



BENDER[®]

The Power in Electrical Safety

A close-up photograph of a person's hand in a white shirt plugging a blue charging cable into the charging port of a dark-colored electric car. The car is parked on a cobblestone street in front of a yellow building with windows. The background is slightly blurred.

Electrical Safety Solutions for EV/EVSE



THE POWER IN ELECTRICAL VEHICLE SAFETY

For over 80 years, Bender's mission has been to make electrical power safe. Our wide portfolio of cutting-edge electrical safety and monitoring products are used in virtually every industry — healthcare, solar, oil and gas, electric vehicle, mining, and many more. With more than 50 offices, representatives and partners around the world, Bender provides customized solutions in electrical safety to meet the needs of the electrical vehicle industry.



Intelligent Electrical Safety for the Mobile Future

For the last 80 years, 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 iso165 & IR155-32xx

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 drive train
- Fully adaptive to varying Y-caps



2 CC612

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 isoEV425 & ISOcha425

Isolation monitor interrupter for level 3 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 level 3 (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.

Electrical safety

Insulation Monitoring

The power supply system in an electrical vehicle is comprised of an HV battery, power distribution, and a drive train. 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® series IR155 or iso165C

Major characteristics:

- Universal for high and low voltage systems
AC/DC 0...1000 V IR155
AC/DC 0...600 V iso165C
- Patented measurement method for preventative detection of insulation faults 0...10 M Ω
- Additional safety via automatic self-test
- Permanent monitoring of ground chassis connection
- Detection of symmetrical insulation faults
- Short-circuit proof outputs for
 - Fault messaging
 - Measured value (PWM signal)
- Conformal coating (SL1301EO-FLZ) on IR155
- Available for DC 12 V and 24 V supply voltage
- Automotive approval e1 according to 72/245/EWG/EEC 2009/19/ G/EC
- CAN interface on iso165C



