ETREL

ELECTRIC VEHICLE CHARGING STATION

ETREL INCH DUO

ELECTRICAL INSTALLATION SPECIFICS

Document version: 1.4
Document date: 11. 11. 2021

TABLE OF CONTENTS

1 BASIC DESCRIPTION

ABOUT THIS DOCUMENT

The safety and installation instructions "Quick Start Guide" that comes with the charging station should be read first and can also help with the installation procedure:

- *Etrel_INCH_DUO_QuickStartGuide.pdf*
- *Etrel_INCH_DUO_QuickStartGuide_Figures.pdf*

The document in front of you contains information on the specifics of electrical installation of the INCH DUO charging station. As it is necessary to consider the physical installation, basic information about it is also included.

More information about physical installation is available in the document “Physical Installation”:

- *Etrel_INCH_DUO_Physical_Installation.pdf*

All the documents are available in the installation manuals section, accessible from the INCH DUO product page, at the web page https://etrel.com/charging-solutions/inch-duo/

SITE PREPARATION

CONFIRMATION OF READINESS

Before carrying out the installation, the client must confirm his readiness usually with a statement, that all the requirements for the preparation of the location and additional image material are met, which allows remote checking of compliance.

ACCESS TO INSTALLATION SITE

An access to the location should be made possible to service vehicle for installation and servicing of charging stations.

SUPPORT DURING INSTALLATION

The responsible staff for both electricity installations and IT communications should be present on the location or available for immediate remote support.

EXTERNAL FACTORS

Installation cannot be carried out in the event of extremely rainy or snowy weather or other external factors that can prevent safe mounting, installation, and commissioning of charging stations. The charging station installation should be cancelled under such circumstances.

INSTRUCTIONS VALIDITY

The client shall check with manufacturer for the latest valid version of instructions before the preparation of location(s) for installation of charging stations. Please make an inquiry with the point of contact at the retailer or manufacturer’s support of your charging station to request the latest instructions version when necessary.

PERMITS

LOCATION AND BUILDING PERMIT

The charging station is a simple object and there is usually no need to acquire any building permits for its installation. If the installation site is a part of municipal property, consent of the relevant authorities must be acquired before the charging station can be installed. Installations must be performed in accordance with possible additional requirements of the national regulation.

CONNECTION TO THE GRID

The charging station must be connected to the low-voltage electricity distribution network. No special permit is required to connect to an existing network behind the metering point. The connection can be done by any authorised electrician. Installations must be performed in accordance with possible additional requirements of the national regulation.

PARKING PERMITS

Parking must be possible in the direct vicinity of the station and permitted by the operator or owner of the parking area. Estimated time for a full charge depends on the current state of the battery and the vehicle's charging power. Charging procedure usually takes between 30 minutes and up to 8 hours. Installations must be performed in accordance with possible additional requirements of the national regulation.

LOCATION

Charging station should be installed in the vicinity of the parking spot that will be used to park and charge electric vehicles. They can have charging socket located in various positions. Consequently, cable length to connect EV and charging station is important.

The sufficient cable length to easily connect the electric vehicle with the charging station, regardless of where the EV's charging socket is located, should be between 3 and 7 m and depends on the charging station location in comparison to parking spot. Shorter length cables are recommended as they are easier to handle.

Make sure that in a typical connection scenario there are no obstructions in the way of the charging cable. When in use, the charging cable should be laid so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.

Charging station should be mounted so that the plug of the charging station is located approximately 120 cm above the ground. This height enables averagely high user the easiest operation of charging station and connection of charging cable. It also provides best view and operation of the LCD screen.

Etrel INCH charging station and its components (cable, casing, LCD screen...) are developed to be installed in the outside area meaning that charging station is resilient to the external actors (UV rays, rain, snow, cold etc.). Installing it in the closed-up area, for example in garage, will prolong the lifespan of the charging station and keep it in a pristine condition for longer.

THERE IS NO FUNCTION OF VENTILATION IMPLEMENTED IN THE CHARGING STATION.

Location of the charging station must meet the following criteria:

- The charging station must not be submersed in water or any other fluid and should not be installed in flood risk areas.
- The operational temperature of the charging station is between - 25°C and + 65°C.

  For locations where the charging station will be exposed to direct sunlight and high ambient temperatures during the day, it is recommended to install protection from direct sunlight, otherwise the temperature inside the station may exceed 65°C.
- Charging station must not be installed in explosion hazardous areas (EX zone)

REQUIRED SPACE

Basic installation of the charging station without arches requires an excavation of minimal dimensions of 550 mm x 420 mm (floor plan) and depth of 600 mm. If the charging station is installed together with two safety arches, dimensions of the required dimensions are approximately 800 mm x 550 mm. Please find more information in chapter Construction Works.

CHARGING STATION DIMENSIONS

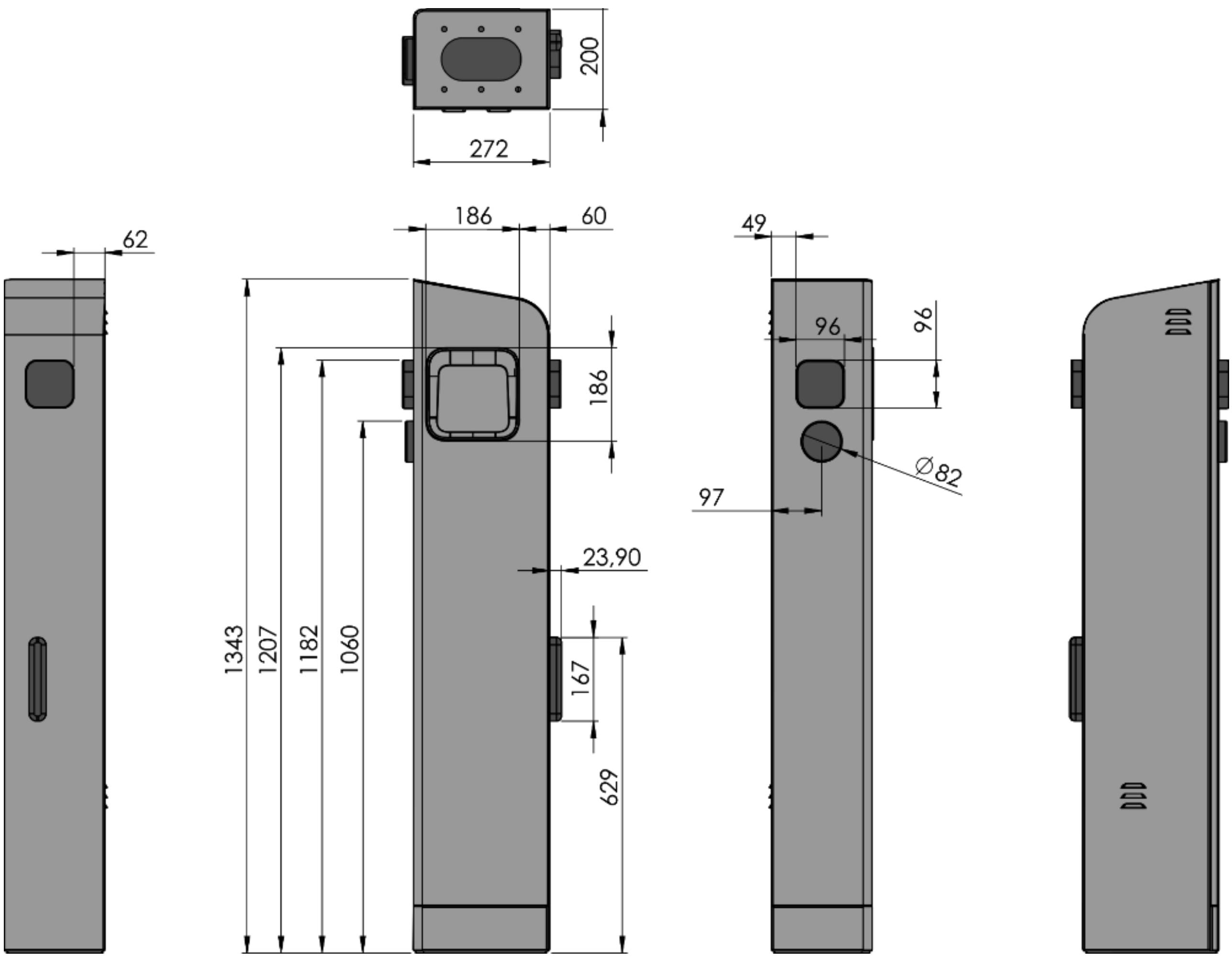


Figure 1: INCH DUO dimensions

Additional considerations of dimensions:

- The height of the charging station is 1343 mm.
- Basic dimensions of the station's base: 272 mm x 200 mm.
- Free space needed:
  - 50 mm in the back.
  - 150 mm on the left and right side.
  - 500 mm at the front (140 mm for opening the station doors and additional space to enable simple maintenance).

Two air vents are built into the station, one on the top of the back side and another in the middle of the back side. Air vents must not be blocked or obstructed by other items or objects. When applicable, air vents must be protected from being covered with snow.

The charging station is equipped with standard sockets (Type 2 according to EN 61851 or EN 62196-2). Charging cables are not a part of the station's equipment. It is expected that the users carry charging cables in their vehicles. EV parking places must be placed within the reach of the charging cable. Minimum length of the charging cable should be 2.5 m (in the case of the most optimal EV parking to charge on both sockets).

CONTENT, OPTIONAL AND EXTRA EQUIPMENT

The table below shows the optional and extra equipment that can be added to the charging station:

Optional / Extra equipment	Use/Description
GPRS router with network switch	GPRS router can be used for communication for several chargers on the same location (required for control centre connection when local connection via Ethernet is not possible). Network switch can be used to connect several stations on the same location with one router.
Safety arches (Protective railing)	Protects the station from vehicle collisions.
Underground anchoring structure	For safe installation of charging station and safety arches.
Different graphical user interface languages	Based on user identification, the station can automatically adjust the language of the user interface.
Visual customisation of the station	Custom labels with client’s design, logotypes, or promotions.
Connection of two sets of supply wires	Special connection terminals can be used to connect several stations in a row.
Etrel Load Guard	Enables management of charging current based on settings in the control centre for management of charging infrastructure.
Etrel Ocean	Control centre for management of charging infrastructure.

TOOLS

To execute the installation of charging station multiple tools are needed:

- Screwdriver,
- Hex screwdriver (if charging station without key lock on maintenance doors),
- Utility knife,
- Self-adjusting crimping pliers for cables' end sleeves,
- Wire trippers and
- Cable rippers.

Figure 2: Equipment used for the installation of charging station

2 PRODUCT DESCRIPTION

The Etrel's public charging station INCH DUO is highly configurable and can be tailored to the client's specific needs. It allows simultaneous charging of two vehicles with power of up to 2 x 22,08 kW and is equipped with standard Type 2 sockets (EN 61851 or EN 62196-2).

The actual number of maximal charging power can differentiate the exact value for one charging spot considering voltage of 230 V is 22,08 kW.

Charging is limited to 32 A, however voltage specified as 230 V, can be between 207 V and 253 V (+- 10 %). This means that the actual charging power can be lower or higher of the specified 22,08 kW.

Another factor heavily influencing what is the charging power is the power factor (cos Fi), which is determined by the internal charger in the electric vehicle. This factor is always lower than one, meaning that all power is not active, there is also reactive component. The correct designation of charging power would therefore be 2 x 22,08 kVA (or 44,16 kVA).

No matter the specifics, the charging power of Mode 3 charging spot is commonly referenced as 22 kW (or 44 kW for charging station with two charging spots). This simplification is used in this document as well.

Charging station comes with the LCD screen that guides through the charging process and provides important charging information. Charging station comes with several connectivity options (including LTE and Ethernet) and open protocol support and can be seamlessly integrated in the smart home system.

Certified utility-grade meters as well as all optional utility feeder equipment are embedded in the station. The station can be equipped with an RFID identification module, which prevents unauthorized use and is necessary to enable different billing and reservation processes and other advanced functionalities. The station also supports remote identification with SMS or other external identification means.

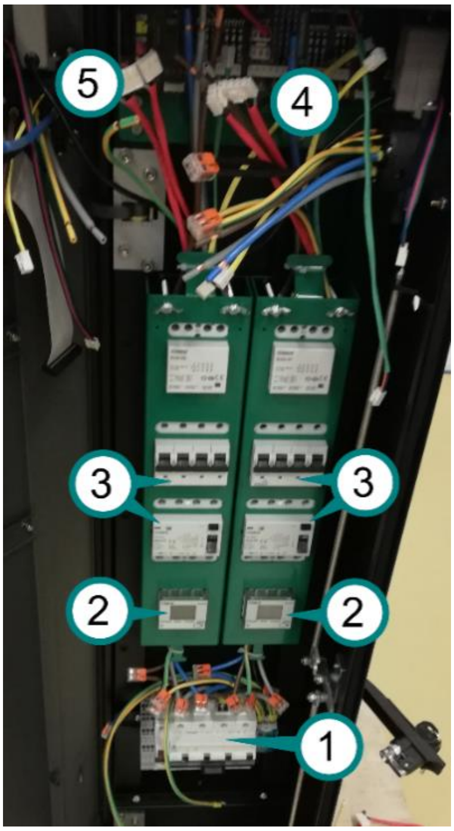
The casing of the charging station is robust enough to withstand any unfavourable weather conditions and potential damage which may occur in open public areas. The compact dimensions of the charging station allow its installation in a small area, for example close to the edge of the pavement or roadside curb.

Modular design allows simple replacement of key components that can become damaged due to wear and tear or vandalism (especially the charging sockets). The station's service doors use a special three-point locking mechanism. The doors open outwards and to the side to simplify the work of maintenance staff.

COMPONENTS OVERVIEW

The Etrel INCH DUO public charging station contains the following components:

- Casing of the station,
- two charging spots (Type 2 sockets, single- or three-phase),
- main controller of the station,
- LCD display that guides user through the charging process,
- user identification module with RFID card reader,
- ethernet communication connection point,
- built-in smart energy meters for each charging spot,
- electrical protection of each socket,
- three-phase grid connection point equipped with standard safety protection.



1) Grid connection of the charging station, which contains terminals for all supply wires (L1, L2, L3, N and PE).
2) Energy meters for each socket. For normal functioning of the station, a working communication connection between the main station controller and the energy meters is required.
3) Differential and overcurrent protection of each socket.
4) Module for communication with electric vehicle (compliant with the IEC 61851 standard), socket voltage monitoring components, socket contactors.
5) Main station controller with RFID reader, RFID antenna and LCD display, control circuit power supply, and communication modules (Ethernet or GPRS router).

Figure 3: Arrangement of equipment inside the station

BASE SPECIFICATIONS

- **Input:** 2x230/400V~; 3W+N+PE; 50/60 Hz; 32 A max.
- **Output:** 2x230/400V~; 3W+N+PE; 50/60 Hz; 32 A max.
- **Maximum charging power:** 2 x 22 kW (3-phase)
- **Device power consumption:**
  - From 5 W, depending on the actual configuration.

GRID CONNECTION

The charging station can be connected directly to the electricity distribution network or to an existing electrical installation nearby. Supply power depends on the charging power of each socket (according to the configuration of the charging station).

The following supply power is required:

- **44 kW (64 A):** 2 x three-phase charging spots, for each Type 2 socket is the maximum current 32 A per phase.

Supply power of the charging station must be dimensioned appropriately to enable simultaneous charging of two vehicles.

Charging power of each charging spot can be limited in the settings of the charging station on the scale between 6 A and 32 A. The charging station can also be set up to allow local power management so that when two vehicles are connected at the same time, the available maximum power is divided between the two vehicles. Power management can also be setup for a cluster of charging stations.

