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EV CHARGING

6mA sensor technology for the protection of AC Residual Current device (RCD) circuits in residential installations

By Frank Mehling & Torsten Gruhn
Illustrations: Bender GmbH & Co. KG

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The potential for superimposed DC currents onto AC systems during the EV charging process poses interesting technological hurdles that must be overcome. The following article describes the subject in more detail and analyzes the problem from the electrical safety side.

The German DIN EN 61851-1 (VDE 0122-1): 2012-1 defines various charge modes for electric vehicles (EV). Typically, these EVs are sourcing power from an existing receptacle or fixed installed EV charging point, fed via charge mode 1 and 2. In accordance with DIN VDE 0100-410 (VDE 0100-410):2007-06, AC RCD protection for receptacles carrying less than 20A is required. The same requirement applies to portable power circuits with a current limitation of 32 A. Proposed standard DIN VDE 0100-722 (VDE 0100-722):2011-09 refines these requirements further by defining the RCD circuit as a type A device. Measures to safely interrupt power must be taken if the load profile causes or carries DC fault currents exceeding 6 mA. These currents can only be detected and interrupted by RCDs of type B. Mixing type A and B devices with the same power distribution is prohibited. New installations may therefore be advised to employ type B RCD circuits only.

Normative requirements for RCD type "A" devices

Residual current devices of type "A" are designed for the following IΔN fault profiles in accordance with IEC 61008-1 and IEC61009-1:

- For pulsating sinusoidal currents
- For pulsating DC currents

Straight DC currents up to 6mA are tolerated. (Ill. 1)

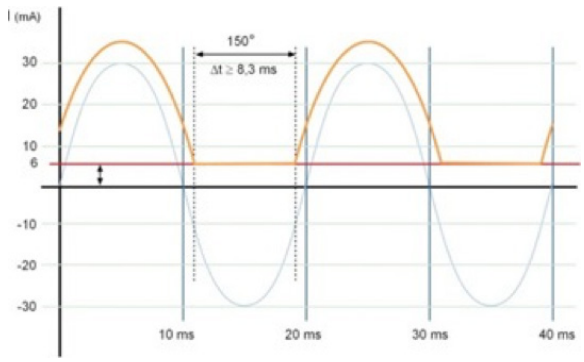

Illustration 1: 6mA DC portion

In case $I_{\Delta N}$ exceeds 6mA, a type A RCD in the distribution may experience negative effects on its response behavior. The worst scenario is the RCD failing to trip completely. The term "DC blinding" is used to describe this possibility.

The RCD safety net is no longer available. To prohibit potential hazards, the implementation of type B RCD is required.

Potential sources for DC currents

EV charging circuits often employ power factor correction (PFC) to fulfill power quality and EMI requirements. A typical schematic is shown in illustration 2.

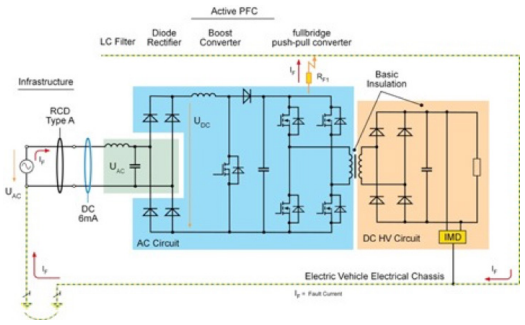

Illustration 2: EV charge schematic

An insulation failure or ground fault on the secondary side of the PFC will cause a DC current to flow. If this current exceeds 6mA, RCD type "A" class devices may no longer function properly. (Ill. 3)

