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EXTENSION OF THE CURRENT FLOW DIAGNOSIS OF THE DC-CHARGING INTERFACE

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Technical task:
Extension of overcurrent detection to include operating mode and direction of battery current.

Various charging options are currently offered in electric vehicles. A distinction can be made between DC and AC charging in the case of the conducted charging options. DC charging in conjunction with appropriate charging stations enables very high charging capacities and therefore short charging times.

Various faults can occur in the DC charging circuit, which are protected by safety devices such as the insulation monitor on the charging column side or on the vehicle side, a fault current protection device depending on the country, or overcurrent protection devices in the vehicle. A protective conductor system, which is connected to the vehicle body in the event of a load, is particularly necessary for the residual current protective device.

For DC charging, very high cross-sections are required for the active conductors in order to enable the high powers of up to several 100kW. However, the current concepts show very small cross-sections (6qmm) for the protective conductor system relative to the cross-sections of the active conductors (>70qmm). In the event of a short-circuit current, overcurrent protection devices (fuses) protect the active conductors. However, this fuse cannot sufficiently protect the protective conductor in the event of a short-circuit, e.g. in the case of a double fault in Figure 1.

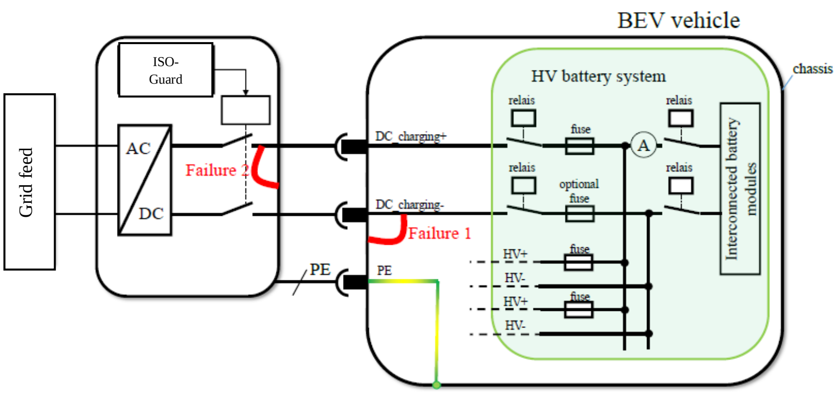

Figure 1: Resulting topology with connected charging station in case of DC charging of a BEV vehicle - double error

The short-circuit current supplied by the charging station is protected by the charging station and can be switched off by opening the contactors on the charging station side. Furthermore, this idea description deals with the possibilities of better detecting and switching off short-circuit currents of the HV battery in the event of charging. Figure 2 shows the resulting current path with regard to the short-circuit current of the HV battery in the case described above. Among other things, the current flows through the protective conductor.

In this case, the current flow cannot even be switched off by the charging station. In addition, the customer cannot see that the charging station already has this fault. The fault current occurs after plugging into the charging station and switching on the DC charging contactors in the battery system. The fuses of the DC charging cables as well as the cross-sections of the cables are designed for the expected current flows during charging (e.g. at 150kW, 400V --> 375A). The current carrying capacity of the protective conductor system is many times lower (e.g. 6qmm Cu --> approx. 50A current carrying capacity).

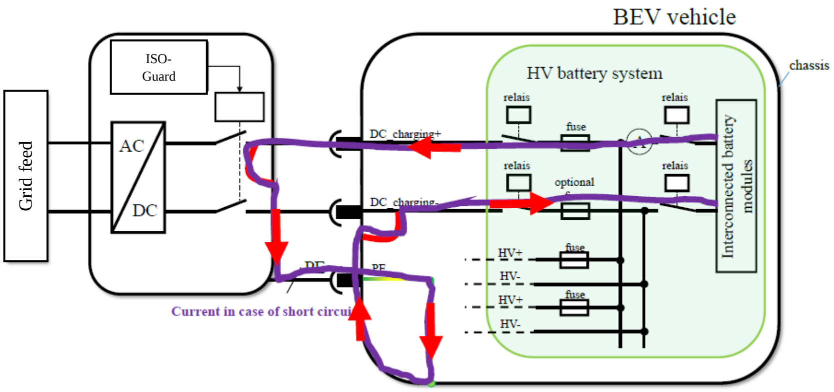

Figure 2: Current path of the short-circuit current from the HV battery in the case of a double fault

