



# 30 kW Wireless Charging System

**MOOV<sup>air</sup>**

User Manual and Professional  
Installation Guide



## LEGAL INFORMATION

This manual applies to the Wireless Charging System (WCS 30kW).

Delta manuals undergo continuous revision in order to provide user with complete information regarding the installation and operation of WCS. Therefore, before starting installation work, always consult Delta to check whether a newer version of the User Manual is available.

This manual is intended for use by electrical installers who are competent for installation and commissioning of grid-connected electrical systems/products.

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## Revision Record

# Table of Contents

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1	Introduction .....	12
1.1	Purpose of this Document .....	12
1.2	Target Audience .....	12
1.2.1	Access to the System .....	13
1.3	Scope of Supply .....	13
1.4	Intended Use .....	14
1.5	References .....	14
1.5.1	Delta Documentation .....	14
1.5.2	Open Source License & Credits .....	14
1.6	Exclusion of Liability .....	15
2	Safety & Regulations .....	16
2.1	Safety Symbols .....	16
2.2	Warning & Other Signs .....	16
2.3	Labels .....	17
2.4	Safety Instructions .....	18
2.4.1	General Safety Instructions .....	18
2.4.2	EMF Safety Instructions .....	19
2.5	Regulatory Compliances .....	24
2.5.1	EU .....	24
2.5.2	FCC .....	25
2.5.3	ISED .....	25
2.5.4	Miscellaneous .....	25
3	System Description & Operation .....	26
3.1	Overview .....	26
3.1.1	Identification of WCS Subsystems .....	26
3.1.2	Wireless Charging .....	27
3.1.3	Models, Variants & Interoperability .....	28
3.2	Subsystem Description .....	29
3.2.1	WPB .....	29
3.2.2	WPP .....	39
3.2.3	WSU .....	41
3.3	System Performance .....	45
3.3.1	Output Power and De-rating .....	45
3.3.2	Efficiency and Losses .....	50
3.4	System Control Modes .....	51
3.4.1	External Commanded CANopen® .....	51
3.4.2	External Commanded Ethernet (Not Implemented) .....	51

## Table of Contents (Cont.)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
3.5	Communications.....	53
3.5.1	WPP & WSU Interface – Pad to Pad Link (PPL).....	53
3.5.2	WPB – Ethernet (Not Implemented) .....	53
3.5.3	WSU - CANopen® .....	54
<b>4</b>	<b>Installation.....</b>	<b>60</b>
4.1	WPB.....	60
4.1.1	Safety Instructions.....	60
4.1.2	Special Tools & Equipment.....	61
4.1.3	Installation Conditions .....	61
4.1.4	Installation Procedure.....	62
4.1.5	Disconnecting the WPB .....	66
4.1.6	Ethernet Connection (Not Implemented) .....	67
4.1.7	Stack Light Installation (Optional) .....	67
4.1.8	Power Up & Health Checks.....	68
4.2	WPP.....	68
4.2.1	Safety Instructions.....	68
4.2.2	Special Tools & Equipment.....	70
4.2.3	Installation Conditions .....	70
4.2.4	Installation Procedure.....	70
4.2.5	Connecting WPP to WPB .....	71
4.2.6	Power Up & Health Checks.....	73
4.3	WSU .....	74
4.3.1	Safety Instructions.....	74
4.3.2	Special Tools & Equipment.....	75
4.3.3	Installation Conditions .....	75
4.3.4	Installation Procedure.....	76
4.3.5	Power Up & Health Checks.....	80
<b>5</b>	<b>System Commissioning / Start-up.....</b>	<b>81</b>
5.1	Safety Instructions .....	81
5.2	Wireless Charging .....	81
<b>6</b>	<b>Maintenance.....</b>	<b>83</b>
6.1	Safety Instructions .....	83
6.2	Preventive Maintenance .....	83
6.2.1	General Cleaning .....	84
6.2.2	Cleaning WPP & WSU .....	85
6.2.3	Cleaning Fans of WPB .....	85
6.3	Corrective Maintenance.....	87
6.3.1	Replacing Fans of WPB.....	87
6.3.2	Replacing Fuses of WPB.....	87

## Table of Contents (Cont.)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
6.4	Firmware Updates.....	90
6.4.1	WPU .....	90
6.4.2	WSU .....	90
7	Troubleshooting .....	91
7.1	Identifying Subsystems to Troubleshoot.....	91
7.2	Troubleshooting on WPB .....	92
7.3	Troubleshooting on WPP .....	92
7.4	Troubleshooting on WSU.....	93
8	Accessories & Spare Parts.....	94
8.1	Parts List.....	94
8.2	Accessories .....	94
8.3	Development Kit.....	94
9	Warranty .....	96
9.1	Warranty Conditions .....	96
9.2	Non-Warranty Conditions.....	96
9.3	Return Procedure .....	96

## List of Illustrations

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
Figure. 1	WCS Subsystems (Example – Forklift).....	26
Figure. 2	Wireless Charging .....	27
Figure. 3	WPB Air-in and Air-out.....	30
Figure. 4	Terminals on WPB .....	32
Figure. 5	WPB Interface.....	33
Figure. 6	Potential Equalization (Earthing) .....	34
Figure. 7	WPB Status LED Panel Location.....	35
Figure. 8	Status LED Panel.....	36
Figure. 9	Ethernet Service Interface.....	37
Figure. 10	Main Components of WPP (New Model) .....	40
Figure. 11	Status LED Panel.....	40
Figure. 12	WSU .....	41
Figure. 13	WSU Deutsch Connector.....	43
Figure. 14	Output Power and Current Limits with Variable Voltage .....	45
Figure. 15	Power De-rating Vs Time at Different Ambient Temperatures .....	46
Figure. 16	Pad Position for Charging.....	47
Figure. 17	Pad position at an Angle (No Charging) .....	48
Figure. 18	WSU positioned at an angle .....	48
Figure. 19	Pad Alignment with Vertical Offset .....	49
Figure. 20	WPB Cover Plates .....	63
Figure. 21	WPB with and without Connection Ring .....	64
Figure. 22	Feeding the Cable through Cable Gland (view without Covers) ....	65
Figure. 23	WPB Stack Light Connection Terminal .....	67
Figure. 24	Installation of WPP – Rear View.....	71
Figure. 25	Connecting WPP Cable to WPB – Part 1 .....	72
Figure. 26	Connecting WPP Cable to WPB – Part 2.....	73
Figure. 27	Mounting WSU on Vehicle .....	77
Figure. 28	WSU Mounting Holes .....	78
Figure. 29	WSU Cable Connections.....	79
Figure. 30	Auxiliary Connections .....	80
Figure. 31	WPB – Accessing Fan Panel Assembly WPB .....	86
Figure. 32	Replacement of Fuses – Part 1 .....	88
Figure. 33	Replacement of Fuses – Part 2.....	89
Figure. 34	Possible Status LED Panel Scenarios .....	91
Figure. 35	Development Kit Connections .....	95
Figure. 36	Magnetic Field Distribution During Charging Process .....	98

## List of Tables

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
Table. 1	Specifications - WPB .....	29
Table. 2	Specifications - WPP .....	39
Table. 3	Specifications - WSU .....	42
Table. 4	WSU Deutsch Connector Pinout .....	43
Table. 5	Efficiency and Losses - Condition 1 (Best).....	50
Table. 6	Efficiency and Losses - Condition 2 (Worst).....	50
Table. 7	Cleaning Agents.....	84
Table. 8	Troubleshooting of WPB.....	92
Table. 9	Troubleshooting of WPP.....	92
Table. 10	Troubleshooting of WSU .....	93

## Abbreviations and Acronyms

Acronym / Abbreviation Used	Definition
A	Ampere
AC	Alternating Current
AMR	Automated Mobile Robot
AGV	Automated Guided Vehicle
AUX	Auxiliary
AUXIN	Auxiliary Input
AWG	American Wire Gauge
approx.	Approximately
BMS	Battery Management System
CAN	Controller Area Network
Cont.	Continued
°C	Centigrade
dB(A)	The unit of measurement of the sound pressure level according to the internationally standardized frequency weighting curve A
DC	Direct Current
DIN	Deutsche Industrie Norm
e.g.	Example
EMF	Electromagnetic Field
EN	European Norm / European standard
EU	European Union
FMS	Fleet Management System
ft	Feet
Gnd	Ground
Hz	Hertz
H x W x D	Height x Width x Depth
i.e.	That is
in	Inch
kBit/s	Kilobit per second
kg	Kilogram
kV	Kilo Volt
KVA	Kilo Volt Amps
kW	Kilowatt

## Abbreviations and Acronyms (Cont.)

Acronym / Abbreviation Used	Definition
lb	Pound
LED	Light Emitting Diode
LV	Low voltage
m	Meter
mA	Milliampere
mm	Millimeter
Max.	Maximum
M32	Metric Thread Diameter 32mm
MHz	Megahertz
NC	Not Connected
NFPA	National Fire Protection Association
Nm	Newton meter
Ohm	Unit of Electrical Resistance
PE	Protective Earth
PG36	Pg thread DIN 40430 "Panzerrohrgewinde" (Armor pipe thread) size 36
PPL	Pad to Pad Link (communication between WPP and WSU)
ROGB/24	Stack light type: Red Orange Green Blue, 24VDC
RMA	Return Material Authorization
RMS	Root Mean Square
SDD	Supply Disconnecting Device
V	Volts
VDC	Volts Direct Current
V <sub>AC</sub>	Volts Alternating Current
VDE 0105-100	"Verband der Elektrotechnik Elektronik Informationstechnik e. V." Standard 0105-100 "Association for Electrical, Electronic & Information Technologies e. V." Standard 0105-100
V <sub>rms</sub>	Volt Root Mean Square
w/o	Without
WCS	Wireless Charging System
WPB	Wireless Primary Box
WPP	Wireless Primary Pad

## Abbreviations and Acronyms (Cont.)

Acronym / Abbreviation Used	Definition
WPU	Wireless Primary Unit (WPB and WPP)
WSU	Wireless Secondary Unit
WMS	Warehouse Management System
µT	Microtesla
µH	Microhenry
%	Percentage
TN-S	Terrestrial Neutral Separated
TN-CS	Terrestrial Neutral Combined and Separated
N connection	Neutral line

# 1 Introduction

## 1.1 Purpose of this Document

This documentation describes the operation, installation and maintenance of the Wireless Charging System 30kW (WCS 30kW) and its subsystems.

It also explains the connections and interfaces for integration with a vehicle's Battery Management System (BMS). The Wireless Secondary Unit (WSU) is installed as part of the vehicle by the vehicle integrator, whereas the Wireless Primary Box (WPB) and Wireless Primary Pad (WPP) are installed in the facility.

The document also includes the important information as follows:

- health and safety
- alignment / positioning
- the charging process
- status indicators
- system maintenance

This information is to be provided to all types of users to make sure the safe and effective use of the WCS before, during and after installation.

This document contains important safety instructions and information that must be read, understood and followed to make sure that the WCS is installed, connected and operated safely. Delta Energy Systems is not liable for any damage or harm resulting from failure to follow the safety instructions or other information contained in this document.

## 1.2 Target Audience

This documentation is intended for:

- Skilled persons for vehicle integration of the WSU.
- Skilled persons for integration of WPB/WPP at the facility.

Although this documentation is not intended for operators of the WCS, it does contain important information that must be provided to operators to ensure safe and effective use of the system after installation.

### 1.2.1 Access to the System

Following table contains the information about the types of users and their accessibility to the system in accordance to IEC 62368-1. In summary:

S.No	Kind of Person	Users	Description
1	Ordinary person	NA	Must not use the system.
2	Instructed person	Operator, Driver	May use the system after being trained by skilled person.
3	Skilled person	Vehicle integrator, Facility integrator, Maintainer	May install and use the system or its parts.

### 1.3 Scope of Supply

Item	Part	Description	Qty
1	WPB 30kW: Wireless Primary Box (Grid connection)	A large rectangular metal cabinet with multiple ventilation grilles and a control panel on the front door.	1
2	WPP 30kW: Wireless Primary Pad (generating magnetic field)	A rectangular metal plate with a coiled cable attached to its side.	1
3	WPP Mounting bracket	A long, thin metal bracket with mounting holes.	1
4	WSU 30kW 100V: Wireless Secondary Unit (Vehicle side, receives magnetic field, charges Battery)	A rectangular metal plate with a coiled cable attached to its side.	1

## 1.4 Intended Use

	No changes or modifications to the system/equipment are allowed unless approved by Delta.
---	---

The intended purpose of the WCS is defined as follows:

- The Delta 30kW WCS is designed to wirelessly charge batteries that contain BMS.
- WCS is made to charge Lithium Ion (Li-Ion) batteries with BMS. It is strictly restricted to industrial purpose only.
- Make sure to follow the specified environmental conditions and electrical values provided by the manufacturer.

The non-intended purpose of WCS is as follows:

- Use of WPP and WSU installed horizontally.
- Use of WPP and WSU installed vertical-portrait.
- Use in stand-alone as power supply without battery connected.
- Use with a connection to the public grid.
- Use to charge lead acid batteries.
- Use of WPP and WSU covered with metal sheet.

## 1.5 References

### 1.5.1 Delta Documentation

Item	Description	Link
1	Ethernet Quick Start Guide	FUTURE
2	Ethernet Control Protocol	FUTURE
3	Ethernet Service Discovery Protocol	FUTURE
4	CANopen® Protocol Spec	-
5	Data Sheet	-
6	Flyer	-

### 1.5.2 Open Source License & Credits

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## 1.6 **Exclusion of Liability**

The firmware and/or hardware may be changed at any time without prior notice. For this reason it is possible that parts of these instructions, technical data and images in this documentation to differ slightly from the product in your possession. All points described in these instructions only serve the purpose of clarification and may not correspond to every situation. Legal claims cannot be made on the basis of this document.

## 2 Safety & Regulations

### 2.1 Safety Symbols

The Danger, Warnings, Cautions, Attention and Note in this publication highlight the areas of concern to installation/maintenance personnel or operator. The definitions of Danger, Warning, Caution, Attention and Notice as utilized throughout this publication are as follows:

**DANGER:**

Indicates a hazard which is an immediate threat. If not avoided, will result in serious injury or death. Strictly adhere to all Dangers.

**WARNING:**

Indicates a hazard which is a possible threat. If not avoided, may result in serious injury or death. Strictly adhere to all Warnings.

**CAUTION:**

Indicates a hazard which is a possible threat. If not avoided, may result in minor injury. Strictly adhere to all Cautions.

**ATTENTION:**

Indicates an operation, sequence, or function which, if not observed, may cause damage/malfunction of equipment or to surrounding objects.

**Note:**

Provides explanatory information/clarification not readily apparent in the text or illustrations of a procedure.

### 2.2 Warning & Other Signs

Wherever required the following labels are also marked with warning signs to indicate the type of hazard.

Symbol	Description
	Risk of Electric shock
	Hot surface
	General warning
	Electromagnetic field (EMF)

Symbol	Description
	Sharp edges

Other signs are also used within the document.

Symbol	Description
	Ground (GND)
	Attention/Informative

## 2.3 Labels



## 2.4 Safety Instructions

### 2.4.1 General Safety Instructions

During handling the system/equipment, following danger, warnings, cautions and notes must be observed.

	<p><b>Electric shock</b></p> <ul style="list-style-type: none"> <li>• Isolate upstream breaker connected to WPB.</li> <li>• Do not open the WCS subsystems during charging as it may lead to death of Personnel.</li> <li>• Do not open the WCS subsystems when WPB connected to mains, and WSU connected to battery.</li> <li>• In order to replace the fuses and fans of WPB, make sure that only skilled person opens the system only when the system is cool and not in operation.</li> </ul>
	<ul style="list-style-type: none"> <li>• Make sure to install WPP and WSU vertically with the chamfered edge at the top, this would avoid any danger caused by foreign objects lying on the edge of the pad.</li> <li>• Make sure that both the pads are free from foreign object to avoid overheat while charging is in progress. Clean the pads as and when needed to avoid danger.</li> </ul>
	<p><b>Electromagnetic Field (EMF)</b></p> <ul style="list-style-type: none"> <li>• The Wireless Primary Pad (WPP) produces a potentially harmful magnetic field during the charging process.</li> <li>• Make sure to maintain a safe distance from WPP when charging is in progress. For more details about the safe distance see <b>2.4.2 EMF Safety Instructions</b>.</li> <li>• Use of the wireless charger may affect or impair the operation of any medical devices, such as an implantable cardiac pacemaker. Check with your medical device manufacturer concerning the effects that wireless charging may have on such devices before using the wireless charger.</li> <li>• Electromagnetic field exposure to pregnant women and Children is strictly forbidden.</li> <li>• Advise all user types about safety distances and affix appropriate warnings.</li> <li>• Warning signs should be clearly displayed at the charging area.</li> <li>• Do not install or operate the system in the public area.</li> <li>• Electronic objects such as cell phones and hearing aids may get damaged.</li> </ul>
	<p>Make sure to observe the battery manufacturers safety instructions. If battery manufacturer instructions conflict with charger instructions then, kindly contact both of them for a right solution.</p>

	<p><b>Hot surfaces</b></p> <ul style="list-style-type: none"> <li>• Do not touch any subsystems of the charging system while charging is in progress.</li> <li>• Do not touch WPP and WSU of the charging system up to 30 minutes (cooling time) after the charging process is finished.</li> <li>• Wear safety gloves while handling the subsystems after charging.</li> </ul>
	<p><b>Sharp edges</b></p> <p>Wear protective gloves when working on WPP and WSU. The back plates of the WPP and WSU have sharp edges.</p>
	<p><b>Heavy loads</b></p> <p>Use suitable lifting or transport equipment while lifting or moving the subsystems of the WCS. They might be too heavy and would cause strain or injury to the personnel. Improper handling of the subsystems may lead to malfunction of the subsystems.</p>
	<p><b>Material damage</b></p> <ul style="list-style-type: none"> <li>• Make sure that the metallic objects do not come in between or in contact with the pads during charging. The magnetic field causes metallic objects to become very hot, and this may lead to damage of the pads surface (WPP and WSU).</li> <li>• Select the installation position of the WPP and WSU accordingly.</li> <li>• All user types of the system must be instructed accordingly.</li> </ul>
	<p><b>Material damage</b></p> <p>Do not use powder or foam fire extinguishers on WPB when there is a fire around, it is recommended to use Co2 fire extinguisher or something similar otherwise WPB may get damaged.</p>

## 2.4.2 EMF Safety Instructions

The following customers are considered for the Wireless Charging System (WCS):

1. Any customer who wants to integrate the secondary part of the system, Wireless Secondary Unit (WSU) in an application to charge a battery e.g. forklift manufacturer, AGV manufacturer etc.
2. The customer where the application is used and who must install the primary part, Wireless Primary Box (WPB) and Wireless Primary Pad (WPP).