In the execution phase of the grid connection project, the following requirements need to be met:

- Selectivity of the functioning of protection devices needs to be ensured:
    - The main overcurrent protection should be at least one class greater than the one used for the protection of the charging station or have a higher delay.
    - Differential protection (RCD) which is used in the charging station operates at a low current (ΔI 30 mA, without delay). The selectivity of this protection on the level of facility is achieved with a higher delay or a greater current differential.
- Five wires are routed to the station, including three phase wires, grounding wire, and the neutral wire (when connecting to an existing installation). For single phase connection (slow charging option), only one phase wire with sufficient diameter can be routed to the station, together with neutral and earthing conductor. Dimensioning of the wires is determined in the project documentation. Grounding wire must be connected to the main grounding busbar.

CONNECTION TO THE STATION OPERATOR'S COMMUNICATION NETWORK

The charging station uses network connection to communicate with the Control centre to cyclically send information about its status, perform identification of users (on the Control centre level), forward events that occur during its operation and execute billing for the services performed.

The connection also enables communication from the Control centre towards the charging station, which enables remote access to the station for needs of maintenance or remote control.

The charging station could require a connection to the station operator's WAN network (charging infrastructure control centre). To access the WAN network via an internet connection, some additional security requirements need to be observed.

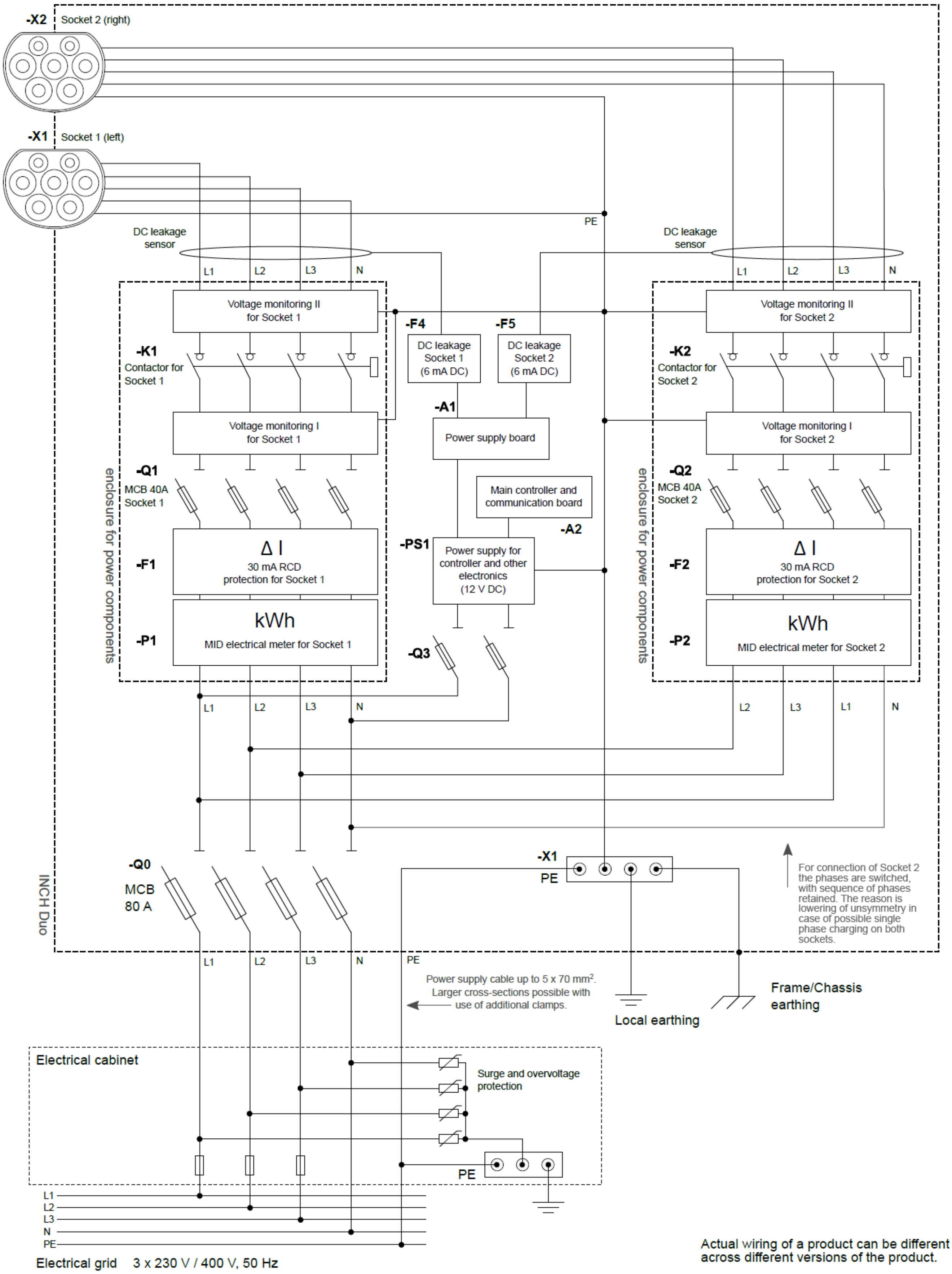
Network connection can be executed in several different ways:

- Direct connection to the station operator's WAN network. Connection can be established directly with a UTP cable or a fibre optic converter.
- Wireless connection. The station connects to an existing LTE 2G/3G/4G mobile network with an GPRS/UMTS router built into the station.

Specification of frequency bands and transmitting power (it is possible that not all modules are part of an actual device).

LTE module	**LTE Router**
Frequency bands: LTE-FDD: B1 (2100 MHz), B3 (1800 MHz), B5 (850 MHz), B7 (2600 MHz), B8 (900 MHz), B20 (800 MHz) LTE-TDD: B38 (2600 MHz), B40 (2300 MHz), B41 (2500 MHz) WCDMA: B1 (2100 MHz), B5 (850 MHz), B8 (900 MHz) GSM/EDGE: B3 (1800 MHz), B8 (900 MHz) Transmitting power: 33dBm±2dB for GSM 24dBm+1/-3dB for WCDMA 23dBm±2dB for LTE-FDD 23dBm±2dB for LTE-TDD	Frequency bands: 4G (LTE-FDD): B1 (2100 MHz), B3 (1800 MHz), B5 (850 MHz), B7 (2600 MHz), B8 (900 MHz), B20 (800 MHz) 4G (LTE-TDD): B38 (2600 MHz), B40 (2300 MHz), B41 (2500 MHz) 3G: B1 (2100 MHz), B5 (850 MHz), B8 (900 MHz) 2G: B3 (1800 MHz), B8 (900 MHz) Transmitting power: 21.9 dB
RFID module Frequency band: 13.56 MHz (HF) Transmitting power: up to 8 dBm	

CIRCUIT DIAGRAM



EXTERNAL SIGNAL

DIGITAL INPUTS AND DIGITAL OUTPUTS

Charger supports connecting four digital inputs and one digital output. Inputs and output are operating on 12 VDC, and maximal allowed load is 100 mA. Check pinout on the image below.

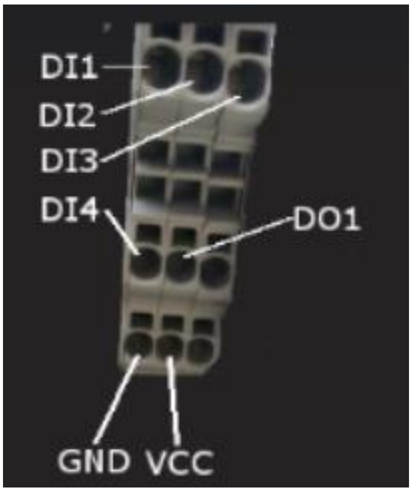


Figure 4: Pins of connector for digital inputs and output

The use and logic of these digital input and outputs is settable via web interface of the charging station.

⚠ **Do not use external 12 VDC or 5 VDC for power supply. Digital output allows maximal load of 100 mA! Be careful not to make short circuit, which could be dangerous to persons and could also damage the charging station.**

3 CABLE CROSS-SECTION SELECTION

The required cable cross-section is determined considering the maximum current, the allowable voltage drop and the expected short-circuit current. Cross-section can be determined by calculation or from a table, in the usual way, in accordance with IEC 60364-5-52.

When determining the cross-section of the cables, it is also necessary to include the method of installation, the material of the conductors and the insulation material. The temperature conditions at the location and the length of the cable also have an impact.

In general, the cable cross-section for the INCH DUO connection is around 10 - 25 mm^2, dependant on the installation method. Larger distances or clustering of several charging stations could require cables with larger cross-section. Direct connection of INCH DUO is possible for cables of cross-section of up to 50 mm^2. With use of additional clamps, it is possible to connect cables with cross-section of up to 95 mm^2.

We recommend that at least the specified cable cross-section is selected for all phase conductors, for the neutral conductor and for the protective conductor. When choosing cables with a larger cross-section, the losses will be smaller, which is especially important for longer cable routes.

MINIMUM CABLES CROSS-SECTION

The calculation of necessary cables cross-sections should be part of electrical project and should consider the specifics of the actual location. The plan of installation should be prepared by licensed electrician or electrical planner in accordance with national legislation. Values given in this chapter are only informational.

The cables cross-sections are determined by three criteria:

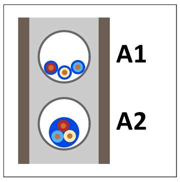
- Continuous operating current.
- Voltage drop.
- Short circuit withstand.

CONTINUOUS OPERATING CURRENT

The cross-section of cables must be large enough that continuous charging with maximal current is safe and does not damage the cables. Different installation options and environmental conditions are possible.

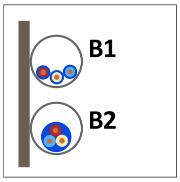
In the following table, the installation method can be checked for the minimum cable cross-section when connecting one INCH DUO charging station. These values apply for copper conductors with XLPE insulation at reference air temperature of 35 ° C. For installation of cables in the ground, temperature of the ground is set as 25 ° C and soil thermal resistivity as 2.5 K*m/W. Charging current of 64 A is being considered.

Table 1: Minimum cable cross-section for continuous operating current of 64 A.



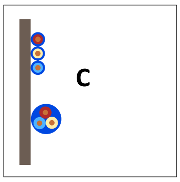
A1 - Insulated single core conductors in conduit in a thermally insulated wall
A2 - Multicore cable in conduit in a thermally insulated wall
This method also applies to single core or multicore cables installed directly in a thermally insulated wall (use methods A1 and A2 respectively), conductors installed in mouldings, architraves and window frames.

A1, A2: **16 mm^2**



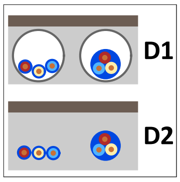
B1 - Insulated single core conductors in conduit on a wall
B2 - Multicore cable in conduit on a wall
This method applies when a conduit is installed inside a wall, against a wall or spaced less than 0.3 x D (overall diameter of the cable) from the wall. Method B also applies for cables installed in trunking / cable duct against a wall or suspended from a wall and cables installed in building cavities.

B1, B2: **16 mm^2**



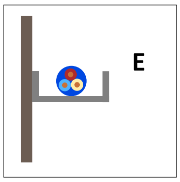
C - Single core or multi-core cable on a wooden wall
This method also applies to cables fixed directly to walls or ceilings, suspended from ceilings, installed on unperforated cable trays (run horizontally or vertically), and installed directly in a masonry wall (with thermal resistivity less than 2 K·m/W).

C: **10 mm^2**



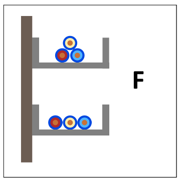
D1 - Multicore or single core cables installed in conduit buried in the ground
D2 - Multicore or single core cables buried directly in the ground

D1, D2: **16 mm^2**



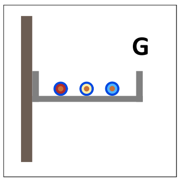
E - Multicore cable in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall. Note that cables installed on unperforated cable trays are classified under Method C.

E: **10 mm^2**



F - Single core cables touching in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall. Note that cables installed on unperforated cable trays are classified under Method C.

F: **25 mm^2**



G - Single-core cables laid flat and spaced in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall and with at least 1 x D spacings between cables. Note that cables installed on unperforated cable trays are classified under Method C. This method also applies to cables installed in air supported by insulators.

G: **25 mm^2**

At sites, where the cross-section of already existent cables is smaller than recommended minimum, the limitation of maximal current can be made in the charging station's web interface to allow the connection of charging station, without the need to replace all the cables.

VOLTAGE DROP

The requirement for the maximum voltage drop of the installation can be different across different countries. Usually, it is required that the voltage drop of the installation is below 4 % (or in some cases below 5 %).

The length of the conductors and charging current are major factors determining the adequacy of cables cross-section, however voltage drop occurs on other components or devices as well. Because of it, some reserve should be considered when selecting cables cross-section.

Table 2: Voltage drop in conductors with 10 mm² cable cross-section and charging current of 64 A.

Charging current 64 A	**Conductor 10 mm² Single phase**	**Conductor 10 mm² Three phase**
L - length [m]	**Voltage drop [%]**	**Voltage drop [%]**
10	1,09	0,94
20	2,18	1,88
30	3,26	2,83
40	4,35	3,77

Table 3: Voltage drop in conductors with 16 mm² cable cross-section and charging current of 64 A.

Charging current 64 A	**Conductor 16 mm² Single phase**	**Conductor 16 mm² Three phase**
L - length [m]	**Voltage drop [%]**	**Voltage drop [%]**
10	0,69	0,60
20	1,38	1,19
30	2,07	1,79
40	2,75	2,39
50	3,44	2,98
60	4,13	3,58

Lower voltage drop also means that the power losses of charging process will be lower. The life cycle assessment and calculation of benefit of using cables with larger cross-section could help mitigate the higher cost of investment.

Table 4: Voltage drop in conductors with 25 mm² cable cross-section and charging current of 64 A.

Charging current 64 A	Conductor 25 mm² Single phase	Conductor 25 mm² Three phase
L - length [m]	**Voltage drop [%]**	**Voltage drop [%]**
10	0,45	0,39
20	0,90	0,78
30	1,35	1,17
40	1,80	1,56
50	2,25	1,95
60	2,70	2,33
70	3,14	2,72
80	3,59	3,11
90	4,04	3,50

Table 5: Voltage drop in conductors with 35 mm² cable cross-section and charging current of 64 A.

Charging current 64 A	Conductor 35 mm² Single phase	Conductor 35 mm² Three phase
L - length [m]	**Voltage drop [%]**	**Voltage drop [%]**
40	1,31	1,13
50	1,64	1,42
60	1,97	1,70
70	2,29	1,99
80	2,62	2,27
90	2,95	2,55
100	3,28	2,84
110	3,60	3,12
120	3,93	3,40

SHORT CIRCUIT WITHSTAND

Charging station INCH DUO has already installed miniature circuit breakers which protect against overload and short circuit. This protection can also be part of installation with different tripping characteristics.

Short circuit protection lowers the possible short-circuit and its duration that downstream installed devices can be subjected to. Normally, 2 kA short circuit of 10 ms duration could be considered for calculations of cables cross-section to withstand short circuit.

Cable with cross-section of 6 mm^2 is enough to withstand 5 kA, 20 ms. This value suggests that short-circuit withstand will not be the strictest criterion.

OTHER CONSUMPTION OR PRODUCTION OF ELECTRICITY AT THE LOCATION

In cases, where there are other loads at the location and there is a possibility that the total load (other loads + charging) overcomes the limitation of the grid connection point, the charging should be controlled.

Because the charging station needs information of other loads (or production) to be able to react appropriately, Etrel Load Guard device can be used.

