WHITE PAPER

Electrical power distribution for Electric Vehicle Charging Infrastructure (EVCI)

Build efficient and reliable AC Distribution Boards for electrified parking spaces

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As the world moves towards reducing carbon emissions, the need for a robust electric vehicle charging infrastructure has become increasingly important. From public charging stations to fast-charging corridors along highways, this infrastructure is transforming the way we travel and helping to minimize environmental impacts.
Explore how ABB can help you design an efficient and reliable Electric Vehicle Charging Infrastructure (EVCI).

Index

Electric Vehicle Charging Infrastructure (EVCI)

An Electric Vehicle Charging Infrastructure (EVCI) is a network of charging stations and supporting infrastructure designed to facilitate the charging of Electric Vehicles (EVs).

The electrical infrastructure of EV Charging typically includes the following components:

POWER SOURCE
This can be the electrical grid, a renewable energy source, a battery backup system, a genset to supply the electricity needed for charging, or a combination of all these elements.

TRANSFORMER
Normally used to step down the voltage from the grid supply to a suitable level for the charger.

CHARGING SUPPLY EQUIPMENT
This equipment connects to and charges the EV battery using AC or DC power.

DISTRIBUTION SWITCHBOARD
This component distributes the power to the individual chargers and incorporates switching and protection functions.

Supply Distribution in Electric Vehicle Charging Infrastructure (EVCI)

Power distribution within the Electric Vehicle Charging Infrastructure occurs at the distribution board level.
This board consists of electrical switchgear, which is typically connected to the main power supply, and distributes power to the individual EV supply equipment.

Every time an EV is connected to a charging station, it impacts the electrical grid. Depending on the power draw and the specific location the power is drawn from, EV charging, like other electrical loads, can lead to operational challenges and require improvements.

These effects can be categorized into three main areas:

CAPACITY LIMITS OF EXISTING GRID COMPONENTS
The various components of the electricity grid, such as lines, transformers, and feeders, may experience capacity limitations due to the additional load from EV charging.

POWER QUALITY FOR END USERS
EV charging can influence the power quality experienced by end users, potentially causing voltage fluctuations or harmonics.

SYSTEM-WIDE IMPACTS
EV charging can contribute to peak demand points, putting strain on the entire electrical system.

To ensure the safe and reliable distribution of power within the EV Charging Infrastructure, careful selection of switching and protection devices is crucial. Proper installation and maintenance of these devices are also essential for efficient and secure operation.
When choosing a complete switchboard, a thorough analysis of system requirements and evaluation of available options is necessary to ensure that the selected switchboard meets safety, reliability and performance criteria. Additionally, incorporating digital solutions can strengthen energy efficiency, enable rapid fault detection and clearance, and enhance overall system performance.

Design Criteria for Electric Vehicle Charging Infrastructure (EVCI)

The essential criteria to be taken into consideration when designing the supply distribution for electrical vehicles are outlined below:

EXISTING ELECTRIC INFRASTRUCTURE
Upgrade existing electric infrastructure for facilities with an existing grid connection, MV/LV transformer, and main distribution boards. It should meet the minimum number of available EV charging points as required by local authorities for the existing infrastructure.

NEW ELECTRIC INFRASTRUCTURE
Design new electric infrastructure for facilities, whether individual or collective, considering all connected loads. All new infrastructure from 2023 onward should be prepared for Vehicle-to-Grid (V2G) technology. It is common that requirements for new facilities to be more restrictive in terms of the minimum number of available EV charging points.

CHARGING SPEED AND CAPACITY
Determine the types of charging stations to be deployed, such as Level 2 AC chargers (1) for slower charging and DC fast chargers for rapid charging. Assess the power capacity required to support simultaneous charging without overloading the local grid.

SCALABILITY AND FUTURE-PROOFING
Anticipate the growing demand for Electrical Vehicles and ensure that the infrastructure can be easily expanded to accommodate increasing numbers of vehicles. Future-proof the design by considering emerging charging technologies.

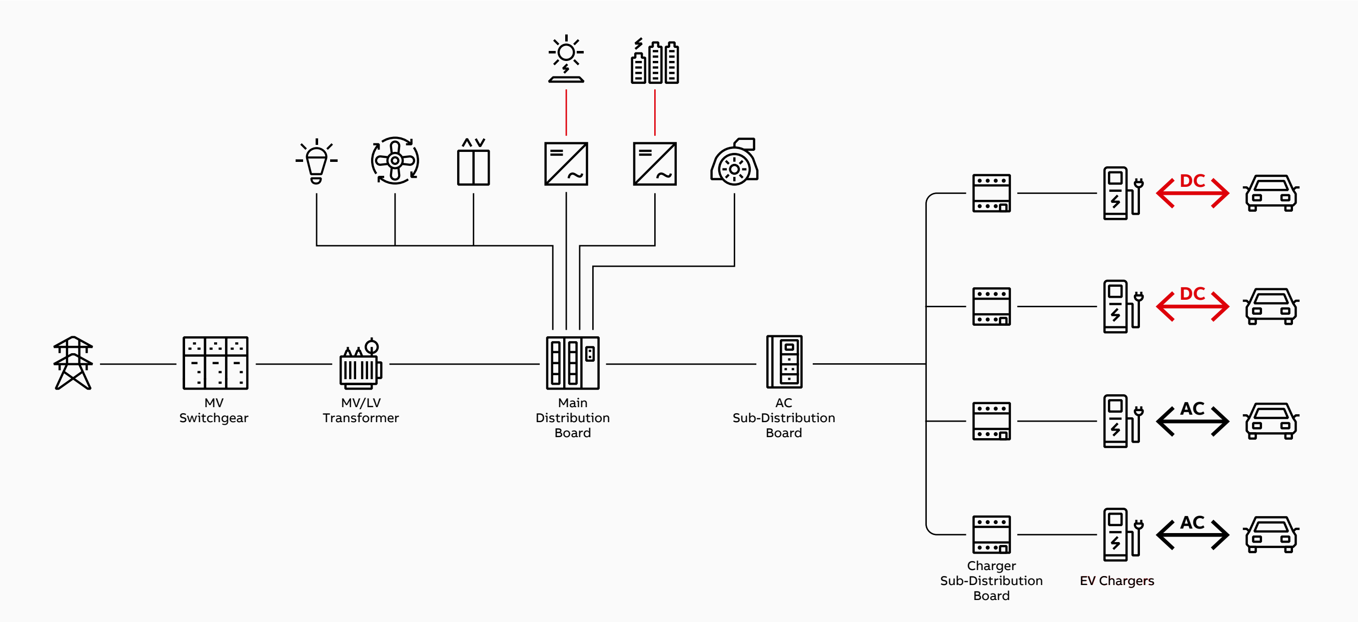
INTEGRATION WITH RENEWABLES
Explore the possibility of incorporating renewable energy sources, like solar to power the charging stations.

APPLICABLE STANDARDS AND REGULATIONS
EV charging stations installed in existing or new buildings must meet minimum requirements, such as those set forth by the European Union. This means ensuring compliance with both the Electrical Infrastructure standards outlined in IEC 60364-7-722, as well as the EV charger standards detailed in IEC 61851*. All member states must adhere to these standards in order to promote interoperability and ensure safe and efficient operation of EV charging infrastructure.

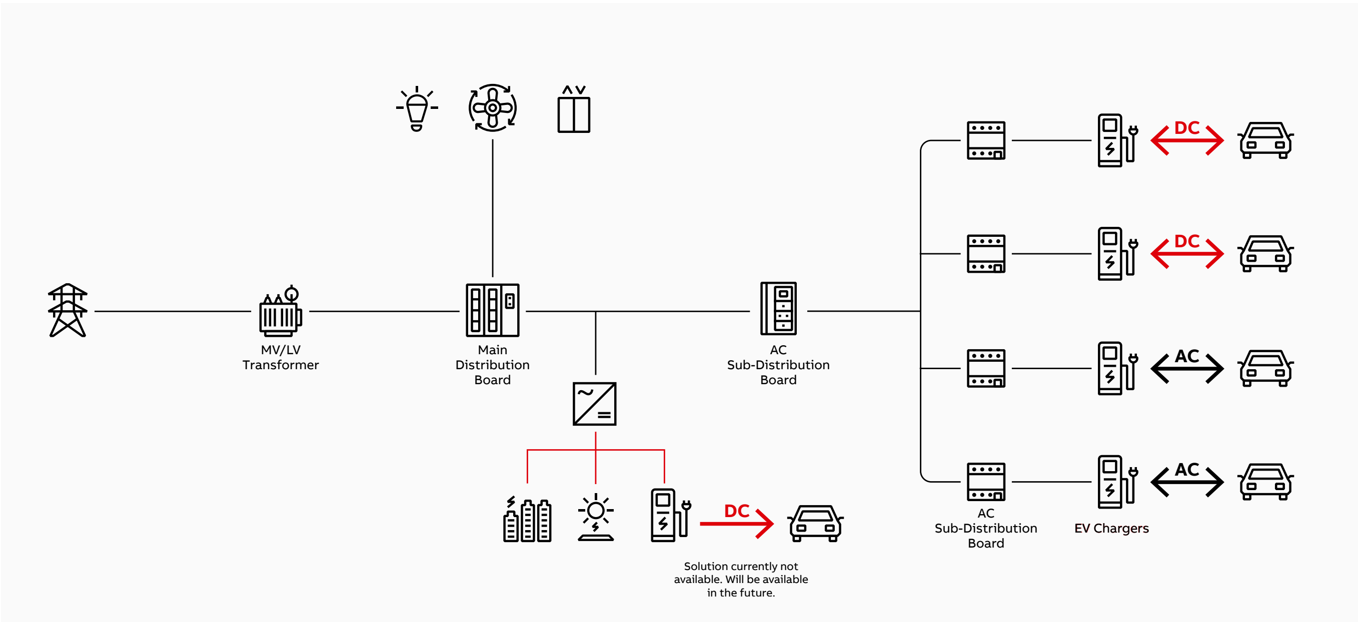
(1) EV chargers vary in size, power and voltage, depending on their charging speed. Level 3 (L3) DC "fast chargers" use direct current for impressively quick charging, but tend to be more expensive. On the other hand, AC Level 2 (L2) chargers (240V single phase or 400V three phase) offer respectable charging times and are cost-effective for both commercial and residential use. The Level 2 (L2) charger is often used in "destination" type settings such as offices, hotels and residences; e.g. where the user will be stationary for several hours, allowing sufficient time for an electric vehicle to charge.