ISOMETER® iso165C

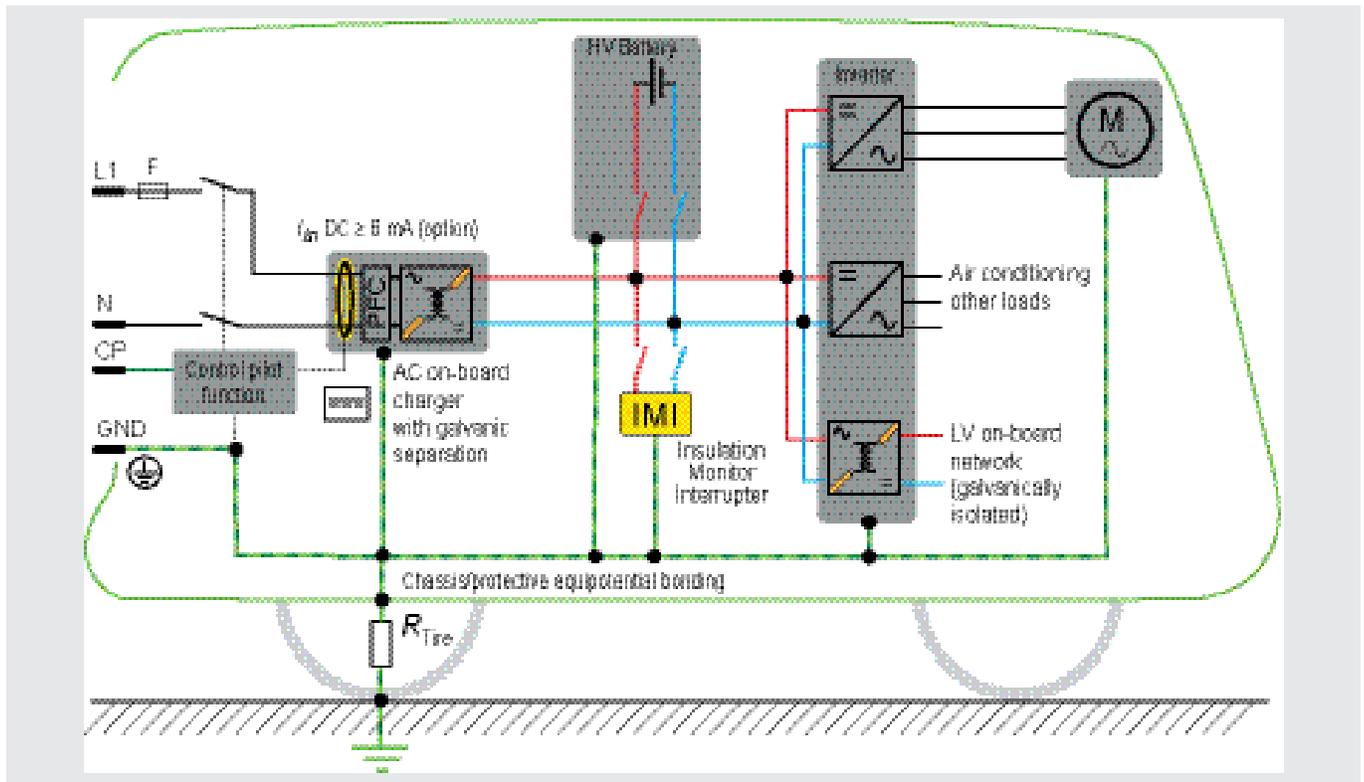


ISOMETER® IR155

Overview of important standards:

- ISO 6469-3:2011-12
Electric propelled road vehicles – Safety inspections – Part 3: Protection of persons against electric shock
- ISO 23273-3:2006-11
Fuel cell road vehicles – Safety inspections – Part 3 – Protection of persons against electric shock
- UL 2231-1:2002-05
Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General requirements
- IEC 61557-8:2007-01
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 IT systems

Application Example



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

IMI = Insulation Monitoring Interrupter

PFC = Power Factor Correction



Electrical Safety for DC Charging Stations- Insulation Monitoring

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.

What are the requirements of the standard?

- IEC 61851-23 (2014-03):2014-11
7.5.101: Monitoring of insulation resistance of the secondary circuit.
Par. CC.5.1: "The secondary circuit shall be designed as an IT system and protection measures in accordance with Par. 411 of IEC 60364-4-41 shall be applied. 411".
- SAEJ1772
- UL2231-1 & UL2231-2
- C22.2 NO.281-1 & NO.281.2
- NMX-J-668/1-ANCE & NMX-J-668/2-ANCE



