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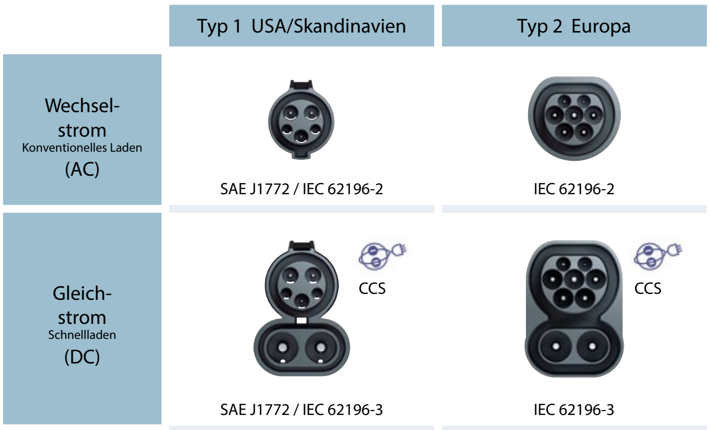
Basic knowledge – charging systems for electromobility

Electromobility has reached the mass market and sales figures for electric cars are increasing continuously. Charging infrastructures conforming to applicable standards are required in order for the vehicles to be charged optimally, efficiently and safely. The DISTRELEC company, your very capable partner for electromobility, stocks a well-rounded range of intelligent and scalable solutions for setting up charging infrastructures.

The various charging plugs

The Type-2 charging plug has become established in Europe and is standardised in accordance with IEC 61851. The Type-1 plug is also used in the USA and certain Scandinavian countries. Both plugs are available as a pure AC voltage variant (which charges slowly) and also with the addition of solid plug-in contacts (plug CCS Type 2) for charging with DC voltage (fast charging, also known as super-charging). The fast-charging plugs are compatible, so that it is always possible to charge purely with AC voltage, i.e. slowly. Slowly at home and fast when on the move.



The various charging modes

Charging mode 2

Charging mode 2 is the simplest way to charge an electric vehicle. The charging cable is plugged into a commercially available domestic socket outlet, generally 13 A, single-phase AC voltage. The electronic charging circuitry, also known as "IC-CPD" (In-Cable Control and Protection Device), between socket outlet and electric vehicle, controls the charging process and checks current flow. This solution can be used as soon as a vehicle is charged over a longer period, for example overnight. This charging mode can also be used as a "makeshift solution" since a domestic socket outlet is generally available at all times. The charge cycle takes longer accordingly owing to the low current flow.

Charging mode 3

Charging mode 3 charges only with AC voltage but uses far higher currents (up to 63 A). Both single-phase and 3-phase. There are two variants of this mode:

Charging mode 3, case B

In case B, the charging cable has a vehicle charging plug at one end and an infrastructure charging plug at the other. So the charging cable does not have a fixed connection to the charging station and can thus be carried on board the vehicle.

