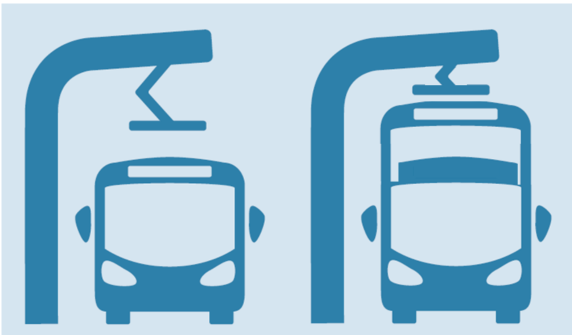
OPPCharge

OPPCharge
Common Interface for Automated Charging of Hybrid Electric and Electric Commercial Vehicles

2nd Edition



April, 2019

OPPcharge

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1. Scope of this document

This document details technical descriptions and considerations for OPPCharge. OPPCharge is defined through the normative standards and the documented deviations from these. This document further contains informative material gathered from existing OPPCharge installations.

2. Objective

The objective is to provide fundamental technical information interface specification required to develop and launch interoperable OPPCharge solutions for commercial operation.

The information provided in this document is intended for:

- Commercial vehicle manufacturers (OEMs)
- Infrastructure equipment manufacturers (EVSE)
- Commercial vehicle and transport operators

Reasonable effort was made to ensure that the information in this document is accurate and complete at the time of its publication. However, the specifications and other information can be subject to change.

3. General

OPPCharge is defined and identified by:

- An Automatic Connecting System (ACS)
- Electric Vehicle Supply Equipment – Type DC conductive charging
- Fixed conductive rails attached to the roof of the vehicle.
- 4 conductive poles
- Wi-Fi communication & control

OPPCharge is a technical solution for charging batteries in electrically powered vehicles. It deploys the principle of opportunity charging, where charging stations are distributed at select locations to replenish vehicle batteries during operation; thus reducing the overall system costs, weight on each vehicle and impact on power grid.

OPPCharge is an automatic interface for charging electrically powered vehicles based on established industry standards, with the intention of supporting a common charging interface for commercial vehicles. Supplier-independent interface can lead to cost reductions, benefiting the city’s ability to offer its citizens more sustainable transportation solutions.

4. Normative References

IEEE 802.11a (1999)
IEEE wireless LAN standard - amendment a
ISO/IEC 15118-1 (2013)
Road vehicles -- Vehicle to grid communication interface
ISO/IEC 15118-2 (2012 DIS)
Part 2: Network and application protocol requirements
ISO/IEC 15118-3 (2015)
Part 3: Physical and data link layer requirements
OpenV2G *OpenV2G edition 0.7 XML schedule*

EN 62262 (2002)
Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
EN 50122-1 (2011)
Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock

IEC 61851-1 (2017 /edition 3.0)
Electric Vehicle Conductive Charging System – General requirements
IEC 61851-21-2 (2017 /edition 1.0)
Electric vehicle charging system – EMC requirements for OFF board electric vehicle charging systems
IEC 61851-23 (2014 /edition 1.0)
Electric Vehicle Conductive Charging System – DC electric vehicle charging station

IEC 61439-7 (2018/ edition 1.0 CFDIS)
Low voltage switchgear and control assemblies

5. Abbreviations

AC	Alternating Current
ACD	Automated Connection Device
ACD Counterpart	Contact system on vehicle roof also named “Charging Rails”
ACS	Automated Connection System
CE	Control Earth
CP	Control Pilot
DC	Direct Current
EMC	Electro-Magnetic Compatibility
EMI	Electro Magnetic Interference
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment – “Charger”
GND	Ground
OEM	Original Equipment Manufacturer
PE	Protective Earth
SECC	Supply Equipment Communication Controller
STD	Standard
TBC	To Be Confirmed
TBD	To Be Defined/Decided
TVS	Traction voltage system
-ve	Negative Pole
+ve	Positive Pole

6. Description

More detailed descriptions of the OPPCharge definitions & identifiers follows in this section.