ISOMETER® isoEV425 with AGH-EV coupling device



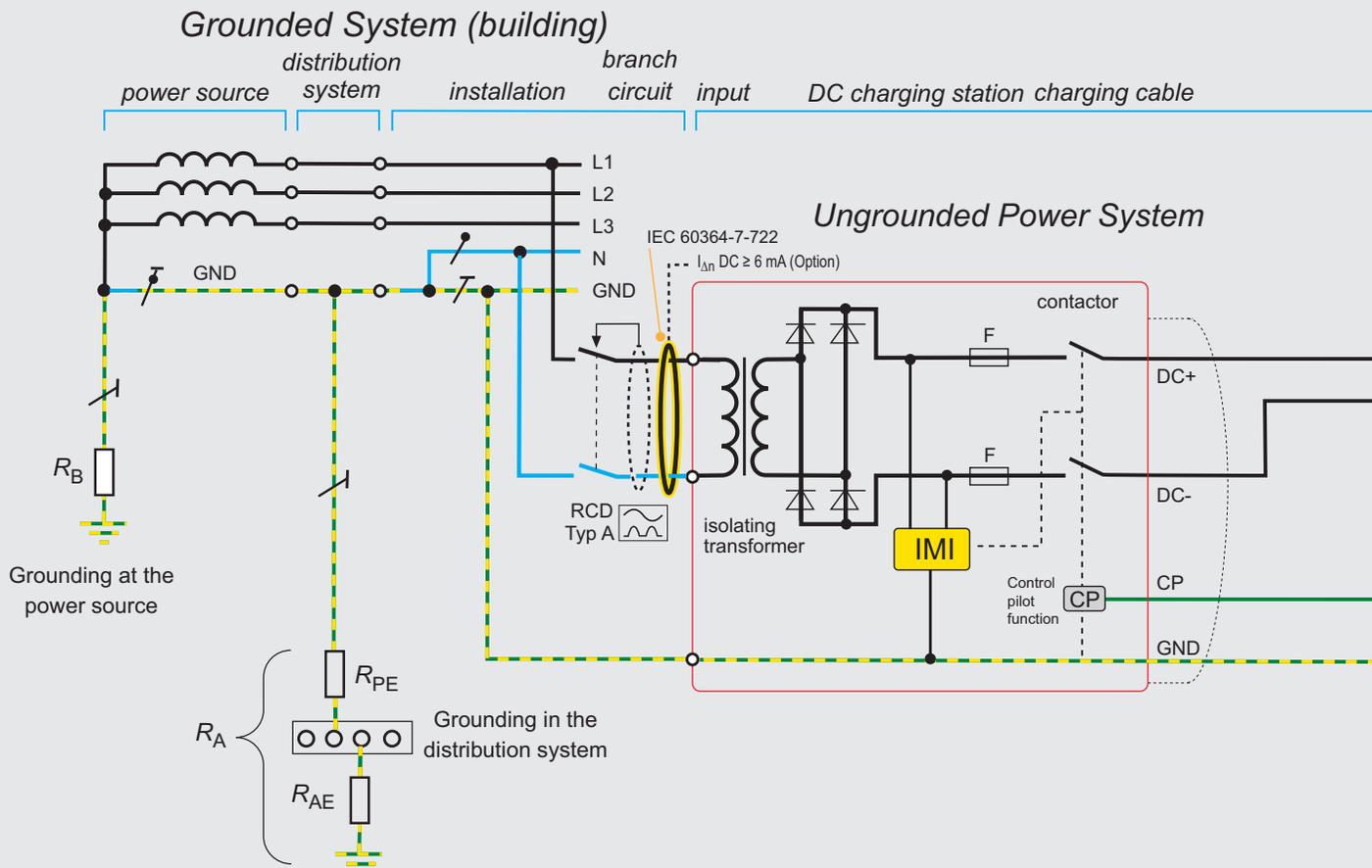
IR155-3210 IMI Board

The perfect solution:

- Monitoring of the HVDC charging circuit using ISOMETER® isoEV425 and AGH-EV coupling device (for voltages of up to DC 1000V).
- ISOCHA425 IMI device for Chademo electrical safety requirements up to 500V*.

*Higher voltage in development

Application examples



LINETRAXX GM420

Overview of important 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

Major characteristics:

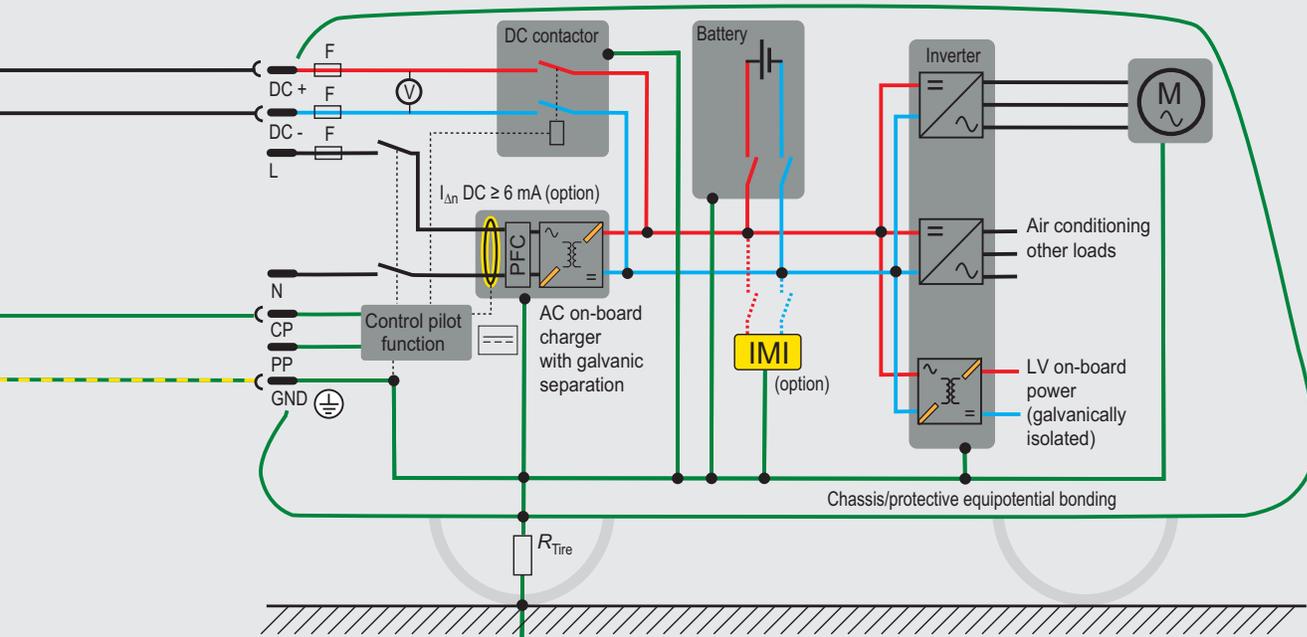
- Ground continuity monitoring
- Two response values that can be set separately
- Basic parameter settings
- LEDs for operation, Alarm 1, Alarm 2
- Internal/external test/reset button
- Two separate alarm relays with single pole (one N/O contact each)
- N/O operation, N/C operation, selectable
- Fault memory selectable
- Self-monitoring with automatic alarm
- Multifunctional LC display