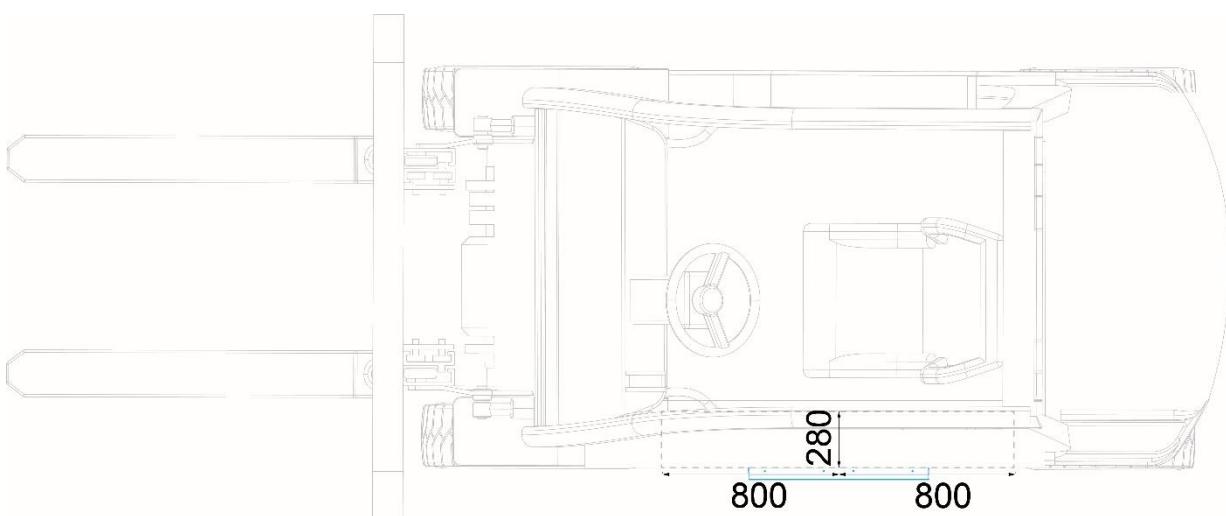
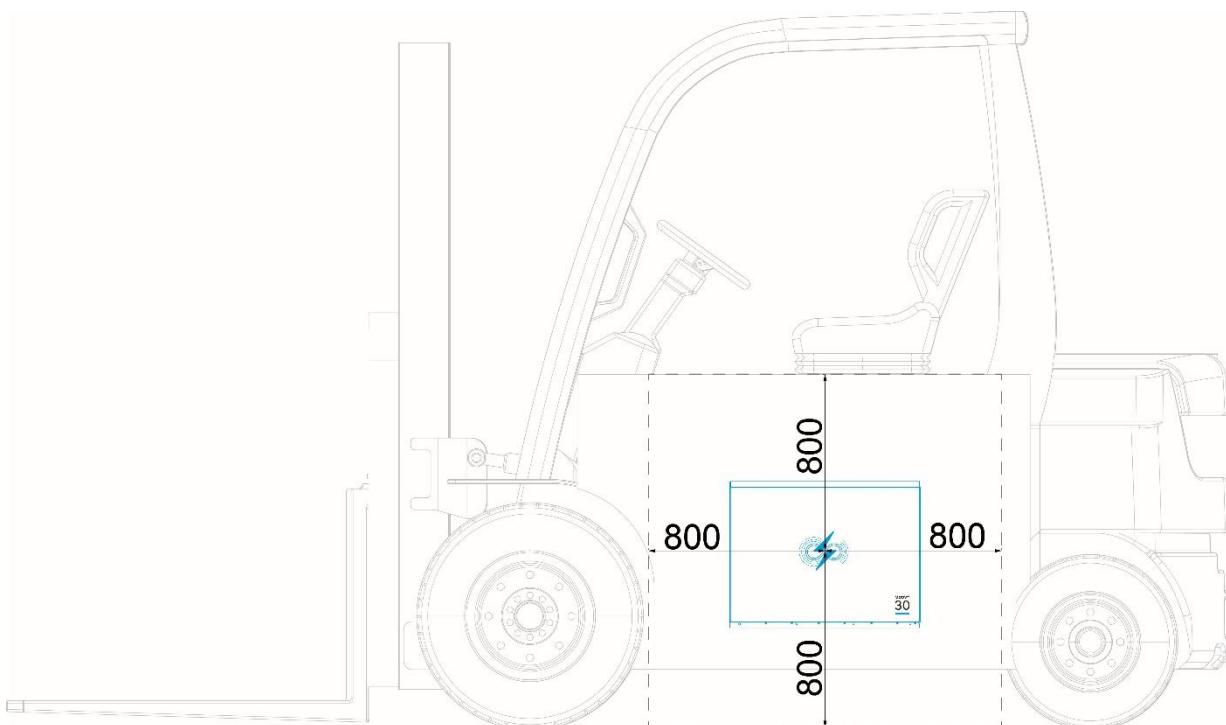
### Vehicle Integrator

The installation of the WSU must be carried out by a skilled person. The Vehicle integrator must:

- consider the keep out areas to ensure that an operator is not exposed to the magnetic field.
- implement the warnings and keep-out areas into the user instructions of their application.

The keep-out area for the operator whilst charging is depicted below:

#### A. WSU mounted on any application



### Facility Integrator

The installation of the WPP must be carried out by skilled persons. Charging must take place in an area where the general public does not have access. A keep-out area is required to inform instructed persons how far they must stay away from the WCS during charging.

The distances defined in the keep-out area are referenced to the magnetic center of the WPP.

The WPP magnetic center is:

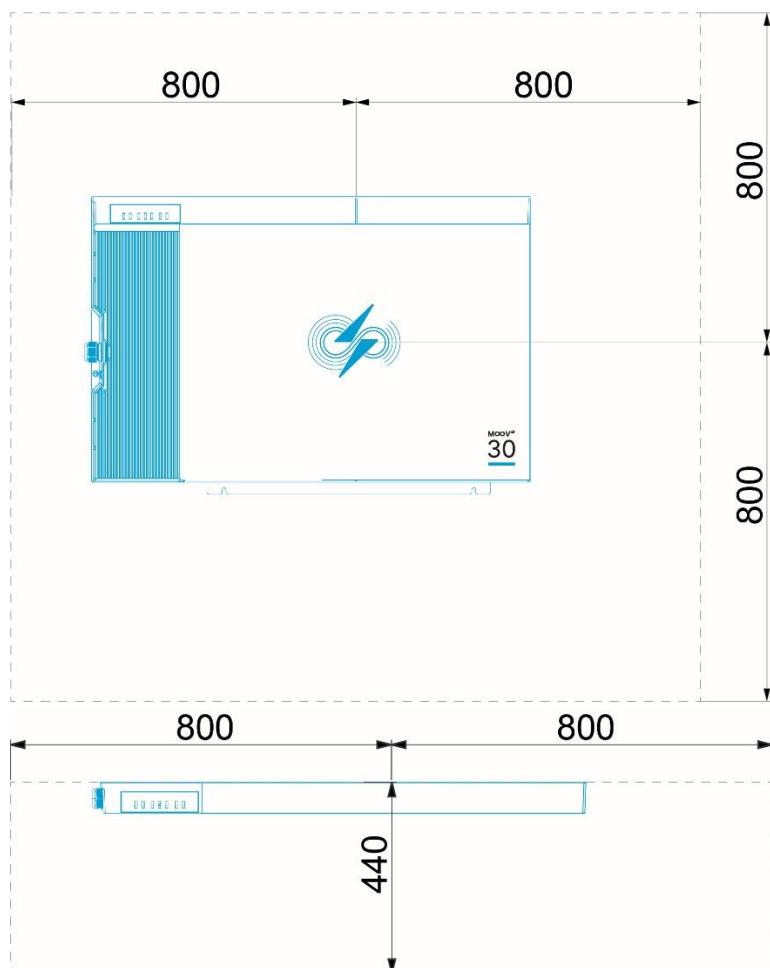
- located in the middle of the logo on the front of the housing
- referenced by side marks on the housing

The keep out area is depicted below for two cases:

- wall mount
- column/post/frame mount

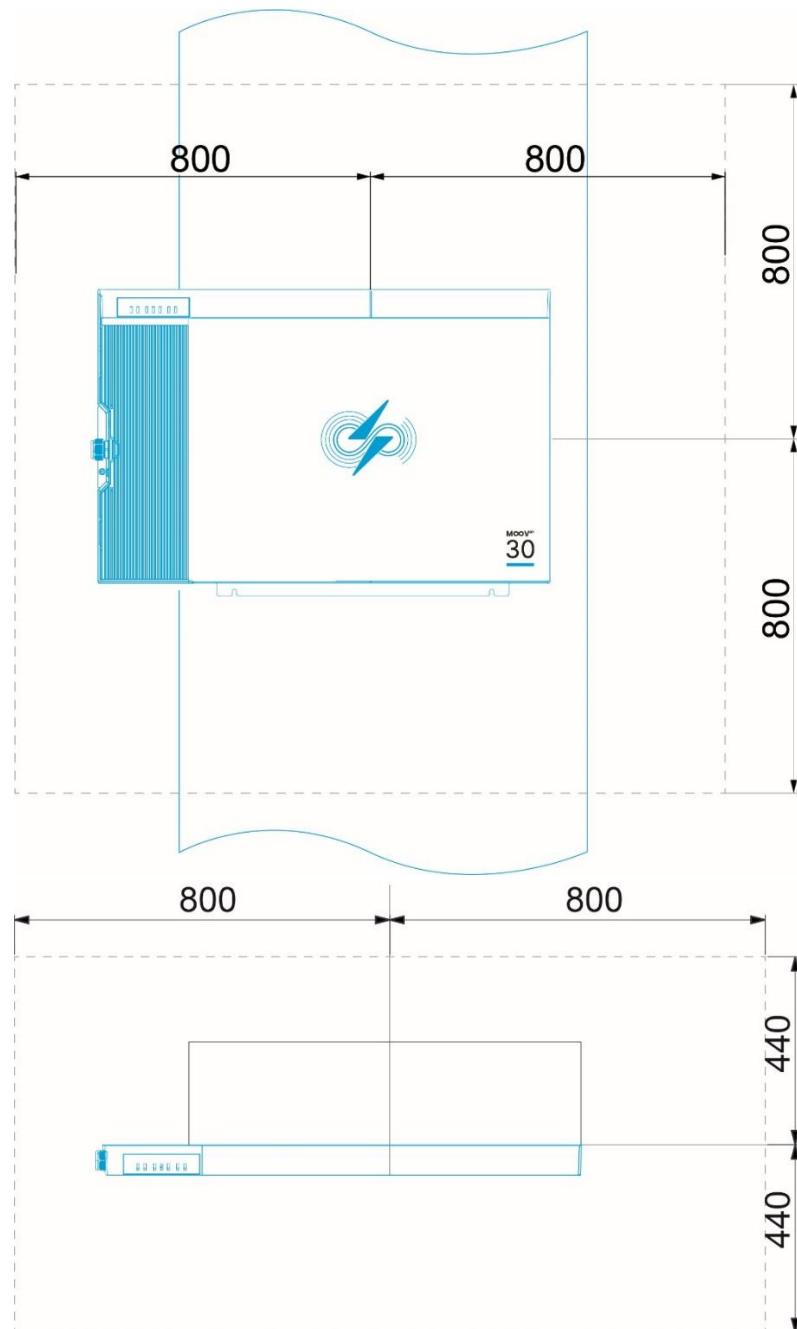
#### A. WPP mounted to a wall

Installer marks a keep-out area as follows:



**B. WPP mounted on a column, post or frame**

Installer marks a keep-out area as follows:



## Communication

When not charging (no power transmission), during communication, any user has to be at least 200mm away from both pads (WSU and WPP) in all directions from the magnetic center. The WSU and WPP will attempt to pair the communications between each other at all times when they are powered on.

## Medical Implant

Use of the wireless charger may affect or impair the operation of any medical devices, such as an implantable cardiac pacemaker. Check with your medical device manufacturer concerning the effects that wireless charging may have on such devices before using the wireless charger.

## General note

The distances provided in this document are valid for the use in free air. If metal is used in the keep-out areas, the magnetic field will be deformed. In this instance, after the WSU is installed into the vehicle, the magnetic field measurement must be performed for the application to ensure the given distances remain valid. If the distances are different to what is provided in this document, then the keep-out distances must be adjusted within the User Instructions for the application.

**Note:** It is likely that the measurement result allows shorter distances.

## 2.5 Regulatory Compliances

### 2.5.1 EU

#### 2.5.1.1 Declaration of Conformity (DoC)



#### EU Declaration of Conformity

Manufacturer : **Delta Energy Systems (Germany) GmbH**  
Address : Tscheulinstrasse 21, 79331 Teningen, Germany

Product description: **Charging System Wireless**

Model:	<b>CS WPB STD 30KW 3AC</b>	EOE18010815
	<b>CS WPP STD 30KW</b>	EOE18010851
	<b>CS WSU STD 30KW 100V</b>	EOE18010850

The manufacturer declares under its sole responsibility that the product described above is in conformity with the provisions of the following European Directives:

**2014/53/EU** Directive of the European Parliament and of the Council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

(Title and / or number and date of issue of the standard(s) or other normative document(s))

- according to article 3.1 (a): Health and Safety of the User  
**EN 62368-1:2014 + A11:2017** (Electrical safety)  
**EN 62311:2020** (EMF exposure)
- according to article 3.1 (b): Electromagnetic Compatibility  
**EN 303 446-2 V1.2.1**  
**EN 301 489-1 V2.2.3 ; EN 301 489-3 V1.6.1**  
**EN 55011:2016 + A1:2017+A11 :2020**  
**EN IEC 61000-6-2:2019**
- according to article 3.2 : Effective use of spectrum allocated  
**EN 300 330 V2.1.1**

**2011/65/EU** Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (including delegated directive (EU) 2015/863 of 31 march 2015).

(Title and / or number and date of issue of the standard(s) or other normative document(s))

**EN IEC 63000:2018**

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#### 2.5.1.2 Radio Equipment

##### Radio Frequency Information:

13.56 MHz: Wireless Communication (PPL), max 200mW

55-65 kHz: Wireless Power Transfer, max 30kW

## 2.5.2 FCC

 <b>WARNING:</b>	<p>During charging/operation there will be electric and magnetic fields between the pads, human bodies must not be in close proximity of the pads. Make sure to follow the installation guidance given in section <b>2.4.2 EMF Safety Instructions</b>. It is the responsibility of the installer to provide sufficient warnings, keep out restrictions and training to all personnel.</p>
--	--

Active charging will generate electric and magnetic fields between the pads. The charger has been designed to minimize stray fields and has been tested as complying with the following standards:

- 47 CFR Part 15.225 in conjunction with ANSI C63.10:2013
- 47 CFR Part 18, Subpart C
- 47 CFR FCC Part 1.1307(clause (b)(1)(i)(B) and (b)(3)(ii)(B)), KDB 447498 D01 General RF Exposure Guidance v06 KDB 680106 D01 RF Exposure Wireless Charging App v03r01

However, it is still necessary to take precautions to work safely with the charger.

- Operators (if any) must be informed that they could be exposed to EMF, and that they must keep enough distance from the WPP at all times, including when not charging.

 <b>ATTENTION:</b>	<p>This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:</p> <ul style="list-style-type: none"><li>• This device may not cause harmful interference.</li><li>• This device must accept any interference received, including interference that may cause undesired operation.</li></ul>
 <b>ATTENTION:</b>	<p>This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.</p>

## 2.5.3 ISED

Information yet to be added.

## 2.5.4 Miscellaneous

Not Applicable.

### 3 System Description & Operation

#### 3.1 Overview

##### 3.1.1 Identification of WCS Subsystems

The wireless charging system consists of three subsystems.

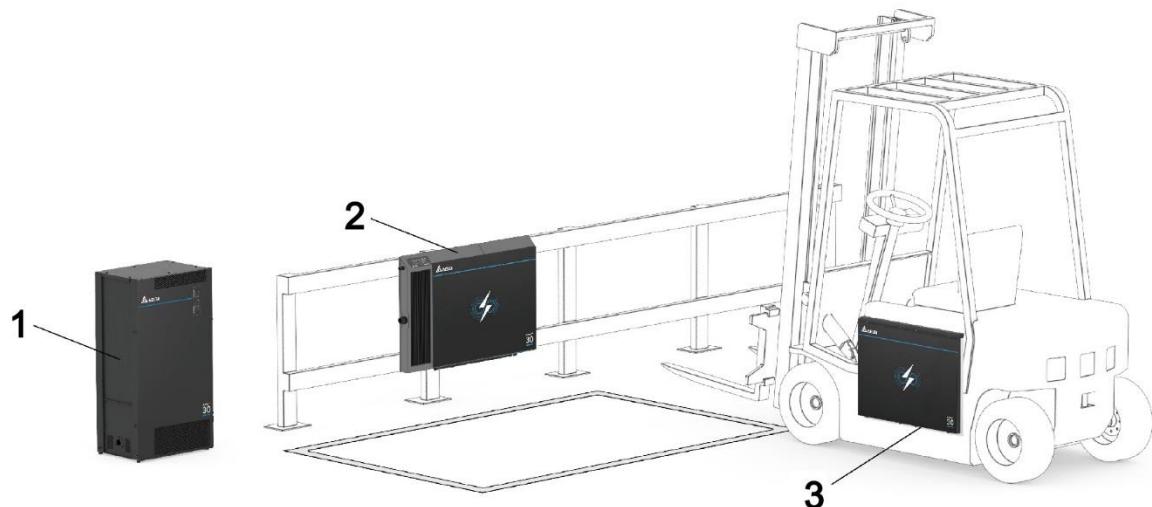


Figure. 1 WCS Subsystems (Example – Forklift)

Item	Description
1	Wireless Primary Box (WPB)
2	Wireless Primary Pad (WPP)
3	Wireless Secondary Unit (WSU)

### 3.1.2 Wireless Charging

The WCS wirelessly charges the battery of an industrial electric vehicle by means of near field coupling between WPP and WSU. A magnetic field is generated by the WPP and coupled to the WSU. The WSU converts the magnetic field back to electrical current and charges the battery. The rated power of the WCS is 30 kW.

<b>ATTENTION:</b> 	<b>Material damage</b> <p>The magnetic field generated during the charging process can cause metal and other foreign objects to become hot. Therefore, it is important to keep the charging area free of foreign objects.</p>
--	--

The magnetic field is only emitted by the WPP when there is a WSU in the charging area. The charging status can be seen on the Status LED panels provided on the WPP and WPB, refer 3.2.1.4.1 Status LED.

The speed and efficiency of the charging process is dependent on different factors, including:

1. Temperature – both the ambient temperature and the internal temperature of the subsystems.
2. Pad positioning – both the distance (air gap) and the alignment of the pads, refer 3.3.1.3 WPP & WSU Positioning.