6.1. Automatic Connecting System

The Automatic Connecting System, ACS, controls and monitors a connection device for conductive charging (e.g. pantograph) fixated to the infrastructure above the vehicle (e.g. on pole, archway, bridge or ceiling etc.).

The Automatic Connecting Device, ACD, is the automated extendable/retractable mechanism to connect/disconnect EVSE conductive components to vehicle interface.

6.2. DC Electric Vehicle Conductive Charging System

The DC Electric vehicle conductive charging system implements the following standards.
IEC 61851-1
IEC 61851-23

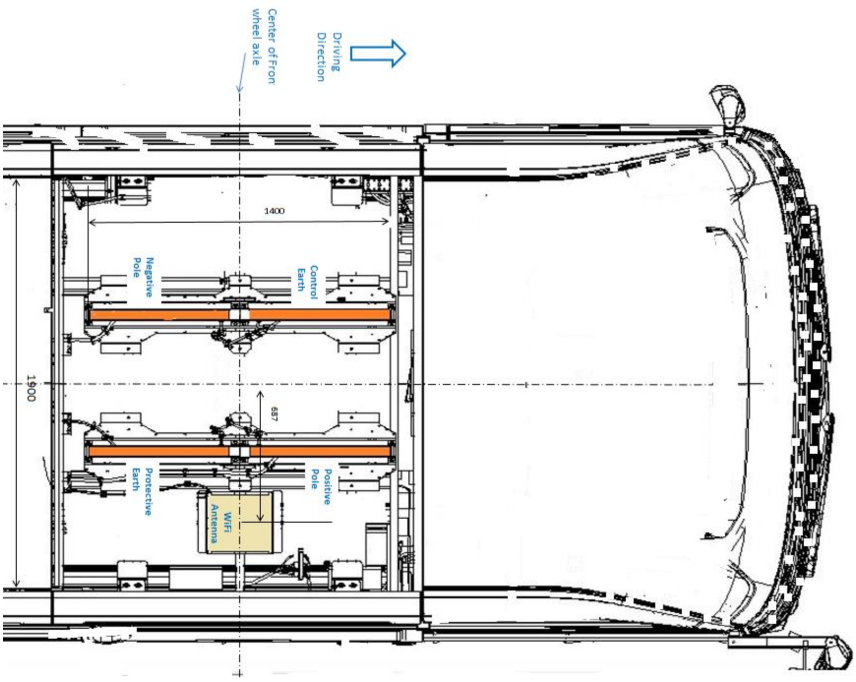
The voltage range is 450V to 750V

The exceptions to the above mentioned standards define the ACS functionality (in work for updated 61851) replacing a manually operated cable & plug system.
This is specified in the following document “Process of Energy Supply (draft)”.
Note: Release documentation is currently in clarification through ASSURED with regard to OPPCharge.

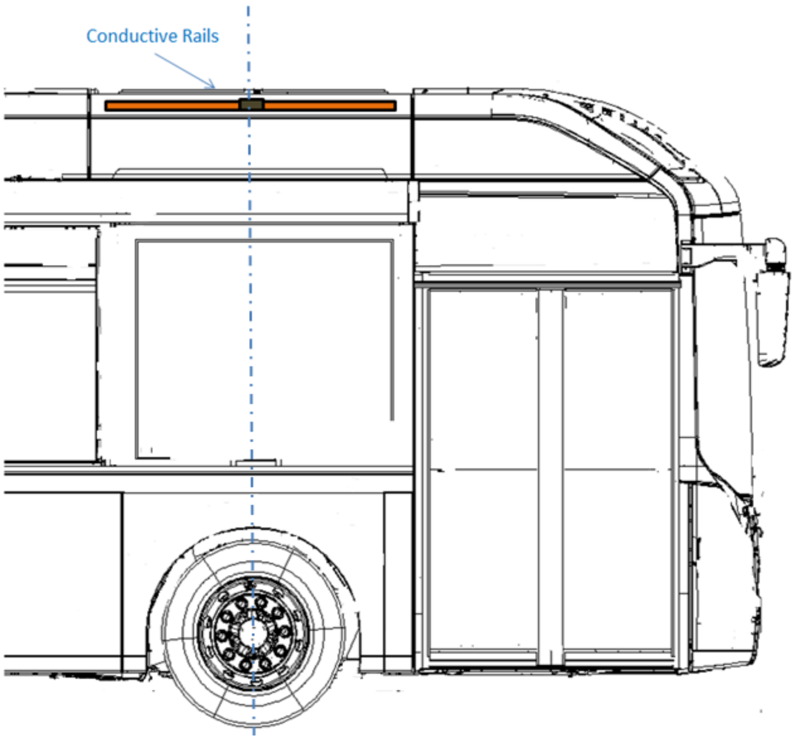
Protection by clearance as specified in EN 50122-1 (2011) is required