The protective conductor is currently designed in such a way that it can carry the resulting current in the event of a normal fault. In this double fault case described, a short-circuit current occurs which exceeds the current carrying capacity of the protective conductor.

Initial situation:

- Possible overloading of the protective conductor system due to excessive short-circuit currents.
- Higher cross-sections required for cables and plug contacts

Solution:

The overcurrent switch-off already consists of a fuse (for very high short-circuit currents) and a software solution by means of current measurement and switch-off by the main protection (for smaller short-circuit currents) in the battery. The background to this is that the fuse does not cover all areas of the possible short-circuit currents, small overcurrents above the rated current lead only after several minutes to tripping / melting of the fuse and consequently to a thermal overload of the installed cables. Therefore, current measurements in the battery are already used today to detect the overcurrent faster than the fuse and to switch it off by means of the contactors.

The idea is now, depending on the current direction and the operating condition of the vehicle, to variably set the overcurrent and to switch it off if this variably defined value is exceeded. Figure 3 schematically shows the logic of the proposed idea. Depending on the detected or selected operating mode (Model 1 ...N), the maximum currents to be expected (setpoint 1 ...N) are specified. If the actual current exceeds the specified maximum value in the respective operating mode, the signal for switching off is generated. This logic can be implemented either by hardware or by software. The current measurement signal is provided by means of the already integrated current measurement technology (in most cases current measurement shunts).

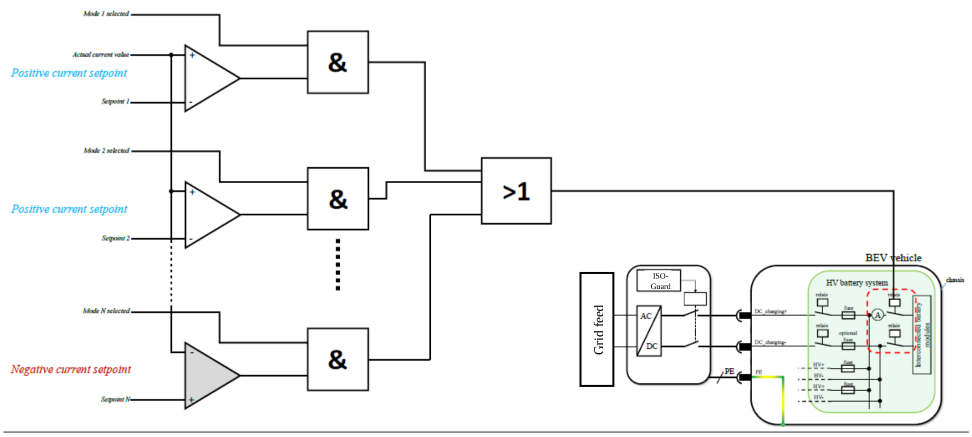

Figure 3: Principle sketch of the proposed overcurrent detection logic

In the case of DC charging, for example, no current flow from the battery is to be expected at the level of the maximum operating currents (e.g. as with boost operation of the drive). If such a high current flows from the battery, a fault in the system can be assumed and the system must be switched off. In the double fault case described above, for example, this has the advantage of switching off in the event of overcurrents below the operating currents (boost operation, e.g. up to 1000A), since the protective conductor system does not have to be designed for these high currents. This can save costs.

Advantages:

- Enabling smaller protective conductor cross-sections
- Increasing the safety of the vehicle
- Increase of diagnostic coverage with little effort