LINETRAXX® GM420
For monitoring of the protective conductor continuity in DC charging stations.

vehicle inlet connector

battery electric vehicle (BEV)



Electrical safety for AC

Charging level 1 & 2 CCID5, 20, 30

In North America, if the electric vehicle is connected to a level 1 or 2 EVSE to charge the battery, the protective measures for ground fault set out in UL2231-1 & -2 must be complied with.

GFI circuits are based on differential current sensing. In the EVSE industry they are classified as CCIDs, or charge current interrupting devices. In North America there is a CCID5 and a CCID20. These trigger at 5mA or at 20mA ground fault current, respectively. The 20 mA trip is allowed when an additional ground check circuit has been installed to monitor for ground wire integrity. Note, the US based CCID devices are only required to trigger on AC current.



RCMB420EC Residual current monitoring module (model example)

The Europeans prefer a slightly different route and allow for a higher threshold of 30mA AC. However, they added an additional requirement for 6mA DC current detection. In the event of a ground fault, if a direct fault current greater than $I_{\Delta n} DC \geq 6 \text{ mA}$ occurs in the charging current circuit, a trip must occur. The background to this is the fact that the function of a type AC GFI can be negatively impacted by direct fault currents greater than $I_{\Delta n} DC \geq 6 \text{ mA}$.

The RCMB series residual current monitors provide a solution which enables direct fault currents $I_{\Delta n} DC \geq 6 \text{ mA}$ to be detected and evaluated.

What are the requirements of the standard?

- *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 devices (RCD)..."
- *IEC 60364-7-722:2015 (Power supply of electric vehicles)*
722.531.2.101
"Residual current protective devices (RCD)
 - A separate type A residual current device (RCD) $I_{\Delta n} \leq 30 \text{ mA}$, min. for each connection point
 - Suitable measures must be taken for direct fault currents $I_{\Delta n} DC \geq 6 \text{ mA}$."
- UL2231-1-2
- C22.2 NO.281-1 & NO.281.2
- NMX-J-668/1-ANCE & NMX-J-668/2-ANCE

The perfect solution:

- The RCMB series residual current monitor detects direct fault currents and can initiate disconnection via a switching element.

Major characteristics:

- Residual current monitoring $I_{\Delta n} DC \geq 6 \text{ mA}$
- Relay types and PCB mount versions available for 1ph/3ph systems up to 32 A
- Permanent connection monitoring of measuring current transformer
- LEDs for operation and alarm
- Internal test button
- Versions for 6,20mA AC - 6mADC, 30mA AC, hybrid versions
- Precise measurement by means of digital measurement method
- Insensitive to load currents thanks to full magnetic shielding
- With optional analogue measurement output

Electrical safety for AC

Charging level 1 & 2

Application example:

The RCMB121-1, 2, 3 are PCB mounted CCID5 and 20 sensors recognized to UL2231. IEC versions are available as well.

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

RCMB420EC provides the same functionality as the units described above but in relay style with dual CTs.

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)