6.3. Fixed Rails attached to the roof of the vehicle.

The Conductive Rails are centred over the front axle of the vehicle for alignment.



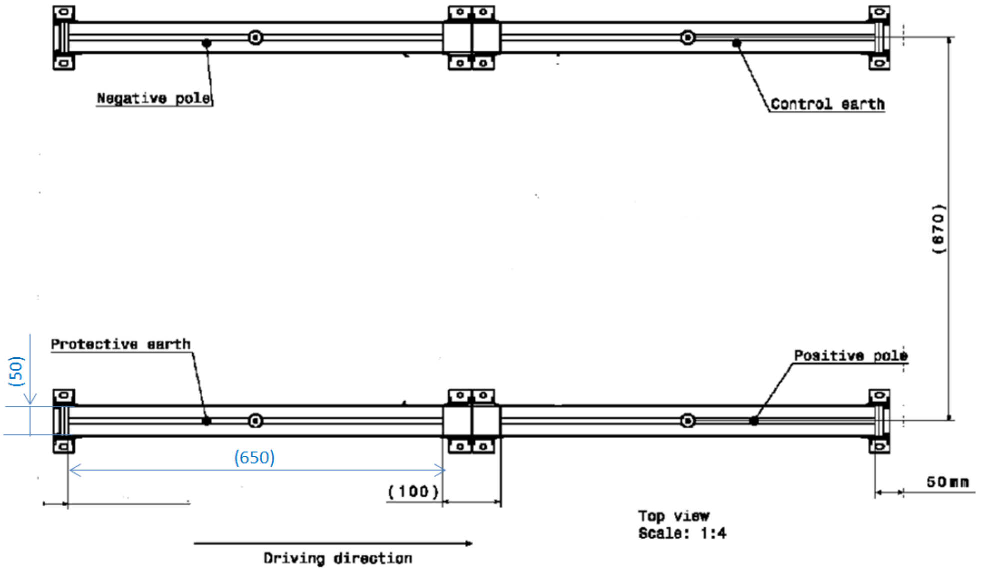
1 Top View of bus roof front section highlighting conductive rails and Wi-Fi antenna



2 Side View of bus roof front section highlighting conductive rails

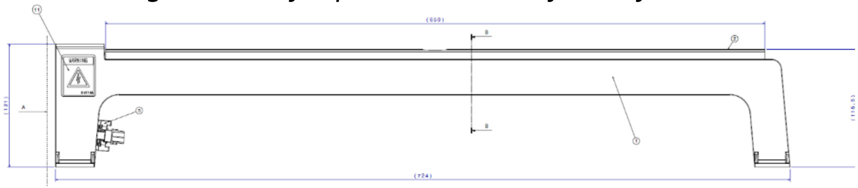
6.4. Conductive Poles

OPPCharge uses 4 conductive poles for the charge interface;
Positive, Negative, Protective Earth (PE) and Control Earth (CE).



3 Top View of conductive rails on roof with dimensions

Note: Driving direction for pole orientation for roof & ASC installation.



4 Side view of a single rail

All functions of the ACD Rails shall have very precise mechanically connected and disconnected positions.
It shall not be possible for the ACD to remain in an undefined position. No unattended activation shall occur physically or electrically.

The minimum application force of the ACD Rails shall be sufficient to fulfil charging requirements.