LOAD GUARD

By using Load Guard device, other loads or production can be measured and used in overload prevention algorithms:

- Static limit of maximum allowed charging current per phase.
- Static limit of maximum allowed charging current per phase in case connection with Load Guard sensor or with Back-End System is lost.
- Detection and visualisation of available supply and automatic adjustment of charging power.
- Detection and visualisation of surplus energy returned to the grid (Production from renewable energy sources).

When the user connects EV to charger, and prior to beginning of charging, the charger determines the current available for charging as the difference between the rated current of the main fuse (reduced by a safety margin that can be pre-set by the user via charger’s web interface) and the last measurement received from Load guard.

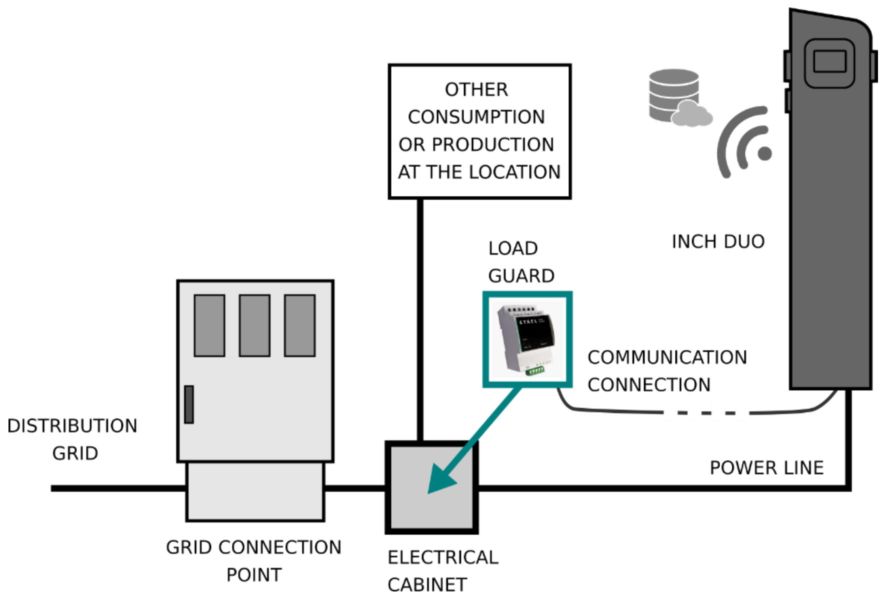


Figure 5: Use of additional consumption data to prevent overload

When there is local production of energy present at the location (e.g., photovoltaics), the available charging current can be higher, and the use of Load Guard make possible to always charge with maximum available current.

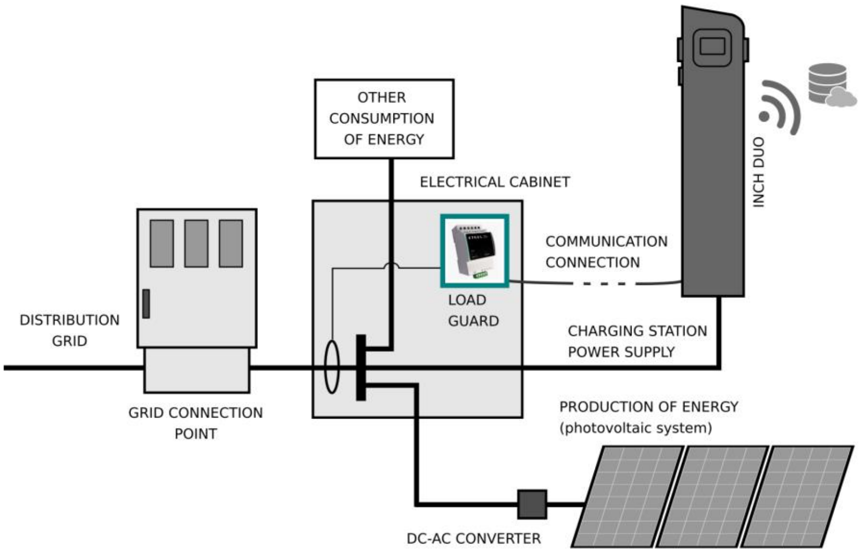


Figure 6: Use of additional consumption and production data to prevent overload

4 DIMENSIONING OF A CLUSTER

When selecting the cluster configuration and cluster master it is important to know that with INCH Duo can handle power management of up to 36 electric vehicles. This is valid for the most unfavourable scenario with low power capacity available, meaning constant need for power management recalculations with inclusion of data obtained from Load Guard. INCH Duo could also control larger clusters, depending on the individual case.

Larger cluster (supply of up to 300 electric vehicles in most unfavourable scenario) is possible with use of industrial computer and connection to Etrel Ocean management software.

Main decision factor in cluster configuration is usually the available charging power at the location. Cluster of charging stations can be planned and configured to allow charging with maximal power to all connected vehicles. Another option is to plan to the limitation of capacity intended for charging and to maximal charging current of the cluster.

When a larger number of parking spots need to be covered with charging stations, the general proposal is to have a dedicated parking spot for each charging connector that can offer at least charging with minimum current of 6 A to connected electric vehicle.

For example:

1) Five INCH DUO charging stations can be configured to be able to charge with maximal charging current of 32 A per phase, per each charging spot. Five INCH DUO charging stations have 10 charging spots, with maximal charging current of 320 A per phase, meaning that maximal charging power is 220,8 kW.
2) Five INCH DUO charging stations can also be configured to be able to charge only with minimal charging current of 6 A per phase. These five INCH DUO charging stations will have maximal charging current of 60 A per phase, meaning that maximal charging power is 41,4 kW.

Normally the cluster is dimensioned for available power and power management limits the total current of the cluster to allowable levels. Also, possible future upgrades should be considered and could lead to decision to install cables with larger cross-sections.

In case of very large clusters and long distances, possible dedicated power transformers could be needed to provide low enough voltage drop.

CABLING ROUTE FOR THE CONNECTION OF MULTIPLE CHARGING STATIONS

Charging station can be installed independently or combined in connection with other stations (the so-called clustering of charging stations).

When multiple charging stations are installed in a single area, the power supply cables can be routed in several different ways. The physical connection of a group of charging stations can be different than the setting of software grouping.

It is recommended, that the charging stations logically belonging to one cluster are also physically connected to the same cluster with common point of power supply.

The main reason would be possible power management of the cluster and limitation of charging power on basis of set and measured data. Also, avoidance of possible confusion during the maintenance or troubleshooting.

Cluster can be defined only on level of charging stations where one charging station is designated as cluster master. They can also be managed from charging infrastructure management system.

POWER CABLES STAR NETWORK TOPOLOGY

Power cables of the charging stations are connected to the common point (electrical cabinet in the following figure).

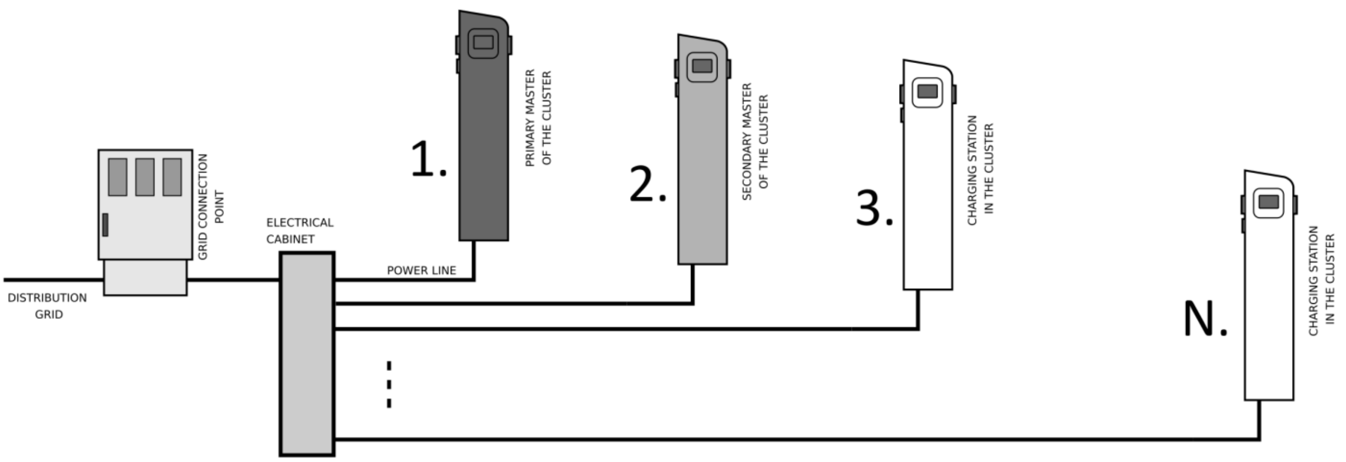


Figure 7: Cluster cabling route for multiple charging stations - star network topology

POWER CABLES POINT TO POINT NETWORK TOPOLOGY

Power cables are routed to the first station, which is then connected to the next station with a separate power cable and a separate communication cable. Each additional station is then connected in the same way with its preceding station.

In case that Point-to-Point communication is needed for the power supply, all INCH Duo's of the cluster with exclusion of the last one, should be equipped with double terminal clamps.

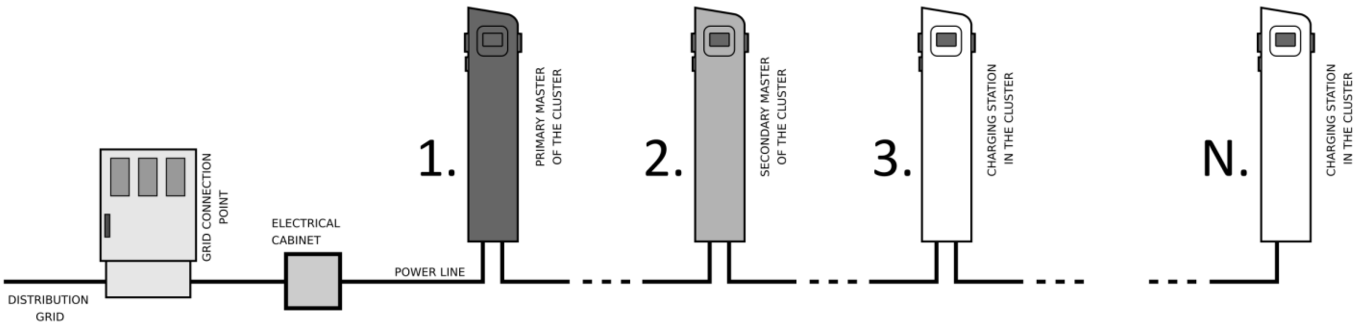


Figure 8: Cluster cabling route - point to point network topology (daisy chain)

POWER CABLES HYBRID NETWORK TOPOLOGY

When considering large clusters, the power supply network topology will most often be a hybrid of star and point to point network topology.

COMMUNICATION

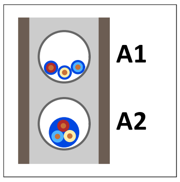
Although charging without network connection is possible, to enable common charging scenarios, network connection is required. Larger clusters are usually also connected to control centre, enabling remote control and management.

Cluster of charging stations can be connected to the network with UTP cable or with ADSL cable to the existing ethernet network, or ethernet network can be created only for the charging stations.

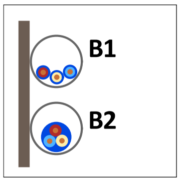
One of the charging stations is designated as a cluster master and represents one point of management for the complete cluster.

All the charging stations of the cluster need to be connected to the network. The communication cables should follow star network topology. Point-to-Point wiring of communication cables is not fully supported yet. When needed all INCH Duo's of the cluster should be equipped with router.

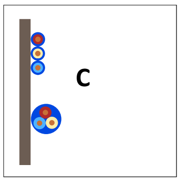
Table 6: Power cables installation method



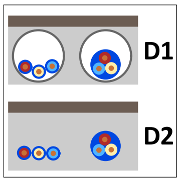
A1 - Insulated single core conductors in conduit in a thermally insulated wall
A2 - Multicore cable in conduit in a thermally insulated wall
This method also applies to single core or multicore cables installed directly in a thermally insulated wall (use methods A1 and A2 respectively), conductors installed in mouldings, architraves, and window frames.



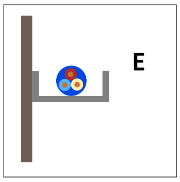
B1 - Insulated single core conductors in conduit on a wall
B2 - Multicore cable in conduit on a wall
This method applies when a conduit is installed inside a wall, against a wall or spaced less than 0.3 x D (overall diameter of the cable) from the wall. Method B also applies for cables installed in trunking / cable duct against a wall or suspended from a wall and cables installed in building cavities.



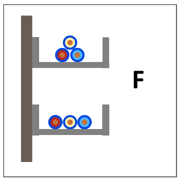
C - Single core or multi-core cable on a wooden wall
This method also applies to cables fixed directly to walls or ceilings, suspended from ceilings, installed on unperforated cable trays (run horizontally or vertically), and installed directly in a masonry wall (with thermal resistivity less than 2 K·m/W).



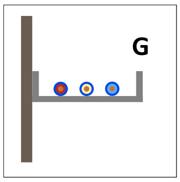
D1 - Multicore or single core cables installed in conduit buried in the ground
D2 - Multicore or single core cables buried directly in the ground



E - Multicore cable in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall. Note that cables installed on unperforated cable trays are classified under Method C.



F - Single core cables touching in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall. Note that cables installed on unperforated cable trays are classified under Method C.



G - Single-core cables laid flat and spaced in free-air
This method applies to cables installed on cable ladder, perforated cable tray or cleats provided that the cable is spaced more than 0.3 x D (overall diameter of the cable) from the wall and with at least 1 x D spacings between cables. Note that cables installed on unperforated cable trays are classified under Method C. This method also applies to cables installed in air supported by insulators.

CLUSTER CABLES CROSS-SECTION

When INCH DUO is designated as cluster master, it is possible to connect 18 INCH DUO charging stations to this cluster, meaning that charging is supported to 36 electric vehicles simultaneously. If industrial computer is designated as cluster master, it is possible to connect 150 INCH DUO charging stations in the same cluster, meaning that charging is supported to 300 electric vehicles simultaneously.

Considering maximal charging current of Mode 3 AC conductive charging point of 32 A (three-phase), the maximal charging power is 22,08 kW, meaning 44,16 kW for one INCH Duo. In large clusters this number rise significantly and can be in a range of large industrial consumers.

The currents presented in the following table require additional considerations from the electrical works planning view, which should be determined in the electrical project. It is possible, that high charging current would require implementation of bus-bar systems and/or possible installation of power transformers and/or additional requirements from the view of electrical safety and documentation preparation.

Table 7: Considering maximal current in case of clusters

Number of INCH DUO	Number of electric vehicles	Max. charging current (per phase)	Maximal charging power
5	10	320 A	220,8 kW
10	20	640 A	441,6 kW
15	30	960 A	662,4 kW
20	40	1280 A	883,2 kW
25	50	1600 A	1104 kW
30	60	1920 A	1324,8 kW

Main factor influencing the design of a cluster is the available charging power at the location of cluster installation. This limitation can also be expressed as maximal current.

When considering charging with full power the available capacity can quickly run out even with small numbers of simultaneously charged vehicles. INCH DUO has implemented power management functionalities with option of software limitation of maximal current of charging for individual charging station or for complete cluster.

Almost all vehicles require minimally 6 A of charging current. Considering that there are some vehicles that require higher minimal charging current, some reserve to the numbers in the following table should be added to ensure all connected vehicles can charge simultaneously.