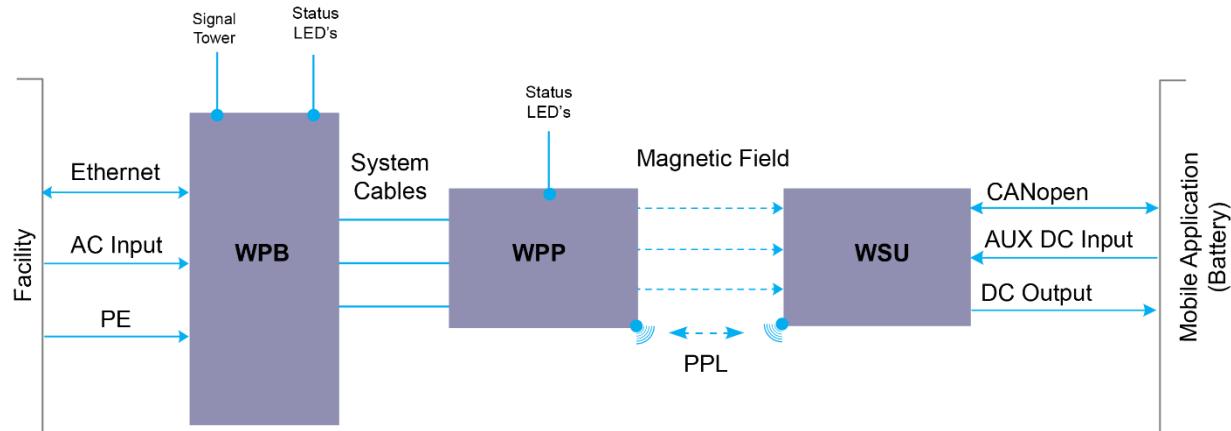


Figure. 2 Wireless Charging

The WCS can be controlled by a:

- BMS via CANopen® on the WSU side or
- Fleet Management System (FMS) (or similar) via Ethernet on the WPB side.

There is an interface on the WPB to connect a stack light.

There are internal interfaces between the subsystems:

- A wired control connection between WPB – WPP,
- A wireless control connection between WPP – WSU referred to PPL (Pad to Pad Link).

For details on the control interfaces, refer 3.5.2 WPB – Ethernet and 3.5.3 WSU – CANopen®.

### 3.1.3 Models, Variants & Interoperability

Not Applicable.

## 3.2 Subsystem Description

### 3.2.1 WPB

#### 3.2.1.1 Function

Wireless Primary Box (WPB) is a power electronics device which enables power transfer via the Wireless Primary Pad (WPP) to the Wireless Secondary Unit (WSU).

The WPB draws power from the industrial grid and converts it to a medium voltage (MV) AC supply which is fed to the WPP. The output power ranges from 300W to 30kW. The WPB communicates with the WPP internally, which forms part of the control loop for safe usage. It also provides User interfaces using Ethernet, Status LED's and an optional Stack Light.

**Table. 1      Specifications - WPB**

	WPB
Dimensions (H x W x D)	1020 x 550 x 400 mm (40.2 x 21.7 x 15.7 in)
Weight	105 kg (231.5 lbs)
Cable Length	5.0 m (196.85 in)
Ingress protection classes	IP21
Cooling	Forced air
Ambient temperature	+5 °C to +40 °C (41 °F to 104 °F)
Ambient relative humidity	5 % to 85 %, non-condensing
Maximum operating altitude	3000 m (9842 ft) above sea level for all subsystems
Noise levels emitted	Up to 75 dB(A), depending on fan speed. Fans will operate if internal temperature is >+40 °C.

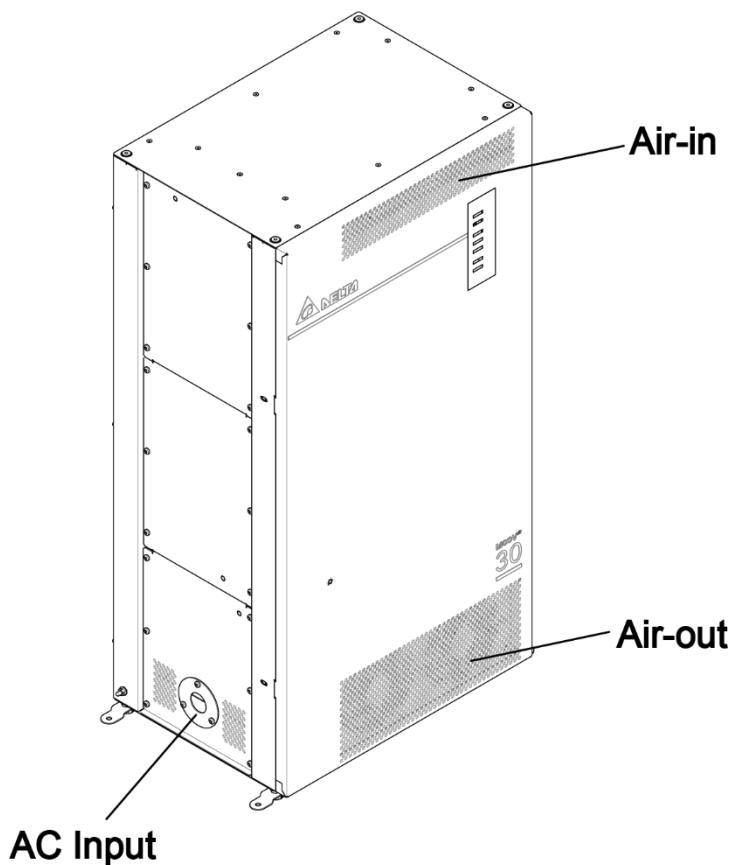


Figure. 3 WPB Air-in and Air-out

### 3.2.1.2 AC Input

Region	EU / UK	US / Canada
AC Input rated voltage	380 V <sub>AC</sub> 3PH	480 V <sub>AC</sub> 3PH
	380 to 480 V <sub>AC</sub> 3PH	$\sim$
AC Input voltage range	342 - 528 V <sub>AC</sub> 3PH	
AC Input frequency	47 Hz to 63 Hz	
Maximum AC Input Current	48 A	
Required supplementary fuse	63 A, tripping characteristic: B  <b>Note:</b> Installed externally to the WPB by site installer.	50 A, tripping characteristic: B
Branch fuse	Use 125 Amp. Branch protection is provided by the branch fuse. <b>Note:</b> Installed externally to the WPB by site installer.	

Region	EU / UK	US / Canada
Required SDD (Supply Disconnecting Device)	CEKON (IEC 60309) plug	A Switch box in accordance with NFPA 70 and C22.1-15
Required short circuit ratio	> 30	
Max. line inductance	≤ 400 µH	
Minimum conductor size (for mechanically protected/unprotected power cords)		10 mm <sup>2</sup> /6 AWG
Input power	34 kVA	
Power factor (100% Load)	0.95	
Peak efficiency	> 95 %	

### 3.2.1.2.1 Earthing System

The WPB requires a 3-phase industrial AC input connection in order to provide power to the other system components.

Earthing Systems supported are TN-C, TN-S, TN-C-S, TT with grounded star points.

### 3.2.1.2.2 Field Wiring Terminals

Terminals on WPB Input Filter and PE/GND connection on chassis:

Name	Signal
L1	Phases of the AC Supply Grid with grounded star point.
L2	
L3	Voltage 400 V 50Hz to 480 V 60 Hz.
PE/GND	PE/GND connected to star point of the AC Supply Grid. PE/GND Bolt on Chassis part close to X105X of Input filter.

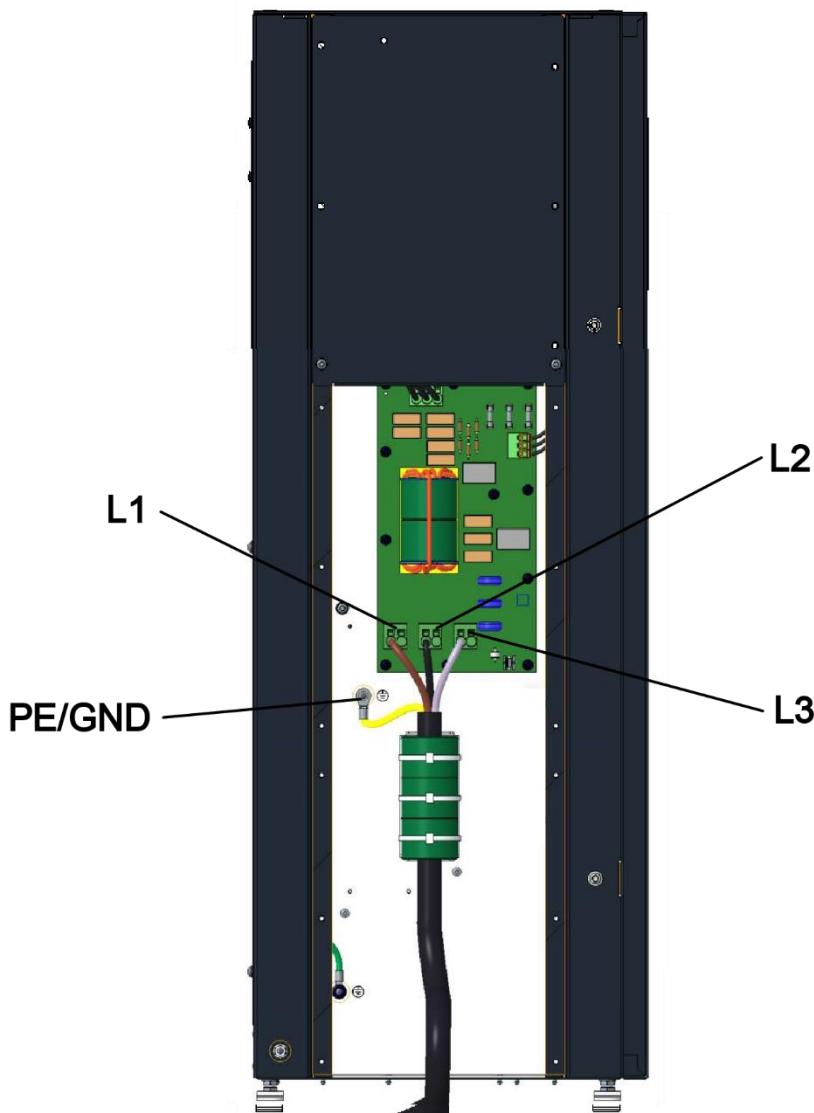


Figure. 4 Terminals on WPB

Fused supply line with SDD (Supply Disconnecting Device)	For installation and operation of the WPB, a fused supply line with a SDD according to the following specifications is required (not supplied by Delta)			
Region	Supply Voltage	Fuse	SDD	
Europe	380 V <sub>AC</sub> /47 Hz	63 A	CEKON (IEC 60309) plug	
US and Canada	480 V <sub>AC</sub> /63 Hz	50 A	A Switch box in accordance with NFPA 70 and C22.1-15	

### 3.2.1.3 WPP Interface

Following are the external cable connections of WPP

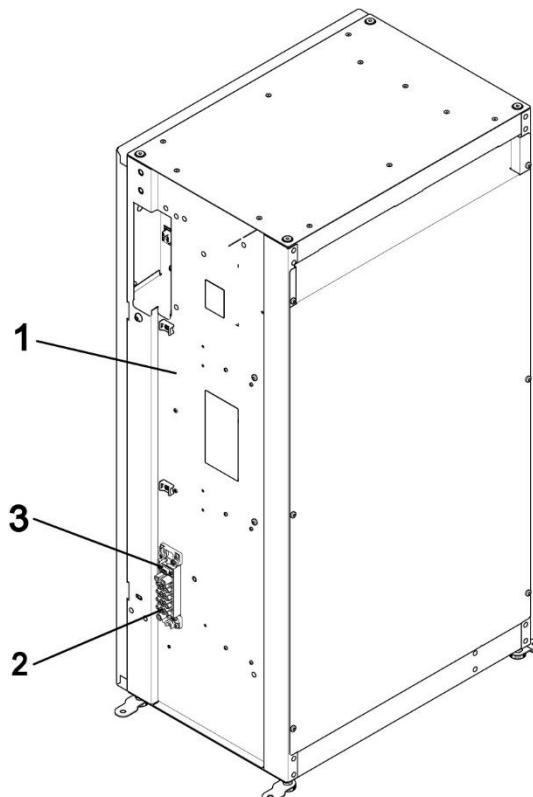


Figure. 5 WPB Interface

Item	Description
1	WPB
2	Heavy duty Connector Socket
3	Signal Connector Socket

### 3.2.1.3.1 Potential Equalization (Earthing)

The PE/GND connection provides protection to the system and the personnel from electric shock. PE/GND Connection (4) is provided in the integrated heavy duty connector (2).

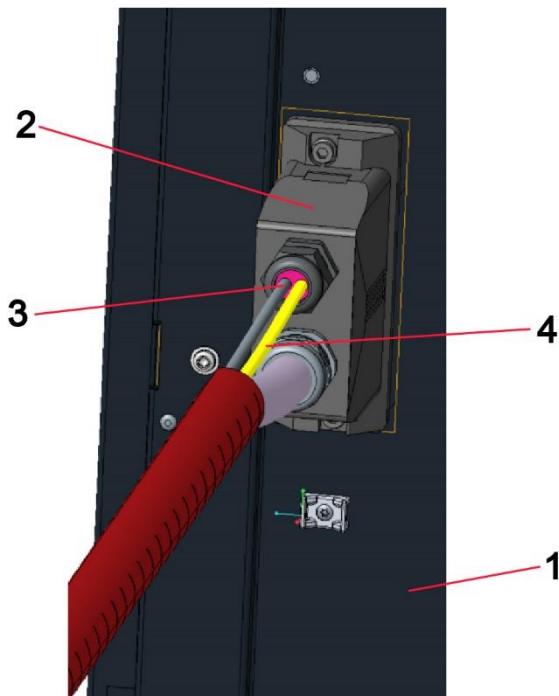


Figure. 6 Potential Equalization (Earthing)

S.No	Description	S.No	Description
1	WPB	3	Signal Connection
2	Heavy duty Connector	4	PE/GND Connection

### 3.2.1.4 User Interface

#### 3.2.1.4.1 Status LED Panel

WPB is provided with a Status LED Panel which indicates the system and operating status. On the WPB, the Status LED Panel is on the front cover:

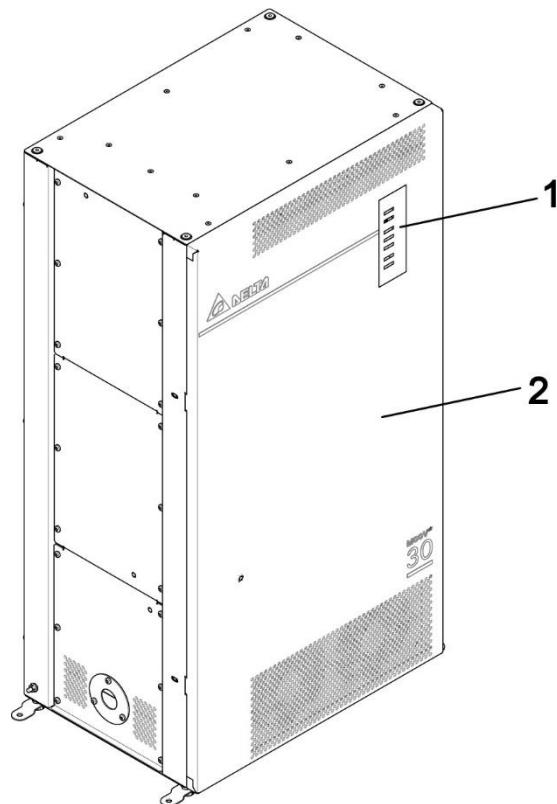


Figure. 7 WPB Status LED Panel Location

Item	Description
1	Status LED panel
2	Front cover

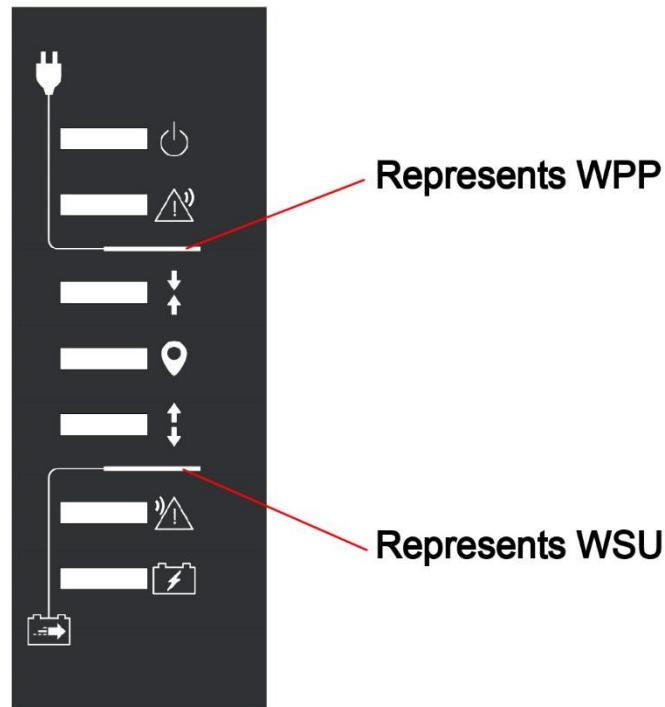


Figure. 8 Status LED Panel

Name	Color	Signal	Description
Power 	Green	ON	AC input power supplied.
WPB/WPP Fault 	Red	ON	WPB and/or WPP Fault active or latched.
Position - Too close 	Yellow	ON	WPP and WSU are positioned too close together.
Position - Optimal 	Green	ON	WPP and WSU positioned within design tolerance

Name	Color	Signal	Description
Position - Too far	Yellow	ON	WPP and WSU are positioned too far apart.
WSU Fault	Red	ON	WSU Fault active or latched.
Charging Status	Green	ON	Battery fully charged. Charger is still occupied by battery/charger.
		Flash	Battery charging
		OFF	Battery is not charging or it is already fully charged e.g. battery disconnected or fault.

### 3.2.1.4.2 Ethernet Service Interface (Not Implemented)

WPB has an Ethernet service interface located on the right hand side of the enclosure. The interface has a physical RJ45 socket configured with 100BASE-TX (Fast Ethernet) as per IEEE 802.3u. The Ethernet service interface can be used for system monitoring and control. For more information refer 3.5.2 WPB – Ethernet.