* In most countries, electrical installations must comply with more than one set of regulations, issued by National Authorities or by recognized private bodies. It is essential to take into account these local constraints before starting the design.

Typical architecture for AC distribution in EV Charging Infrastructure



Typical architecture for AC distribution including a DC microgrid in EV Charging Infrastructure



Storage may be used to reduce power demand to the public AC grid
Several AC/DC and DC/AC conversions will be required in this case, with extra power losses.

Main components
- Switching and protective devices
  - Air circuit breaker
  - Moulded case circuit breaker
  - Miniature circuit breaker
  - Switch-disconnector
- Residual current device
- Surge protection device
- Power supply for auxiliary circuit

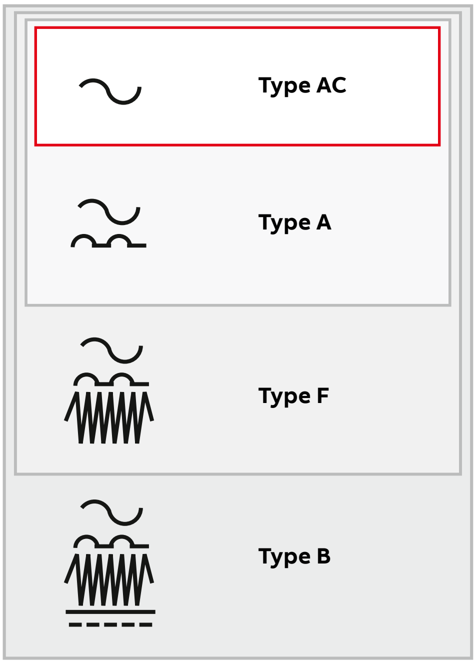
Optional components
- Arc flash mitigation solution
- Energy meter
- Temperature monitoring relay

Selection of Residual Current Devices

When designing the EVCI system, it is important to select residual current devices correctly. These protect both the EV charging infrastructure and users.

Residual current devices (RCDs) detect earth leakage (i.e. residual current), for which the waveform depends on both electric power supply and load characteristics. Depending on the detectable waveforms, RCDs are classified into several types:

- **Type AC** RCDs detect residual sinusoidal alternating currents at power frequencies (50 or 60 Hz). Type AC RCDs, suitable for general use, cover linear loads.
- **Type A** RCDs, in addition to the detection characteristics of type AC RCDs, can also detect pulsating DC residual current. Such waveforms can be caused by modern electronic equipment containing diodes, thyristors, etc. Type A RCDs remain functional in the presence of a smooth direct current of up to 6mA superposed to a sinusoidal or pulsed DC earth current.
- **Type F** RCDs, in addition to the detection characteristics of Type A RCDs, are specially designed to detect composite residual currents caused by single-phase variable speed drives. Type F also offers enhanced immunity against unwanted tripping (non-tripping on surge current). Type F RCDs remain functional in the presence of a superposed smooth direct current of up to 10mA.
- **Type B** RCDs, in addition to the detection characteristics of Type F RCDs, can detect residual currents characterized by non-negligible DC, with or without ripples, and with high harmonic content up to 1 kHz. Type B RCDs are intended for the protection of circuits supplying loads not covered by Type F RCDs.



The type of RCD must be chosen according to the expected earth current, considering the loads that are likely to be connected to the installation. Where necessary, EV charger manufacturers should specify the correct type of RCD required. In fact, certain loads may produce DC earth leakage current not only during a fault, but also under normal operating conditions. In any case, in faulty or normal operation, a DC component in the earth current caused by the loads may impair the protective function of RCDs of type AC, A and F, if its value exceeds the immunity level for which the respective RCD is designed. According to standard IEC 61140 (1), any pluggable electrical equipment with a rated input ≤ 4 kVA must be designed to have an earth current with a smooth superimposed DC current component not exceeding 6 mA.

Remember that type AC RCDs are not designed to operate with DC content of any amplitude. In all the above cases, the risk of "blinding" is related to the internal fault-sensing principle of RCDs. An excessive high level of DC component in the residual current may lead to saturation of the magnetic material constituting the current transformer core, strongly decreasing its responsiveness to a time-varying earth leakage stimulus. Correspondingly, the trip threshold increases, and the correct level of protection cannot be guaranteed.

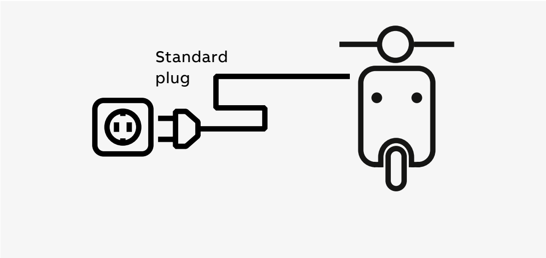
On the contrary, type B RCDs are immune to any risk of blinding: they simply remain operational until tripping, when the earth leakage DC current exceeds the threshold value as per Standards, i.e., 2 × $I_{\Delta n}$ (e.g., 60 mA DC for a type B RCD with $I_{\Delta n}$ = 30 mA).

The choice of suitable RCD is related to the charging mode implemented at the charging station of interest. Here is an overview of the charging modes and RCD type requirements.

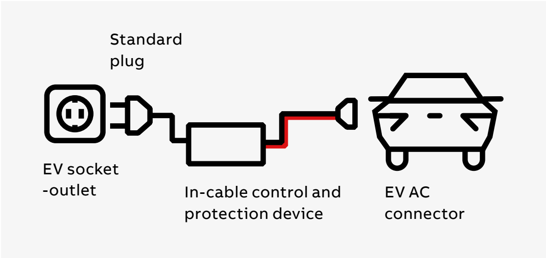
Selection of Residual current devices

1. Standard socket-outlet charging means a connection of an EV to a standard socket-outlet (domestic or industrial) of an AC supply network, with several modes described as follows:

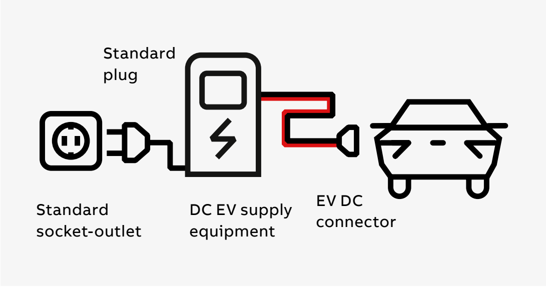
1.1 Mode 1*
means a direct connection utilizing a cable and plug, both not fitted with any supplementary pilot or auxiliary contacts. This is normally used for low power charging.



1.2 Mode 2
utilizes an AC EV supply equipment with a cable and plug, equipped with an AC vehicle connector according to IEC 62196-2, with a control pilot function and system for personal protection against electric shock placed between the standard plug and the EV.



1.3 Mode 4 plug and cable
utilizes a DC EV supply equipment with a cable and plug, equipped with DC vehicle connector according to IEC 62196-3, with a control pilot function that extends from the pluggable DC EV supply equipment to the EV.

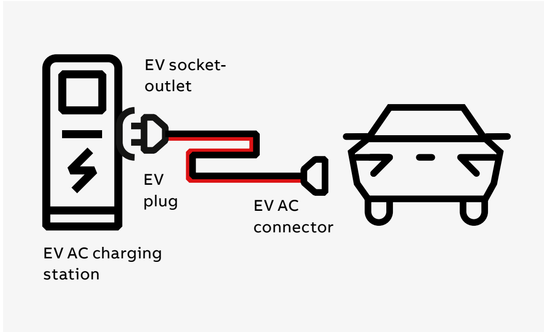


Each AC standard socket-outlet intended for mode 1, mode 2 or mode 4 plug and cable EV charging must be individually protected by an RCD at least of type A with a IΔn ≤ 30 mA. This requirement complies with the standards IEC 61851-1 and IEC 60364-7-722.

Careful attention must be paid to the so-called “InCable Control and Protection Devices” used for mode 2 charging. These cannot be used for fixed charging stations.