Table 8: Considering minimal current in case of clusters (three-phase wiring)

Number of INCH DUO	Number of electric vehicles	Min. charging current (per phase)	Maximal charging power
5	10	60 A	41,4 kW
10	20	120 A	82,8 kW
15	30	180 A	124,2 kW
20	40	240 A	165,6 kW
25	50	300 A	207 kW
30	60	360 A	248,4 kW

In the previous table the numbers of minimal charging current are presented. Such system allows charging of individual electric vehicles with maximal power of 22,08 kW.

Power management can be used to set limitation of the maximal current of the complete cluster (determined by the location, e.g., main fuses). If this limitation is active, individual charging stations limit the charging power of the connected vehicles.

Considering that there are some vehicles that require higher minimal charging current, some reserve to the numbers in the following table should be added to ensure all connected vehicles can charge simultaneously.

All presented values are only indicative and are not a substitution for exact calculation of required cross-sections. Specified voltage drops are considering only voltage drop in a cable of defined cross-section and for specified current.

When calculating complete voltage drop of installation, the lowering of voltage across all the elements of the current path should be taken into consideration.

CONTINUOUS OPERATING CURRENT

Determining the right cross-section of conductors, the method of installation need to be considered. Additional consideration is the material of the conductor and material of its isolation. The real current must also be determined using the selected planning temperature.

Informational values of minimal cables cross-section were selected using the following:

- Three-phase system with copper conductors with XLPE insulation
- Ambient temperature 35 °C
- Ground temperature 25 °C
- Thermal resistivity of the soil 2,5 K·m/W

Table 9: Minimal cables cross-sections under specified conditions (1/2)

Current of the cluster [A]	32	64	96	128	160	192	224
Method of installation A1 [mm]	6	16	35	50	70	95	120
Method of installation A2 [mm]	6	16	35	70	95	120	150
Method of installation B1 [mm]	4	16	25	35	50	70	95
Method of installation B2 [mm]	4	16	25	50	70	95	120
Method of installation C [mm]	4	10	25	35	50	70	95
Method of installation D1 [mm]	4	16	35	50	70	120	150
Method of installation D2 [mm]	4	16	25	50	70	95	120
Method of installation E [mm]	2,5	10	16	25	35	50	70
Method of installation F [mm]	25	25	25	25	35	50	50
Method of installation G [mm]	25	25	25	25	25	35	50

Table 10: Minimal cables cross-sections under specified conditions (2/2)

Current of the cluster	[A]	256	288	320	352	384	416	448
Method of installation	A1 [mm]	150	185	240	240	300	300	X
Method of installation	A2 [mm]	185	240	240	300	X	X	X
Method of installation	B1 [mm]	95	120	150	185	240	240	300
Method of installation	B2 [mm]	120	185	185	240	300	300	X
Method of installation	C [mm]	95	120	150	150	185	240	240
Method of installation	D1 [mm]	185	240	300	X	X	X	X
Method of installation	D2 [mm]	150	185	240	240	300	X	X
Method of installation	E [mm]	70	95	95	120	120	150	150
Method of installation	F [mm]	70	70	95	95	120	150	150
Method of installation	G [mm]	50	70	70	95	95	120	120

VOLTAGE DROP

The requirement for the maximum voltage drop of the installation can be different across different countries. Usually, it is required that the voltage drop of the installation is below 4 % (or in some cases below 5 %).

The length of the conductors and charging current are major factors determining the adequacy of cables cross-section, however voltage drop occurs on other components or devices as well. Because of it, some reserve should be considered when selecting cables cross-section.

In large clusters of charging stations also the distances can be large. Because of it the voltage drop in the cables can be determining factor choosing the cables cross-section and configuration of the cluster.

Voltage drop in the power cable is proportional to the current of the load. When installing two INCH DUO charging stations, also voltage drops are twice as high as in case of one INCH DUO without considering any additional elements.

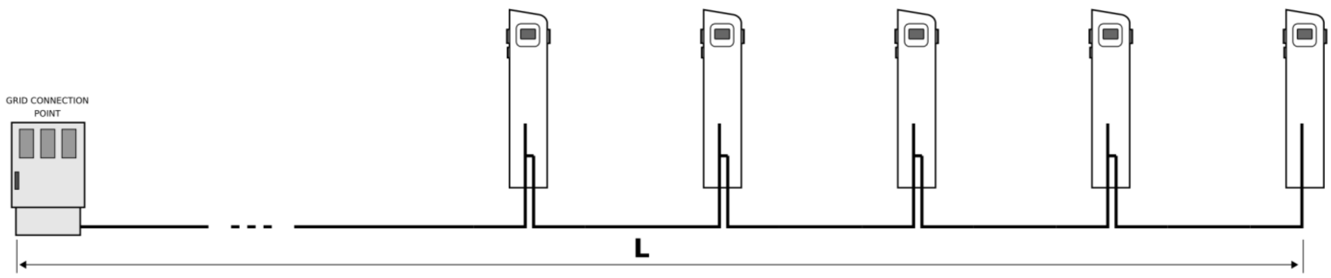


Figure 9: Cluster cabling route length

The voltage drop presented in the tables are calculated for single-phase and three-phase connection. Although the connection of INCH DUO is almost always three-phase, using values of voltage drop in single-phase can represent beneficial reserve when planning the correct cable cross-section.

Table 11: Voltage drop in conductors with 35 mm² cable cross-section and charging current of 128 A.

Charging current 128 A (Two INCH DUO with max. current)	Conductor 35 mm² Single phase	Conductor 35 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
40	2,62	2,27
50	3,28	2,84
60	3,93	3,40

Table 12: Voltage drop in conductors with 50 mm² cable cross-section and charging current of 128 A.

Charging current 128 A (Two INCH DUO with max. current)	Conductor 50 mm² Single phase	Conductor 50 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
60	2,84	2,46
70	3,31	2,87
80	3,78	3,27
90	4,25	3,68

For example, looking at the table determining minimal cross-section of cables for maximal continuous current of 320 A, depending on the installation method, either 70 mm² (Method G) or 150 mm² (Method C) cables could be used when connecting 5 INCH DUO charging stations with maximum charging current available. Reviewing the selection of the cable with consideration of voltage drop, shows that allowable distance of conductors is a lot lower than if selecting higher cable cross-section.

Table 13: Voltage drop in conductors with 70 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 70 mm² Single phase	Conductor 70 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
40	3,51	3,04
50	4,39	3,80

Table 14: Voltage drop in conductors with 95 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 95 mm² Single phase	Conductor 95 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
30	2,03	1,76
40	2,71	2,35
50	3,39	2,93
60	4,06	3,52

Table 15: Voltage drop in conductors with 120 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 120 mm² Single phase	Conductor 120 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
50	2,80	2,43
60	3,36	2,91
70	3,93	3,40
80	4,49	3,88

Table 16: Voltage drop in conductors with 150 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 150 mm² Single phase	Conductor 150 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
40	1,89	1,64
50	2,36	2,04
60	2,83	2,45
70	3,30	2,86
80	3,78	3,27
90	4,25	3,68

Table 17: Voltage drop in conductors with 240 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 240 mm² Single phase	Conductor 150 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
80	2,71	2,35
90	3,05	2,64
100	3,39	2,94
110	3,73	3,23
120	4,07	3,52

Table 18: Voltage drop in conductors with 300 mm² cable cross-section and charging current of 320 A.

Charging current 320 A (Five INCH DUO with max. current)	Conductor 300 mm² Single phase	Conductor 300 mm² Three phase
L - length [m]	Voltage drop [%]	Voltage drop [%]
100	2,95	2,55
110	3,24	2,81
120	3,54	3,06
130	3,83	3,32
140	4,13	3,57

There are several options considering larger distances of cable path and larger charging currents. The main conductor could have larger cross-section, that could be distributed through junction boxes, each connecting small cluster. The use of busbar trunking systems could be beneficial.

SHORT CIRCUIT WITHSTAND

Although the short circuit withstand criterion must be evaluated when dimensioning cables cross-section, in practice requirements of the first two criteria are stricter (continuous operating current and voltage drop).

Table 19: Minimum cable cross-section able to withstand specified short circuit

Short circuit	**Initial temperature 65 ° C**		**Initial temperature 35 ° C**	
	XLPE, copper	PVC, copper	XLPE, copper	PVC, copper
2 kA, 10 ms	1,28 mm^2	1,69 mm^2	1,16 mm^2	1,43 mm^2
2 kA, 20 ms	1,81 mm^2	2,39 mm^2	1,63 mm^2	2,03 mm^2
3 kA, 10 ms	1,91 mm^2	2,53 mm^2	1,73 mm^2	2,15 mm^2
3 kA, 20 ms	2,71 mm^2	3,58 mm^2	2,45 mm^2	3,04 mm^2
5 kA, 10 ms	3,19 mm^2	4,22 mm^2	2,89 mm^2	3,58 mm^2
5 kA, 20 ms	4,51 mm^2	5,96 mm^2	4,09 mm^2	5,07 mm^2

EXAMPLES OF CONNECTION

CASE 1: POWER CABLES FOR CLUSTER OF 15 INCH DUO IN EXPANDED STAR NETWORK

The case presented in the following figure is possible with normal configuration of INCH DUO. The cable cross-sections must be determined in accordance with all three criteria.

The distances are depending on the arrangement of parking spots and available space. One, two or more levels of electrical junction boxes could be used. On the figure two levels are presented and the first could be omitted (the grey box on the left).

Keep in mind that if the cables cross-section changes (e.g., in first junction box, from cross-section used on L1 to cross-section used on L2) and is lowered to level that cannot sustain the full current, the over-current protection element should be installed.

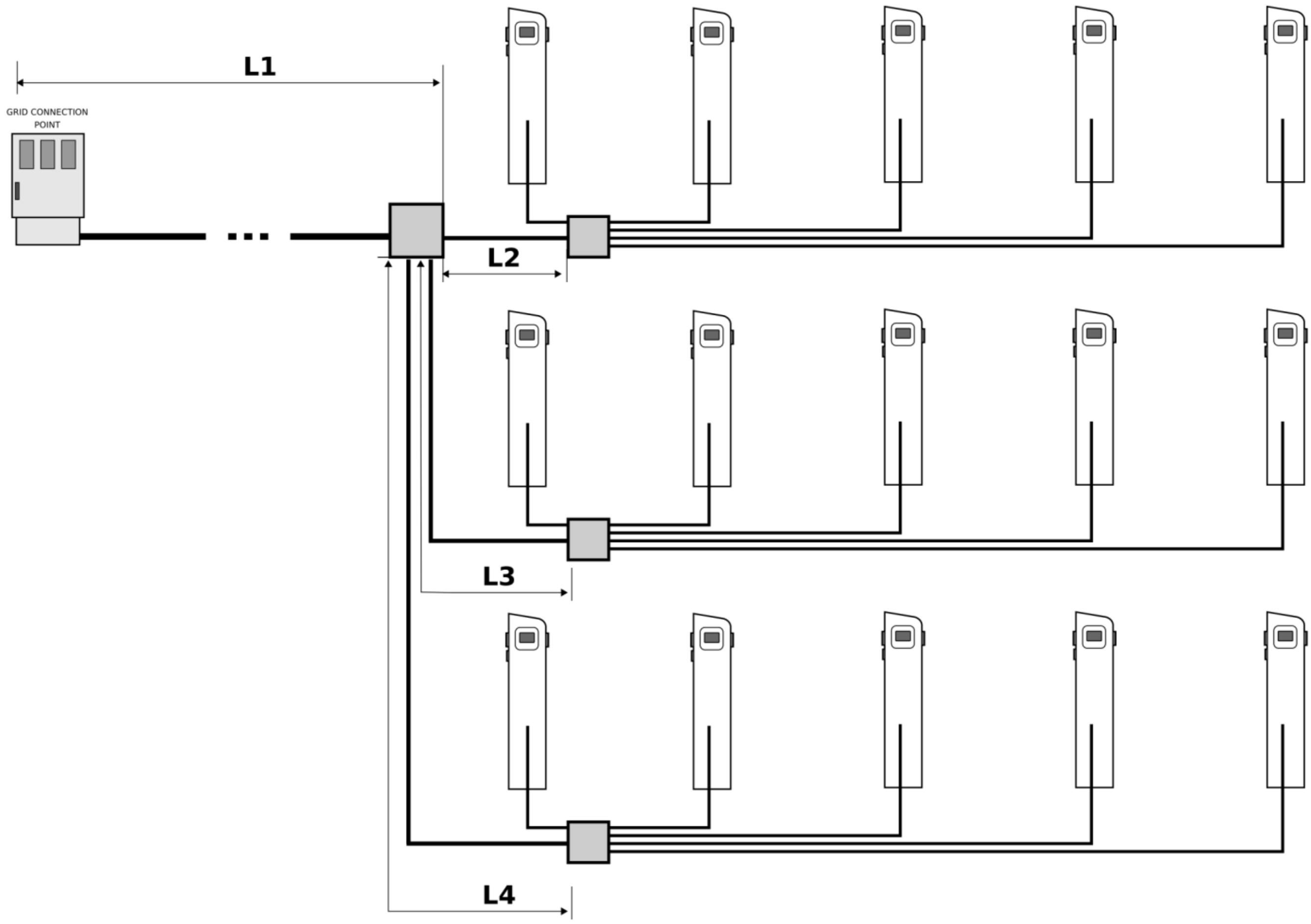


Figure 10: Example of INCH DUO connection – standard configuration

Maximal continuous current of the cluster

Maximal operating current of the presented case is 960 A. Cables supporting this current would need to be installed in E, F or G method of installation or a bus-bar system could be used. For cables used at L1, the cross-sections would need to be:

- Method of installation E: 400 mm^2
- Method of installation F: 500 mm^2
- Method of installation G: 400 mm^2

Such a high requirement indicates the possibility of using three main power lines to separate groups of the cluster, each designed for 320 A. These cables selection is the same as on the presented figure at L2 and L3 and L4, where the maximal operating current is 320 A. Cables used at L2, L3 or L4 would need to have cross-sections of at least:

- Method of installation A1: 240 mm^2
- Method of installation A2: 240 mm^2
- Method of installation B1: 150 mm^2
- Method of installation B2: 185 mm^2
- Method of installation C: 150 mm^2
- Method of installation D1: 300 mm^2

- Method of installation D2: 240 mm^2
- Method of installation E: 95 mm^2
- Method of installation F: 95 mm^2
- Method of installation G: 70 mm^2

Cables from the 2nd level junction boxes to individual charging stations need to be dimensioned for 64 A, meaning minimum cross-section of 10 mm^2.

Voltage drop

- Voltage drop in cable at L1

Table 20: Voltage drop in conductors with 400 mm^2 cable cross-section and charging current of 960 A.

Charging current 960 A	**Conductor 400 mm^2 Single phase**	**Conductor 400 mm^2 Three phase**
Distance [m]	**Voltage drop [%]**	**Voltage drop [%]**
10	0,75	0,65
20	1,50	1,30
30	2,25	1,95
40	3,00	2,60
50	3,75	3,25
60	4,51	3,90

For 960 A and copper conductors with cross-section of 400 mm^2, the voltage drop is quite large, indicating the possible need of more main power cable routes or need for limitation of maximal charging current.

- Voltage drop in cable at L2 (L3, L4)

Please check values of voltage drop according to distance and cable cross-section in tables 11-18.

- Voltage drop in cable of charging station connection

Please check values of voltage drop according to distance and cable cross-section in tables 2-5.

CASE 2: POWER CABLES FOR CLUSTER OF 15 INCH DUO IN EXPANDED POINT TO POINT NETWORK

The case presented in the following figure is possible only with double clamp terminals installed in all INCH DUO charging stations, instead of the last one of the power lines (three INCH DUOs that are completely right on the figure). The cable cross-sections must be determined in accordance with all three criteria.