Note:

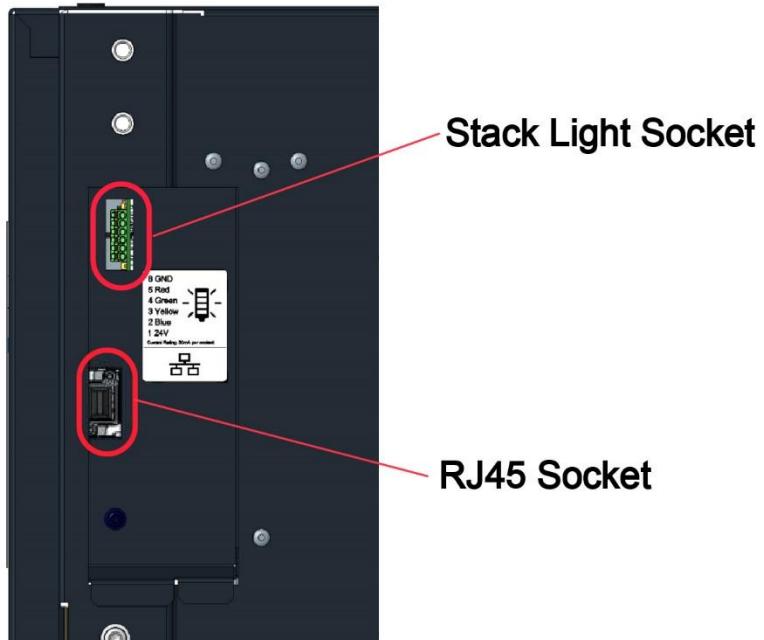


Figure. 9 Ethernet Service Interface

<b>ATTENTION:</b> 	<ul style="list-style-type: none"> <li>• Ethernet service interface must be used by skilled person during the service and should be disconnected once the service is done.</li> <li>• The ethernet service cable length is restricted to 3 m.</li> </ul>
--	--

### 3.2.1.4.3 Stack Light (Optional)

The WPB provides an interface for installation of an optional Stack light of up to 4-colors, e.g. of type Tend Technology TPTL4-L7ROGB-S, or equivalent. The Stack Light indicates the current (charging) status of the system. Refer to Figure. 23.

Signal Name	Color	Signal	Status Indicated	
Fault	Red	ON	Indicates fault at WPB/WPP	
		Flash	Fault at WSU when paired with WPP	
		OFF	No faults active	
Warning	Yellow / Amber	ON	Warning active (performance related including de-rating)	
		OFF	No warning active	
Status of WPB/WPP	Green	ON	WPB/WPP is operating normally	
		OFF	WPB/WPP is powered OFF in abnormal conditions.	
Charge process	Blue	ON	Charging complete	
		Flash	Charging	
		OFF	Not Charging	

**Note:** The stack light is not included within the system or provided by Delta Energy Systems. It must be purchased separately and installed as described in Section 4.1.6.

### 3.2.2 WPP

#### 3.2.2.1 Function

The WPP is fed by the WPB with a medium voltage (MV) AC supply and transfers it to the WSU via magnetic field. The WPP supplies the WSU with 300W to 30kW wireless power. The WPP further communicates its operating limits to the WPB. WPP also enables communication to the WSU via PPL, refer 3.5.1 WPP & WSU Interface – Pad to Pad Link (PPL). The status of the WPP can be monitored using the Status LED panel provided on the chamfered edge. Refer 3.2.2.3 User Interface for more information. The chamfered edge is provided to assist in the prevention of metallic foreign objects being placed on top of the WPP

See Figure. 10 Main Components of WPP for major components of WPP.

Refer to 3.2.1.4.1 Status LED for more information on status LED's.

**Table. 2      Specifications - WPP**

Description	Value
Dimensions (H x W x D)	665 x 1020 x 65 mm (26.2 x 40.2 x 2.6 in)
Weight	77 kg (169.7 lbs)
Cable Length	5.0 m (196.85 in)
Ingress protection classes	IP69
Cooling	Convection
Ambient temperature	-40 °C to +70 °C (-40 °F to 158 °F), output de-rating above +40 °C
Ambient relative humidity	4 % to 100 %
Maximum operating altitude	3000 m (9842 ft) above sea level for all subsystems

### 3.2.2.2 WPB Interface

Following are the WPB interface connections,

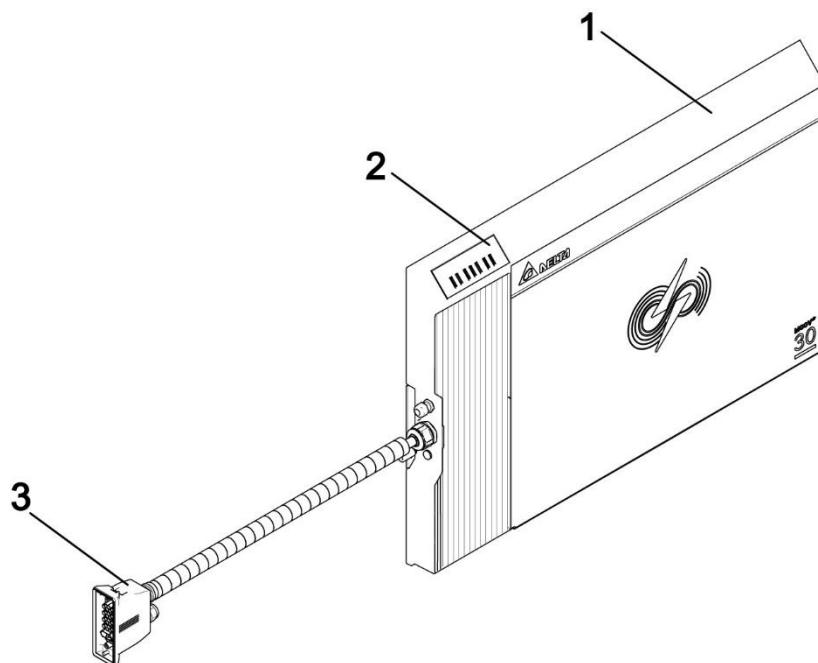


Figure. 10 Main Components of WPP (New Model)

Item	Description
1	Chamfered Edge
2	Status LED panel
3	Heavy Duty Connector

### 3.2.2.3 User Interface

#### 3.2.2.3.1 Status LED

WPP is provided with a Status LED Panel which indicates the system and operating status.

The Status LED Panel is located on the front cover of WPP. Figure. 10 Main Components of WPP for location of Status LED on WPP.

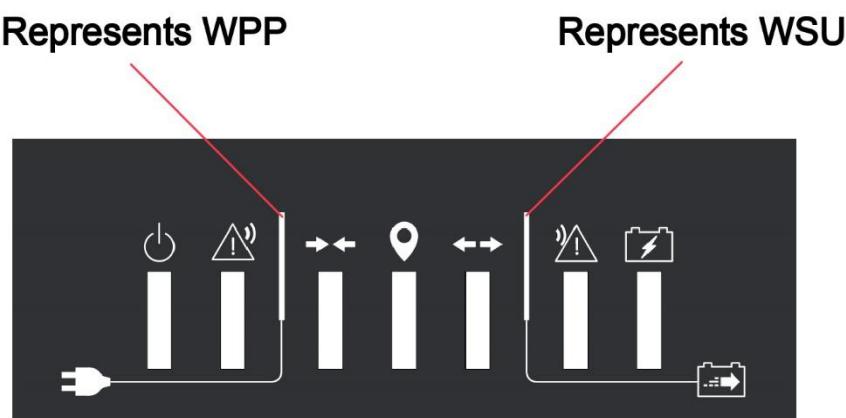


Figure. 11 Status LED Panel

Refer Section 3.2.1.4.1 Status LED for detailed explanation of Status LED functions.

### 3.2.3 WSU

#### 3.2.3.1 Function

The WSU couples to the magnetic field of the WPP. It converts the energy to an el current to charge the battery. The WSU communicates with WPP using PPL, refer 3.5.1 WPP & WSU Interface – Pad to Pad Link (PPL), and with the BMS via CANopen®. The WSU is provided with over voltage protection, over current protection, reverse polarity protection and short circuit protection. Refer 4.3.4.2 WSU Cable Connections for cable connections.

Following are the main parts of the WSU.

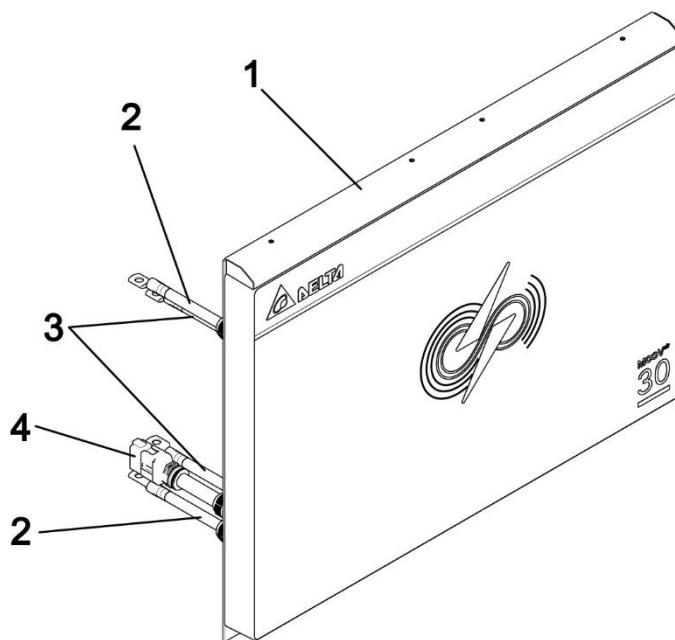


Figure. 12 WSU

Item	Description	Item	Description
1	Edge Cover	3	Power output cable BLACK (-)
2	Power output cable RED (+)	4	Control cable

**Table. 3      Specifications - WSU**

Description	Value
Dimensions (H x W x D)	565 x 735 x 50 mm (22.2 x 28.9 x 2.0 in)
Weight	47 kg (103.6 lbs)
Ingress protection classes	IP69
Cooling	Convection
Ambient temperature	-40 °C to +80 °C (-40 °F to 176 °F), output de-rating above +40 °C
Ambient relative humidity	15 % to 100 %
Maximum operating altitude	3000 m (9842 ft) above sea level for all subsystems

### 3.2.3.2 DC Output (WSU)

Connect all the four power cables (two Black (-) and two RED (+)) of WSU to the same battery, otherwise charging is not possible. For more information refer 4.2.6 Power Up & Health Checks.

Description	Value
DC Output Nominal voltage	100 V <sub>DC</sub>
DC Output voltage range	72 to 120 V <sub>DC</sub> — —
Maximum charge current	300 A (For more details refer 3.3.1.1 Output Operating Area).
Maximum output power	30 kW
	See also 3.3.1 Output Power and De-rating.
Output protection	<ul style="list-style-type: none"> <li>• over voltage</li> <li>• over current</li> <li>• over temperature</li> <li>• short circuit</li> <li>• open circuit</li> <li>• reverse connection</li> </ul>
Length of RED (+) power cables	2 m (78.74 in)
Length of BLACK (-) power cables	
Ring Terminal	10 mm M10 stud

### 3.2.3.3 User Interface

The WSU has a multipurpose control cable for connection to the vehicle, with Auxiliary input power, Auxiliary output power and CANopen® communications interfaces. The control cable is 0.5m (0.02 in) in length and has a single Deutsch connector on the far end.

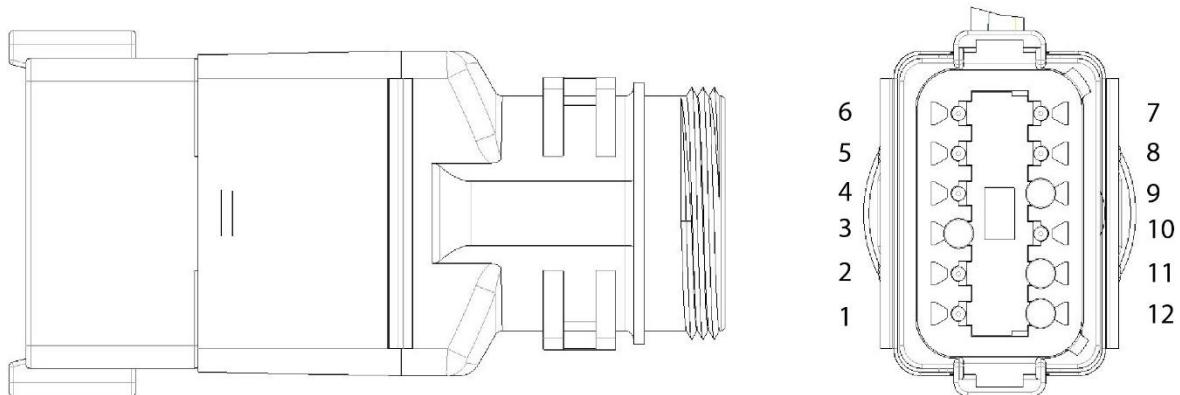


Figure. 13 WSU Deutsch Connector

The pinout of the WSU control interface are assigned as:

**Table. 4** WSU Deutsch Connector Pinout

Pin	Signal	Function
1	AUXIN+	AUX supply from battery, fused 2A at Vehicle side
2	AUXIN-	AUX supply reference from battery
3	NC	
4	AUXOUT+	AUX supply for external devices, max. output: 5 V, 100 mA
5	CANOUT_H	BMS Vehicle CAN/2nd WSU/120 Ohm in cable
6	CANOUT_L	BMS Vehicle CAN/2nd WSU/120 Ohm in cable
7	CANIN_H	BMS Vehicle CAN
8	CANIN_L	BMS Vehicle CAN
9	NC	
10	AUXOUT-	AUX supply reference for external devices
11	NC	Reserved
12	NC	Reserved

### 3.2.3.3.1 Auxiliary Input Power

The WSU has an auxiliary input power interface which must be supplied by the vehicle to power the WSU internal controller. This is required to be able to establish communications with the WPP for a charge cycle to commence and for the vehicle to acquire data from the WSU for system monitoring.

For integration purposes the WSU can be powered from a 24Vdc PSU when the battery is not available.

Aux Input Voltage	24V to 120V
Aux Input Max Current	200mA
Aux Input Nominal Current without Aux Output connected	20mA
Aux Input with Wireless Power Transfer (from WPP)	0mA
Aux Input Voltage	24V to 120V

### 3.2.3.3.2 Auxiliary Output Power

The WSU has an optional auxiliary output power interface that can be used to power small components/modules on the vehicle. It supplies 5V with a maximum current of 100mA.

### 3.2.3.3.3 CANopen® Interface

The WSU has a CAN bus interface that is used for monitoring the system and also for the BMS to control the WCS.

The CAN bus communications interface is compliant to ISO 11898-1 and 11898-2. It provides both a CAN IN and a CAN OUT interface for flexibility of the wiring configuration within the vehicle. The WSU does not include CAN bus termination, instead this can be achieved using the CAN OUT if desired.

See section 3.4.1 External Commanded CANopen® for details on CANopen® Control Mode and section 3.5.3 WSU - CANopen® for details on CANopen® Communications.

#### CAN bus Termination:

If a CAN termination is needed, it can be placed in between Pin5 and Pin 6 of WSU Deutsch connector. Refer 3.2.3.3 for pins position.

### 3.3 System Performance

#### 3.3.1 Output Power and De-rating

##### 3.3.1.1 Output Operating Area

Output current and output voltage can be set within the limits as shown in Figure. 14.

##### 30kW 100V

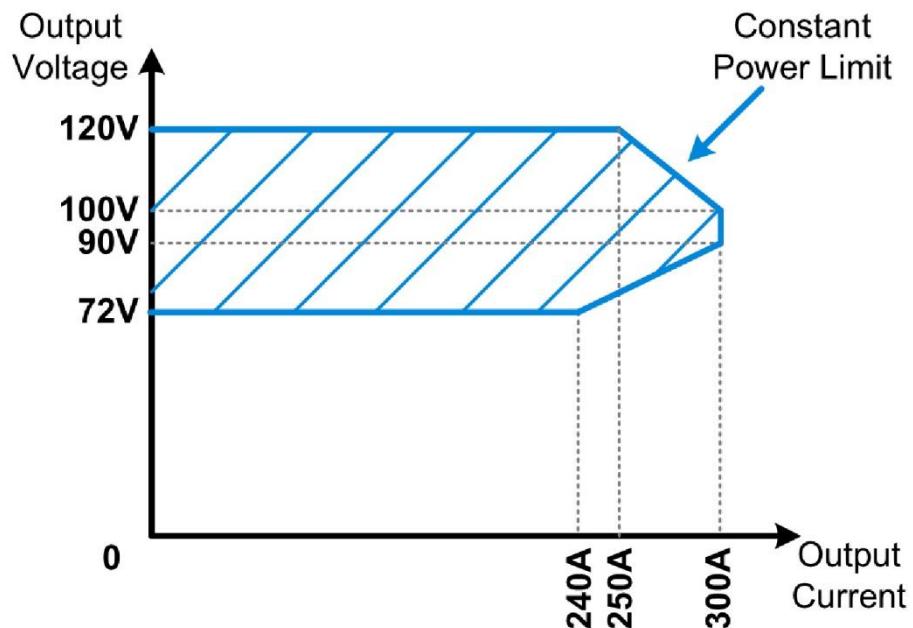


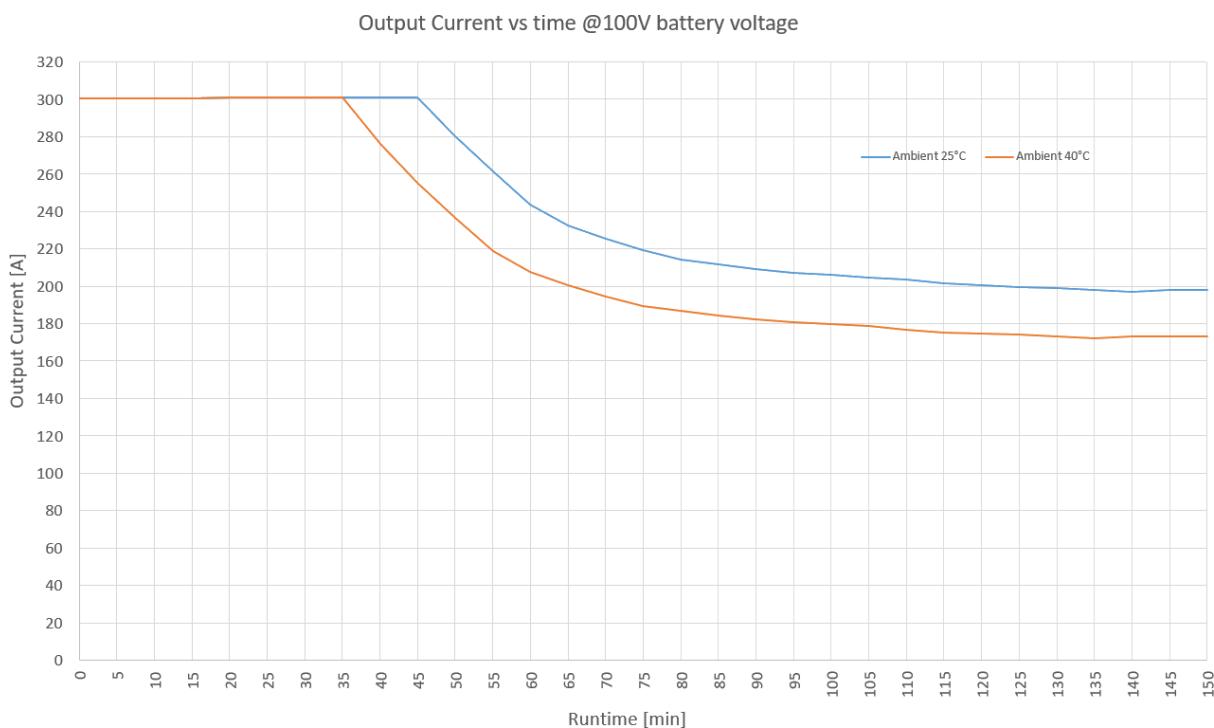
Figure. 14 Output Power and Current Limits with Variable Voltage

Using the 30kW WCS, the system can achieve the following results:

- at 72 V the WCS can provide a maximum output of 240 A (17.3 kW)
- at 90 V or 100 V the WCS can provide a maximum output of 300 A
- above 100 V, the constant power mode starts and the system cannot achieve more than 30 kW, as the current starts de-rating.