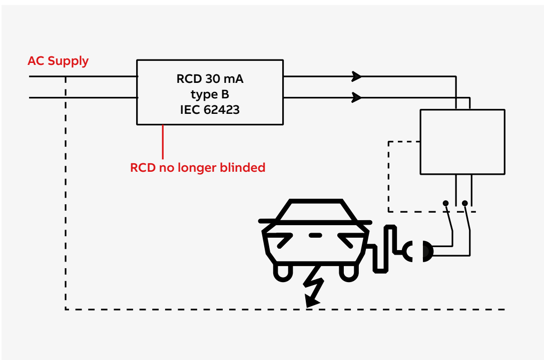
* not permitted in certain countries

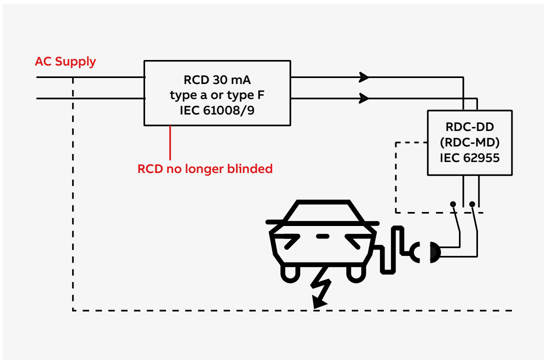
2. Mode 3 AC charging means connection of an EV to an AC EV charging station permanently connected to an AC supply network, with a control pilot function that extends from the AC EV charging station to the EV, equipped with AC EV socket-outlet or AC vehicle connector according to IEC 62196-2.
The connecting cable from the charging station to the EV can be either permanently attached to the charging station or detachable.



Each AC EV socket-outlet or AC vehicle connector for mode 3 charging must be individually protected by an
- RCD type B with IΔn ≤ 30 mA, or
- RCD type A/F with IΔn ≤ 30 mA in conjunction with Residual DC-Detecting Device (RDC-DD), or

These protection devices may be part of the upstream installation or incorporated in the EV charging station according to information given by the manufacturer, provided that they are compliant with the product standards. The RDC-DD is not an RCD and must always be used in conjunction with an RCD in series.
The two cases are shown here:



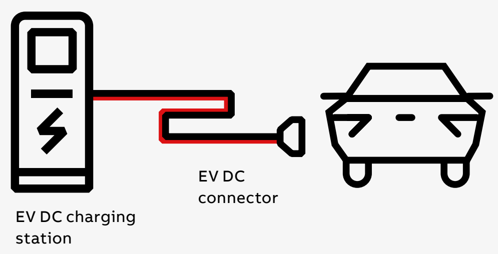


This requirement is aligned with the standards IEC 61851-1, IEC 62955 and IEC 60364-7-722.

The charging station manufacturer may incorporate RCDs. If so, the incorporated RCDs shall fully comply with product standards for RCDs, as required in IEC 6036-7-722. Some charging stations claim to have a "built-in" complete RCD protection (type A or B) rated 30mA AC / 6mA DC. This RCD-like function – even if it has the same trip levels and timing limits as defined for RCDs – does not fully comply with product standards for RCDs (e.g., regarding mechanical requirements, behaviour in case of short-circuit, isolation requirements, marking, ageing, etc). Therefore, it cannot be used instead of an authentic RCD. The information with the product about a "built-in" RCD and not needing an external RCD is deceiving for the customer and for the installer.

Selection of Residual current devices

3. Mode 4 DC charging means the EV is connected to a DC EV charging station, which is permanently connected to a supply network, with a control pilot function that extends from the DC EV charging station to the EV, equipped with DC vehicle connector according to IEC 62196-3.



In this case, if according to installation manual under normal and fault conditions any resulting DC component of the current in the protective conductor can exceed 6 mA, only type B RCDs are allowed to supply DC charging stations for fixed installation.

No RCD at the AC input of a DC charging station can protect the DC output, but it can protect the primary circuit of the charging station.

The installation designer should account for:
- the earthing system of the installation,
- the presence of RCD incorporated in the charging station and what parts are protected
- the need for protection against the risk of fire (RCD with Idn 300 mA)
- any information or requirements from the manufacturer, in particular if the resulting DC component of the current in the protective conductor under normal and fault conditions higher 6 mA (type B) or not (type A/F)
- any applicable local standards.

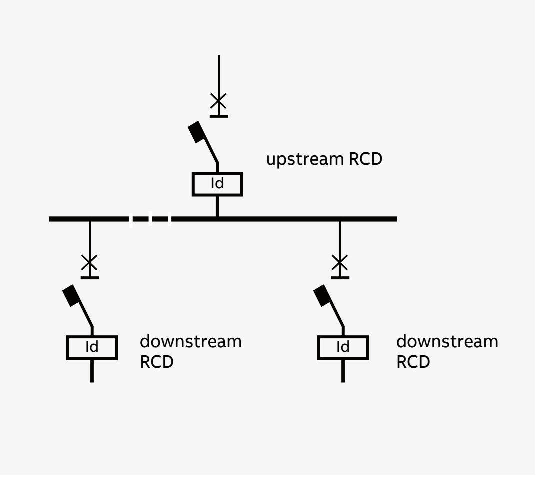
In the case of ABB charging stations, the requirement for the type of external RCD to be chosen is summarized in Table:

ABB Charging Stations	Input AC supply	External RCD	
		Required	Type, Idn
Terra AC WallBox	≤ 40A single-/three-phase	Yes (mandatory by IEC 60364-7-722)	at least type A, 30mA
Terra DC WallBox*	40A three-phase	Yes	at least type A, 30mA
Terra 54/54 HV/24**	≤ 125A three-phase	Mandatory for TT network only	suggested type B selective, 300mA
Terra 94/124/184**	≤ 188A three-phase	Mandatory for TT network only	type B, 100-300mA
Terra 360/180/602	≤ 560A three-phase	Mandatory for TT network and models with CHAdeMO output	type B, 100÷300mA
Terra HP*	350A three-phase per power cabinet 175kW	Mandatory for TT network and models with CHAdeMO output	type B, 100-300mA
HVC-C*	250A three-phase per power cabinet 150kW	Mandatory for TT network only	type B, 100-300mA

* DC leakage limited up to 6 mA according to design of the charger
** Internal 30 mA RCD of type B for AC branch if present

In many installations, two or more RCDs are installed in series: one common upstream RCD protects the distribution circuit and one or more downstream RCDs protect the final circuits; see Figure 1.

First, the correct types for downstream RCD(s) must be selected, based on load characteristics. This implies that the installation must be properly designed, so that protecting RCDs are operated within their intrinsic limits.
Then, the upstream RCD must be selected accounting for the total DC earth fault expected at the upstream point of installation, when the loads are in both faulty and compliant conditions.



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01

Selecting the right combination of RCDs and Circuit Breakers involves understanding the specific requirements of the charging station, the power rating of the charger and the anticipated usage patterns.

Starting out from the minimum requirements of the standards and local regulations, the selection of the RCD and circuit breaker combination can be determined by different factors, such as the type of installation, placement of the distribution boards or the distance from the charging stations to the boards.

To better understand the selection of RCDs connected in series, please consult this document.

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Selection of upstream RCD type allowed when using ABB RCDs

Case	Downstream RCD (s)			Upstream ABB RCD	
	Type	$I_{\Delta n,dw}$	Max quantity	Type	$I_{\Delta n,up}$
1	B	30 mA	1	A or F, general use (*)	100 mA
2			2	A or F, selective (S) (**)	100 mA
3				A or F, general use (*)	300 mA
4			5	A or F, selective (S) (**)	300 mA
5			No limit	B	//
6	A or (F + charger embedding RDC-DD, e.g. ABB Terra AC)	30 mA	10	A or F, general use (*)	100 mA
7			20	A or F, selective (S) (**)	100 mA
8				A or F, general use (*)	300 mA
9			50	A or F, selective (S) (**)	300 mA
10			No limit	B	//

(*) RCDs for general use (instantaneous non-selective) are allowed but not recommended for this use.
(**) Time-delayed industrial type ABB residual-current circuit breakers, including cases with a separate toroid (MRCD), according to Annex B or Annex M of IEC 60947-2, are equivalent to selective, if non actuating time is ≥ 0.06 s.

Selection of Surge Protection Devices (SPDs)

Surge Protection Devices (SPDs) must be installed as close as possible to the origin of the installation. For protection against the effects of lightning and against switching overvoltages, class II tested SPDs must be used. Where the structure is equipped with an external lightning protection system or protection against the effects of direct lightning strikes is otherwise specified, class I tested SPDs must be used.

Digital SPDs eOVR

OVR T1-T2-T3 25 kA
High energy Leaflet

If the EV Charging Infrastructure is non-portable and connected via cable, then the installation is under the scope of IEC 60364 standards.
60364-4-44 clause 443 specifies when SPDs must be installed. 60364-5-53 clause 534 specifies which surge protection devices must be chosen and how to install them.

The **selection of SPDs** must be based on the following parameters:

- Voltage protection level (Up) and rated impulse voltage (Uw) of the EV charger to be protected.
- Continuous operating voltage (Uc) according to supply system
- Nominal discharge current (In) and Impulse discharge current (Iimp)
- Expected short-circuit current
- SPD coordination with upstream protection

The communication lines of EV chargers must also be protected to avoid any damage to the internal electronics.

Residential EV Chargers:
if the wallbox installed < 10 m from a protected Distribution Board then installation is within the range of protection.
If the wallbox installed > 10 m from protected Distribution Board then additional protection is required.

For Main Distribution Board in residential buildings with or w/o external lightning:

- OVR T1-T2 3N 12,5-275s P TS QS
- ESP 180H (communication lines)

For wallbox located >10m from Low Voltage Distribution Board:

- OVR T2-T3 3N 20-275 P TS QS
- OVR Cat-6 PoE (for Ethernet connection)
- ESP 30SE/PT (for twisted-pair signal lines)

EV charging stations and bus charging stations:
An external lightning protection system is recommended
as well as SPDs protecting the different charging points.