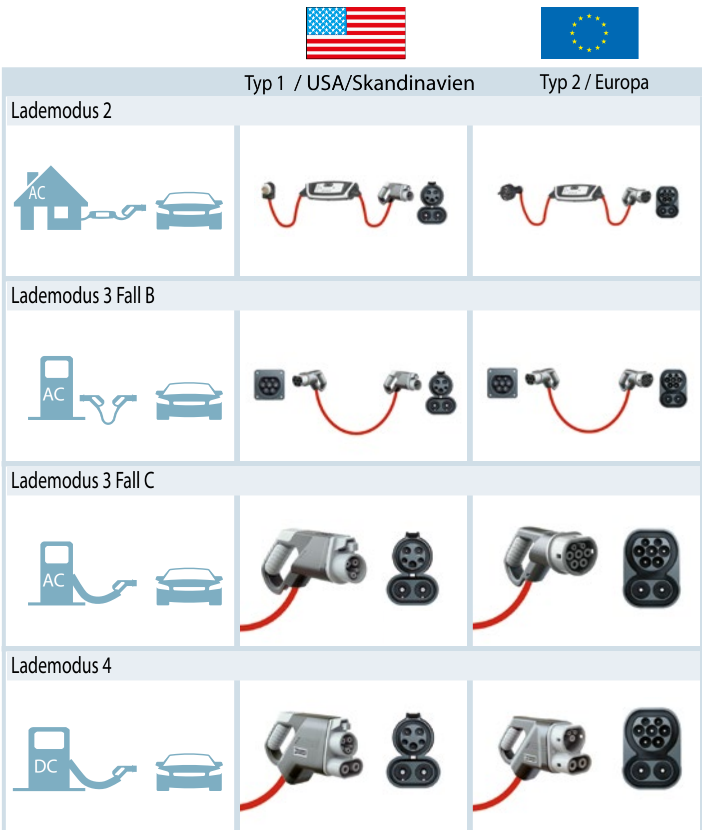
Charging mode 3, case C

In case C, the charging cable has a fixed connection to the charging station.

Charging mode 4

Charging mode 4 complements charging mode 3 in that charging can also be performed with DC voltage and very high transfer currents (200 A and above). Generation of this DC voltage means a more complex charging infrastructure. AC voltage is converted to DC voltage using a rectifier. The current leads must also be sized accordingly. Standard DC charging stations have power rating of approx. 50 kW.

This allows electric vehicles to be charged in minutes.



Charge controllers

A charging point for an electric vehicle always requires fault current monitoring. In accordance with applicable Standards, this can take the form of a residual-current device or corresponding sensor systems. A charge controller ensures that the maximum current flow to the vehicle corresponds to the cross-section of the charging cable. One of its tasks is also to stop charging when the battery is charged. Various charge controllers are used depending on charging mode, as described above.
Other requirements, such as integration of an energy metering circuit, help to select the appropriate charge controller.

EV Charge Control Advanced

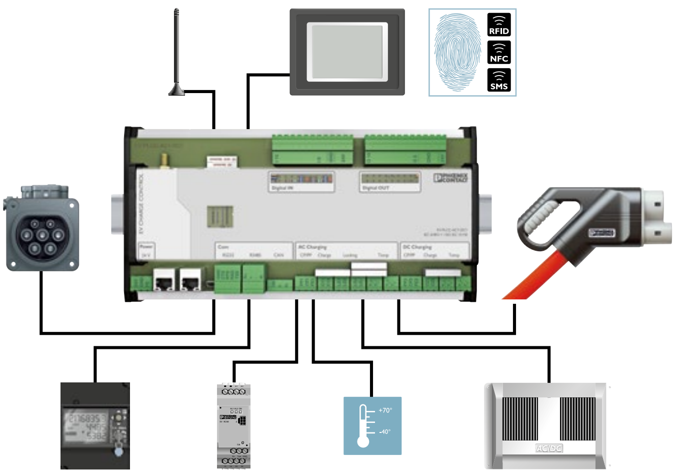
EV Charge Control Basic

Charging infrastructure for several users and fast charging or super-charging

If more than one vehicle simultaneously uses a charging infrastructure, installation is more complex

- Who belongs to the user group?
- Is the charging station a public one?
- May only vehicles licensed, for example by means of a PIN, be charged?
- Is the energy to be billed on or debited on the basis of the consumer or credit principle?
- Is the standardised interface to OCPP (Open Charge Point Protocol) for example to be used for this?

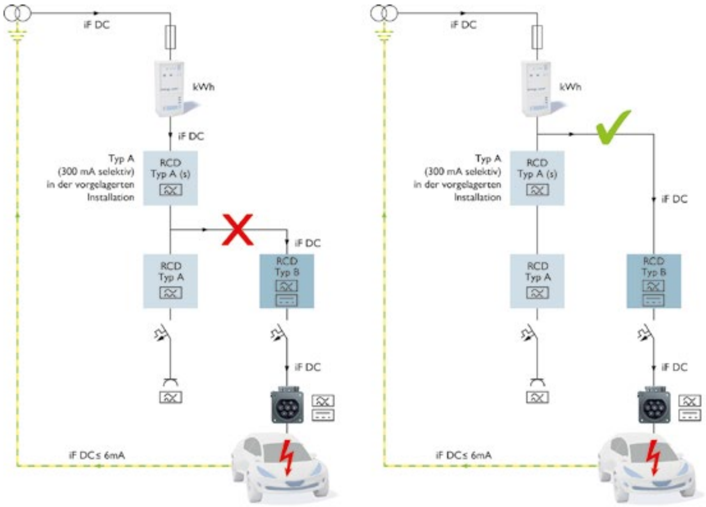
Corresponding charge controllers with all required interfaces, including those which dynamically control the AC/DC converter, are available on the market. One important aspect for dimensioning the electrical supply lead is the number of vehicles to be charged simultaneously. In this, the various charging modes, be they conventional charging or fast charging (super-charging) with DC voltage, play very central roles.