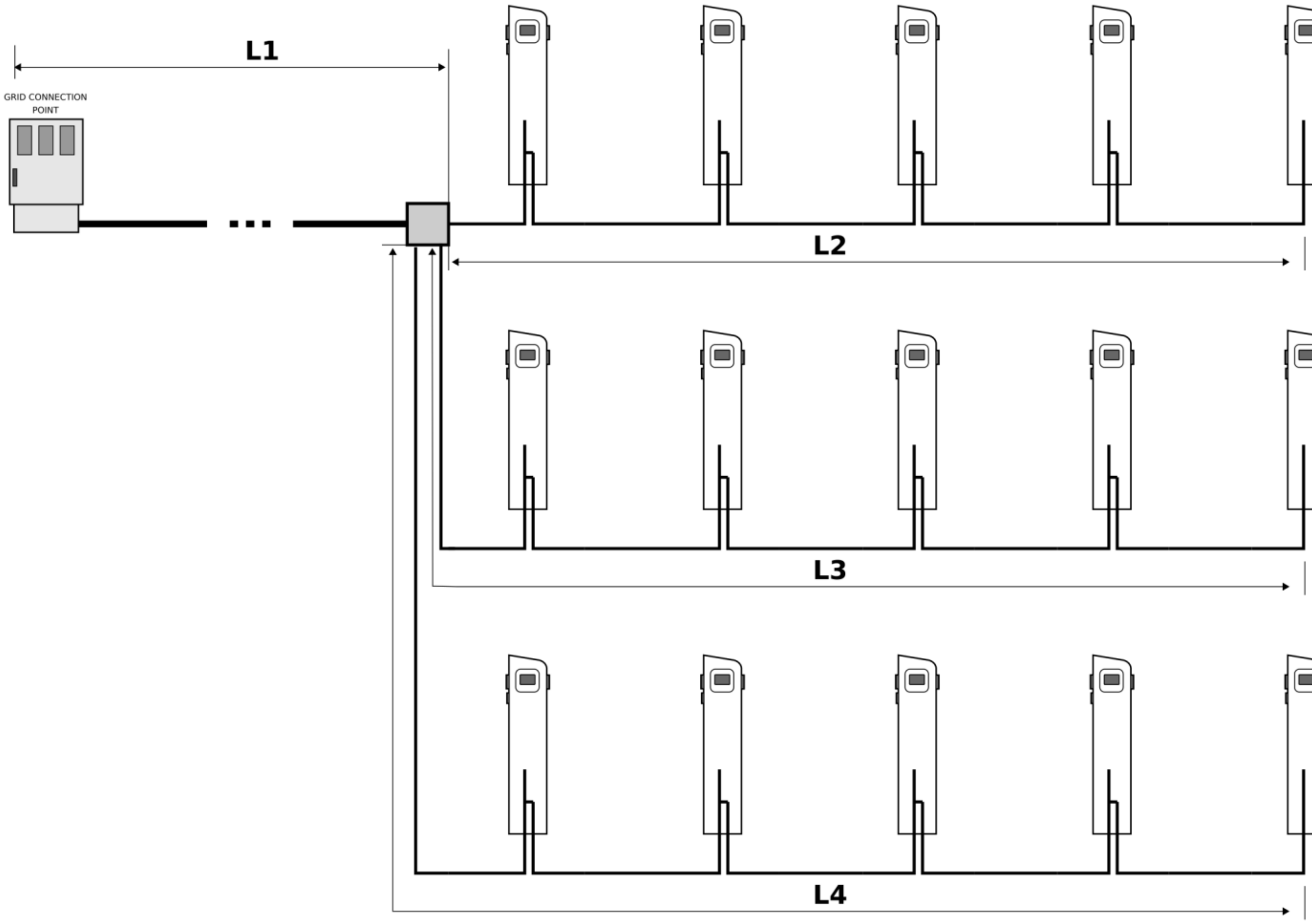


Figure 11: Example of INCH DUO connection – use of double terminal clamps

Maximal continuous current of the cluster

Maximal operating current of the presented case is 960 A. Cables supporting this current would need to be installed in E, F or G method of installation or a busbar trunking system could be used. For cables used at L1, the cross-sections would need to be:

- Method of installation E: 400 mm^2
- Method of installation F: 500 mm^2
- Method of installation G: 400 mm^2

Such a high requirement indicates the possibility of using three main power lines to separate groups of the cluster, each designed for 320 A.

These cables selection is the same as on the presented figure at L2 and L3 and L4, where the maximal operating current is 320 A. Cables used at L2, L3 or L4 would need to have cross-sections of at least:

- Method of installation A1: 240 mm^2
- Method of installation A2: 240 mm^2
- Method of installation B1: 150 mm^2
- Method of installation B2: 185 mm^2
- Method of installation C: 150 mm^2
- Method of installation D1: 300 mm^2
- Method of installation D2: 240 mm^2
- Method of installation E: 95 mm^2
- Method of installation F: 95 mm^2
- Method of installation G: 70 mm^2

Voltage drop

The length of L1 is the decisive factor. Table 20 shows that practical maximal length of this cable with cross-section of 400 mm^2 is around 10 - 30 m (considering reserve, because voltage drop occurs on all elements).

There are three possible main obstacles:

- At L1 the cable cross-section is extremely large indicating the possible need to use e.g., three main power lines, each connecting 5 x INCH DUO as shown on the following figure.
- At L2, L3 and L4 the cables are relatively large. Because of the point-to-point network configuration of five INCH DUOs, the cables should not exceed 95 mm^2, to be able to use additional double terminal clamps inside all INCH DUO units, except in the last one. If larger cables cross-section is needed, the double terminal clamps are too large to fit inside INCH DUO and the connection would be possible with use of additional junction boxes in front of every INCH DUO except the last.
- It is very likely that dedicated transformer will be required to connect 15 or more INCH DUO charging station, or the total charging current of the cluster will need to be limited.

CASE 3: POWER CABLES FOR CLUSTER OF 15 INCH DUO IN EXPANDED POINT TO POINT NETWORK

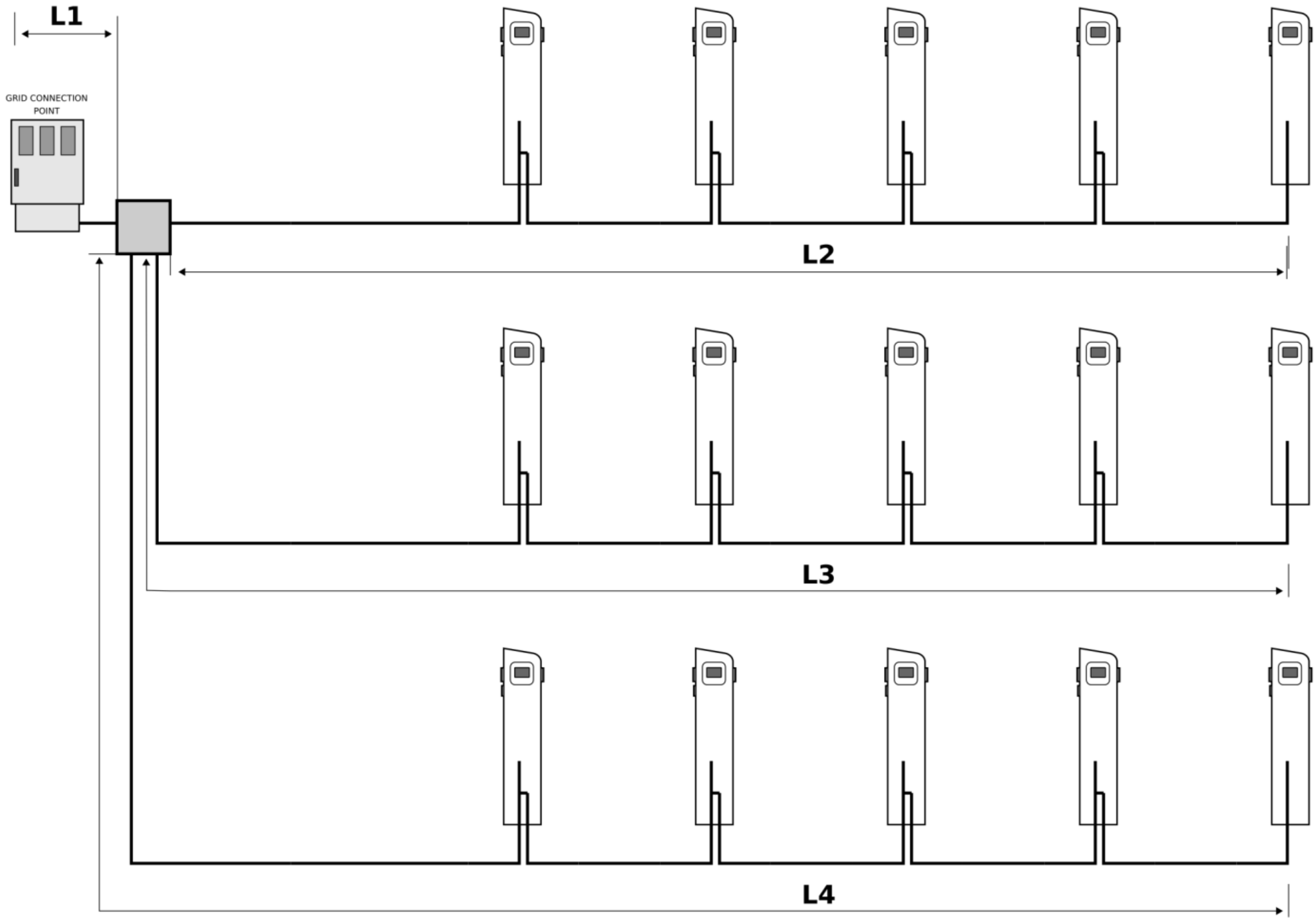


Figure 12: Example of INCH DUO connection – use of double terminal clamps

The figure presented above is showing possible selected configuration, after reviewing Case 1 and 2. It could be more expensive to install three main routes of cables, however using more conductive material (copper) will lower the voltage drop of installation (and with it the power losses).

CALCULATION OF TOTAL VOLTAGE DROP

The presented tables include only values of voltage drops in the cables. Voltage drops occur on all elements of electrical system and not only in cables and this should be evaluated or enough reserve when selecting cables cross-section is needed.

The distances play a major role when selecting cluster configuration.

When installing larger number of charging stations, the electrical project of such high power and currents needs to be prepared by licensed electrical designer.

5 CONNECTING CHARGING STATION

INSERTION OF CABLES THROUGH THE INSTALLATION PIPE

After the installation pipe is built into the concrete foundation, it is used for cabling and connection of the charging station. The concrete foundation must be left to dry for at least two days before the cables can be inserted in the installation pipe.

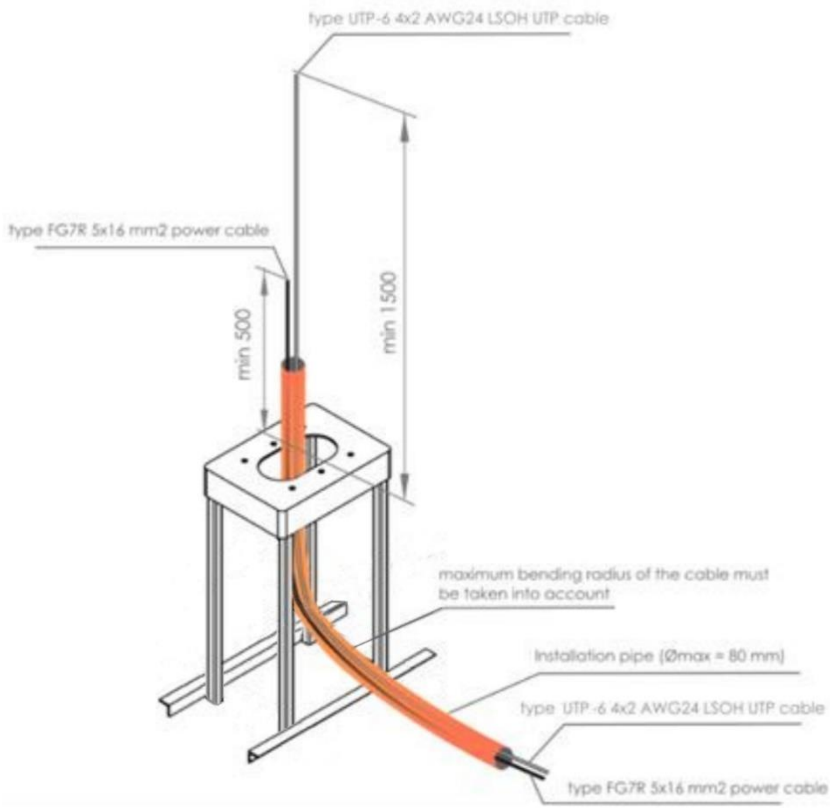


Figure 13: Placing of installation pipe and insertion of cables

Supply cables are routed through the underground anchoring structure with the use of installation pipe as shown in the figure above. The exact way of cable routing depends on the type of cables used and their diameter (which is determined in the project documentation). When dealing with cables with larger diameters, their bending radius must be considered.

Appropriate length of cables must reach through the upper opening for later connection of the charging station. At least 50 cm of the power cable and at least 150 cm of the optical / UTP cable (if the station's mode of communication does not use a wireless LTE 2G/3G/4G connection) must reach through the upper opening of the anchoring structure.

These minimum lengths of cables must be strictly observed to enable later effortless connection of the charging station.

PREPARATION OF CABLES

Remove 20 mm of insulation from all cables and attach and compress the appropriate crimp tubes on all cables. To prevent cables from getting in the way of mounting the charging station, twist them into an installation pipe. Length of cables on the other side of the gland should be:

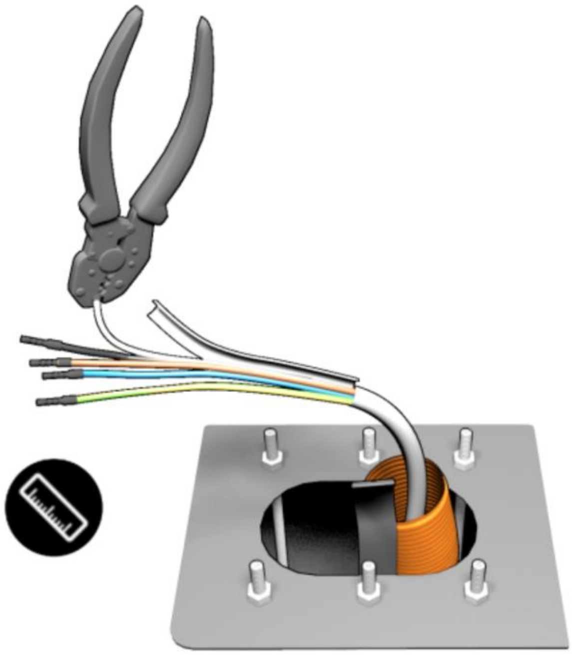


Figure 14: Preparation of cables

POWER SUPPLY COMPARTMENT

The power and communication cables are routed through the foundation after the casing of the charging station is installed. Care must be taken not to damage the equipment inside the charging station.

According to the dimensions of the power cable, the contracting entity chooses the proper configuration of the charging station with the appropriate terminals.

A three-phase 5-wire power cable is used for the connection, based on the type of connection. Standard terminals enable connection of cables of up to 50 mm^2 diameter. Customization with additional clamps is possible and they enable double connection up to 95 mm^2.