The total maximum application force for the ACD Rails shall be less than 600 N.

The maximum application force for each pole shall be less than 150 N during connection, charging and disconnection.

Impact sound created by the contact of the ACD contactors shall be lower than 50 dB. Measuring points are inside vehicle and adjacent to bus roof at rail position.

6.5. Wi-Fi Communication

OPPCharge uses Wi-Fi as the communication method between the vehicle and EVSE. Directional antennas are used for communication and association.

IEEE 802.11a specifications are implemented for Wi-Fi communication.

OPPCharge Wi-Fi operates using 5GHz channels.

ISO/IEC 15118 is used as High-level protocol for charging communication with the modification listed within OPPCharge.org.

IEC 61851-1 is used as Low-level protocol for charging communication.
Control Pilot states are implemented.

6.6. Position

The relative position of the ACS and the vehicle's conductive rails is centered over the front axle of the vehicle.

This allows for interoperability between different infrastructure and vehicle manufacturers
The positioning of the vehicle is secured using the front wheel as a reference.

OPPCharge

7. Interfaces

7.1. Electrical

Electrical interfaces defined in detail in IEC 68151 standards
Isolation resistance monitoring according to IEC 61851-23

Output Requirements	
Power levels (kW)	150, 300, & 450 kW
DC Voltage (V DC)	450 – 750
Frequency (Hz)	50/60 ± 2 [1]
Output Current (A)	Sufficient for output power 0 to 200 @ 750 V – 150 kW 0 to 400 @ 750 V – 300 kW 0 to 600 @ 750 V – 450 kW

Performance Requirements	
peak to peak ripple 0 to100 (A) DC	10
peak to peak ripple >100 (%)(I_{ripple} / I_{dc})	< 10
Max Voltage peak to peak ripples during charge (V)	±5
Minimum output current (A)	0
Maximum output current (A)	Sufficient for output power
Maximum incremental steps (A) * resolution*	2
Duty Cycle (hrs/day)	18 or TBD[3]
Short Circuit Current Protection *"pole to pole"* (A)	3000
Short Circuit Current Protection timing (ms)	100
Charger Pole to Pole capacitance (mF)	< 10
Differential Mode inductance: Charge Automatic Connecting Device (µH)	≤ 100
Blocking Voltage protection for reversed current (V)	900

Note[1] Frequency is determined by local electrical standards
Note[3] The duty cycle for the station may be more based on bus operation cycles.

7.1.1. Electric safety

The electrical safety levels for the application shall be met according to standards, regulations, norms and legal requirements. All hazardous voltages shall be clearly marked and shielded from unauthorized handling.

To ensure safe vehicle operation the EVSE shall control the following electrical safety considerations amongst others not listed here. Internal Charging station failure should be trapped internally. Built-in protection against short-circuits, voltage and current surges is required, conductors carrying TVS current shall be designed to withstand short-circuiting.

Consider: Emergency Shut off Switch on EVSE

7.1.2. Discharge of Capacitances at Shut- down

To avoid that the cable connector exposes parts with hazardous voltage when disconnected, the DC link capacitance must quickly be discharged at shut-down. There shall be a discharge circuit in the charging station which reduces the capacitor voltage down to a non-hazardous level (<60 V DC) in less than 5 s when the system is disabled due to hardware or a software signal.

7.1.3. Insulation voltage withstand level

The appropriate insulation voltage withstands levels are to be chosen with respect to ISO 6469-3 with Class 1 equipment (basic insulation).
The insulation shall withstand 2.5 kV AC RMS and 1100 VDC for 5 min.

7.1.4. Protection against reverse power flow from ESS

The charging station shall be equipped with a protective device against the uncontrolled reverse power from the ESS during charging.

7.1.5. Electromagnetic compatibility

The electromagnetic compatibility shall comply with:

IEC 61851-21-2 as well as relevant normative EMC standards for EVSE

ECE R10 rev5 as well as relevant normative EMC standards for EV

7.1.6. Common mode filter

The Charging converter shall implement a common-mode filter to prevent EMI in the TVS and also to protect itself from EMI.