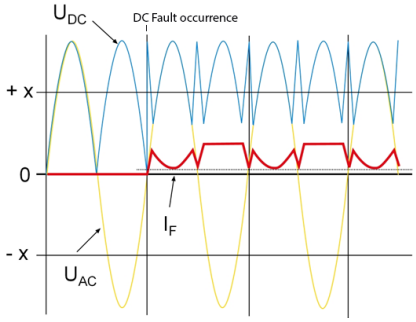

Illustration 3: Insulation fault causing DC current

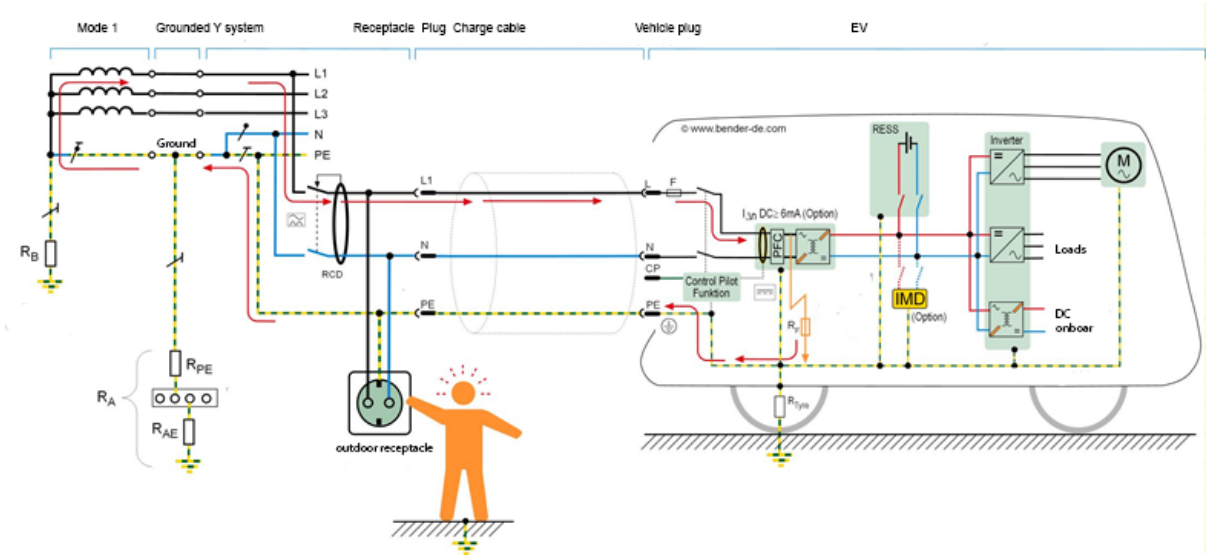

Illustration 4: Negative influence on RCD type A

This occurrence of DC blinding is currently not described in DIN VDE 0100-530 9VDE 0100-530):2011-06. Its lack of mention is the result of a relatively new situation caused by modern drives and power supplies with PFC and rectification. The DC fault current will return to the AC source circuits via neutral ground connections and negatively influence all RCD type "A" that are part of the loop. (Ill. 4)

Sensor technologies to detect DC fault currents $I_{\Delta N} \leq$ 6mA

In accordance with DIN standard EN61851-1 (VDE0122-1):2012-01, a charging system must detect and protect against DC and non-sinusoidal currents when a malfunction or single fault occurs. Of particular importance is the situation where these currents could negatively influence the functionality of RCDs or other similar safety related equipment.

Similar requirements are posted in the standard proposal E DIN VDE 0100-722 (VDE 0100-722): 2011-09 in segment 722.531.2.101: "When DC fault currents of $I_{\Delta N} \leq$ 6mA occur, adequate corrective measures have to be taken". An example of compliance with this statement includes detection of $I_{\Delta N} \leq$ 6mA with a special sensor, connected in series with an existing type A RCD. Both may be connected in a manner where the sensor detects $I_{\Delta N} \leq$ 6mA and provides this information to the charge controller via a relay circuit. The charging operation will then be interrupted by:

- Control of the main power switch in a charging station (Mode 3)
- Control of the power contactors inside of a IC-CPD

This method provides DC blinding protection for an existing type A RCD without the need to replace the type A RCD completely.

Summary

Protection against electric shock is a prerequisite for the success of the electric vehicle industry. Wide ranging standards efforts are underway in various committees, such as DKE and DIN. DC capable sensor technology offers a significant improvement in electrical safety and helps to ensure currently installed RCDs function as intended.