For Power distribution boards in the C&I building:

- ESP 30SE/PT
- OVR T1-T2 1L 25-255 P TS or OVR T1-T2 3N 100-255 P TS

Electrify parking spaces with ABB solutions

From Brownfield to Greenfield installations, and E-Stations in public spaces, ABB's solutions are catered to different settings, addressing the challenges faced in each scenario in order to build efficient and sustainable EV Charging Infrastructures.

In the following pages we take a deeper look at a solution for each of the following scenarios:

1

SCENARIO 1

Brownfield

Starting from an existing commercial or industrial user plant, the goal is to install EV chargers for employees and visitors supplied by the already installed MV/LV transformer, without overloading it. Usually the transformer's rated power is selected in order to allow the transformer to work at its maximum efficiency point, namely 75-80% of the rated power. Hence, the transformer can deliver an additional 20-25% of the rated power without being overloaded.
In order not to overload the transformer, the Power Controller feature will be used to reduce the power drawn by the whole EV charging infrastructure. (only for Terra AC 3 phases Chargers)

2

SCENARIO 2

Greenfield

New installation of both user plant and EV Charging Infrastructure. Thanks to the Power Controller, it will be possible to reduce the size of the transformer, the main cables/busbar system, and the switching/protection devices, offering cost savings. (only for Terra AC 3 phases Chargers)

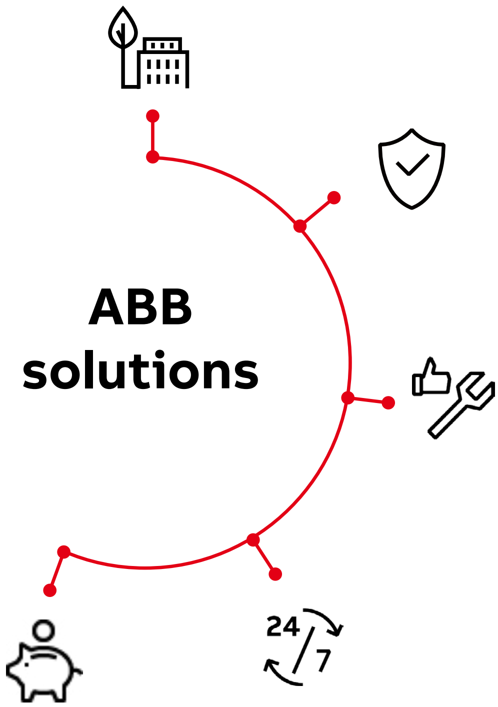
3

SCENARIO 3

E-Station

E-Stations are dedicated stations for charging EVs quickly. In order to prevent AC Utility overload and reduce grid power draw, local energy resources, such as photovoltaics and battery systems, will be installed. This is necessary due to the large amount of power delivered.

Why ABB Solutions are the right choice



Reliability
Designed and built to provide reliable and consistent operation over the expected life of the system

Safety
Designed to meet all relevant safety standards and regulations

Compatibility
Compatible with the charging stations and other electrical equipment used in the EV Charging Infrastructure system

Continuous Operation
Prevent downtime and costly service interruptions by safeguarding the entire electrical circuit with our solutions featuring advanced specifications.

Cost Optimization
60% less commissioning time than conventional cabling, thanks to ABB's Intelligent Distribution

EV Charging Infrastructure in an Existing Building
Brownfield scenario

1

SCENARIO
Brownfield

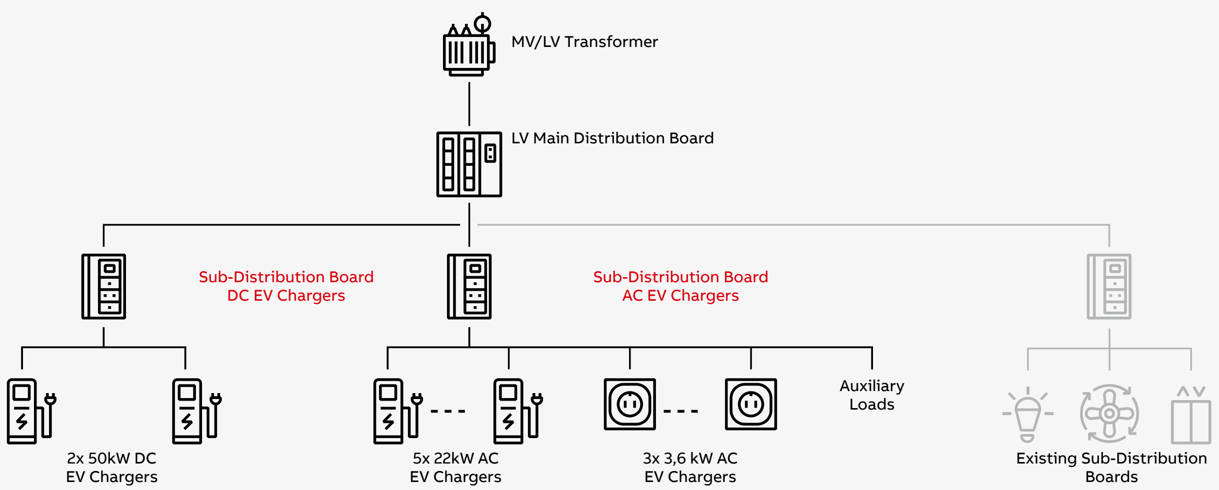
Scenario:

- Office building with 50-space indoor car park for employees, and ten outdoor spaces for visitors and company pull-in cars
- Estimated need for five EV charging stations and three wired connections for indoor parking, and 2 charging stations for visitor parking
- Local TN-S Distribution system

Electric Chargers selection:
Indoor: Recommended slow charging stations, with parking time aprox 8h
5 x 22 kW – 3 Phase AC EV charging stations
3 x 3.6 kW – pre-wired installed with socket-outlet

Visitors:
Recommended fast charging stations, with parking time less than 1h also for commercial pull-in cars.
2 x 50 kw DC fast Charging stations

EV Charging Infrastructure configuration (IEC) – Principle electrical diagram



EV Charging Infrastructure in a New Building

Greenfield scenario

2

SCENARIO
Greenfield

Scenario:

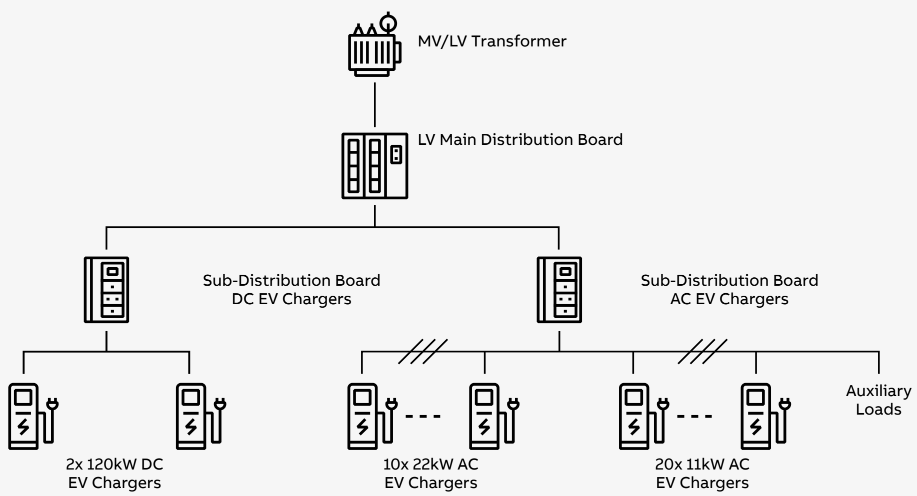
- New building with 50 indoor parking spaces for employees and ten outdoor spaces for visitors and company pull-in cars
- According to local regulations (i.e. …), 10 EV chargers and 20 wired connections must be installed for indoor parking, and two chargers for visitor parking
- Local TN-S Distribution system

EV Charger selection:

Indoor:
Minimum requirements:
10x EV chargers
20 pre-wired installed
ABB Recommended slow chargers, with parking time approx 8h
10 x 22 kW – 3-Phase AC EV chargers
20 x 11 kW – 3-Phase AC EV chargers

Visitors:
Minimum Requirements: 2 x EV chargers
ABB Recommends fast chargers, with parking time lower than 1h for commercial pull-in cars as well.
2 x 120 kW DC fast chargers