7.1.7. Electric isolation

The EVSE shall have galvanic isolation between the traction voltage side and the low voltage side.

The EVSE shall have galvanic isolation from the grid supply.

7.1.8. Grounding connection

The off-board charger shall have a ground connection to connect the *Chassis Frame Potential* on the vehicle to the charging station ground. The ground connection is required to be checked for proper connection with the *Chassis Frame* of the bus by the station in order to avoid false isolation resistance reading.

7.1.9. Parasitic capacitance

The parasitic pole-chassis capacitance of the charging system shall be ≤100nF in total in order to reduce leakage currents between TVS and chassis.

7.2. Communication

7.2.1. Wi-Fi (Channel and Password)

Wi-Fi communication shall be implemented on the following channels:
36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140

For Wi-Fi communication password contact administration at OPPCharge.org.

7.2.2. SW Communication & Process

Low level communication shall be implemented in accordance with IEC 61851-1 and IEC 61851-23 with the exemptions listed in “OPPCharge deviations from IEC 61851-1 and -23”
High level communication implemented is based on ISO 15118 using Wifi as the physical layer. An example implementation may be found in “Network and application protocol specification for Siemens — Volvo OppCharge implementation”

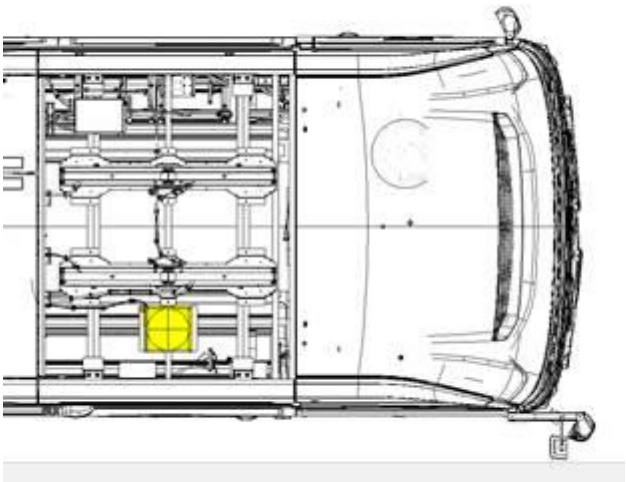
7.3. Wi-Fi antenna information

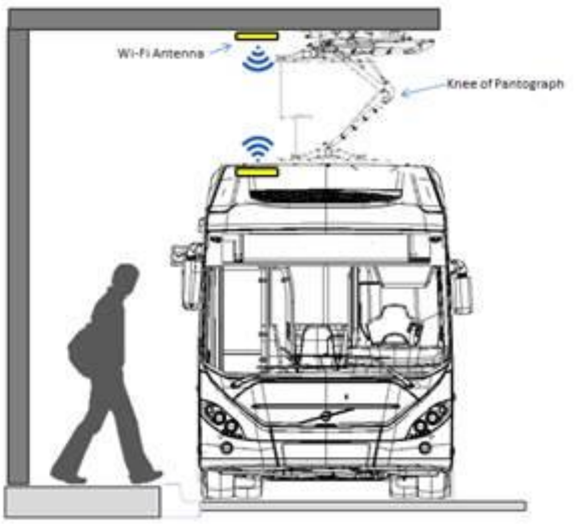
7.3.1. Type:

HUBER+SUHNER
Sencity SPOT-L Antenna: 1356.17.0008
or equivalent directional and polarized antenna.

7.3.2. Position:

Over the RH side of vehicle
Centered over wheel axel
(yellow highlighted marks the position of the Wi-Fi antenna on bus)

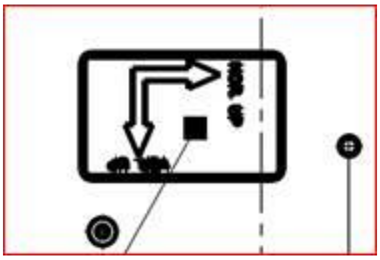




7.3.3. Orientation:

The antenna type defined above is directional and polarized.