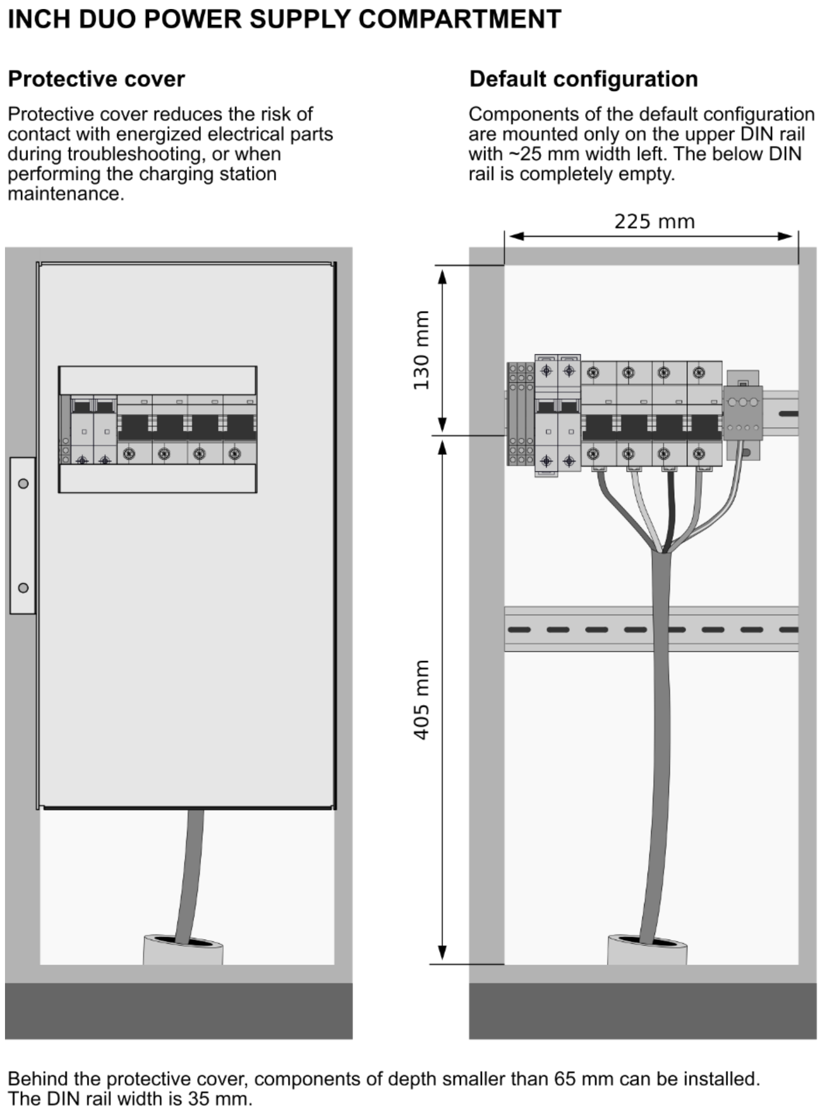


Figure 15: Overview of the power supply compartment

The configuration of the charging station depends also on the type of grid connection. The charging station is usually connected to an existing installation.

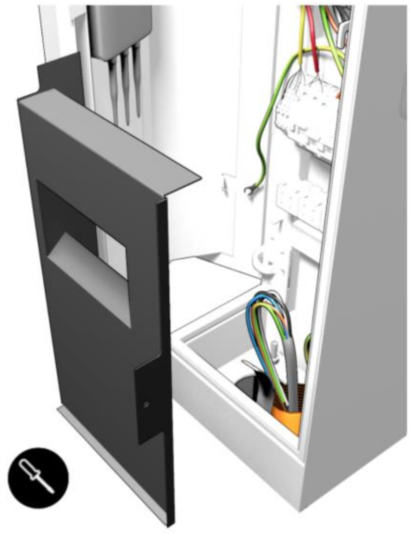


Figure 16: Power supply compartment cover

To enable access to the power supply compartment first unscrew and remove the protective cover.

There is a sticker on main connection element showing the correct designation of phases and neutral conductor. Remove the sticker and make sure that screws inside the main miniature circuit breaker (MCB) in which wires will be connected are unscrewed.

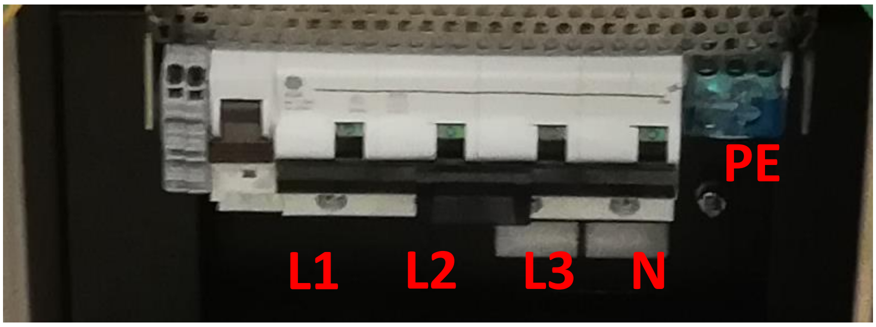


Figure 17: Connection of charging station to the power grid

To the main circuit breaker of the charging station, three supply phase conductors are connected in right order of phases. Normally, this would mean connecting from left to right, phase 1 (L1, brown), phase 2 (L2, black), phase 3 (L3, grey).

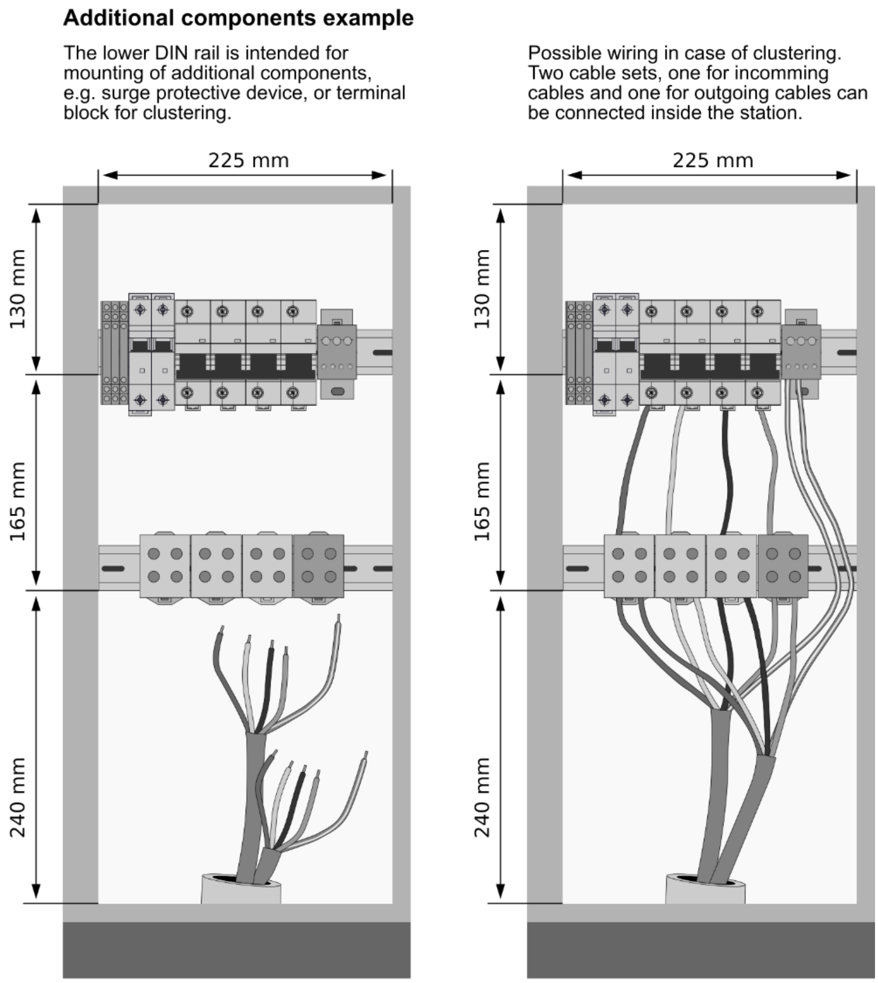


Figure 18: Example of the power supply compartment additional components

The neutral conductor (N, blue) must be connected to the neutral pole of miniature circuit breaker and PE conductor (PE, yellow/green) to the earthing clamp.

The order of phase conductors could be different in case of clustering of more charging stations. The reason is avoidance of current and voltage asymmetry in case of possible charging of one phase electric vehicles.

This means that if three charging stations are installed, the first phase of first station would connect to L1 of the system, the first phase of the second station would connect to L2 of the system and the first phase of the third stations would connect to L3 of the system. The sequence of phases must be kept (L1, L2, L3).

The software configuration must be properly made in charging station web interface and in the charging management platform (e.g., Etrel Ocean).

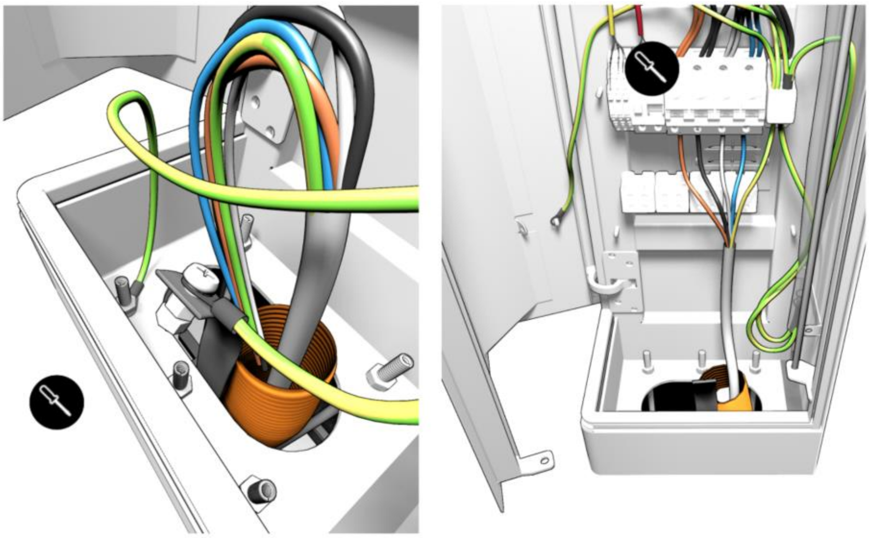


Figure 19: Connecting the cables

CONNECTION OF THE PROTECTIVE EARTHING (PE)

If the charging station is grounded locally, the grounding strip needs to be connected to the grounding busbar of the charging station.

The connection is performed as follows:

1. A hole is drilled into the grounding strip.
2. The grounding wire which connects the grounding busbar inside the station with the grounding strip is equipped with a cable shoe on one end and a hollow connector on the other end.
3. The cable shoe is fixed to the grounding strip on one end.
4. The grounding wire is fixed to the grounding busbar on the other end.

CONNECTION OF THE POWER CABLE

Prior to the beginning of work make sure that the main power supply is turned off.

Required tools: Allen key (Hex key), wire stripper pliers (for stripping of insulation and for fine-core cables), crimping pliers.

1. Cut off three (five) wires of the power cable to the appropriate length to reach the connectors. Do not make the wire routing too tight or too loose.
2. Use wire stripper pliers to remove 20 mm of the insulation from the end of all wires (L1, L2, L3, N, PE).
3. Loosen the bolts on the MCB terminals (all phase conductors and the neutral conductor N).
4. Loosen the bolts on PE clamp.
5. Insert all wires into their terminals and tighten the bolts.

CONNECTION OF THE COMMUNICATION CABLE (UTP)

Required when wireless LTE communication is not used.

Required tools: network cable pliers, RJ45 connector.

Procedure:

1. Cut off the network cable to the appropriate length to reach the Ethernet connector. Do not make the wire routing too tight or too loose.
2. Use the network cable pliers to attach the RJ45 connector to the network cable.
3. Insert the RJ45 connector into the Ethernet connector.
4. If a network switch is installed in the station, the UTP cable is connected to its Port 4 (for means of clustering or DLMS communication with the meters). When there is no network switch installed, the network cable is connected directly to the Ethernet port of the main controller of the charging station, located on the station's doors. Ethernet port is located on the lower left side.

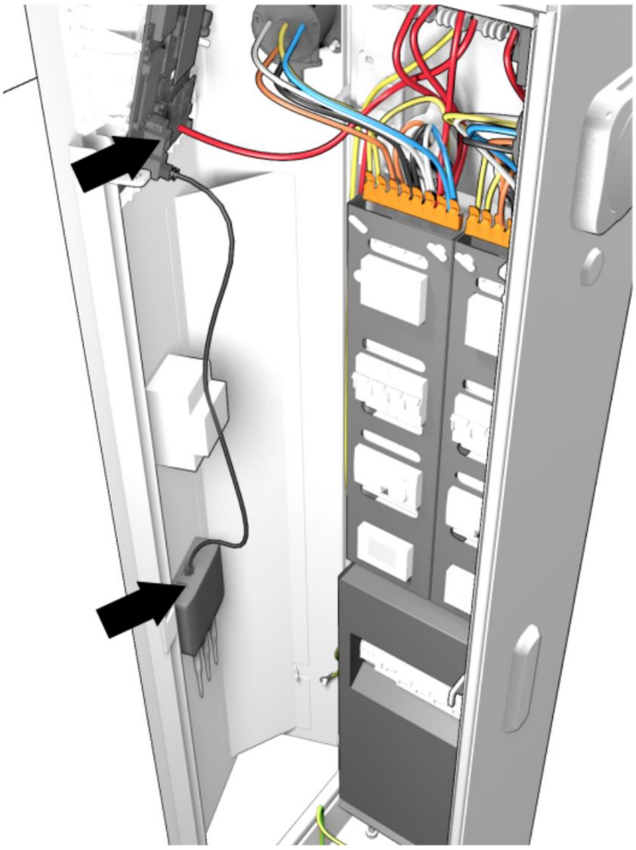


Figure 20: Connecting the UTP cables

FINISHING WORK

Before closing the station, check the condition of the over-current protection elements and the residual current devices. Switches must be set to ON position.

The charging station has built-in overcurrent protection with miniature circuit breakers (MCBs) and leakage circuit breakers (RCD).

Check that all circuit breakers are on:

- There is a main circuit breaker and an electronics power circuit breaker at the bottom of the station. Check the condition of both.
- Each of the component's baskets contains a branch circuit breaker and a residual current protection switch.

Check the condition of all four elements. Close the charging station door and lock it. Connect the charging station to the power supply in the electrical cabinet. Turn on the power supply where the station is connected.

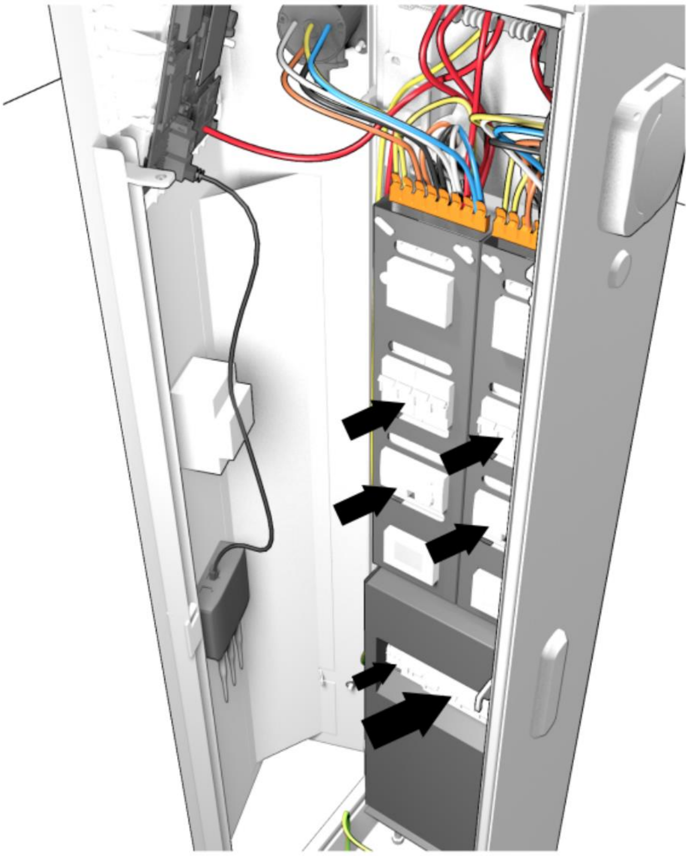


Figure 21: Positions of MCBs and RCDs

The hole in the bottom of the charging station should be filled with polyurethane foam filler (or similar material).