EV Charging Infrastructure configuration (IEC) – Principle electrical diagram



Infrastructure for EV Charging in a New E-Station
E-Station scenario

3

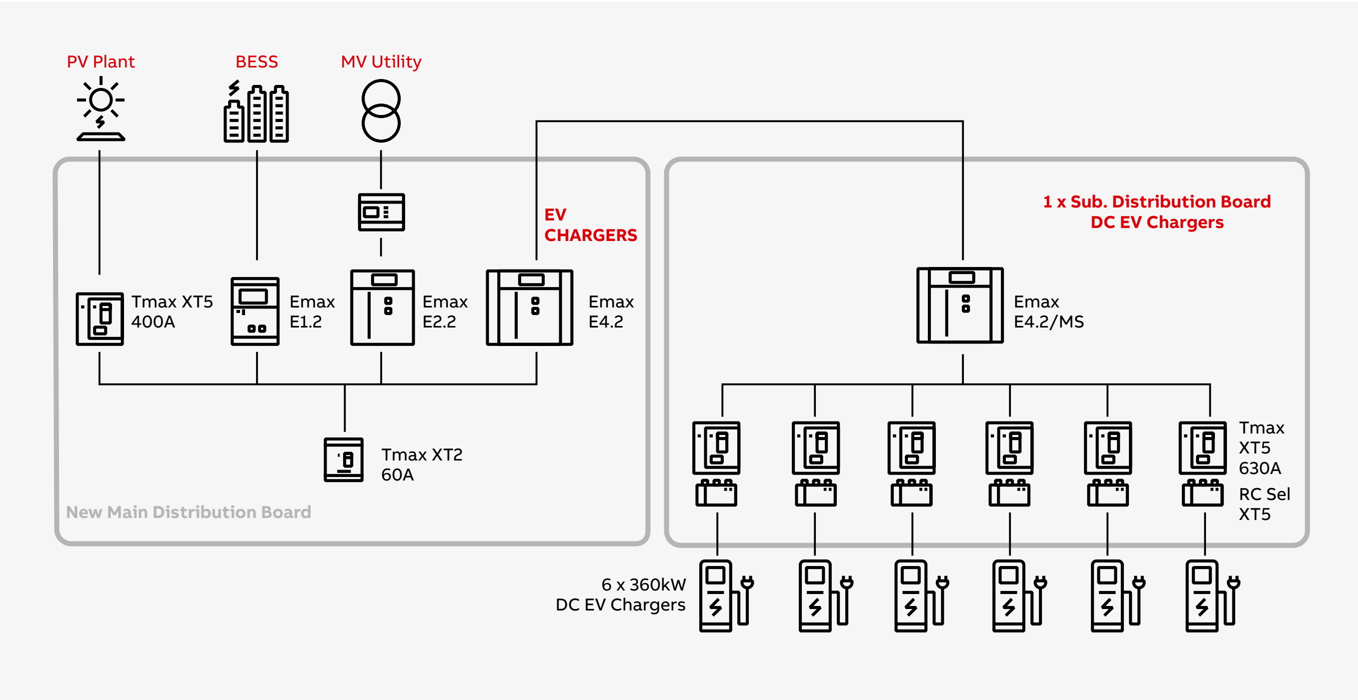
SCENARIO
E-Station

Scenario:

- E-Station connected to the MV Utility, with DC Super-fast Chargers.
- Local renewables, namely PV plant and Energy storage system to reduce the energy drawn from the Grid and to mitigate the peak power demand drawn from the Grid
- Local TN-S Distribution system

System main components:
Electric Chargers selection: 6 x 360 kW DC Super-fast Charging stations
MV/LV Transformer: 1.5 MVA dry-type transformer
Energy Storage system: 1 MWh Li-ion Batteries
PV plant: 250 kW made up of 250 W panels installed as carport shelters above the parking spaces
Facility: 30 kW

Principle electrical diagram



* For DC charging stations, RCDs, i.e. Type A or B, are not strictly required (at least in TN systems where fault protection is provided by PE + overcurrent protection).
Nevertheless, an RCD with a rated residual current ≤ 300mA is always advisable (also in TN systems), incorporated in the charging station or upstream, to cover the case of non-bolted fault and/or fire protection.

Simultaneity in Electric Vehicle Charging Infrastructure (EVCI)

Simultaneity of EV chargers refers to the concept of the simultaneous charging demand at a specific location or charging station.

The simultaneity factor measures the likelihood of multiple Electric Vehicles being connected and charging at the same time. This concept is essential for planning and designing charging infrastructure, as it helps estimate the required capacity and ensure that the infrastructure can handle the potential load during peak times.

A higher simultaneity means a greater likelihood of multiple EVs charging simultaneously, necessitating higher capacity and proper management of charging resources.

Factors to be considered during the design:

DEMAND FACTOR:
ratio, expressed as a numerical value or as a percentage, of the maximum demand of a circuit or a group of circuits within a specified period, to the corresponding total installed load of the circuit(s).

DIVERSITY FACTOR:
ratio of the sum of the individual maximum demands of the various subdivisions of a system to the maximum demand of the whole system. Loads do not normally all peak at the same time.
The sum of the individual peak loads will therefore inevitably be greater than the peak load of the composite system. The diversity factor normally has a value greater than 1 and is only equal to 1 if all the individual demands occur simultaneously

SIMULTANEITY FACTOR:
ratio of the maximum demand of a group of loads to the sum of the individual maximum demands, therefore the inverse of the diversity factor.

According to the requirements of IEC 60364-7-722:
the demand factor of the final circuit supplying the connecting point is equal to 1, since it must be considered that in normal use each single connecting point is used at its rated current unless the connecting point is configured at a maximum current lower than the rated current of the related charging station.
The means that configuration of the maximum charging current must only be made using a key or a tool and only be accessible to skilled or instructed persons.

Therefore, according to the Case Studies in this document, the demand factor will be considered equal to 1 for each charging station and socket-outlet. The diversity factor of the distribution circuit must be taken as equal to 1 unless load control is incorporated in the EV supply equipment or installed upstream, or a combination of both.
In the Case Studies in this document, both these scenarios will be evaluated.

Power Controlled Electric Vehicle Charging Infrastructure (EVCI)

To achieve simultaneity in EV Charging Infrastructure, ABB provides a solution for designing EVCI with power control.

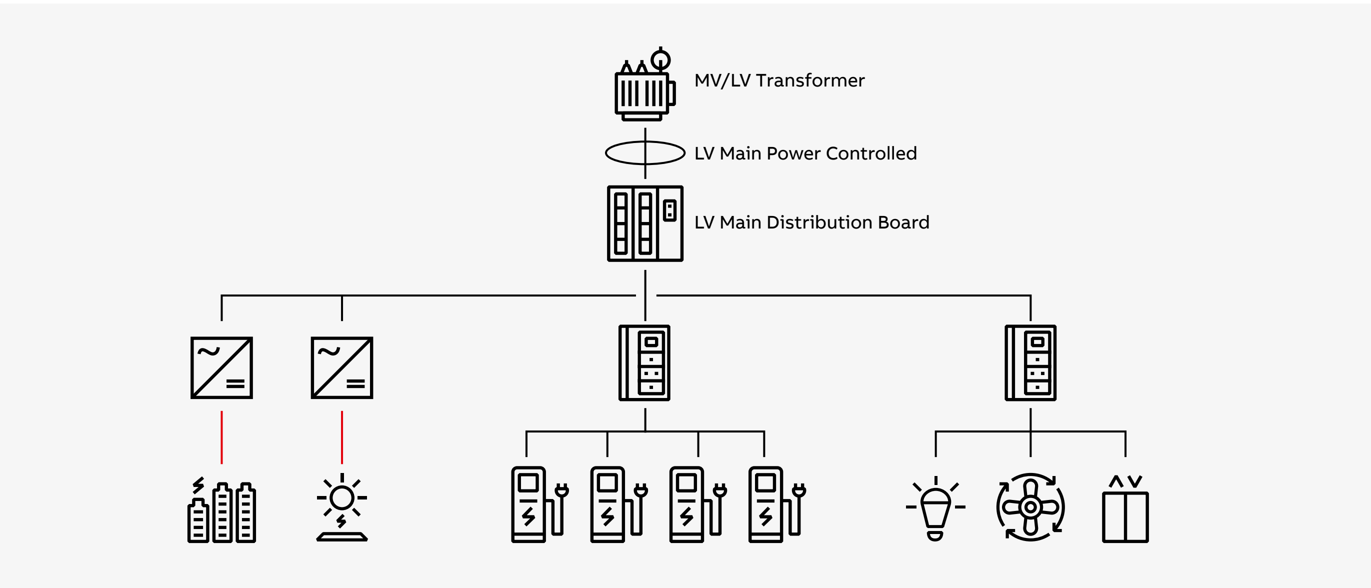
This solution avoids main supply failure due to operation of main (incoming) protection fuses/ breakers through momentary reduction of the power drawn by the EV Charging infrastructure. Such a system is suitable only with Terra AC 3 phase chargers, and can act in two different ways:

PAUSE:
The Power Controller will pause the charging if started, and if not in use will pause once a car is connected

AVAILABILITY:
If a car is charging nothing will stop; if not in use, the Power Controller will disable the EV charging station

For simple charging points (i.e. socket-outlets) and for DC fast chargers, design and dimension of the Simultaneity Coefficient must be 1, assuming all loads can be connected at same time, because for these type of chargers, this solution is not yet available.
For Terra AC chargers and those with similar functionality, the Power Controller function will allow the selection of a Simultaneity factor lower than 1 (in the Application scenarios it will be set to 0.3 for the first and second Scenario and 0.5 for the third, but this depends on country-specific regulations).

Principle electrical diagram



Power Controller function

The Power Controller function is based on a patented algorithm that allows a load list to be controlled via the remote command for relevant switching devices or control circuits, according to a defined priority. The EV Charging Infrastructure owner defines the EV charger command priority.

Load management with Ekip Power Controller for SACE Emax 2

The algorithm is designed for the anticipated average power draw, which can be set by the user over a determined time interval. Whenever this value exceeds the fixed power, the Power Controller function intervenes to bring it back within limits.
No other supervision and control system is required: it is sufficient to set the required load limit on the main circuit breaker with the Power Controller function, which can then control the downstream EV charging stations.