Note: the “Horizontal Up” Arrow label on the back side of the antenna shall point in the driving direction of the bus.



7.3.4. Connection:

The electric vehicle communication controller EVCC shall allow charging with a signal strength of -70 dBm or higher.

Recommended signal strength at the EVCC is between -40 dBm to -60 dBm.
The signal shall not be too strong thus communicating with the vehicle well out of range of the charging position.

Installation, routing and connection of Wi-Fi communication equipment shall follow the rules of good practice for installation in order to maximize signal integrity.

7.3.5. Weatherproofing:

This directional antenna type is normally installed vertically to buildings and masts.
Additional measures are required to protect the back-side of the antenna and connector from water intrusion.

7.4. Physical

The OPPCharge equipment shall be designed for:
Commercial electric vehicles LHD & RHD
Heights between 3000 to 4500mm (i.e. single decker, double decker).

It is not intended that the OPPCharge equipment is capable to charge all of the above variants at the same installation.
Keep in mind the variants when designing & preparing equipment (i.e. Poles) for installing ACD, Wi-Fi antennas, cables as well as other equipment.

The ACD shall comply with variable height, angle, pitch and roll due to kneeling function and road conditions.
The ACD shall have satisfactory contact to charge with vehicle rails while the bus is:

- In upright position
- In kneeling position
- During kneeling downward
- During return to upright position
- Passengers boarding and disembarking from vehicle

The OPPCharge equipment shall fulfill Impact Resistance rating IK10 according to EN 62262

Bus Stop designs are most often standardized within regions describing the placement of weather shelters, benches, waste bins, information signs, landscaping and layout of guide stones for the disabled.

Where OPPCharge is implemented at a bus stop the standardized layout may need modification to allow for placing a pole and charge interface. Furthermore the opportunity to align guide-stones and positioning solutions (see chapter 6.6) is possible with design discussions and input together with the city architect.
It is recommended to use of the standardized "Kassel" curbs for bus parking to improve passenger access and allow for less wear on tires.

Vehicle Approach path to the charge position shall be considered to allow the driver to easily line up and park underneath the ACS (i.e. away from sharp curves or obstacles to mirrors and chassis).

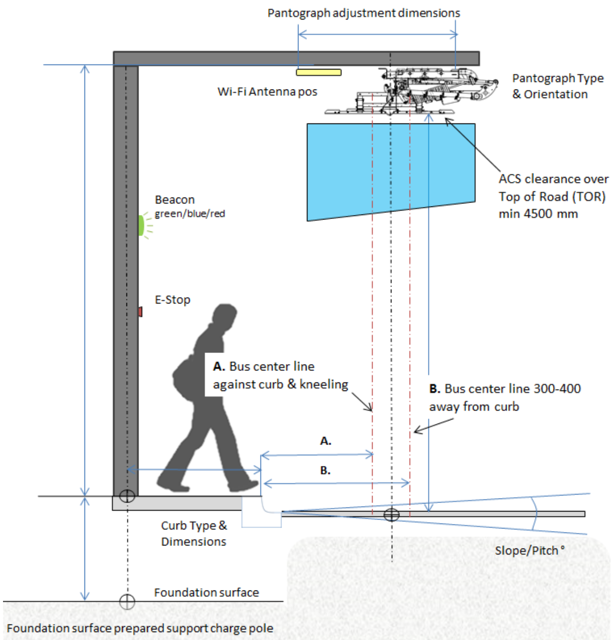
OPPCharge should not be installed where road conditions have slopes, inclines or pitches greater than ±3,5 °.

All overhead equipment shall have a minimum clearance of 4,5 meters to the top of road surface as well as follow local road safety and civil installation legislation.