6 ELECTRICAL MEASUREMENTS

Electrical measurements must be performed by licensed electrician and must be in accordance with requirements set in national legislation. In this chapter only information on specifics of some of the electrical measurements is given.

EARTHING CONDUCTOR CONTINUITY TEST

Continuity measurement should be performed for protective conductors, including conductors in the main and additional equipotential. Measurement will have to be made between PE terminal of charging station's socket and inlet PE conductor. If the charging station is equipped with cable, the measurement should be made between PE conductor of the cable plug and inlet PE conductor.

WARNING!
Before carrying out the measurements, switch off the charging station or main power supply.

Continuity measurement should be made with a current greater than or equal to 200 mA. The open circuit test voltage should be between 4 and 24V (AC or DC). The measuring range shall include values 0,2 Ω to 2 Ω and the maximum percentage operating uncertainty within this measuring range shall not exceed +- 30 %. The resolution of digital equipment shall be at least 0.1 Ω.

The use of instrument, with option of measuring at higher current than 200 mA increases the accuracy of the measurement. The method of measurement is shown in the figure:

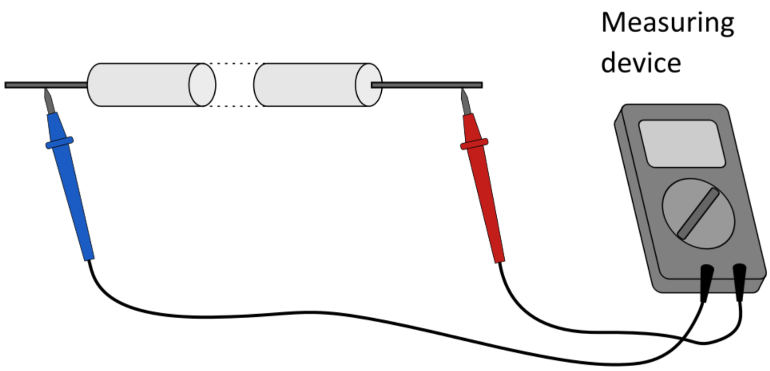


Figure 22: Continuity measurement

Continuity of the wire is considered to be met if the connection resistance does not exceed the value of 2 Ω.

INSULATION RESISTANCE MEASUREMENT

Measurements of the insulation resistance of electric cables are performed between active conductors and between active conductors and the protective conductor connected to the earthing system.

Insulation resistance, measured at a test voltage of 250 V d. c. is satisfactory if its value is not less than 1 MΩ.

Table 1: Insulation resistance measurement conditions

Nominal voltage	Test voltage	Insulation resistance
230/400 V, up to 500 V **(Applicable to all charging station from Etrel)**	**250 V d. c.**	**≥ 1 MΩ**

BECAUSE THE CHARGING STATION HAS VARISTORS INSTALLED, THEY MAY AFFECT THE MEASUREMENT RESULT OR MAY BE DAMAGED.

THE TEST VOLTAGE FOR THIS CIRCUIT SHOULD BE SET TO 250 V DC.

THE MEASURED INSULATION RESISTANCE SHOULD BE AT LEAST 1 MΩ.

TO PERFORM THE INSULATION RESISTANCE TEST, THE POWER SUPPLY MUST BE DISCONNECTED.

Explanation:

Please follow the procedure as stated in the standard IEC 60364-6, which is stating that all current-using equipment must be disconnected before the test of insulation resistance, Chapter 6.4.3.3. To perform the insulation resistance test, the power supply must be disconnected.

As specified in IEC 60364-6, 6.4.3.3 Insulation resistance of the electrical installation:

Because the charging station has varistors installed, they may affect the measurement result or may be damaged. It is not possible to disconnect the varistors and the test voltage for this circuit should be set to 250 V d. c. and the measured insulation resistance should be at least 1 MΩ.

The standard values of insulation resistance measurement, shown in the table below ***are not applicable****.*

Table 2: Standard values of insulation resistance measurement are not applicable

Nominal voltage [V]	Test voltage d. c. [V]	Insulation resistance [MΩ]
SELV and PELV	250	0,5
Up to 500 V including FELV	500	1
Above 500 V	1000	1

RCD TEST

The effectiveness of the automatic disconnection of the power supply by RCD devices should be checked with the use of appropriate test equipment, confirming that the relevant requirements are met and considering the operating characteristics of the device. The effectiveness of the protection measure can be considered satisfied if the trip occurs at a certain value of the leakage current and within a certain time.

Each socket of the charging station should always be protected with an individual RCD, which can be part of device or part of the installation.

The standard IEC 61851-1 specifies that this RCD should have sensitivity of 30 mA and be of Type B or equivalent. The possible equivalent is the use of RCD of Type A with additional DC leakage sensor.

The effectiveness of the automatic disconnection of the power supply by RCD devices should be checked with the use of appropriate test equipment, confirming that the relevant requirements are met and taking into account the operating characteristics of the device.

The effectiveness of the protection measure can be considered satisfied if the trip occurs at a certain value of the leakage current and within a certain time.

Table 3: Type AC and A residual current circuit breakers without built-in overcurrent protection - normalized switching time values

Normalized tripping time values for residual current $I_{\Delta n}$				
RCD Type A General purpose	Testing current	$I_{\Delta n}$	$2\ I_{\Delta n}$	$\geq 5\ I_{\Delta n}$
	Maximum tripping times	0.3 s	0.15 s	0.04 s

Table 4: Type B RCDs - normalized tripping time values for residual currents in rectifier circuits and for smoothed residual current

Normalized tripping time values for residual current $I_{\Delta n}$				
RCD Type B General purpose	Testing current	$2\ I_{\Delta n}$	$4\ I_{\Delta n}$	$\geq 10\ I_{\Delta n}$
	Maximum tripping times	0.3 s	0.15 s	0.04 s

EFFECTIVENESS OF THE PROTECTION AGAINST ELECTRIC SHOCK

In the case of TN systems, the effectiveness of protective measures in the event of damage by tripping the power supply is checked by:

a) measurement of fault loop impedance,

b) verification of the characteristics and/or effectiveness of the associated protection.

For the TN system, the following condition should be met:

$$Z_S \times I_a \leq U_o$$

Where:

- Z_S is the fault loop impedance,
- I_a is a current that causes an automatic power cut-off within the time specified in the table below,
- U_o is the rated AC or DC voltage with respect to earth.

.

Table 5: Maximum switch-off times

System	**120 V < Uo ≤ 230V** AC	**230 V < Uo ≤ 400V** AC
TN	0,4 s	0,2 s
TT	0,2 s	0,07 s

In TN systems, for distribution circuits and circuits with a rated current above 32 A, the permissible maximum time of switching off is 5 s.

EARTH ELECTRODE RESISTANCE MEASUREMENT

Measuring of the resistance of an earth electrode shall be made by an appropriate method. Various methods exist and none of them is ideal, as they all have advantages and disadvantages. The methods, described below, are proposed in standard IEC 60364-6.

Other methods may be used if allowed by national legislation. The value of the measured resistance shall be less than 100 mΩ.

An example is a method of measurement using two auxiliary earth electrodes, Method C1. Where the location of the installation is such that it is not possible in practice to provide the two auxiliary earth electrodes, measurement of the earth fault loop impedance according to Methods C2 or C3 will give an acceptable approximate value.

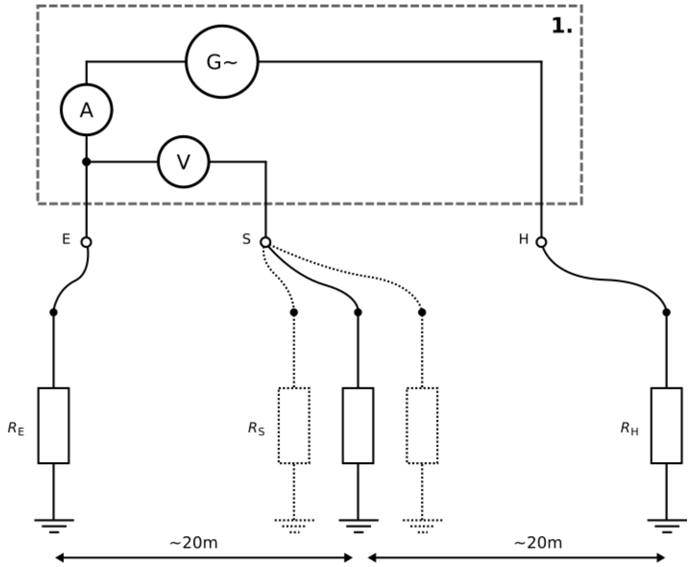
MEASUREMENT OF EARTH ELECTRODE RESISTANCE USING AN EARTH ELECTRODE TEST INSTRUMENT (METHOD C1)

An alternating current of a steady value is passed between the disconnected earth electrode, E, and a temporary auxiliary earth electrode, H, placed at a distance from E such that the resistance areas of the two electrodes do not overlap.

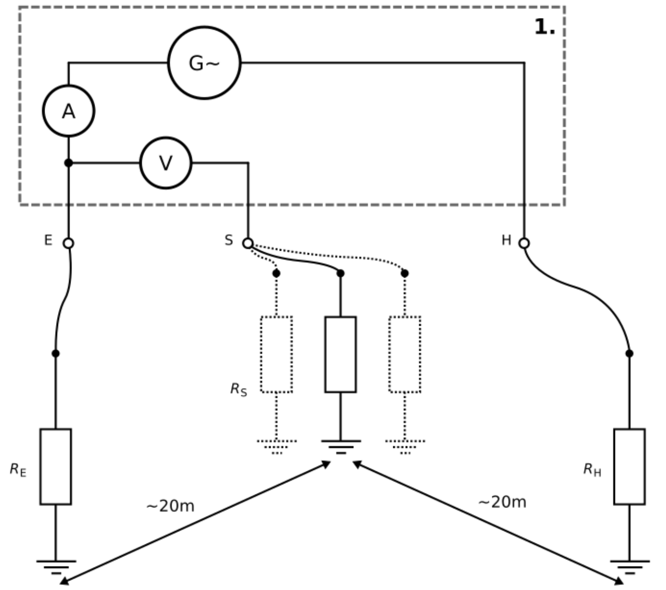
A second temporary probe electrode, S, which may be a metal spike driven into the ground, is then inserted half-way between E and H, and the voltage drop between E and S is measured. In most cases S should be placed at approximately 20 m from E and H. The electrodes may be arranged in a linear formation (see following figure, a. case) or triangular formation (see following figure, b. case) to suit available space.

The resistance of the earth electrode is then the voltage between E and S, divided by the current flowing between E and H, provided there is no overlap of the resistance areas.

To check that the resistance of the earth electrode is a true value, two further readings are taken with the second electrode, S, moved approximately 10 % of the linear distance between E and H from the original position. If the three results are substantially in agreement, the mean of the three readings is taken as the resistance of the earth electrode E. If there is no such agreement, the tests are repeated with the distance between E and H increased.



a) Electrodes arranged in linear formation



b) Electrodes arranged in triangular formation

Key

1.	Earth electrode test instrument according to IEC 61557-5
R_E	Earth electrode resistance
R_S	Temporary probe electrode resistance (voltage)
R_H	Temporary auxiliary probe earth electrode resistance (current)

Figure 23. Measurements of the earth electrode resistance

MEASUREMENT OF EARTH ELECTRODE RESISTANCE USING A FAULT LOOP IMPEDANCE TEST INSTRUMENT (METHOD C2)

Measurement of the earth fault loop impedance at the origin of the electrical installation may be carried out with a test instrument according to IEC 61557-3.

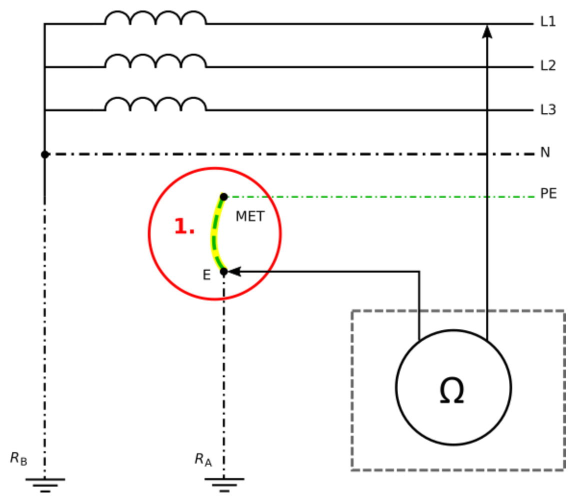
The test should be performed on the live side of the main switch with the supply to the installation switched OFF and with the earthing conductor temporarily disconnected from the main earthing terminal (MET).

The test instrument should be set to a range appropriate for the value of earth fault loop impedance likely to be expected for a given system earthing arrangement (typically in the region of 0 Ω to 20 Ω).

The test instrument should be connected as shown in the following figure. Where any doubt exists, the instrument should be connected as described in the manufacturer's instructions.

Only a small proportion of the measured earth fault loop impedance is derived from those parts of the loop other than the electrode and so the result obtained from this test can be taken as a reason able approximation of the earth electrode resistance.

It is important that the earthing conductor is reconnected to the MET of the installation before the supply is reinstated.



1. Earthing conductor temporarily disconnected from the main earthing terminal (MET).

Figure 24. Measurement of the earth electrode resistance using an earth fault loop impedance test instrument

MEASUREMENT OF EARTH ELECTRODE RESISTANCE USING CURRENT CLAMPS (METHOD C3)

With reference to the following figure the first clamp induces a measuring voltage U into the loop, the second clamp measures the current I within the loop. The loop resistance is calculated by dividing the voltage U by the current I.

As the resulting value of parallel resistances R1 … Rn is normally negligible, the unknown resistance is equal to, or slightly lower than, the measured loop resistance.

The voltage and current coils may be in individual clamps separately connected to an instrument or in a single combined clamp.

This method is directly applicable to TN systems and within meshed earthing of TT systems.

In TT systems, where only the unknown earth connection is available, the loop can be closed by a temporary connection between earth electrode and neutral conductor (quasi-TN system) during measurement.

To avoid possible risks due to currents caused by potential differences between neutral and earth, the system should be switched off during connection and disconnection. It should be noted that the values of resistance obtained using Method C3 will typically be higher than those obtained using Method C1 because of the earth loop measurement.

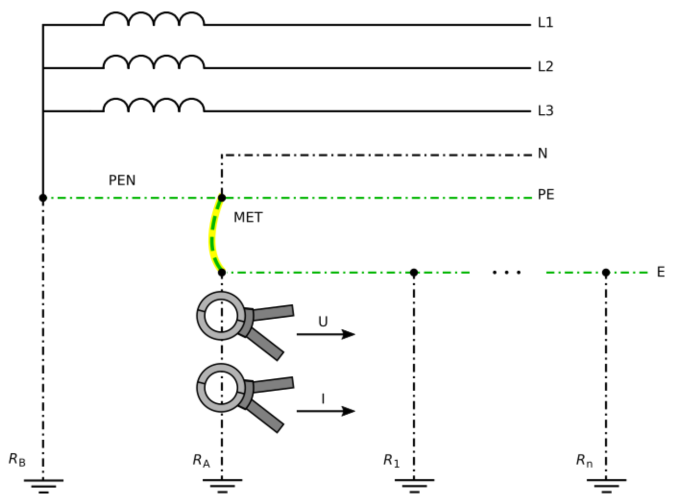


Figure 25. Measurement of earth electrode resistance using current clamps

2-POINT (DEAD EARTH) METHOD

In areas where driving ground rods may be impractical, the two-point method can be used. With this method, the resistance of two electrodes in a series is measured by connecting the P1 and C1 terminals to the ground electrode under test; P2 and C2 connect to a separate all-metallic grounding point (like a water pipe or building steel).