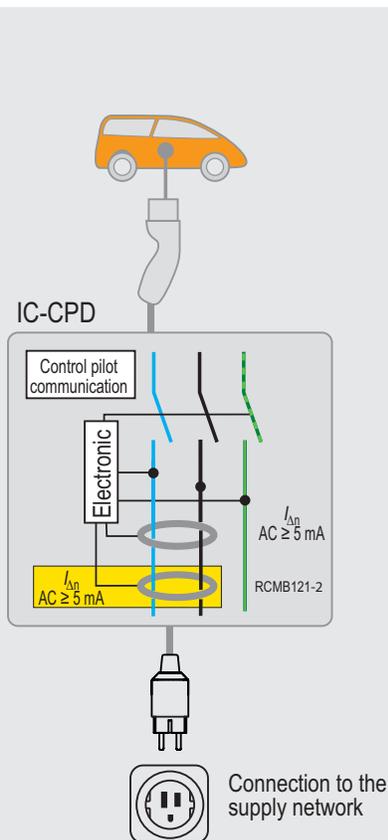


Residual current monitoring module RCMB121

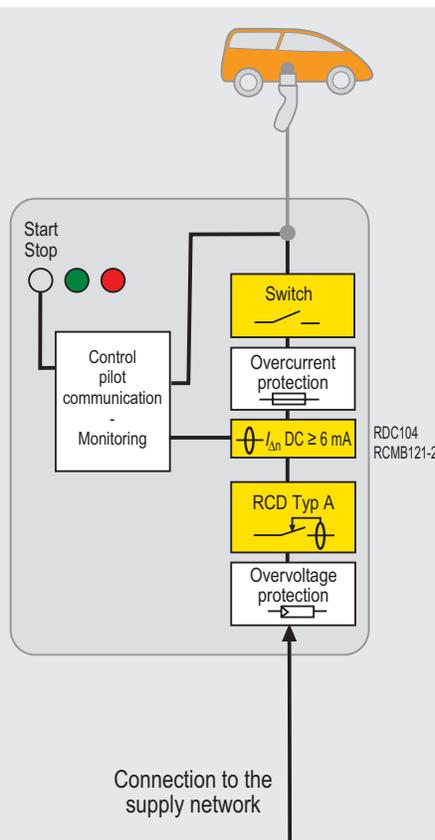


Residual current monitoring module RDC104

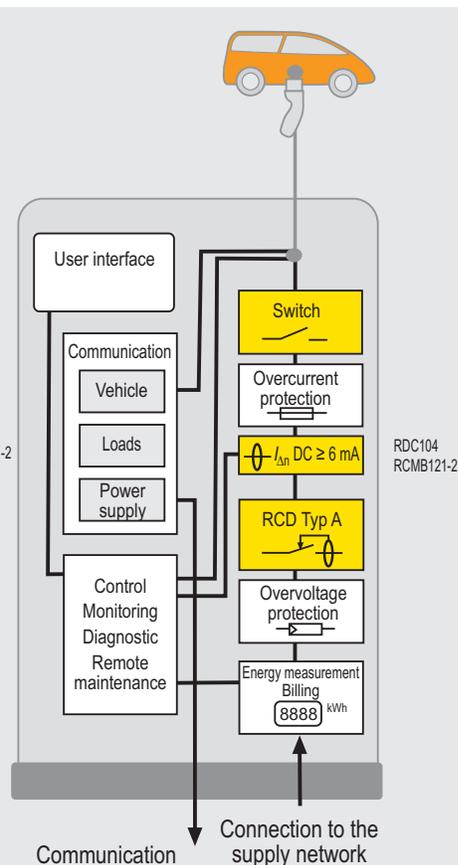
Charging Mode Level 1 Charging from sockets



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 CC612 combines the electrical safety requirements of AC charging points with the vehicle charging requirements.

It is optionally available with an AC/DC sensitive residual current monitoring device. Monitoring is done via an externally connected shielded current transformer which is connected to the CC612. Thereby, the requirements of the standards series DIN VDE 0100 or rather DIN VDE 61851 regarding protective measures directly in the Charge Controller are complied with. A residual current device (RCD) type A can be used in the infrastructure. The measured values are available to the backend system via the integrated modem.

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 backend system together with a well-known and reliable communication protocol is required. Since most of the backend 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 backend 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.



Charge Controller CC612

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 white list of authorised RFID cards.



Monitoring of direct fault currents

$I_{\Delta n} \text{ DC} \geq 6 \text{ mA}$

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 $I_{\Delta n} \text{ DC} \geq 6 \text{ mA}$ 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.

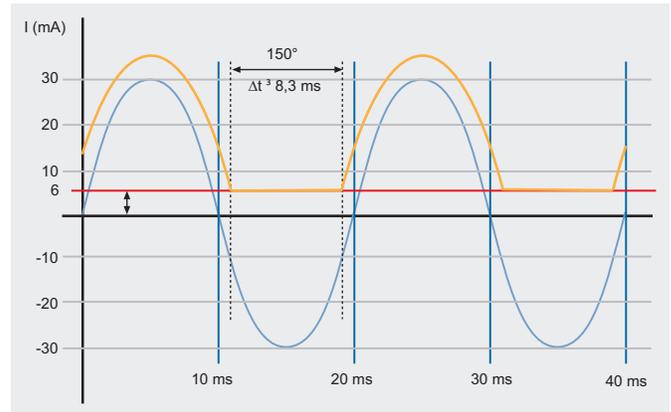
Suitable measures could be: Detection of $I_{\Delta n} \text{ DC} \geq 6 \text{ mA}$ using RCMB420EC and therefore

- 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 $I_{\Delta n} \text{ DC} \geq 6 \text{ mA}$ 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) $I_{\Delta n} \leq 30 \text{ mA}$, min. for each connection
- When direct fault currents $I_{\Delta n} \text{ DC} \geq 6 \text{ mA}$ occur, suitable measures must be taken."