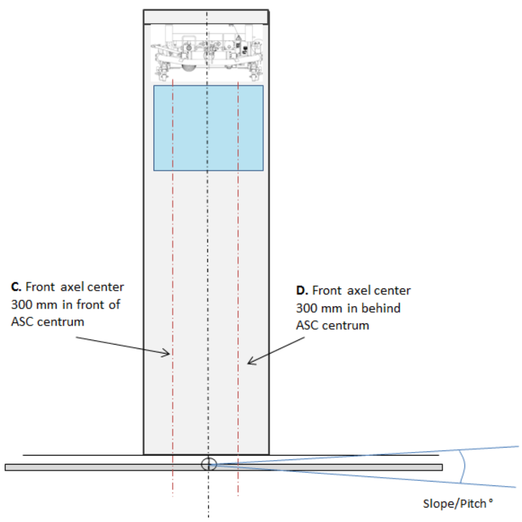
Drivers are generally instructed to park close to the curb to allow passengers to “step” aboard the bus. Positioning the ACS on the pole shall allow for optimal parking possibility for the driver in normal circumstances. A site survey of the proposed OPPCharge location and consultation with local operators regarding parking behavior are recommended. The following example expresses optimized parking tolerances:

A. Min Y position: The driver shall be allowed to park with the tires against the curb and kneel the bus.
B. Max Y position: The driver shall be allowed to park the bus 300-400 mm away from the curb and bus upright
C. Max X position: The driver shall be allowed to park the bus 300 mm in front of the pantograph center
D. Min X position: The driver shall be allowed to part the bus 300 mm behind the pantograph center.

Front View



Side View



8. Considerations

8.1. General

In addition to compliance with the above technical requirements review of the following site specific topics with both vehicle and infrastructure supplier is advised prior to launching a commercial operation:

- Suitable for commercial applications and public installations and operations
- Local Electrical Safety regulations
- Crash Safety
- Charging Scenario
- Equipment placement & site set up (approach, positioning etc.)
- Ownership
- Service plan
- Contractor and Drawings
- Maintenance & Repair
- Data collection / Communication

8.2. Cabling

Cabling shall follow electrical engineering guidelines for optimal function

- Use separate cable ducts for Power Cables and Signal cables.
- The ducts shall be separated 300 – 500 mm apart to reduce EMI.
- Shielded cables are to be used where needed.
- Implement Wi-Fi installation guidelines to reduce signal attenuation
- Define cable lengths to fulfil function
- Fulfil lightning protection where required
- Underground cables and ducts shall fulfil necessary environmental requirements

8.3. HW Pilot Signal

The HW pilot signal determines the various states in the charge process in accordance with IEC 61851.

- ACD rails not connected
- ACD rails connected to vehicle – initialization - not charging
- ACD rails connected to vehicle – charging
- ACD rails connected to vehicle – shut down - charging to not charging
- Error

It is important in the design of the HW pilot control to safeguard the signal tolerances from EMI caused by for example power cables which are in close proximity.

8.4. HMI

Human Machine Interfaces (HMI) may be designed to assist the operator with intuitive and user friendly OPPCharge functionality.

- Positioning and Identification used to easily locate charge interface and park.
- Information in the driver display to inform driver over charging process (position, charge status, messages and notifications).
- Beacons or lamps indicating charging status on the charge infrastructure.
- E-Stop buttons to end the charge session quickly
- Visual & audio verification methods as well as haptic responses to inform user of charge status.

8.5. Positioning

Stopping the vehicle in the correct position underneath the ACS can be improved by for example:

- Parking lines in front of and alongside bus
- Guiding landmark (i.e. Bus info sign aligned with bus front)
- Curbs (type “Kassel” for alignment without wear on tires) on one or two sides of bus
- Wheel bumps (to give the driver a haptic response they are in correct position)
- Semi-automatic or automatic parking systems.

9. Options

Depending on local conditions the following options should be considered.

9.1. De-Icing conductors

OPPCharge Conductors may have integrated heaters for de-icing purposes.
Vehicle side conductor heating system shall not exceed 300W power consumption.
The heating system shall be temperature controlled to only be activated when needed.

9.2. Emergency Stop

OPPCharge equipment may have Emergency stop switches to actively stop the charge process at any time “in case of emergency”.

On OPPCharge equipment installed in public areas an emergency stop switch can be protected with a switch cover to avoid unwanted activation.