##### 3.3.1.2 Power Vs Ambient Temperature

The WPB and WPP can run continuously at full power in an ambient temperature of up to 40 °C. The WSU can run in cyclic intermittent operation at full power, or in continuous operation with reduced power as shown in the following graph.



**Figure. 15 Power De-rating Vs Time at Different Ambient Temperatures**

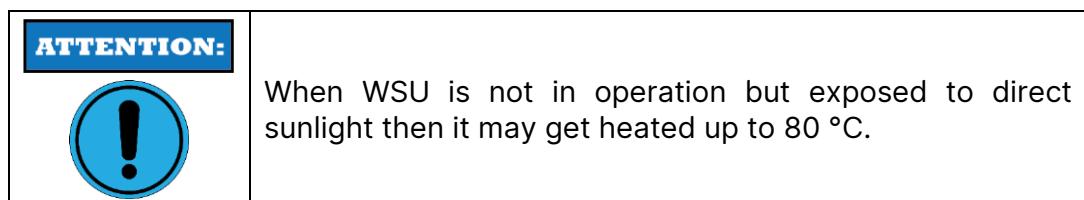
At 25 °C: Full power can be given for a maximum of 45 minutes. After 45 minutes the output current will be de-rated and will eventually reduce to approximately 200 A.

At 40 °C: Full power can be given for a maximum of 35 minutes. After 35 minutes the output current will be de-rated and will eventually reduce to approximately 170 A.

At higher ambient temperatures, the output from the WSU is de-rated: at +40 °C the WSU will deliver over 66 % of the maximum output for at least 300 minutes. At higher temperatures up to the maximum operating temperatures for WPP and WSU (see below) the output will decrease further.

The operating temperatures for the WCS subsystems are given in the following table:

Description	WPB	WPP	WSU
Ambient Temperature	+5 °C to +40 °C (41 °F to 104 °F)	-40 °C to +70 °C (-40 °F to 158 °F)	-40 °C to +80 °C (-40 °F to 176 °F)



### 3.3.1.3 WPP & WSU Positioning

WPP is stationary whereas the WSU is movable, as it is attached to vehicle. Position of WSU is an important factor for the charging process. The better the WSU position is the more efficient and faster the results are. Improper positioning leads to lower output, longer charging time, lower charge levels and more heat.

The WSU should be positioned in front of WPP for charging with the center marks aligned as closely as possible and with a gap of  $105^{+/-5}$  to  $155^{+/-5}$  mm (4.1 $^{+/-0.2}$  to 6.1 $^{+/-0.2}$  in) between the faces of the pads.

In some cases it might not be possible to position the WSU completely aligned to WPP, so a lateral offset of the WSU center mark from the WPP center position (indicated by the WPP center mark) is referred to as misalignment. Charging is possible with a maximum misalignment of 50 mm (2 in) to either side of the center position.

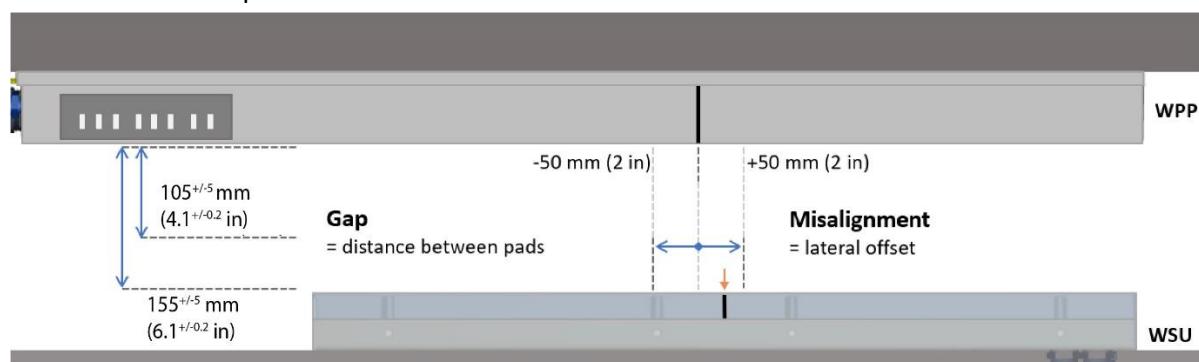


Figure. 16 Pad Position for Charging

The wireless control connection between WSU and WPP – referred to as the pad-to-pad link (PPL) is only possible when the WSU is positioned within the charging area. The position LEDs do not light up until the pad-to-pad link (PPL) is made. For effective and complete charging, the WSU must be positioned with a gap of  $105^{+/-5}$  to  $155^{+/-5}$  mm (4.1 $^{+/-0.2}$ –6.1 $^{+/-0.2}$  in) and a center-to-center misalignment (lateral offset) of up to 50 mm (2 in).

<b>Note:</b>	<ul style="list-style-type: none"><li>Once the WSU is in charging position and the pad-to-pad link (PPL) is made, either the vehicle BMS or the facility FMS takes control and determines when the charging process begins.</li><li>The WCS can report to the vehicle and/or FMS the approximate positioning coupling factor as a percentage.</li></ul>
--------------	---

### 3.3.1.3.1 Pad Positioning at an Angle

The WSU needs to be placed exactly to the center mark of WPP, there could be a slight angle (up to about  $\pm 3.8^\circ$ ) between the pads.

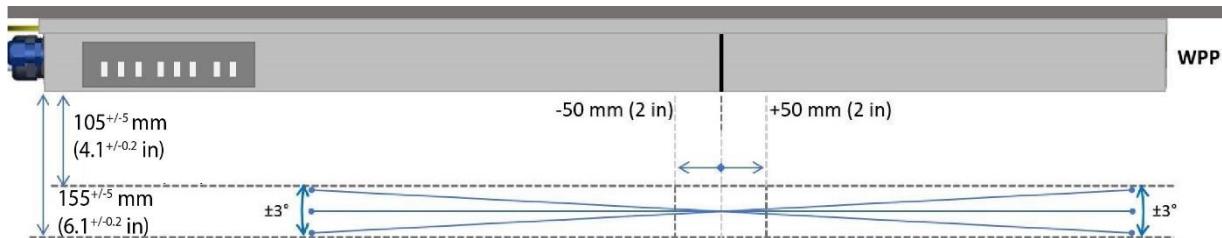


Figure. 17 Pad position at an Angle (No Charging)

**Note:** The air gap tolerance decreases as the positioning angle increases. For example, at an angle of just  $\pm 2^\circ$  the air gap tolerance is reduced to approx. 24 mm, compared to 50 mm (2 in) with parallel positioning.

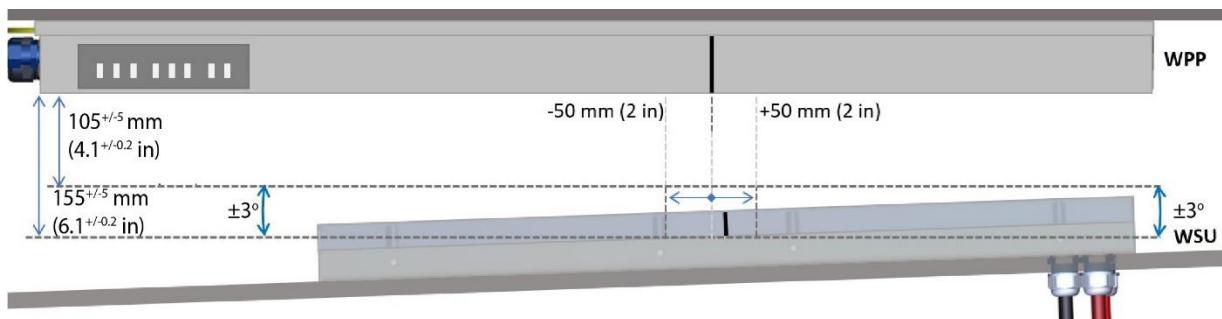


Figure. 18 WSU positioned at an angle

### 3.3.1.3.2 Pad Alignment with Vertical Offset

As described above, the pads can be positioned with an offset (misalignment) of  $\pm 50$  mm (2 in) between the centering marks on the top of WSU and WPP. This is not only the case in lateral, but also in vertical direction: a vertical offset (misalignment) of up to 50 mm (2 in) between the centering marks on the side of WSU and WPP is possible.

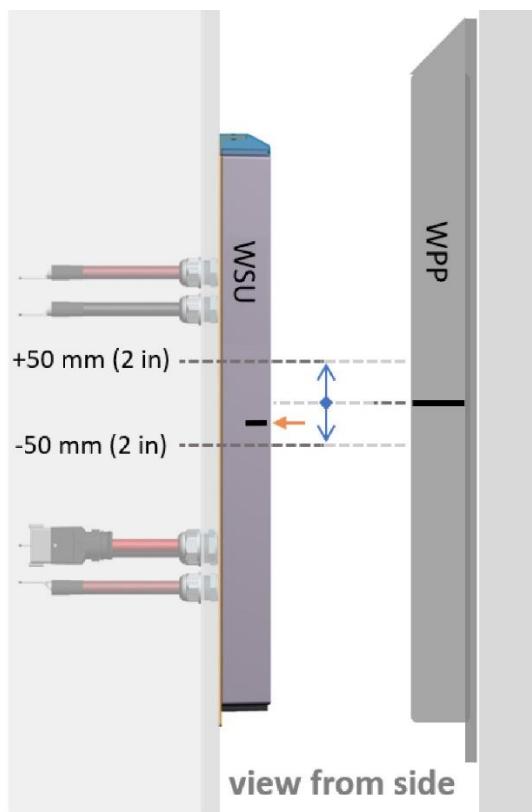


Figure. 19 Pad Alignment with Vertical Offset

### 3.3.1.3.3 Suboptimal Positioning

If the WPP and WSU are positioned between the optimal working area and too far away, the WSU will not be able to support the maximum output voltage. In this instance, the system will report a Suboptimal Far status through Ethernet, CANopen® and also the WPB/WPP Status LED Panel:

- Positioning - Optimal LED - ON
- Positioning - Too Far LED - ON

If the WPP and WSU are positioned between the optimal working area and too close, the WSU will not be able to support the maximum output current. In this instance, the system will report a Suboptimal Close status through Ethernet, CANopen® and also the WPB/WPP Status LED Panel:

- Positioning - Optimal LED - ON
- Positioning - Too Close LED - ON

### 3.3.1.4 Operating Limits

1. Only 50 mm misalignment is accepted between WPP and WSU otherwise charging will not start.
2. Maximum output power is 30kW and minimum output power is approx. 300W.
3. Make sure to install the WPP and WSU at the same height within a tolerance limit of 50 mm (2 in) otherwise charging will not start.

### 3.3.2 Efficiency and Losses

Efficiency and losses are measured under best and worst conditions as given below:

**Condition 1:** Input 380 V<sub>AC</sub>/480V<sub>AC</sub>, Output 100V/300A (30kW), Misalignment 0mm, Air gap 105<sup>+-5</sup> to 155<sup>+-5</sup> mm (4.1<sup>+-0.2</sup>-6.1<sup>+-0.2</sup> in)

**Table. 5 Efficiency and Losses - Condition 1 (Best)**

System	Loss	Efficiency
WPB	650W	97,8%
WPP	350W	98,8%
WSU	500W	98,3%
Total	1500W	95,0%

**Condition 2:** Input 380 V<sub>AC</sub>/480V<sub>AC</sub>, Output 100V/300A (30kW), Misalignment 50mm Airgap 160mm.

**Table. 6 Efficiency and Losses - Condition 2 (Worst)**

System	Loss	Efficiency
WPB	1100W	96.3%
WPP	410W	98.6%
WSU	590W	98.0%
Total	2100W	93.0%

#### 3.3.2.1 Factors that Influence Losses

Following table gives information regarding the factors influencing the losses. When the input voltage raises losses at WPB goes down. Similarly, when the output voltage raises losses at WPB and WPP raises.

Criteria	Losses per Subsystem		
	WPB	WPP	WSU
Input voltage ↑	↓	-	-
Output voltage ↑	↑	↑	-
Output Power ↑	↑	↑	↑
Misalignment ↑	↑	↑	-
Airgap ↑	↑	↑	-

#### 3.3.2.2 Temperature of the WPP

As well as the ambient temperature, four other factors can influence the WPP temperature:

- Airgap, misalignment, output power and output voltage.
- Up to 40°C the WPP can run under all conditions with full power above 40°C a strong de-rating must be expected.

## 3.4 System Control Modes

The WCS has two methods for an external entity to control the charge process; External Commanded CANopen® and External Commanded Ethernet (Not Implemented).

The WCS is capable of delivering 300W to 30kW of power to the vehicle battery. To prevent overcharging of the battery, the vehicle or fleet management system (provided by others) is to control the charging process by enabling the charge, disabling the charge and providing routine voltage and current setpoints as required.

### 3.4.1 External Commanded CANopen®

The charging process is initiated and controlled by the vehicle Battery Management System (BMS). The WSU is connected to the BMS via the control interface (refer 4.3.4.2.1 Communications ) based on CANopen®.

This enables the exchange of status information and control messages between the BMS and the WSU, of which the WSU requests power from the WPU over a control loop.

#### 3.4.1.1 Charging with Configured System

1. Battery Power up.
2. Charger power up.
3. NMT-Master set Charger and Battery to “operational” state.
4. Charging is Running.

**ATTENTION:**

The Delta product will never switch automatic after restart, from “pre-operational” to “operational” state on CANopen®-side. Only NMT-Master controls the CANopen® devices states in its CANopen® network.

#### 3.4.1.2 Default CAN Bus Configuration

The WSU CANopen® interface is not pre-configured. This means that the WSU will need to be configured as necessary upon first use before interfacing to a BMS. It has no valid node-id (bus address) and would start with a default bitrate (125kbit/s). Details CiA-301.

Refer 3.5.3.4 User Configuration.

### 3.4.2 External Commanded Ethernet (Not Implemented)

The charging process is initiated and controlled by the Fleet Management System (FMS) or other similar system that controls the facility AMR/AGVs. The

WPB is logically connected to the FMS via the Ethernet service interface, with communications protocol based on HTML/JSON.

This enables the exchange of status information and control messages between the FMS and the WSU via the WPB & WPP, of which the WSU requests power from the WPU over a control loop.

This provides the customers the ability to enable their systems for Industry 4.0 and Industrial Internet of Things (IIoT) by controlling the charge process centrally.

**Note:** It is the responsibility of the FMS to know the status/needs of the battery/BMS.

The WPB Ethernet connectivity will allow for either a physical LAN interface for connecting directly to a customer network via field cabling or connect to a RF Access Point to connect to the customer wireless network (supplied and powered by others).

## 3.5 Communications

### 3.5.1 WPP & WSU Interface – Pad to Pad Link (PPL)

The communications interface between WPP and WSU is referred as Pad to Pad Link (PPL). In the default mode the WPP is chosen to be inactive and the WSU is actively looking for WPP using the PPL. Neither the WPP nor WSU are transferring/receiving power until there is a charging request via CANopen® or Ethernet. Also WPP and WSU are within nominal proximity (<160 mm) of each other and successful communication between the two has been established. If the communication is interrupted (i.e., vehicle/WSU moves away) then the power transfer stops.

### 3.5.2 WPB – Ethernet (Not Implemented)

#### 3.5.2.1 Overview

The Ethernet service interface will give the customer, the flexibility of retrieving data and controlling the WCS in the field. It also provides the customers, the ability to enable their systems for Industry 4.0 and Internet of Things (IoT).

The systems incorporating Ethernet will allow for a physical LAN interface for connecting to a customer network via field cabling to connect to the customer wireless network (if option chosen). Only the charger systems that are permanently fixed in place will have an Ethernet service interface. The Ethernet capability will be generic for many customer use cases including:

- Stationary Charger connecting to a WMS/FMS
- Stationary Charger connecting to an AMR/AGV
- WCS connecting to a WMS/FMS

An industrial Ethernet service interface is provided via an RJ45 connector. It allows the user to,

- Lab use
- System startup use
- Routine test Support
- Customer use
- Service use
- To do Firmware-update
- Data-Logging read-out
- Set Date and Time
- Any errors can be seen

Power over Ethernet is not supported. Ethernet controller is set to sleep mode.

### 3.5.2.2 Protocol

See reference document Ethernet Control Protocol, Section Protocols.

### 3.5.2.3 Webpage

The WPB has an embedded webserver, which allows a User to access the WCS information, data and settings using a web browser such as Chrome. It is similar to a home Wireless Router webpage.

## 3.5.3 WSU - CANopen®

### 3.5.3.1 Overview

For controlling the WCS with External Commanded CANopen® mode, the WSU to BMS CANopen® interface is to be configured. The following instructions detail the necessary steps to establish a basic form of the communications interface to start and stop a charge cycle using Process Data Objects (PDO), as defined within CiA 419. Refer to 4. CANopen® Protocol Specification for detailed information including the Object Dictionary.

### 3.5.3.2 Protocol

This section explains the CANopen® protocol in order to control and monitor the charging process. The protocol complies with CANopen® standards CiA301.

#### 3.5.3.2.1 Bitrate

Bitrate explains the number of bits processed in a given unit of time. Considering two different cases, below tables shows the supported bit rates.

**Case 1:** Sample Point 87.5% (Recommended by CiA-301)

Item	Supported Bitrate
1	125 kBit/s
2	250 kBit/s
3	500 kBit/s

**Case 2:** Sample Point 80% (optional for special network scenarios, future implementation)

Item	Supported Bitrate
1	125 kBit/s
2	250 kBit/s
3	500 kBit/s
4	1000 kBit/s

#### 3.5.3.2.2 How to initialize CANopen®

The product out-the-box will have a default bitrate of 125kbit/s and has no configured node ID. These can be updated using the Layer Settings Services (LSS) defined in CiA 305.