RCMB104



RCMB121



Why Bender is Better

In the charging industry the Bender corporation provides electrical safety devices for Level 1, 2, and 3 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. Benders 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 drive train 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.

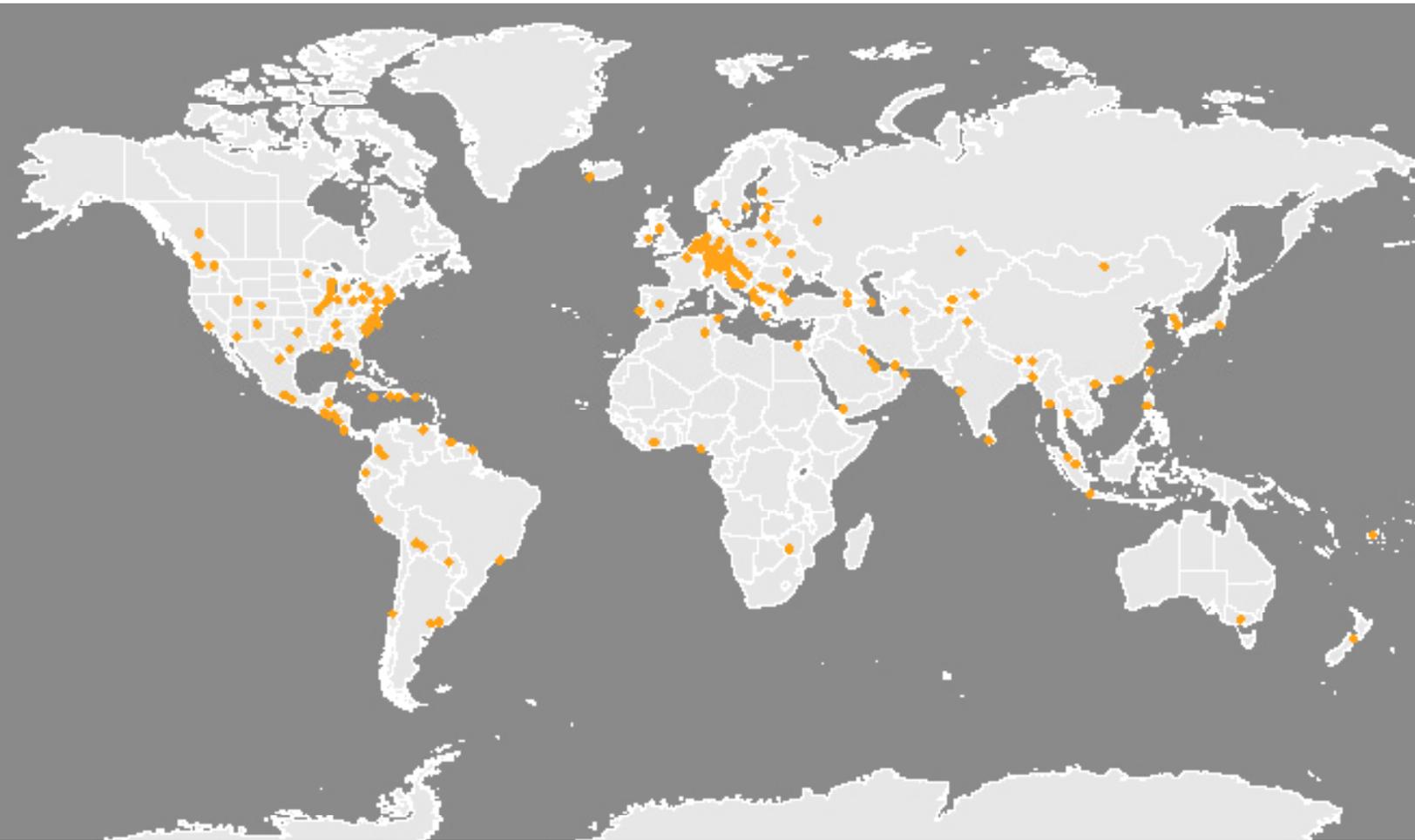
In the vehicle

- Accurate insulation measurements from the battery into the drive train
- Capable of measuring a de-activated bus
- Capable of adjusting to varying Y-caps





Bender is located in over 70 countries around the world



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