Commands sent to downstream devices can be performed in three different ways:

- Via wired solution, by either controlling the shunt opening/closing releases, the motor operators, the contactor coils of the loads to be managed, or by sending the step reduction signal to reduce the power draw of the EV charger converter
- Via a dedicated communication system (Internal bus, Ekip link)
- Combination of wired and communication system solutions

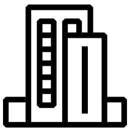
For more information on the Power Controller, refer to the relative White Paper

EV Charging Infrastructure in an Existing Building: Brownfield Scenario

Scenario without Power Controller & with current threshold latest protection

SCENARIO

Brownfield



Considering the input data in the table below:

The DC fast chargers can deliver power to visitors' Electric Vehicles at the same time (simultaneity factor = 1) and cannot be disconnected in the event of transformer overload.

The AC chargers and the socket-outlets can deliver power to employees' Electric Vehicles at the same time (simultaneity factor = 1) but, in the worst-case scenario where the AC chargers and the socket-outlets are delivering their maximum power, the existing transformer would be overloaded, with the risk of the transformer overload protection tripping and shutting down the whole system. In order to avoid this undesired situation, the current threshold ultimate protection installed on the transformer circuit breaker has to be coordinated with the transformer overload protection.

In this case, the current threshold ultimate protection will send the opening command to the related charger group circuit breaker as soon as the total power drawn by the whole system exceeds the transformer's rated power.

Current thresholds feature of Emax2 and Tmax XT circuit breakers

This function enables four independent thresholds to be specified to enable implementation of corrective action before the overload L protection trips the circuit breaker. For example, by disconnecting loads located downstream of the circuit breaker that are controlled by Ekip Signalling.

LC1/2	Current threshold	LC1=50% – 100% I1	1%
Iw1/2		LC2=50% – 100% I1	1%

EV Charging Infrastructure in an Existing Building: Brownfield Scenario

Scenario without Power Controller & with current threshold ultimate protection

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Electrical Parameters for solution without Power Controller with current threshold ultimate protection

FACILITY		Input data (IEC)	
Existing Building Main Electrical data		Rated LVAC voltage [V]	400
		Existing MV/LV transformer rated power [MVA]	2
		Existing installed load active power [MW]	1.7
		Existing installed load power factor	0.95
		Existing installed load reactive power [MVAr]	0.56
EVCI	Design Parameters	EV Charger Power factor	0.96
		EVCI Demand Factor	1
		EVCI Simultaneity Factor for DC fast chargers	1
		EVCI Simultaneity Factor for AC fast chargers	1.0
	DC EV Chargers	Rated DC charger active power [kW]	50
		Rated DC charger reactive power [kVAr]	15
		Rated DC charger current [A]	75
		Number of DC fast chargers	2
		Rated total DC charger active power [kW]	100
		Rated total DC charger reactive power [kVAr]	29
		Rated total DC charger current [A]	150
	22 kW AC EV Charger	Rated AC charger active power [kW]	22
		Rated AC charger reactive power [kVAr]	6
		Rated AC charger current [A]	33
		Number of AC chargers	10
		Rated total AC charger active power [kW]	220
		Rated total AC charger reactive power (kVAr]	64
		Rated total AC charger current [A]	331
	3.6 kW Socket-Outlet	Rated AC socket-outlet active power [kW]	4
		Rated AC socket-outlet reactive power [kVAr]	0
		Rated AC socket-outlet current [A]	16
		Number of AC socket-outlets	6
		Rated total AC socket-outlet active power [kW]	22
		Rated total AC socket-outlet reactive power [kVAr]	0
		Rated total AC socket-outlet current [A]	96
	Total EVCI	Rated total EVCI active power [kW]	342
		Rated total EVCI reactive power [kVAr]	93
		Rated total EVCI current [A]	514
EVCI + building plant		Total active power [MW]	2.0
		Total reactive power [MVAr]	0.7
		Total apparent power [MVA]	2.1

EV Charging Infrastructure in an Existing Building: Brownfield Scenario

Scenario with Power Controller & current threshold latest protection

Considering the input data given in the table below:

The DC fast chargers can deliver power to visitors' Electric Vehicles at the same time (simultaneity factor = 1) and cannot be disconnected in the event of transformer overload.

Thanks to the Power Controller function embedded in the transformer circuit breaker, the simultaneity factor of 3 phase AC chargers and the socket-outlets can be considered equal to 0.3. As a result, the transformer will not be overloaded, even when the existing plant draws its full rated power value. Nevertheless, the current threshold ultimate protection is still present and coordinated with the transformer overload protection, in the unlikely event of failure of the above function.

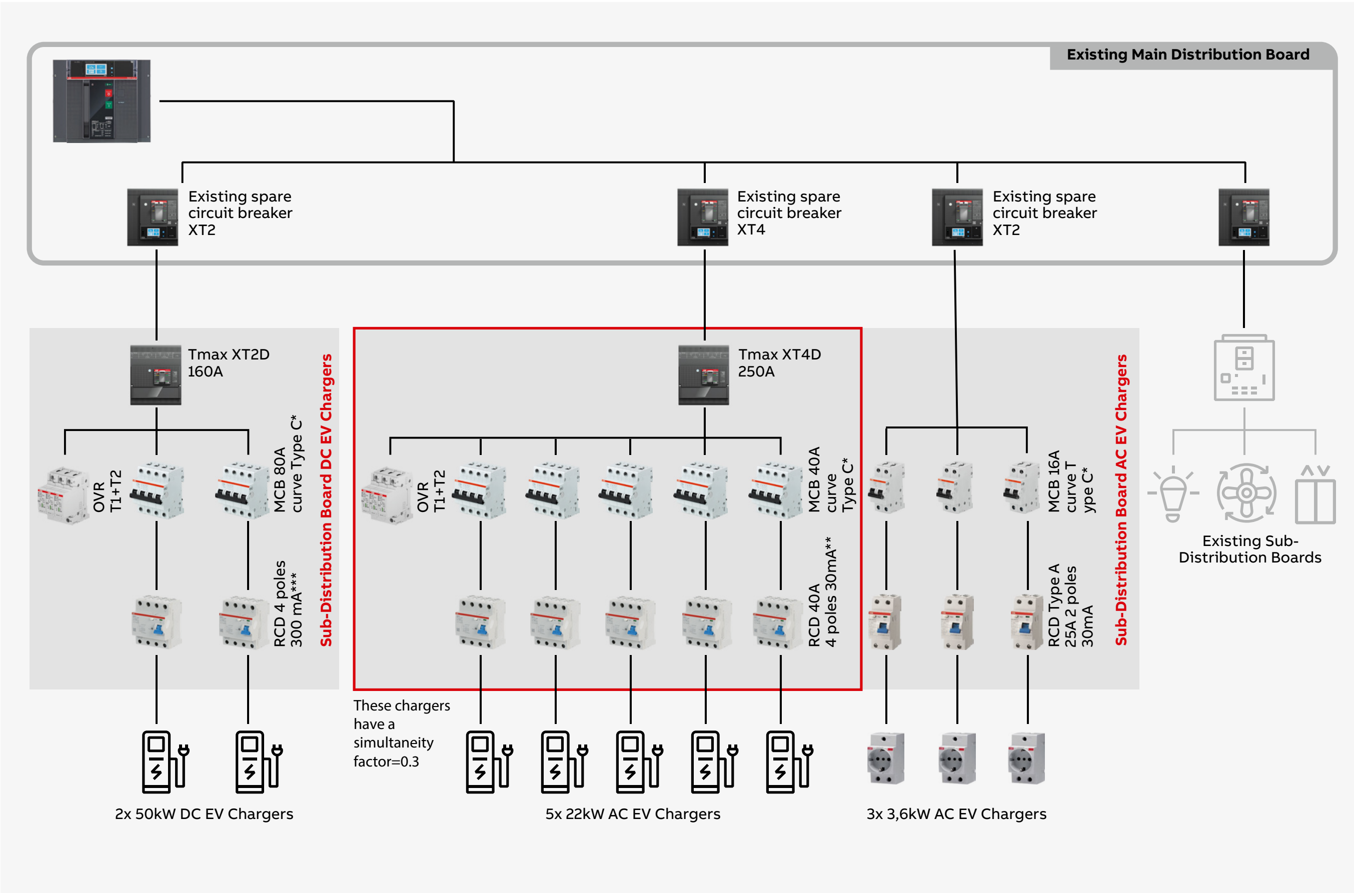
Electrical Parameters for solution with Power Controller with current threshold ultimate protection

FACILITY		Input data (IEC)	
Existing Building Main Electrical data		Rated LVAC voltage [V]	400
		Existing MV/LV transformer rated power [MVA]	2
		Existing installed load active power [MW]	1.7
		Existing installed load power factor	0.95
		Existing installed load reactive power [MVAr]	0.56
EVCI	Design Parameters	EV Charger Power factor	0.96
		EVCI Demand Factor	1
		EVCI Simultaneity Factor for DC fast chargers	1
		EVCI Simultaneity Factor for AC fast chargers	0.3
	DC EV Chargers	Rated DC charger active power [kW]	50
		Rated DC charger reactive power [kVAr]	15
		Rated DC charger current [A]	75
		Number of DC fast chargers	2
		Rated total DC charger active power [kW]	100
		Rated total DC charger reactive power [kVAr]	29
		Rated total DC charger current [A]	150
	22 kW AC EV Charger	Rated AC charger active power [kW]	22
		Rated AC charger reactive power [kVAr]	6
		Rated AC charger current [A]	33
		Number of AC chargers	5
		Rated total AC charger active power [kW]	66
		Rated total AC charger reactive power (kVAr]	9
		Rated total AC charger current [A]	50
	3.6 kW Socket-Outlet	Rated AC socket-outlet active power [kW]	4
		Rated AC socket-outlet reactive power [kVAr]	0
		Rated AC socket-outlet current [A]	16
		Number of AC socket-outlets	3
		Rated total AC socket-outlet active power [kW]	12
		Rated total AC socket-outlet reactive power [kVAr]	0
		Rated total AC socket-outlet current [A]	48
	Total EVCI	Rated total EVCI active power [kW]	145
		Rated total EVCI reactive power [kVAr]	38
		Rated total EVCI current [A]	248
EVCI + building plant		Total active power [MW]	1.9
		Total reactive power [MVAr]	0.6
		Total apparent power [MVA]	2.0