The product needs to be configured with the following parameters:

- Valid and free Node-ID in the CANopen® network
- Valid bitrate according to the other devices in the CANopen® network

### 3.5.3.2.3 How to Control the Charger via CANopen®

The product would need the following minimum controls:

#### Charger RPDO1 Mapping:

COB-ID	Process data in binary code														
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7							
RPDO1 200h + Node-Id	Battery status CiA-419 (Object: 0x6000)	Charge current request 1/16A CiA-419 (Object: 0x6070)	Not used												
COB-ID of Receive- PDO 1 (RPDO1)	0x220, (0x200 + Node-Id)														
Transmission Type	0xFF (details see CiA-301)														
Timeout	If timeout is reached charging is stopped (charge request = 0) Battery must send this cyclic message within the timeout limit.														
Number of mapped objects	2														

#### Charger TPDO1 Mapping:

COB-ID	Process data in binary code														
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7							
TPDO1 180h + Node-ID	Charger status CiA- 419 (Object: 0x6001)	Not used													
Transmission type:	0xFF														
Inhibit Time (1/10ms):	0														
Event Timer:	200 ms														
Sync counter:	0														

**Corresponding Battery TPDO1 Mapping:**

COB-ID	Process data in binary code															
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7								
TPDO1 200h + Node-ID of charger	Battery status CiA-419 (Object: 0x6000)	Charge current request 1/16A CiA-419 (Object: 0x6070)	Not used													
Transmission type:	0xFF															
Inhibit Time (1/10ms):	0															
Event Timer:	200 ms															
Sync counter:	0															

**Corresponding Battery RPDO1 Mapping:**

COB-ID	Process data in binary code								
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
RPDO1 180h + Node-ID of charger	Charger status CiA- 419 (Object: 0x6001)	Not used							

<b>ATTENTION:</b> 	This is the minimum configuration for a charge process. Please add additional objects for your specific project. The charge process occurs only, when the NMT-Master commanded the charger and battery to enter NMT operational state.
--	--

**Byte 0:** Battery status (here must be set to "1" for a valid charge request, is "0" then no charge request).

**Recommendation:** setup RPDOs on the charger to receive TPDOs sent cyclically by the battery, with the Max current and Max voltage and battery ready being broadcast.

The charger can receive these values in a number of formats (see Objects in EDS file) can be used according to the common voltage/current data scaling available and broadcast by CANopen® batteries).

The charger will not operate unless the NMT master has commanded the charger to enter NMT state Operational.

**The normal sequence of operation is:**

- **Un-configured System:**

- Setup Node-ID and bitrate, Layer Settings Services (LSS) defined in CiA 305.
- Configuration of TPDO and RPDO (charger and battery), refer 3.5.3.2.3 How to Control the Charger via CANopen®.
- Save configuration (object: 0x1010, details see CiA-301).
- NMT-Master commanded charger and battery to enter NMT operational state.
- Check the charger and battery is operating.

- **Configured System:**

- NMT-Master commanded charger and battery to enter NMT operational state
- Check the charger and battery is operating

**NOTE:** A CANopen® virtual node can be setup and used to send set points to the WSU for assessment purposes if a battery / BMS is not available.

#### 3.5.3.2.4 Charging Data Example

**Precondition:** Delta-product with Node-Id: 0x20

<b>ATTENTION:</b> 	For a controlled charge, make sure to configure and use the Receive PDO only. For examples refer 3.5.3.2.3 How to Control the Charger via CANopen®.
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#### 3.5.3.3 GUI

The charger is designed to operate with commercially available BUS analyzer tools that supports CANopen®.

For example **Emotas CANopen® Device Explorer** to communicate with WSU.

### 3.5.3.4 User Configuration (Example: Emotas CANopen® Device Explorer)

1. Power the WSU via connection to an battery with the appropriate voltage and connect the PC/Notebook to the CANopen®-Network from the WSU (Example: PCAN).
2. Make sure to install the **PEAK System Installation package** from here [PCAN-USB: PEAK-System](#), if it is not already installed.  
From Windows Start, open **Emotas CANopen® Device Explorer**.

<b>ATTENTION:</b> 	<ul style="list-style-type: none"><li>• At the bottom right corner of the <b>CANopen® Device Explorer</b> window user could see  <b>Disconnected</b>, this means connection is not yet done.</li><li>• <b>Emotas CANopen® Device Explorer</b> is just for an example.</li></ul>
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3. At first, go to **Connection -> CAN Interface Settings**, a window pops up.
4. In **Current interface -> Interface Type** -> select **PCAN Advanced** from drop down list and in **Bitrate** select **125kbit/s** -> click on **Add new interface**.
5. Now, select the newly added PCAN by clicking on the **Primary** column of the newly added PCAN -> next **Close** the window.
6. Import the EDS file supplied by Delta, **File -> Load EDS -> WSU.eds**.
7. Once the EDS is loaded, click on **Connect** button .
8. Once the connection is done, user would see  **PCAN Advanced - PCAN USB 16 (125 kBit/s) - 0 %**.
9. Now go to **PDO Configuration** tab  
**Note:** RPDO (Receive-PDO, cyclic messages from battery to charger) and TPDO (Transmit-PDO, cyclic messages from charger to battery).
10. In PDO segment select **TPDO 1 (0x1800/0x1a00) - dynamic**.
11. In PDO Properties (EDS) give values as:  
**Note:** Item 1 to 5 in the given table is also described in CiA-301.

Item	Description	Values
1	COB-ID	0x1A0  <b>Note:</b> The battery must have a RPDO with this COB-ID. Otherwise the battery would not receive the data in the message.
2	Transmission Type	0xFF
3	Inhibit Time (1/10 ms)	0
4	Event Timer (ms)	User defined (Example 200 ms)
5	Sync Counter	0x0

12. In **PDO Mapping Table (EDS)** table double click on each **Name** to delete the default objects.
13. Now on the left side open the **Manufacturer Segment / Device Profile Segment** tree. Drag and drop the required objects.
14. Repeat this process until user could see the required objects, in the **PDO Mapping Table (EDS)**.
15. Based on number of objects available in the table, give the number value in **Number of mapped objects**. Give 4 if the number of objects in the PDO Mapping Table is 4.
16. Now Click on **Write to Device** followed by **Read from Device**.
17. Now go to **Network** tab -> click on **Update Network Overview**, let it complete by 100%.
18. Once the desired Device name is displayed, user could stop the process by clicking on **Stop** button.
19. Select the desired Device -> Start **Heartbeat** to update NMT state automatically then click on **Start Node**.
20. User could quit the process, **File -> Quit**.  
Note: For RPDO and TPDO examples refer 3.5.3.2.3 How to Control the Charger via CANopen®.

## 4 Installation

The User type installing the WPB and WPP within the end facility is different from a User type installing the WSU on a vehicle, which would typically happen in a manufacturing plant refer to Section 1.2.1 Access to the System. As such, the instructions below cater for this.

### 4.1 WPB

#### 4.1.1 Safety Instructions

	<b>Electric shock</b> <ul style="list-style-type: none"><li>• Make sure that there is no power supply to WPB for the installation process, it may lead to death of Personnel.</li><li>• Once the WPB is installed and operating, it should not be opened. In case of emergency, only skilled persons should open it. Make sure to disconnect the main power supply and wait for 30 min before opening WPB.</li></ul>
	<b>Electric shock</b> <p>Do not connect the WPB to any public grid, always connect to industrial grid. On public grid, our system will work as intended, but it might cause malfunction of other devices.</p>
	Connect to ground before connecting it to power supply.
	<b>Heavy loads</b> <p>The WPB is heavy. To avoid strain or injury, take care when lifting and carrying the WPB and use lifting and transport aids as required.</p>
	<b>Material damage</b> <p>Do not use powder or foam fire extinguishers on WPB when there is a fire around, it is recommended to use Co2 fire extinguisher or something similar otherwise WPB may get damaged.</p>
	The WPB does not have any serviceable parts except fans and fuses. Once installed and in operation the user must never open WPB.

<b>ATTENTION:</b> 	<p>WPB could be disconnected using Supply Disconnecting Device (SDD) and must be disconnected only in following conditions,</p> <ul style="list-style-type: none"><li>• in case of an emergency</li><li>• for maintenance/service (replacement of fans or fuses)</li></ul> <p>Disconnecting is recommended only when charging process is not happening. A skilled person could also disconnect the WPB using supplementary fuses in the building or area.</p> <ul style="list-style-type: none"><li>• In Europe - As SDD a CeKon connector could be used in order to disconnect the WPB.</li></ul> <p>In North America - An SDD in accordance with NFPA70 and C22.1-15 must be part of the building infrastructure.</p>
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#### 4.1.2 Special Tools & Equipment

Following table gives the information of the special tools used while installing WPB.

Item	Special Tool	Specification
1	T25 Driver	-

#### 4.1.3 Installation Conditions

Item	Conditions	Description			
1	Location	The WPB must be installed in weather protected temperature-controlled enclosed location.			
2	Fused supply line with SDD (Supply Disconnecting Device)	For installation and operation of the WPB, a fused supply line with a SDD according to the following specifications is required,			
		Region	Supply Voltage	Fuse	SDD
	Europe	400 V/50 Hz	63 A	CEKON (IEC 60309) plug	
	US and Canada	480 V/60 Hz	50 A	A Switch box in accordance with NFPA 70 and C22.1-15.	
3	Power supply cord	The power supply cord must have a minimum conductor size of 10 mm <sup>2</sup> /6 AWG (refer to 3.2.1.2 AC Input). Use only copper cord and make sure to comply with wiring rules of the respective country where equipment is to be installed.			

Item	Conditions	Description
4	Connection cable to WPP	The power cable between WPP and WPB has a length of 5 m (16.4 ft). The installation positions must be chosen accordingly. If the WPP is positioned closer to the WPB, the slack cable can be coiled up. Shortening of the cable after production is not possible and must not be attempted.
5	Ventilation air flow	Make sure to maintain a proper ventilation to allow free flow of air to and from the fan outlets and air vents of the WPB.
6	Operating noise levels	The WPB can emit noise levels up to 75 dB(A), depending on the speed of the ventilation fans. The installation position of the WPB must be chosen accordingly (industrial workplace).

#### 4.1.4 Installation Procedure

<b>WARNING:</b> 	Only skilled persons should install WPB.
<b>CAUTION:</b> 	WPB is provided with M8 threaded holes (5) at the top, that can be used with eyebolts for lifting purposes (supplied by others), See Figure. 20. Replace provided bolts after eyebolts are removed to retain ingress protection.
<b>CAUTION:</b> 	WPB shall be fixed only on the floor with 4 screws with nominal diameter of 8 mm through the floor fixing brackets. The height of each floor fixing bracket can be adjusted by rotating them.

1. Make sure to read and understand all the safety messages. Refer 4.1.1 Safety Instructions.
2. On the left hand side of the WPB, remove the twelve screws (2) and remove middle cover plate (1) and lower cover plate (3).  
**NOTE:** Earth conductors do not need to be removed from cover plates.
3. On the lower cover plate (3) there is an opening (4) for a cable gland or conduit.

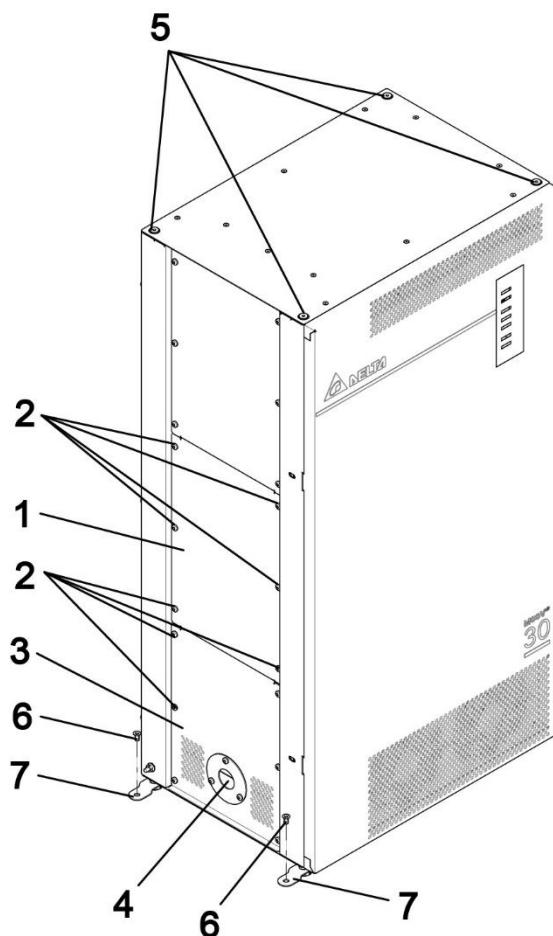


Figure. 20 WPB Cover Plates

Item	Description	Item	Description
1	Middle cover plate	5	M8 Eyebolt thread holes
2	Screws M5 Eco-fix	6	Screw M8
3	Lower cover plate	7	Floor Fixing Brackets
4	Cable Gland or Conduit Opening		

4. Choose the suitable opening for installation as per your requirement:

**Note:** Use C2 without connection ring, when a cable/conduit diameter is in between 34.8 mm to 50 mm.

**Note:** Use C1 with connection ring, when a cable/conduit diameter is below 34.8 mm.

C1 with connection ring	C2 without connection ring
Diameter: 34.8 mm	Diameter: 50.0 mm
For cable gland/conduit: <ul style="list-style-type: none"><li>• M32</li><li>• 1 inch</li></ul>	For cable gland/conduit: <ul style="list-style-type: none"><li>• PG36</li><li>• 1.5 inch</li></ul>



Figure. 21 WPB with and without Connection Ring

<b>DANGER:</b> 	Make sure that the cable gland matches the diameter of cable in order to prevent possible removal or pushing the cable in the unit.
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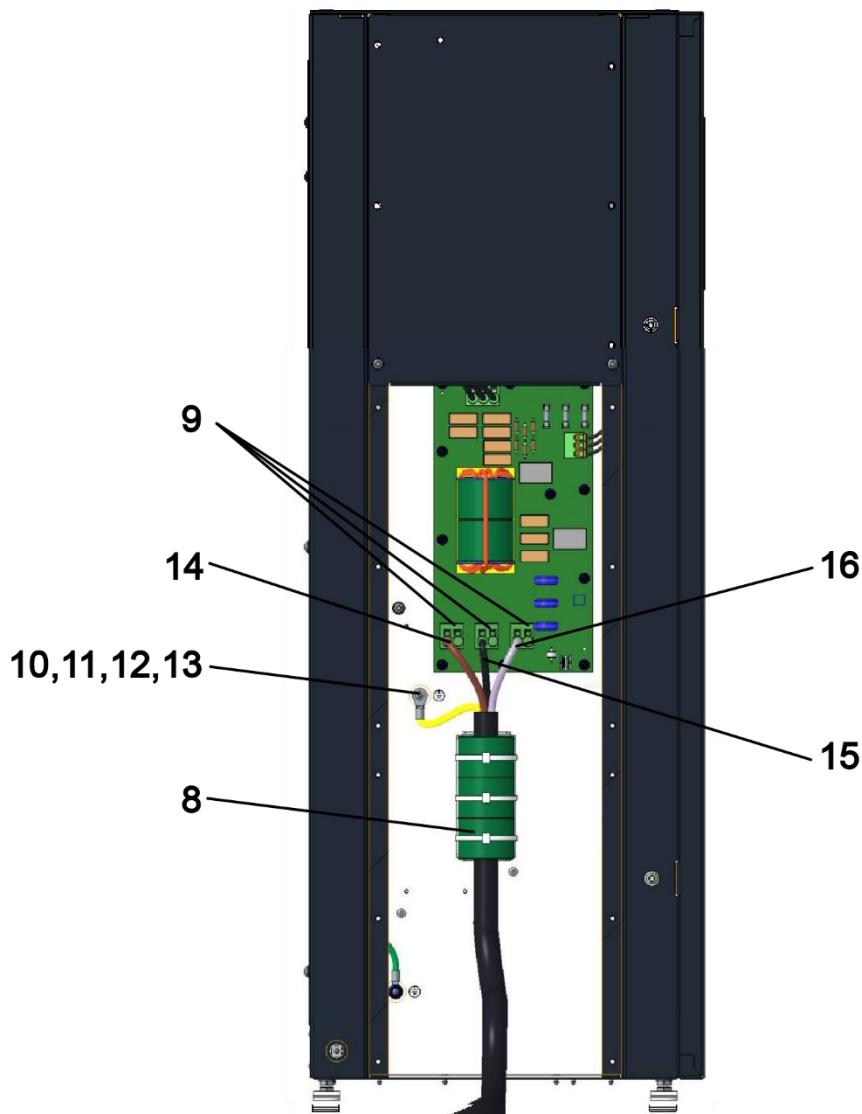


Figure. 22 Feeding the Cable through Cable Gland (view without Covers)

**Note:** EU wire colors are shown in Figure. 22.

**Note:** PE/GND wire shall be longer than supply wires.

Item	Description	Item	Description
8	Ferrite ring core unit	13	M6 Nut
9	Terminal block	14	L1 wire
10	M6 Protective ground stud	15	L2 wire
11	M6 PE/GND cable lug	16	L3 wire
12	Contact washer		

5. Attach the cable gland or conduit and feed the cable through to reach the ferrite ring core unit (8), see Figure. 22.  
**Note:** Make sure not to damage the lower cover plate (3).
6. Carefully feed the cable through the ferrite ring core unit (8).

7. Pull enough cable through the ferrite ring core unit (8) to reach the connections at the protective ground stud (10) and the terminal block (9) without causing any tension.

	<b>Electric Shock</b> <ul style="list-style-type: none"><li>• Always connect the PE/GND conductor before connecting the power conductors.</li><li>• The system leakage current is 150 mA<sub>RMS</sub>.</li><li>• When WPB is up and running, there are high touch currents which may lead to electric shock or injury to personnel.</li></ul>
<b>Note:</b>	<ul style="list-style-type: none"><li>• The minimum conductor size for the PE/GND connection is 10 mm<sup>2</sup>/6 AWG.</li><li>• PE/GND wire shall be longer than L wires.</li></ul>

8. Tighten the cable gland and attach the lower cover plate (3) using the six screws (2) (Torque T25 driver).
9. Connect the M6 PE/GND cable lug (11) to the protective ground stud (10) with contact washer (12) and nut (13), torque (10 Nm/14 lb-ft).
10. Make sure that the M6 PE/GND cable lug (11) is attached firmly.
11. Connect the three L wires (L1, L2, L3) (14,15,16) to the terminal block (9) by stripping them approx. 15 mm, attach ferrules and insert the ends of the wires into the three connection points in the terminal block (9).
12. Make sure that the L wires (L1, L2, L3) (14,15,16) are tight enough by pulling them carefully.
13. If the cable contains Neutral (N) wire, snip it off and isolate the end to prevent unwanted contact with the WPB.
14. Attach the middle cover plate (1) using six screws (2) (Torque T25 driver).
15. Now fix the WPB to the floor using four screws (6) with nominal diameter of 8 mm through the floor fixing brackets (7).