Integration of residual-current devices (RCDs)

Electric vehicle, charging infrastructure and domestic wiring are separate systems. This is the case until the vehicle is connected electrically to the charging facility. As of this point in time, direct currents occurring may act on the domestic wiring's RCD elements.
Domestic wiring is connected to a protective earthing system. An AC fault current is classically detected by an RCD, Type A, and current flow is interrupted immediately.
An electric vehicle is an autarkic system. If it is now connected electrically to the charging station, the vehicle chassis - ground - is at PE potential of the domestic wiring. Thus, a possible in-vehicle DC fault current can be transferred unhindered to the domestic wiring. Entrained DC fault currents can be tolerated by domestic wiring only conditionally. They are not detected by the RCDs, characteristic Type A, normally fitted. The consequences are serious, such as destruction of electrical appliances but also the risk of lethal injury.

The remedy is to use an RCD with characteristic Type B. This class of device reliably detects both AC fault currents and DC fault currents. The major disadvantage of this family of devices is that their technical structure is far more complex than that of variant Type A. This means that an RCD with characteristic Type B is a bigger cost factor per charging point.

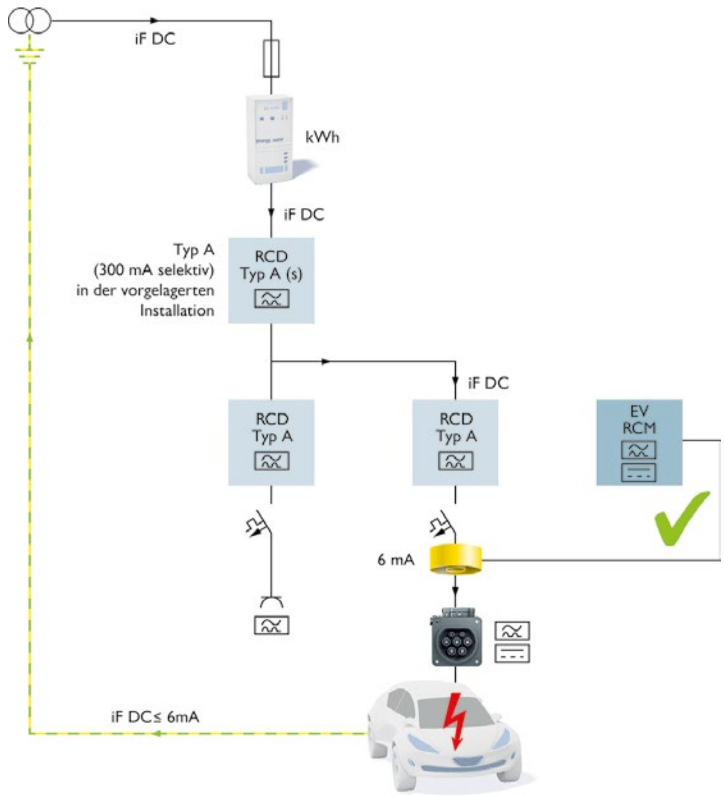


Incorrect (left) and correct (right) arrangement of an RCD Type B

A differential-current monitoring module instead of an RCD Type B is low-cost and the charging point also has a higher availability

A low-cost RCD Type A which is already fitted remains in place or can simply be installed for every charging point. An instrument transformer monitors a possible DC fault current for each charging point instead of a costly RCD Type B. If a DC fault current flows, it is detected reliably. The RCM monitoring module interrupts charging and sets the charge controller to an error status. When the DC fault current abates, the charging point is automatically available again for the next electric vehicle.