EV Charging Infrastructure in an Existing Building: Brownfield Scenario

Reference Architecture

Principle electrical diagram



* Number of Poles to be considered according to earthing systems and local regulations
** As specified by IEC 60364-7-722, use type B or type A RCD in conjunction with a residual direct current detecting device (RDC-DD). Device sensitivity of 30 mA is mandatory. This may be already integrated in the charging station, provided it complies with the product standards.
*** For DC charging stations, RCDs, i.e. Type A or B, are not strictly required (at least in TN systems where fault protection is provided by PE + overcurrent protection). Nevertheless, an RCD with a rated residual current ≤ 300 mA is always advisable (also in TN systems), incorporated in the charging station or upstream, to cover the case of non-bolted fault and/or fire protection.

EV Charging Infrastructure in a New Building: Greenfield scenario

Scenario without Power Controller

SCENARIO

Greenfield

Considering the input data given in the table:

- The DC fast chargers can deliver power to visitors' Electric Vehicles at the same time (simultaneity factor = 1) and they should not be disconnected in the event of transformer overload because they have priority within the EV charging loads.

- The AC chargers and the socket-outlets can deliver power to employees' Electric Vehicles at the same time (simultaneity factor = 1) without the risk of overloading the MV/LV transformer, since this system has a rated power higher than the maximum power drawn by both the user plant and by the electric vehicle charging infrastructure.

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Electrical Parameters for solution without Power Controller with current threshold ultimate protection

FACILITY		Input data (IEC)	
New Building Main Electrical data		Rated LVAC voltage [V]	400
		Existing MV/LV transformer rated power [MVA]	3
		New installed load active power [MW]	1.5
		New installed load power factor	0.95
		New installed load reactive power [MVAr]	0.49
EVCI	Design Parameters	EV Charger Power factor	0.96
		EVCI Demand Factor	1
		EVCI Simultaneity Factor for DC fast chargers	1
		EVCI Simultaneity Factor for AC fast chargers	1.0
	DC EV Chargers	Rated DC charger active power [kW]	120
		Rated DC charger reactive power [kVAr]	35
		Rated DC charger current [A]	180
		Number of DC fast chargers	2
		Rated total DC charger active power [kW]	240
		Rated total DC charger reactive power [kVAr]	70
		Rated total DC charger current [A]	361
	22 kW AC EV Charger	Rated 22 kW AC charger active power [kW]	22
		Rated 22 kW AC charger reactive power [kVAr]	6
		Rated 22 kW AC charger current [A]	33
		Number of 22 kW AC chargers	10
		Rated total 22 kW AC charger active power [kW]	220
		Rated total 22 kW AC charger reactive power [kVAr]	64
		Rated total 22 kW AC charger current [A]	331
	11 kW AC EV Charger	Rated 11 kW AC charger active power [kW]	5
		Rated 11 kW AC charger reactive power [kVAr]	1
		Rated 11 kW AC charger current [A]	7
		Number of 11 kW AC chargers	20
		Rated total 11 kW AC charger active power [kW]	94
		Rated total 11 kW AC charger reactive power [kVAr]	27
		Rated total 11 kW AC charger current [A]	141
	Total EVCI	Rated total EVCI active power [kW]	554
		Rated total EVCI reactive power [kVAr]	162
		Rated total EVCI current [A]	833
EVCI + building plant		Total active power [MW]	2.1
		Total reactive power [MVAr]	0.7
		Total apparent power [MVA]	2.2

EV Charging Infrastructure in a New Building: Greenfield scenario

Scenario with Power Controller & current threshold latest protection

SCENARIO

Greenfield

Considering the input data given in the table below:

- The DC fast chargers can deliver power to visitors' Electric Vehicles at the same time (simultaneity factor = 1) and cannot be disconnected in the event of transformer overload.

- Thanks to the Power Controller function embedded in the transformer circuit breaker, the simultaneity factor of AC chargers can be considered equal to 0.3.
  As a result, the transformer, the main circuit breaker and the cable/busbar sizes can be reduced. Nevertheless, the current threshold ultimate protection is present and coordinated with the transformer overload protection, in the unlikely event of failure of the above function.

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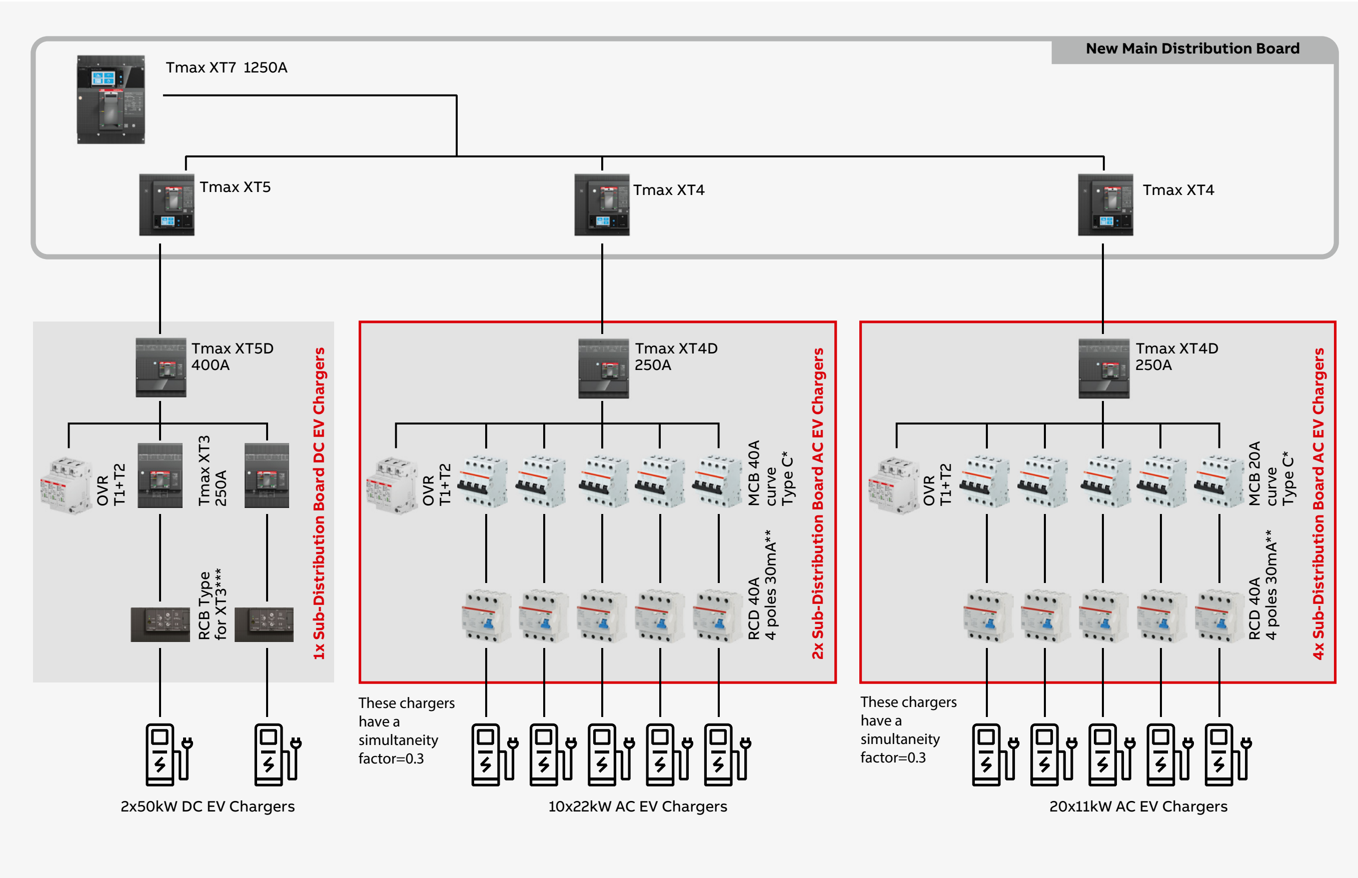
Electrical Parameters for solution with Power Controller with current threshold ultimate protection