#### 4.1.5 Disconnecting the WPB

WPB could be disconnected using Supply Disconnecting Device (SDD) and must be disconnected only in following conditions,

- in case of an emergency
- for maintenance/service (replacement of fans or fuses)

Disconnecting is recommended only when charging process is not happening. A skilled person could also disconnect the WPB using supplementary fuses in the building or area.

- In Europe - An SDD CeKon connector could be used in order to disconnect the WPB.
- In North America - An SDD in accordance with NFPA70 and C22.1-15 must be part of the building infrastructure.

#### 4.1.6 Ethernet Connection (Not Implemented)

The RJ45 connector for the Ethernet service interface is provided on the right hand side of the WPB at the top corner. The interface is compatible with CAT5 cable or greater, with a maximum cable length of 100m. On the right hand side of the WPB, there are cut-out holes that cable ties (or similar) can be used for cable management purposes.

#### 4.1.7 Stack Light Installation (Optional)

A stack light can be installed by a facility integrator on the WPB which allows the user to know the current status of the system. It could be connected to the WPB with two M8 threaded screws (pitch 34 mm) with a max length of 15 mm. Stack light of type ROGB/24V are supported, e.g. Tend Technology TPTL4-L7ROGB-S. The connection terminal for the Stack Light is provided on the right hand side of the WPB at the top corner.

Alternatively, the Stack Light could also be mounted away from the WPB, e.g. on a wall, frame or in closer proximity to the WPP etc. In this case, the total length of the connection cable between WPB and Stack Light must not exceed 3m (9.84 ft).

The Stack Light interface comprises of a 6-way Phoenix connector on the WPB with the mating half attached (P/N 1748011). On the right hand side of the WPB, there are mounting points that cable ties (or similar) can be used for cable management purposes.

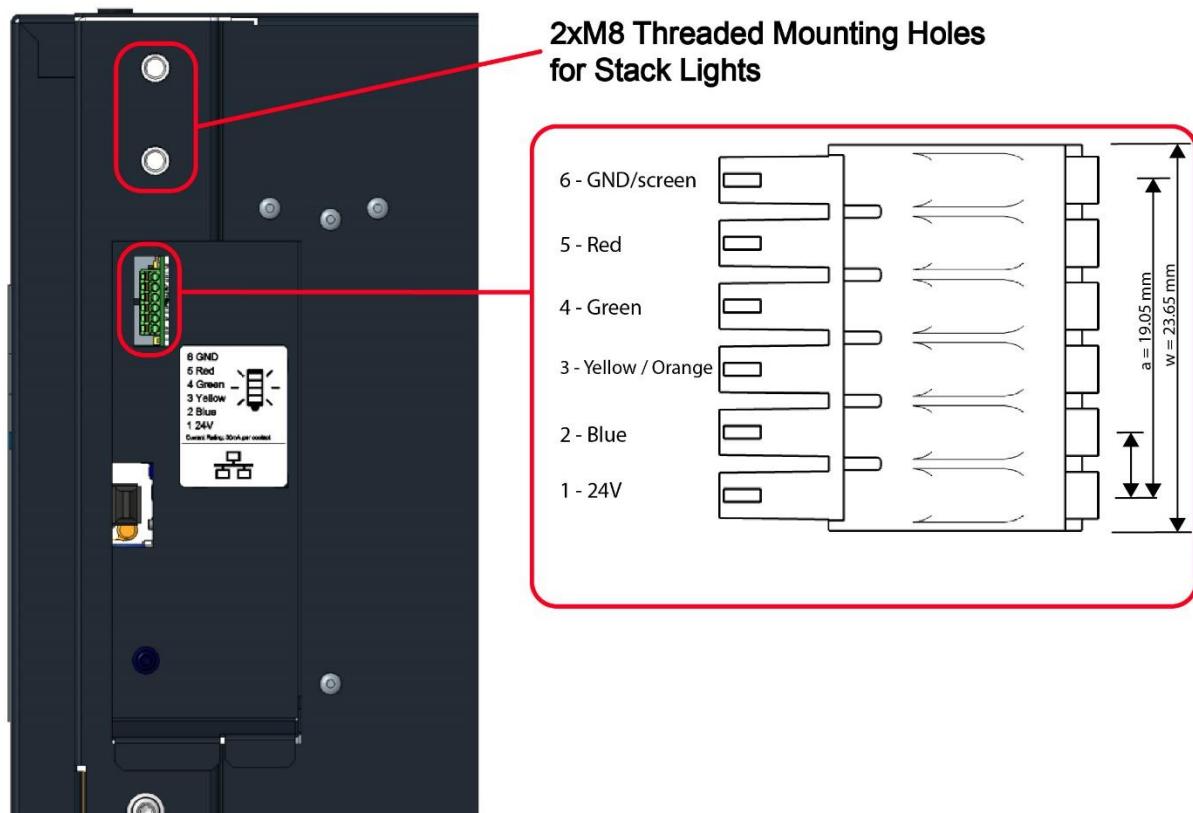


Figure. 23 WPB Stack Light Connection Terminal

The pin connections of the Stack Light interface are as follows:

Pin	Name	Description
1	24V	Common 24 V <sub>DC</sub> supply
2	Blue	Open collector connection for Blue light, 30 mA
3	Yellow / Amber	Open collector connection for Yellow / Amber light, 30 mA
4	Green	Open collector connection for Green light, 30 mA
5	Red	Open collector connection for Red light, 30 mA
6	Gnd/Screen	WPB ground/screen connection

#### 4.1.8 Power Up & Health Checks

It is best practice to install and connect the WPB and WPP prior to powering up and performing health checks.

### 4.2 WPP

#### 4.2.1 Safety Instructions

	<p><b>Electromagnetic Field (EMF)</b></p> <ul style="list-style-type: none"><li>• The Wireless Primary Pad (WPP) and Wireless Secondary Unit (WSU) produces a potentially harmful magnetic field during the charging process.</li><li>• Make sure to maintain a safe distance from WPP when charging is in progress. For more details about the safe distance see <b>2.4.2 EMF Safety Instructions</b>.</li><li>• Use of the wireless charger may affect or impair the operation of any medical devices, such as an implantable cardiac pacemaker. Check with your medical device manufacturer concerning the effects that wireless charging may have on such devices before using the wireless charger.</li><li>• Electromagnetic field exposure to pregnant women and Children is strictly forbidden.</li><li>• Advise all user types about safety distances and affix appropriate warnings.</li><li>• Warning signs should be clearly displayed at the charging area.</li><li>• Do not install or operate the system in the public area.</li><li>• Electronic objects such as cell phones and hearing aids may get damaged.</li></ul>
---	--

<b>WARNING:</b> 	<b>Electromagnetic Field (EMF)</b> Make sure that there is no WSU in charging range when the installation of the WPP is carried out, particularly when connecting the WPP cable to the WPB. Charging could begin unexpectedly, which enables the magnetic field.
<b>WARNING:</b> 	<b>Electric Shock</b> Disconnect all cable connections to WPP to make sure that there is no power supply to WPP for the installation process, otherwise there could be a danger of electric shock.
<b>CAUTION:</b> 	<b>Sharp edges</b> The back plates of the WPP have sharp edges. Protective gloves should be worn during the handling and installation of the WPP.
<b>CAUTION:</b> 	<b>Heavy loads</b> The WPP is heavy. To avoid strain or injury, take care when lifting and carrying the WPP and use lifting and transport aids as required. See section 3.2.2.1.
<b>CAUTION:</b> 	<b>Hot surfaces</b> <ul style="list-style-type: none"><li>• Do not touch the WPP while charging is in progress.</li><li>• Do not touch the WPP for at least 30 minutes (cooling time) after the charging process is finished.</li></ul> Make sure to wear safety gloves while handling the subsystems after charging.
<b>ATTENTION:</b> 	<b>Material damage</b> Output cables shall not be exposed to outdoor environment.
<b>ATTENTION:</b> 	<b>Material damage</b> Do not to alter the cables of the WPP otherwise the system will not operate correctly.
<b>ATTENTION:</b> 	If the WPP needs to be replaced in the field, best practice is to disconnect the Supply Disconnecting Device (SDD) of the WPB before replacing WPP.

**ATTENTION:****Charging**

The WPP does not have any serviceable parts and must never be opened.

#### 4.2.2 Special Tools & Equipment

No special tools are required while installing WPP.

#### 4.2.3 Installation Conditions

Item	Conditions	Description	
1	Location	The WPP is designed to withstand harsh climatic conditions, however a solar shield is recommended to protect it from direct sunlight, as overheating of WPP may result in de-rating of the output power.	
2	Position	Make sure to install the WPP vertically on the wall.	
		Alignment of WPP with WSU	Make sure to install the WPP and WSU within a tolerance limit of 50 mm (2 in) of the pads magnetic centers (both pads have horizontal and vertical markers which indicates center) otherwise wireless power transfer is not possible. Also consider applicable vehicle tire wear that may change the height of the WSU over time. See Figure. 19.
		Cable connection	The length of the power cable between WPB and WPP has a length of 5 m. Choose the installation positions of WPB and WPP accordingly. If the WPP is positioned closer to the WPB, the slack cable can be coiled up. Shortening of the cable after production is not possible and must not be attempted.
		Installation	Make sure to use appropriate screws and dowels while mounting the WPP to the supporting wall/fixture with respect to the WPP weight.

#### 4.2.4 Installation Procedure

**Note:** The lifting hole provided on the WPP cannot be used when it is mounted on the wall.

**Note:** WPP shall be installed only in vertical-landscape orientation, not in portrait orientation.

1. Make sure to read and understand all the safety messages. Refer **4.2.1 Safety Instructions** and **2.4.2 EMF Safety Instructions**.
2. Remove the metal mounting strip (2) from WPP packaging (see Figure. 24).

3. Mark and drill three holes on the mounting wall/fixture in order to install the mounting strip (2). The mounting strip has 9 mm diameter holes.
4. Mark and drill two holes on the mounting wall/fixture in order to attach the WPP (1). The mounting strip has 9 mm diameter slots.
5. Attach the mounting strip (2) to the mounting wall/fixture using suitable stainless steel screws e.g. 3x M8 hexagon head screws. Make sure that the screws are tightened firmly.
6. Hang the WPP (1) onto the mounting strip (2). Refer to section 4.2.1 Safety Instructions.
7. Attach the WPP (1) to the mounting wall/fixture using suitable stainless steel screws e.g. 2x M8 hexagon head screws. Make sure that the screws are tightened firmly.
8. Make sure that WPP is fixed in a level position.

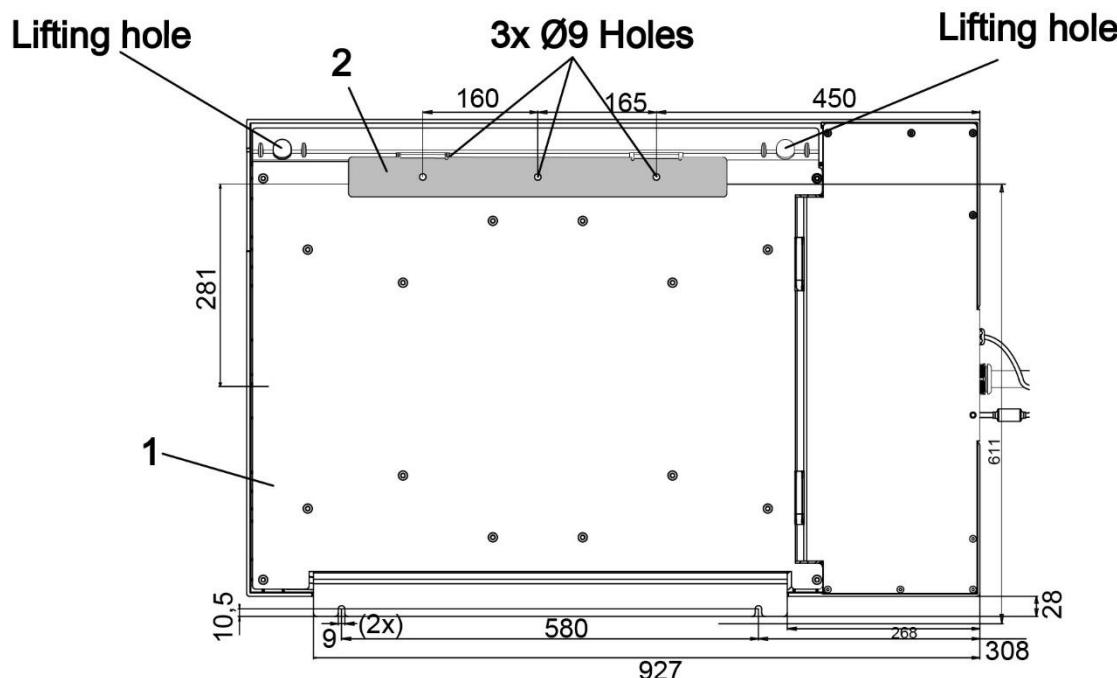


Figure. 24 Installation of WPP – Rear View

Item	Description
1	WPP
2	Mounting strip

#### 4.2.5 Connecting WPP to WPB

**WARNING:****Electric shock**

Make sure to disconnect the Supply Disconnecting Device (SDD) of the WPB before connecting WPP to WPB, as it may lead to death of Personnel.

The connector for the WPP cable is on the right side of the WPB, see Figure. 25 and Figure. 26. Connect the cable as follows:

1. Make sure to read and understand all the safety messages. Refer 4.2.1 Safety Instructions.
2. Connect the heavy duty WPP connector onto the WPB and tighten the connector screws with a screw driver to secure the connection.

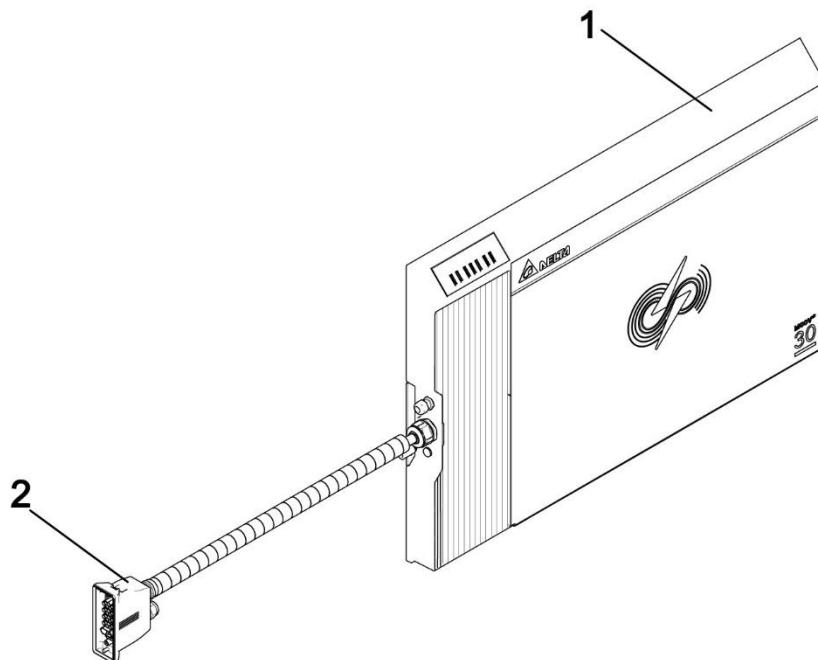


Figure. 25 Connecting WPP Cable to WPB – Part 1

Item	Description
1	WPP
2	Heavy duty connector

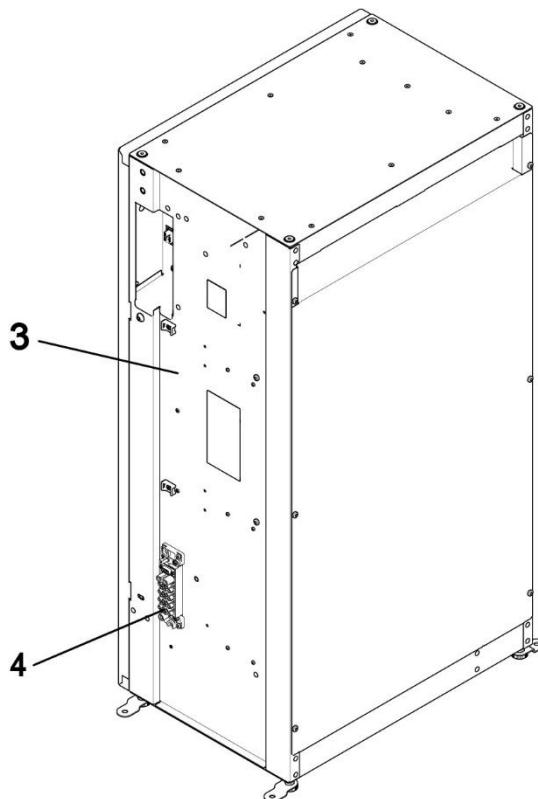


Figure. 26 Connecting WPP Cable to WPB – Part 2

Item	Description
3	WPB
4	WPP Connector Socket

#### 4.2.6 Power Up & Health Checks

1. Verify that the previous WPB and WPP installation instructions have been carried out successfully.
2. Enable the Supply Disconnecting Device (SDD) connected to the WPB AC Input.
3. Observe that the Power LED is illuminated green on the WPB and WPP Status LED Panels.
4. Observe that there is no other LED illuminated on the WPB and WPP Status LED Panels, including the WPU Fault LED.
5. Observe that the green lamp is illuminated on the Stack Light (if fitted).
6. If the WPU Fault LED and/or the Stack Light Fault is illuminated, refer to section 6.4 Firmware Updates.
7. The WPB Ethernet service interface can now be accessed, see section 3.5.2. Log onto the Ethernet webpage.

8. Verify that the WPB and WPP SW versions by can read and are the latest revisions.
9. Verify that the WPB and WPP are not reporting any Warnings/Faults.
10. Check and/or modify the User Configurable parameters as required.
11. Log out of the Ethernet webpage.