The dead earth method is the simplest way to obtain a ground resistance reading but is not as accurate as the three-point method and should only be used as a last resort, it is most effective for quickly testing the connections and conductors between connection points.

7 OPERATION AND CHARGING PROCEDURE

INCH DUO charging station can be controlled locally or remotely, through web interface, or through charging station management system.

FIRST POWER UP

Before starting the station, it is absolutely necessary to read this manual and the technical specification of the device.

- Connect charging station to the power supply in the electrical cabinet. Installation feeder should be turned on.
- When the charging station has either overcurrent or RCD protection installed, check whether the protection element is in ON position.
- Charging station is powered up automatically when it is connected to the electricity.
- When the charging station is power up for the first time it can take several minutes for station to get ready to start using it to charge EV.

STATUS OF LED

LED colour	State	LED action	Sub-state
Green	- Booting - OK - Available	Steady green	Booting
		Steady green	Connector available
		Blink green slow	Preparing for charging
		Blink green fast	Waiting for vehicle
Blue	- Charging	Blink blue	Charging
		Steady blue	Charging ended
		Steady blue	Charging paused (by EV or by EVSE)
Red	- Fault - Unavailable	Blink red	Fault
		Steady red	Connector unavailable

SETTING OF MAXIMAL CHARGING CURRENT

Max power is set by the installer based on the grid capabilities where charging station is installed. If there is need to change it, please set the current limitation in the charging station's web interface before starting the first charging session.

FIRST CHARGING SESSION

When the charging station is ready to be used, follow the procedures described on the LCD screen. Two charging modes can be selected:

- Fast charging (default)
- Interactive charging

Charging modes are chosen during the charging session.

During the fast charging, EV will be charged with the max available charging power as fast as possible. Max power is set by the installer based on the grid capabilities where charging station is installed.

When Interactive charging is chosen the charging schedule will be modified based on the inserted departure time. If it is not inserted, it will be based on the default value. Historic data are recorded from the first charging session onward and can only be used after the first charging session is finished.

More charging session means more accurate session prognosis and schedules. Charging schedule will be created based on electricity prices, other loads, and PV production to make sure EV is charged in appropriate time while taking in consideration other constraints.

CHARGING PROCEDURE

Step 1: Wake

In normal conditions, the charging station's LCD screen will likely be in the screen saver mode. Charging station can be woken up by simply tapping the screen.

Screen saver mode can be chosen in the charging station's web interface. Three options of display setting exist: Turned on all the time, blinking or turned off until touched.

Step 2: Authorization

Depending on the charging station authentication mode chosen different screens will be shown that will need different actions from user in order to continue with the charging session.

What authorization is allowed can be setup in the charging station's web interface Configuration menu.

Plug and charge mode

In the plug and charge mode message is shown to insert the cable and start the charging session.

Needed authentication

If authentication is needed, select the type of authentication that will be used to authorize and continue with the charging session.

a. Insert PIN code

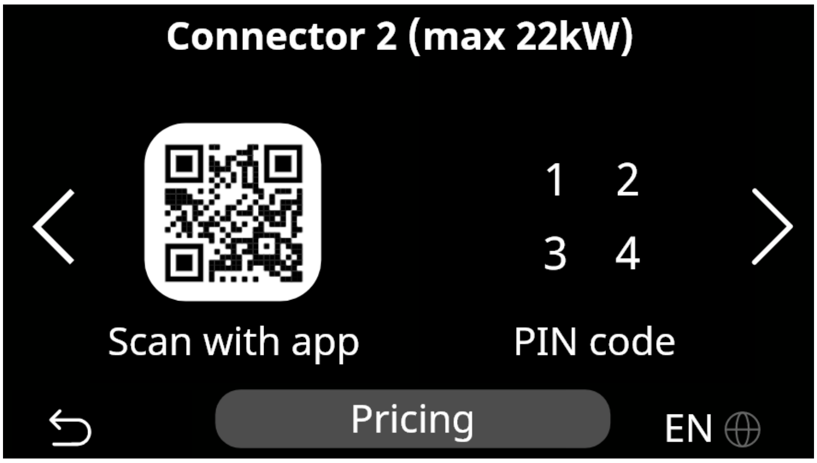


Figure 26: Insert PIN code

b. Use mobile app to authenticate

Figure 27: Insert charging station's EVSE code

Either type the code of the station to the mobile app or scan QR code with mobile.

c. Swipe RFID card

By simply swiping the RFID card below the LCD touch screen where the RFID module is installed, the authorization on the charging station is made and the charging session can begin.

Step 3: Connecting the cable

After the successful authorization, the screen with the description to connect the cable is shown.

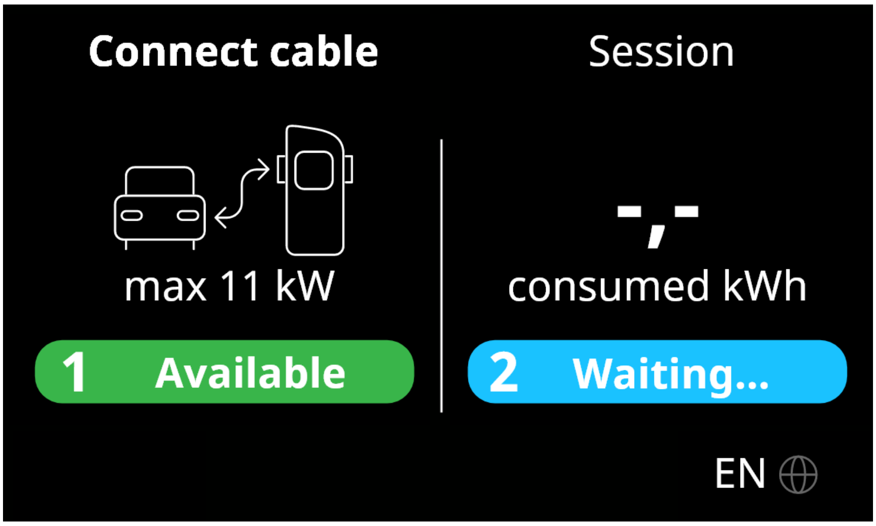


Figure 28: Connect the cable to charging station and EV

If the cable is connected before the authorization this screen will be left out and after the authorization next screen "Waiting for vehicle to respond" will be shown. When the cable is connected charging station will start charging as soon as EV responds.

Figure 29: Charging station is waiting for EV to responds and starts charging

Step 4: Departure time input

As soon as the charging session begins, the screen to input departure time is shown. Presented departure time is the one calculated by the charging station based on previous charging habits. The presented departure time can be changed to make sure that the EV is charged.

When the departure time is set, or default setting is let through charging data will be shown. What charging information is presented depends on the settings of Web interface.

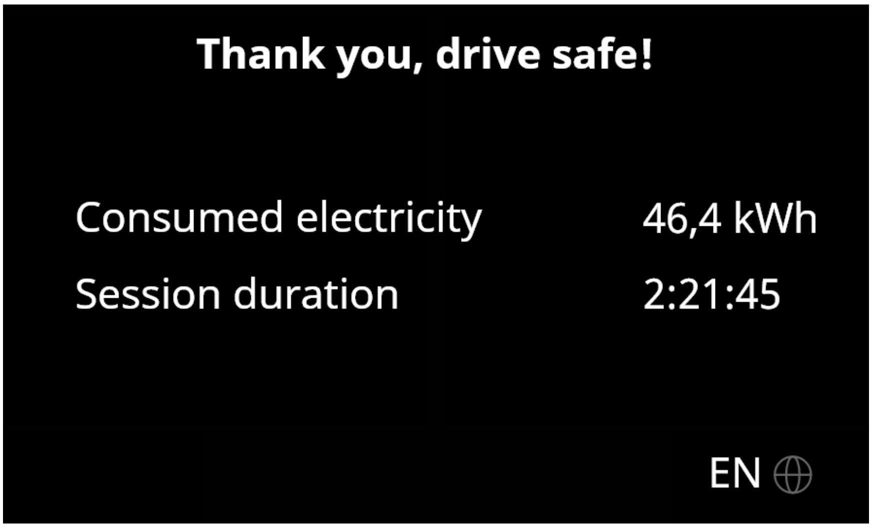


Figure 30: Example of shown energy on the LCD screen

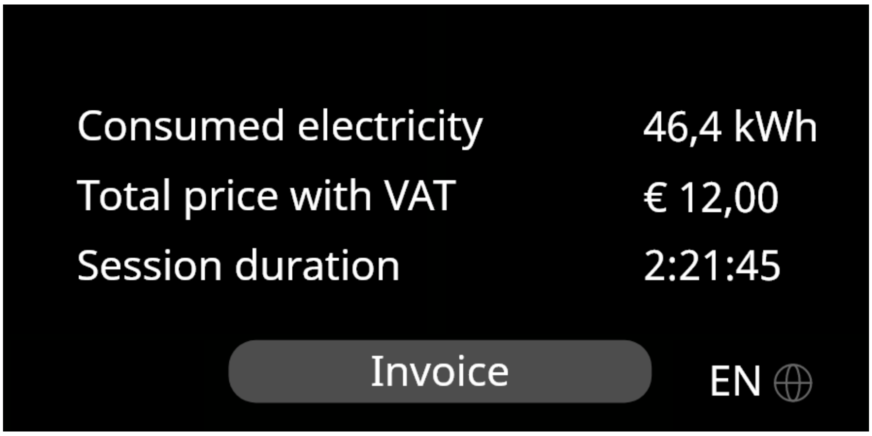


Figure 31: Display of charging time

CHECK STATUS OF THE CHARGING STATION

In the web interface the information of the current session can be seen. The departure time can be changed using web interface by pressing the »Interactive mode« button.

STOP THE CHARGING SESSION

Charging station can be stopped locally or remotely.

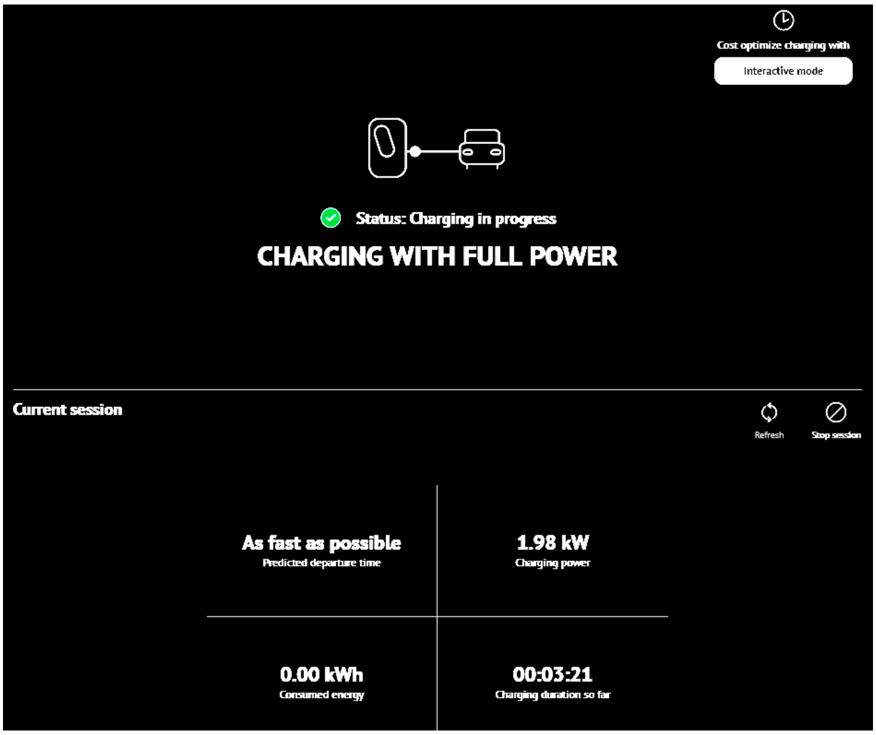


Figure 32: Current session information displayed in the web interface

LOCALLY

Ending the session can be performed with the same authorization method as for starting a session (using RFID cards, mobile application, PIN code) and removing the plug from the charging sockets or, in case of configuration of charging station without authorization permissions, by unplugging the charging cable.

REMOTELY

Stop of charging session can be done remotely with the use of Web interface.

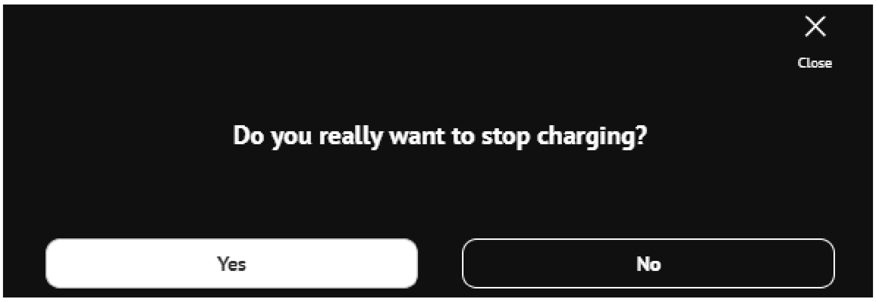


Figure 33: Confirmation window to stop the charging session using web interface

PAYING PROCEDURE IN CASE OF CLUSTER OF CHARGING STATIONS

It is possible to implement several INCH DUO charging stations into the same cluster and having the paying terminal installed only on one of them. In this case, the LCD display will lead the customer, on which charging station it is possible to pay for the charging.

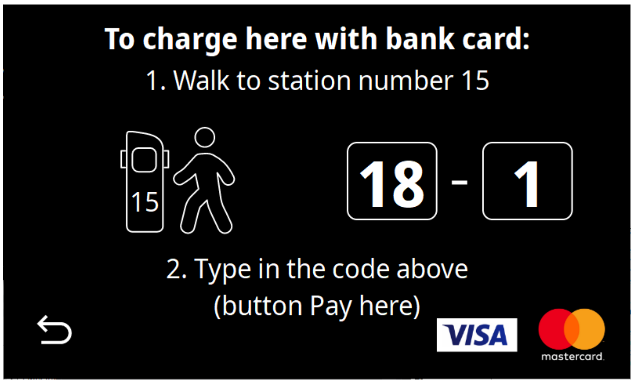


Figure 34: Paying procedure in case of clusters, notification at charging station where charging was made

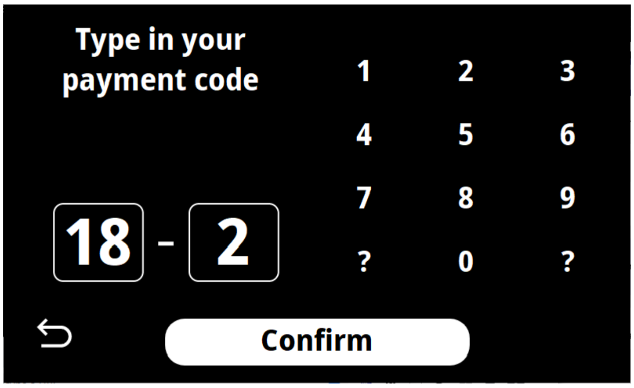


Figure 35: Paying procedure in case of clusters, input of designation of charging station where charging was performed at another charging station with paying terminal

8 CONTACT INFORMATION

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