FACILITY		Input data (IEC)	
New building plant		Rated LVAC voltage [V]	400
		Existing MV/LV transformer rated power [MVA]	2
		New installed load active power [MW]	1.5
		New installed load power factor	0.95
		New installed load reactive power [MVAr]	0.49
EVCI	Design Parameters	EV Charger Power factor	0.96
		EVCI Demand Factor	1
		EVCI Simultaneity Factor for DC fast chargers	1
		EVCI Simultaneity Factor for AC fast chargers	0.3
	DC EV Chargers	Rated DC charger active power [kW]	120
		Rated DC charger reactive power [kVAr]	35
		Rated DC charger current [A]	180
		Number of DC fast chargers	2
		Rated total DC charger active power [kW]	240
		Rated total DC charger reactive power [kVAr]	70
		Rated total DC charger current [A]	361
	22 kW AC EV Charger	Rated 22 kW AC charger active power [kW]	22
		Rated 22 kW AC charger reactive power [kVAr]	6
		Rated 22 kW AC charger current [A]	33
		Number of 22 kW AC chargers	10
		Rated total 22 kW AC charger active power [kW]	66
		Rated total 22 kW AC charger reactive power [kVAr]	19
		Rated total 22 kW AC charger current [A]	99
	11 kW AC EV Charger	Rated 11 kW AC charger active power [kW]	5
		Rated 11 kW AC charger reactive power [kVAr]	1
		Rated 11 kW AC charger current [A]	7
		Number of 11 kW AC chargers	20
		Rated total 11 kW AC charger active power [kW]	28
		Rated total 11 kW AC charger reactive power [kVAr]	8
		Rated total 11 kW AC charger current [A]	42
	Total EVCI	Rated total EVCI active power [kW]	334
		Rated total EVCI reactive power [kVAr]	97
		Rated total EVCI current [A]	502
EVCI + building plant		Total active power [MW]	1.8
		Total reactive power [MVAr]	0.6
		Total apparent power [MVA]	1.9

EV Charging Infrastructure in a New Building: Greenfield scenario
Reference Architecture

Principle electrical diagram



* Number of Poles to be considered according to earthing systems and local regulations
** As specified by IEC 60364-7-722, use type B or type A RCD in conjunction with a residual direct current detecting device (RDC-DD). Device sensitivity of 30 mA is mandatory. This may be already integrated in the charging station, provided it complies with the product standards.
*** For DC charging stations, RCDs, i.e. Type A or B, are not strictly required (at least in TN systems where fault protection is provided by PE + overcurrent protection). Nevertheless, an RCD with a rated residual current ≤ 300 mA is always advisable (also in TN systems), incorporated in the charging station or upstream, to cover the case of non-bolted fault and/or fire protection.

Digital Product Range for AC Distribution Boards in EVCI Main components

Monitoring of AC distribution boards for EV chargers is important to ensure that they are functioning correctly and efficiently.

Considering that different brand EV chargers may have their own specific monitoring platforms, only the electrical infrastructure is taken into consideration in this document.

It is possible to detect any potential issues early on and address them before they cause significant problems or downtime. This also helps owners optimize the use of charging infrastructure, allowing them to better understand the charging patterns of their customers and adjust charging rates accordingly. Additionally, maintaining a high level of customer satisfaction is another benefit that comes from intelligent EV Charging Infrastructure, as well as providing consumers with access to reliable and functional charging infrastructure.

ABB's Digital Offering for EV Charging Infrastructure means

OBTAINING MEASUREMENTS OF ELECTRICAL DATA

Monitoring and reporting of complete EV Charging Infrastructure consumption for building energy management systems or compliance with environmental regulations.

ENSURING QUICK DATA AVAILABILITY

Data at your fingertips, thanks to cloud-based web application instead of local manual readings by operators, lowering operational costs.

Easy integration of new infrastructure with existing management systems, such as BMS or SCADA.

AVOIDING DOWNTIME THANKS TO 24/7 REAL-TIME MONITORING AND INSTANTANEOUS ALERTS

Notification of changes in the status of devices.

Remote indication alerts the user to surge events or earth faults, enabling them to reset or replace the protective device, while avoiding costly downtime.

Digital Product Range for AC Distribution Boards in EVCI Main components

Intelligent Distribution (ID) for MV Switchgear

- Due to communication with the relative MV relays, it is possible to see MV circuit breaker status, contact wear, electrical data measurements and diagnostics alarms.
- In the event of overloads, rising temperatures in transformers can be monitored through temperature monitoring relays or Ekip Signalling 3T devices.

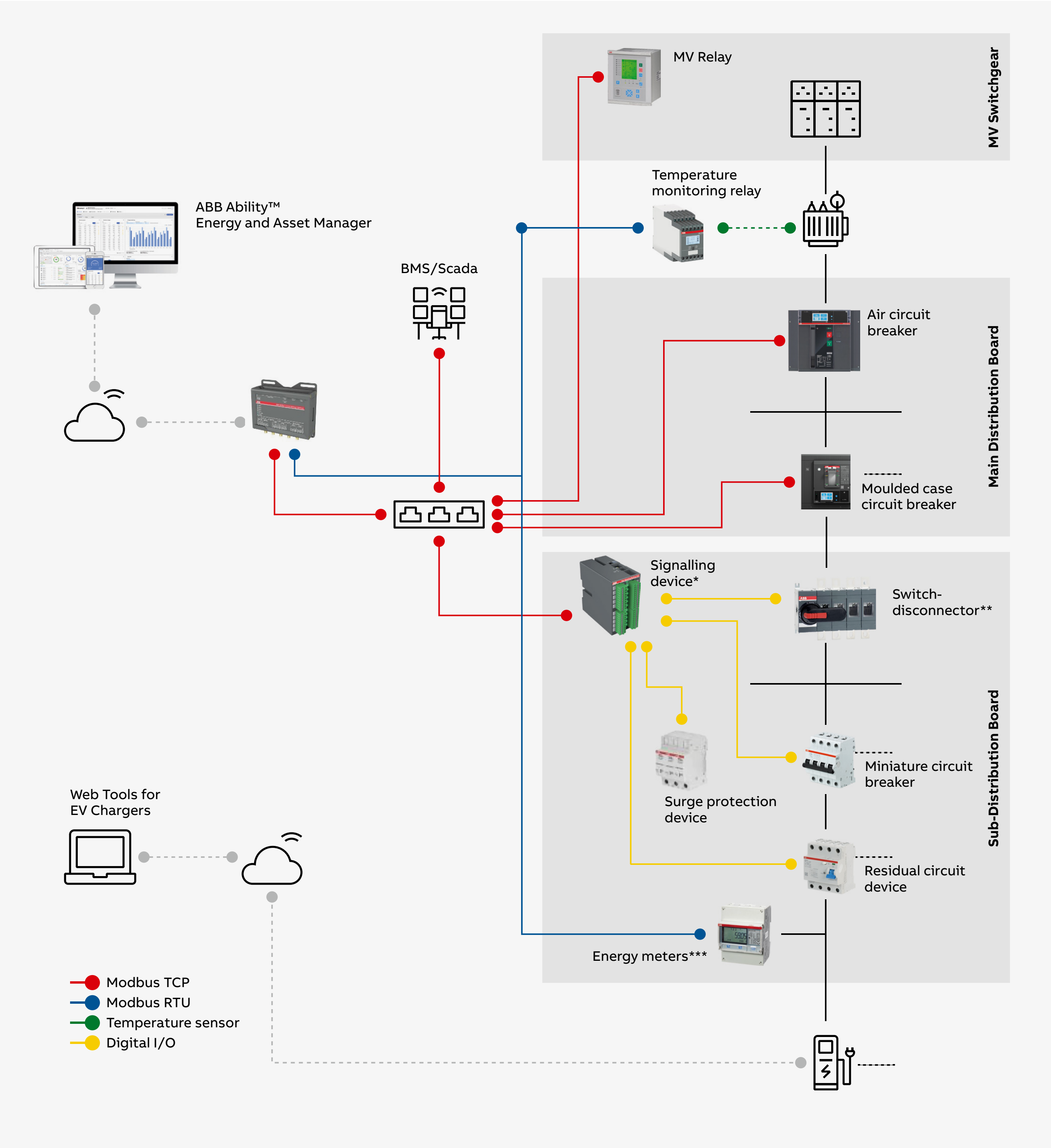
Intelligent Distribution (ID) for LV Main distribution boards

- If a new main distribution board is to be installed, incoming and outgoing circuit breakers can be chosen with embedded measurement functions to enable detailed current measurement and energy usage; easily achieved without additional components.
- Predictive maintenance function for Emax 2 and XT7 circuit breakers increases system reliability while decreasing maintenance costs.

Intelligent Distribution (ID) for LV Sub-distribution boards

- * Ekip Signalling Modbus TCP device can collect status and trip signals from incoming switch-disconnector, surge protection devices, miniature circuit breakers or residual circuit device
- ** Measurement function of incoming sub-distribution board devices is important when extension of LV installation in existing buildings for EVCI is evaluated. In such cases, this device can be chosen as circuit breaker with smart electronic trip units instead of switch-disconnectors.
- *** Power meters for each charger branch may also be needed when EV chargers do not include metering devices.

Digital Product Range for AC Distribution Boards in EVCI Main components
Reference Architecture



AWG 16-22 cables with a maximum external diameter of 1.4 mm must be used to connect the power supply signals and the inputs and outputs.

Product Offering

Emax 2 – Emax 2 / MS

WEB PAGE

Tmax XT

WEB PAGE

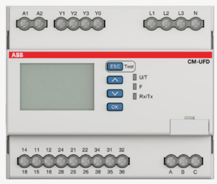
OVR

WEB PAGE

RCD

WEB PAGE

CM-UFD



WEB PAGE

S200

WEB PAGE

Temperature Monitoring Relays

WEB PAGE

Ekip Signalling

WEB PAGE

Ekip 3T

WEB PAGE

ABB Ability™
Energy Manager – Watching

WEB PAGE

ABB Ability™
Edge Industrial Gateway

WEB PAGE

Note

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9AKK108468A6297 January 2024