In the event of an Emergency stop activation. The ACD shall retract to the upper position and the SECC shall inform the EVCC of the ACD position.

9.3. Beacon (Lamp) Function

OPPCharge equipment may have beacons to actively indicate the charge equipment status. The beacons should be visible to the driver to show if the charge equipment is operational or not.

The beacon(s) should be visible in daylight and at nighttime.

9.4. Convex mirror

A Convex mirror placed in an appropriate spot may give drivers visual feedback if the ACD is Up, Down or Moving.

9.5. Position Assistance

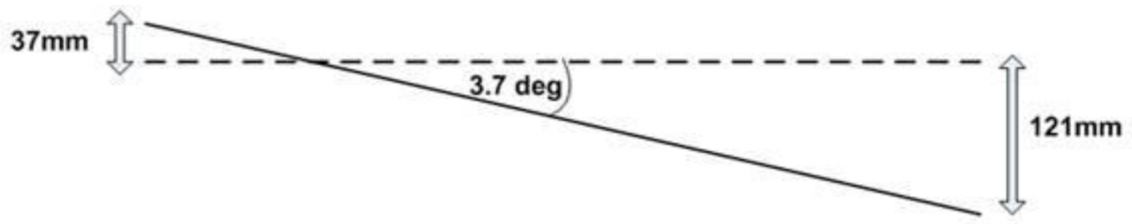
Position assistance systems are available to help drivers center the vehicle underneath the ACD. Such systems need to consider interoperability as well as constraints defined by the environment such as dirt, rain and snow.

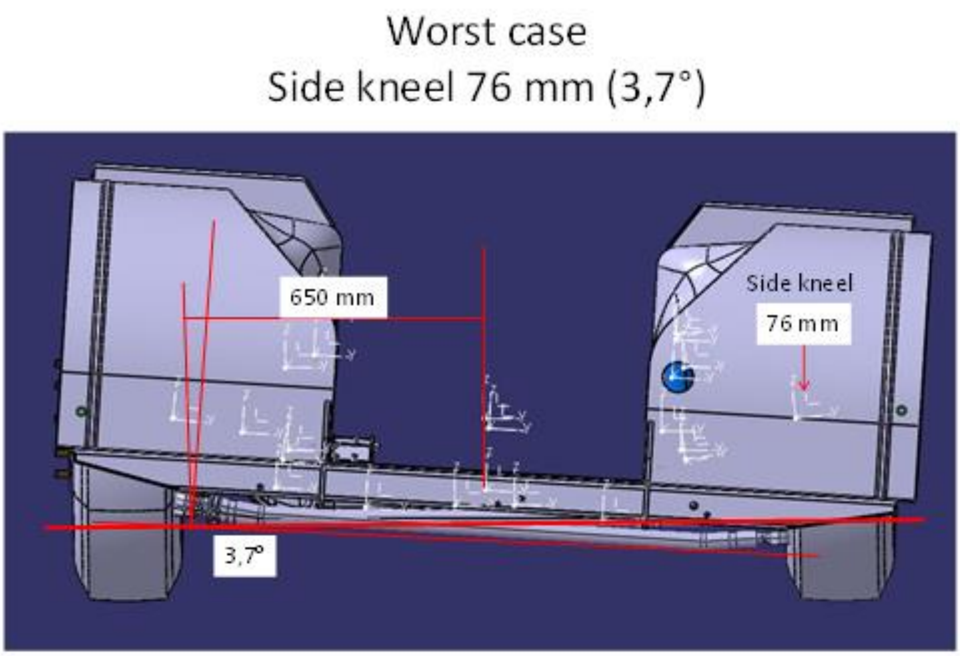
10. Appendix

10.1. An example for bus kneeling

The following is a calculation of vehicle kneeling illustrating the changes in angle and height. Please note that vehicle kneeling characteristics can vary between OEMs.

All calculations are done on the wheel axis as shown on the figure below.
Maximum tilt for the left wheel = 37mm
Maximum tilt for the right wheel =121mm
Vehicle width = 2544





Low rotation in z-dir – estimated on the ground and 650 mm to the side in y-dir.