An RCD Type B would also have responded to DC fault currents and would have tripped. However, further charging operations are not possible for this period even if the cause of the fault is no longer connected electrically to the charging station. Further charging operations are only possible when an authorised person has switched the RCD back on again.



Positioning of a sensor system for detecting DC fault currents on a charging station

Summary: RCD/differential-current monitoring:
It is always mandatory to integrate an RCD (min. Type A/30 mA).
In the event of a fault, DC fault currents may be entrained from the electric vehicle into the domestic wiring via the charging cable.

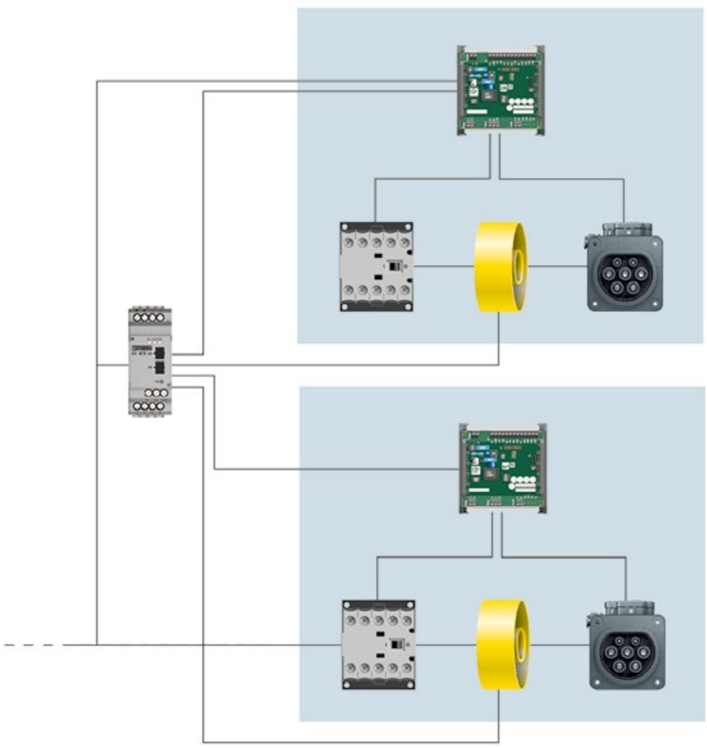
As an alternative to the RCD Type B, it is also possible to use a differential-current monitoring module RCM in combination with an RCD Type A. On the 2-channel versions, one of the charging points continues to be available as an autarkic unit while the defective one is interrupted.

If no further fault current is detected, the charging point is activated automatically again and is thus available for the next charging operation. An RCD Type B would typically remain tripped. Manual actuation is required in order to enable a further charging operation. The availability of the charging station is thus restricted and this means that additional costs may be incurred for servicing and maintenance.

Solutions must be scalable
In a few cases, the buildings are constructed with a complete charging infrastructure right from the very start. It is frequently the case that only a few charging points are installed initially so as to be able to respond flexibly to future needs. At all events, it is advisable to lay empty conduits for supply and data cables.

Intelligent charging controllers communicate with the vehicle in order to cut costs
A typical modern office block, e.g. a bank with 220 staff, consumes an average of 180 kW of energy per day. If only five percent of the staff charge their electric vehicles at work, this corresponds to an additional load of almost 20 percent in the case of single-phase charging with 13 A.
However, if 25 percent of staff with an electric vehicle charge them during working hours, the power demand of the building doubles. The system necessarily collapses without intelligent communication between the vehicles, the electronic charging modules and the office block.

Charging Standard 3 in accordance with IEC 61851-1 is intended to counter this. It allows for the power demand of the building, the number of vehicles to be charged and when they are to be used again. It also dynamically evaluates the up-to-date charging currents of the individual vehicles. Individual vehicles can be prioritised automatically in the case of load peaks or energy shortages. Load management can also be coupled to production of regenerative energy. This flexibly matches the charging power to the current output of the solar-panel installation on the roof of the building.



The simplified structure of an AC charging station in a commercial environment with the EV CC Basic and the two-channel EV-RCM Compact module permits separate monitoring of two charging points

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