fault currents

If direct fault currents $I_{\Delta n}$ DC ≥ 6 mA occur, e.g. during charging, then both the response time and the response level of residual current devices (RCD) can be negatively affected. In the worst case, a type A residual current device will no longer respond to a high level of direct fault current. In order to prevent this, either type B residual current devices (RCD) can be used or other suitable measures taken.

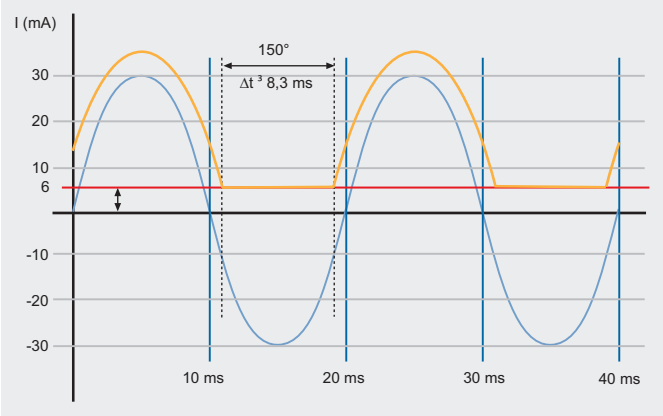
Suitable measures could be: Detection of $I_{\Delta n}$ DC ≥ 6 mA using RCMB420EC and therefore

- Controlling the charging switch in a charging station (Mode 3)
- Controlling the relay in an IC-CPD
- Controlling the vehicle electronics

One of these measures can be used to guarantee that there is no negative impact on the function of (any) type A residual current device (RCD) in the building installation.

Note

The use of a detection system for $I_{\Delta n}$ DC ≥ 6 mA with RCMB420EC also makes a residual current device (RCD) necessary in accordance with DIN VDE 0100. It protects the type A residual current device (RCD) against malfunction.



Quote from:
DIN EN 61851-1 (VDE 0122-1):2012-01
Electrical equipment of electric vehicles – Electric vehicle conductive charging system –
Part 1: General requirements; section 7.6

"The charging system must limit the introduction of **direct currents** and non-sinusoidal currents which could affect the functionality of residual current device (RCD)..." (Translation: Bender GmbH & Co KG).

Quote from:
DIN VDE 0100-722(VDE 0100-722):2012-10 Low-voltage electrical installations

"722.531.2.101 Residual current devices (RCD)

- A separate type A residual current device (RCD)
  $I_{\Delta n}$ ≤ 30 mA, min. for each connection
- When direct fault currents $I_{\Delta n}$ DC ≥ 6 mA occur, suitable measures must be taken."

CTBC17

RCMB121

Why Bender is Better

In the charging industry, we provide electrical safety devices for Level 1, 2, and DC fast charging stations. Here, it is of utmost importance to ensure reliable and accurate measurements to enable the charging station to interrupt power when a hazardous electrical situation occurs. These safety circuits have to be able to perform their duty 24/7 in a variety of conditions over a wide temperature range. Our sensing devices are capable of detecting miniscule fault currents in the mA range out of multiple to hundreds of amps of full-load current. This for single-phase AC, DC and even 3-phase systems. The mA current sensors usually provide multiple trip outputs and have self-check capabilities to enable a safe shutdown in case of a failure. These safety features have been evaluated by UL to UL2231 and enable the integrator to provide an already approved safety solution in their EVSE.

Chargers

- Bender has the highest performing measurement technology on the market
- Capable of doing the 6mA DC measurement (required in Europe/IEC market)
- Capable of doing AC/DC true RMS measurements in the mA range
- Capable of doing the above across a wide temperature range

The powerpack of an EV utilizes high voltages and multiple hundreds of amps to generate the power needed to propel the vehicle adequately and reliably over long distances. The powersystems on board are comprised of a battery, electronic equipment (such as inverters), and a drivetrain which can feature a large variety of motor types. Such a complex powersystem has multiple potential points of insulation failure to the frame which need to be adequately monitored with high accuracy to ensure the passengers' safety. The Bender IMI (Insulation Monitoring Interrupters) are capable of providing accurate data on the vehicles insulation status along the entire powersystem. Its AMP (Adaptive Measuring Pulse) adapts to any vehicles Y-caps and progressively filters out any disturbance to provide a true ohmic insulation value.

In the vehicle

- Accurate insulation measurements from the battery into the drivetrain
- Capable of measuring a deactivated bus
- Capable of adjusting to varying Y-caps

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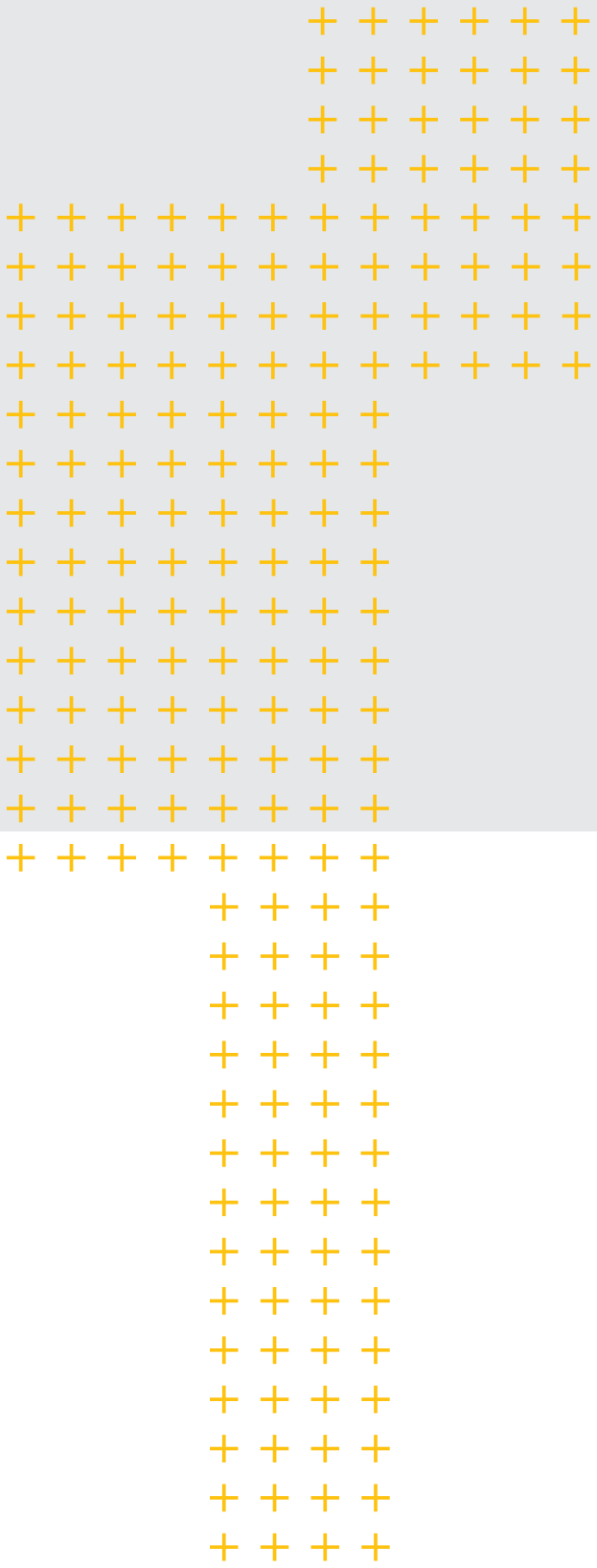

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