## 4.3 WSU

### 4.3.1 Safety Instructions

	<b>Electric shock</b> Only skilled person shall install the WSU.
	<b>Electric shock</b> Make sure to disconnect or switch off all the power sources before installing the WSU.
	WSU cables should not be connected in the vicinity of WPP to avoid the danger of electric shock.
	<b>Electric shock</b> <ul style="list-style-type: none"><li>• Make sure to disconnect the power to WSU before removing it from Forklift for service or maintenance.</li><li>• Always refer to Forklift user manual as power cables are fixed to the batteries.</li><li>• Only skilled person shall remove WSU from forklift and shall make sure that WSU is completely disconnected from all power sources.</li></ul>
	<b>Electromagnetic Field (EMF)</b> WSU cables should not be connected in the vicinity of WPP to avoid the danger of magnetic field.
	<b>Electromagnetic Field (EMF)</b> <ul style="list-style-type: none"><li>• The Wireless Primary Pad (WPP) and Wireless Secondary Unit (WSU) produces a potentially harmful magnetic field during the charging process.</li><li>• Make sure to maintain a safe distance from WPP when charging is in progress. For more details about the safe distance see <b>2.4.2 EMF Safety Instructions</b>.</li><li>• Use of the wireless charger may affect or impair the operation of any medical devices, such as an implantable cardiac pacemaker. Check with your medical device manufacturer concerning the effects</li></ul>

	<p>that wireless charging may have on such devices before using the wireless charger.</p> <ul style="list-style-type: none"> <li>• Electromagnetic field exposure to pregnant women and Children is strictly forbidden.</li> <li>• Advise all user types about safety distances and affix appropriate warnings.</li> <li>• Warning signs should be clearly displayed at the charging area.</li> <li>• Do not install or operate the system in the public area.</li> <li>• Electronic objects such as cell phones and hearing aids may get damaged.</li> </ul>
	<p><b>Polarization</b></p> <p>Connect the DC output wires properly with correct polarization:</p> <ul style="list-style-type: none"> <li>• RED → connect with positive (+) pole</li> <li>• BLACK → connect with negative (-) pole</li> </ul> <p>The WSU will not start the charge process if it detects a reverse polarization.</p>
	<p><b>Charging</b></p> <p>Make sure to install the WSU at the same height as the WPP and within a tolerance limit of 50 mm otherwise charging is not possible.</p>
	<p>The WSU does not have any serviceable parts and must never be opened.</p>

#### 4.3.2 Special Tools & Equipment

No special tools are required while installing the WSU.

#### 4.3.3 Installation Conditions

Item	Conditions	Description	
1	Location	Make sure to install the WSU vertically on any side of the vehicle.	
2	Position	Alignment of WSU with WPP	Make sure to install the WSU and WPP within a tolerance limit of 50 mm (2 in) of the pads magnetic centers (both pads have horizontal and vertical markers which indicates center) otherwise wireless power transfer is not possible. Also consider applicable vehicle tire wear that may change the height of the WSU over time. See Figure. 19.
		Cable connection	The WSU cable connections must be protected from access to unskilled persons.

Item	Conditions	Description	
		Installation	Make sure to use appropriate screws and dowels while mounting the WSU to the vehicle with respect to the WSU weight.
3	Magnetic field		The magnetic field generated during the charging process extends behind the WSU and could interfere with vehicle electronics, and/or present a health risk to the driver, depending on their location, for further information see section 2 Safety & Regulations and <b>Appendix B – Stray Field Distances</b> .

#### 4.3.4 Installation Procedure

##### 4.3.4.1 Mounting the WSU on the Vehicle

1. Make sure to read and understand all the safety messages. Refer 4.3.1 Safety Instructions.
2. Make sure to disconnect all the cable connections to WSU (1). Refer 4.3.4.2 WSU Cable Connections.
3. Remove the screws (3) and remove the edge cover (2) from the WSU (1).
4. There are 8 mounting holes ( $\varnothing 7$  mm), four at the top edge and four at the bottom edge of the WSU (1). See Figure. 28.
5. Install the WSU (1) to the vehicle with 8xM6 stainless steel screws (4) (strength class  $\geq 8.8$ )  
**Note:** Make sure to select the screw length based on the installation vehicle requirements.
6. Make sure that all the connections are tight.
7. Install the edge cover (2) with screws (3), torque 0.6 Nm/0.84 lb-ft.

**ATTENTION:**

- WSU could also be installed on a metal sheet which acts as a heat sink, this improves the heat dissipation during the charging process.
- Mounting the WSU with a heat sink would increase the operation time at full output current before de-rating occurs (refer 3.3.1 Output Power and De-rating).

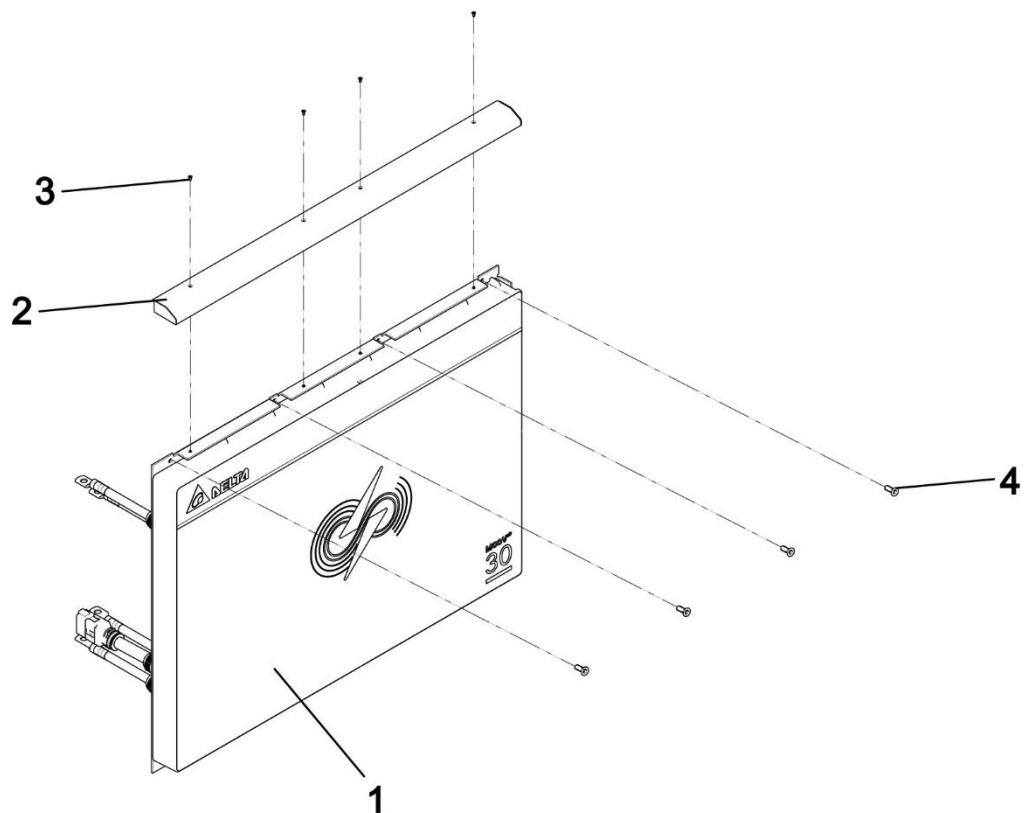


Figure. 27 Mounting WSU on Vehicle

Item	Description	Item	Description
1	WSU	3	Screws M3
2	Edge Cover	4	M6 stainless steel screws

## Mounting Hole 4x Ø7 mm

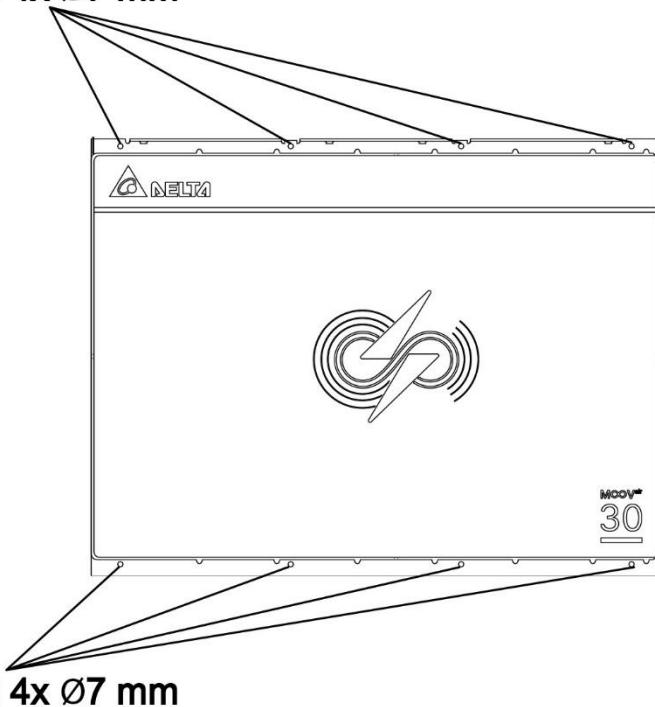


Figure. 28 WSU Mounting Holes

### 4.3.4.2 WSU Cable Connections

	<p><b>Electric shock</b></p> <p>Make sure to power off WSU before disconnecting the cables. The output voltage of battery is very high so make sure to take appropriate measures before working on cables.</p> <ul style="list-style-type: none"><li>The WSU cable connections (battery connection cables and control cable) must always be installed and serviced only by skilled persons.</li></ul>
	<p><b>Electric shock</b></p> <p>Dangerous voltage levels are output by the WSU during charging.</p> <ul style="list-style-type: none"><li>Do not handle the cable connections during the charging process.</li><li>Make sure to disconnect the WSU from all electrical connections during installation or service of the cable connections. Disconnecting WSU from battery is done in reverse order.</li></ul>

1. Make sure to read and understand all the safety messages. Refer 4.3.1 Safety Instructions.
2. Connect the DC output cables RED (1) to the positive pole (+) of the battery and BLACK (2) to the negative pole (-) of the battery.

3. Connect the control cable (3) to the BMS. The control cable (3) connection on the WSU is of type Deutsch receptacle DT04-12PA (refer 3.2.3.3 and 4.3.4.2.1), which requires a mating half of Deutsch plug DT04-12PA-C015 (refer 8.2 Accessories).

<b>ATTENTION:</b> 	<ul style="list-style-type: none"><li>The AUX power input connections in the control interface (Pin1 AUXIN+/Pin2 AUXIN-) must be connected to the respective poles of the battery.</li><li>The AUX power input connection to Pin1 (AUXIN+) of the control interface must be provided with a 2A fuse (short-circuit protection) with breaking capability appropriate for the respective battery.</li><li>The charging process cannot begin until the battery and the control interface are both connected.</li><li>The WSU will not initialize when there is no battery connected or when the battery voltage is less than 23V of the rated battery voltage.</li><li>The vehicle AUXIN- shall have the same potential as the DC Power OUT-.</li></ul>
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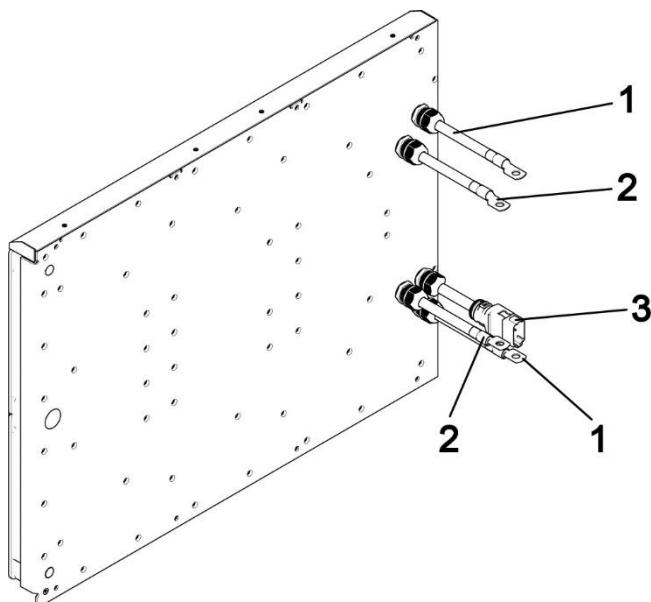


Figure. 29 WSU Cable Connections

Item	Description	Item	Description
1	Power output cable RED (+)	3	Control cable
2	Power output cable BLACK (-)		

#### 4.3.4.2.1 Communications Interface

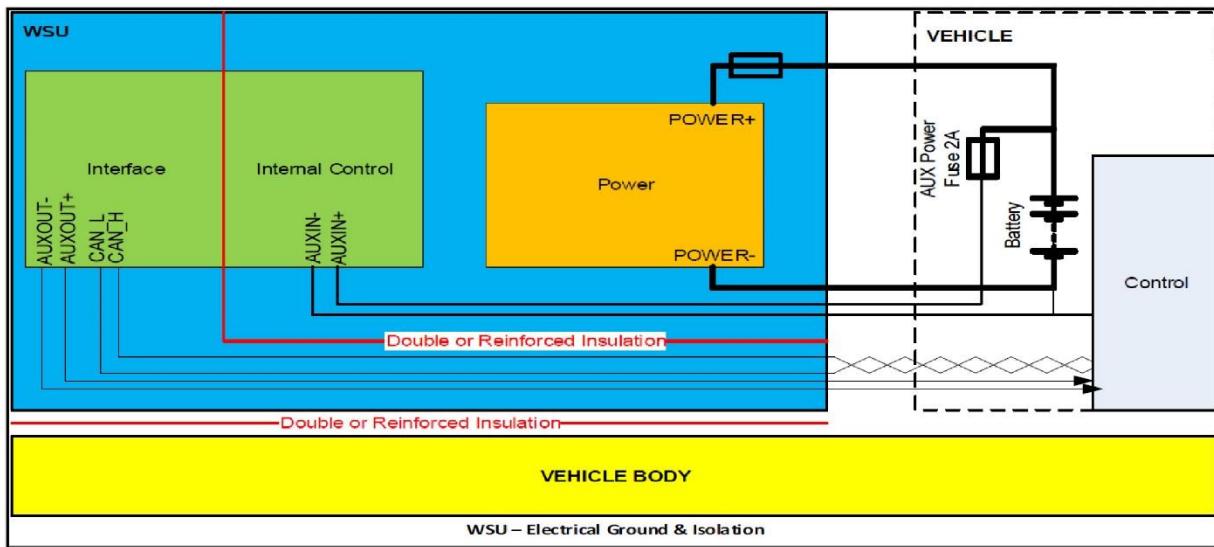


Figure. 30 Auxiliary Connections

#### 4.3.5 Power Up & Health Checks

1. Depending on where the WSU AUX-IN power supply is being sourced from, either:
  - a. Enable the power source within the vehicle that is supplying the WSU AUX-IN.
  - b. Check the voltage on the battery terminals is within voltage tolerance of the WSU AUX-IN interface if it is being supplied from the battery directly.
2. Establish CANopen® communications, refer to section 3.2.3.3.3.
3. Verify that the WSU SW version by can read and is the latest revision.
4. Verify that all information that is desired is being received by the vehicle.
5. Verify that the WSU is not reporting any Warnings/Faults.
6. Check and/or modify the User Configurable parameters as required.

## 5 System Commissioning / Start-up

### 5.1 Safety Instructions

	<p><b>Electromagnetic Field (EMF)</b></p> <ul style="list-style-type: none"><li>• The Wireless Primary Pad (WPP) and Wireless Secondary Unit (WSU) produces a potentially harmful magnetic field during the charging process.</li><li>• Make sure to maintain a safe distance from WPP when charging is in progress. For more details about the safe distance see <b>2.4.2 EMF Safety Instructions</b>.</li><li>• Use of the wireless charger may affect or impair the operation of any medical devices, such as an implantable cardiac pacemaker. Check with your medical device manufacturer concerning the effects that wireless charging may have on such devices before using the wireless charger.</li><li>• Electromagnetic field exposure to pregnant women and Children is strictly forbidden.</li><li>• Advise all user types about safety distances and affix appropriate warnings.</li><li>• Warning signs should be clearly displayed at the charging area.</li><li>• Do not install or operate the system in the public area.</li><li>• Electronic objects such as cell phones and hearing aids may get damaged.</li></ul>
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### 5.2 Wireless Charging

Once the subsystems have been installed, powered up and health checked successfully, the wireless charging process can then be performed on a battery that requires charging.

1. Position the vehicle so that the WSU is within range of the WPP (see [3.3.1.3 WPP & WSU Positioning for correct positioning](#)).
2. Send the charge enable and setpoint commands via [Ethernet](#) or [CANopen®](#).
3. Verify that the following WPB & WPP Status LEDs are illuminated only:
  - a. AC Power: Green
  - b. Positioning: Green
  - c. Charging: Green Flash

4. Verify that the following WPB Stack Light lamps are illuminated only (if fitted):
  - a. Green: WPU Power ON, normal conditions
  - b. Blue Flash: Charging
5. Logon to the Ethernet webpage and check the health status and make sure that there are no Warnings/Faults, including de-rating.
6. If applicable, verify that all data that has been configured to be sent from the vehicle to the WPB (via WSU & WPP) is being received e.g. Vehicle ID, Vehicle Fault Status, Battery SoC.
7. If applicable, verify that all data that has been configured to be sent from the WCS to the vehicle is being received e.g. positioning information.
8. Monitor the Battery SoC from the vehicle and ensure that the charge time is as expected (calculation).
9. After the battery has been charged, verify that the following WPB & WPP Status LEDs are illuminated only:
  - a. AC Power: Green
  - b. Positioning: Green
  - c. Charging: Green (charge complete)
10. Verify that the following WPB Stack Light lamps are illuminated only (if fitted):
  - a. Green: WPU Power ON, normal conditions
  - b. Blue: Charge Complete

<b>ATTENTION:</b> 	<p>The Charge Complete indication will illuminate when either:</p> <ul style="list-style-type: none"><li>• Vehicle stops sending CANopen® set-points to WSU or</li><li>• FMS stops sending Ethernet set-points to WPB.</li></ul> <p>The Charge Complete indication will turn off when either:</p> <ul style="list-style-type: none"><li>• WPP &amp; WSU PPL communications is lost e.g. vehicle drives away.</li><li>• Vehicle starts sending charge request over CANopen®</li><li>• FMS starts sending charge request over Ethernet.</li><li>• WPU and/or WSU is in Fault.</li></ul>
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## 6 Maintenance

This section contains detailed step-by-step instructions necessary to carry out all types of maintenance tasks on the system.

### 6.1 Safety Instructions

During maintenance, the following warning, cautions and notes must be observed. Refer to 2.4 Safety Instructions.

### 6.2 Preventive Maintenance

	<b>Hot Surfaces</b> Make sure that both the pads (WPP and WSU) are free from foreign object to avoid overheating while charging is in progress. Clean the pads as and when needed to avoid danger of overheating.
	<ul style="list-style-type: none"><li>• Make sure to check all the cables (external and PE) for any damages and if necessary replace them.</li><li>• Only skilled person shall replace the cables.</li></ul>

	<b>Daily Check</b>	<b>Yearly Inspection</b>
WPB	Make sure that the Status LED panel indicates correct function and status: Power LED on, Fault LEDs off, other indicators working as intended.	<ul style="list-style-type: none"><li>• Periodic inspection according to the NFPA 70B, EN 50110 or regional/country equivalent is recommended.</li><li>• The PE/GND stud on the right side of the WPB (PE/GND connection to WPP) can be used as reference point for the protective earth conductivity.</li></ul>
WPP	<ul style="list-style-type: none"><li>• Make sure that the Status LED panel indicates correct function and status: Power LED on, Fault LEDs off, other indicators working as intended.</li><li>• Check for metallic foreign objects on the WPP, if present clear away with a soft brush or similar.</li><li>• Check the WPP for visible damage. If any damage is detected, discontinue use of the WPP and disconnect it from WPB, refer to section 4.2.5.</li></ul>	Periodic inspection according to NFPA 70B, EN 50110 or regional/country equivalent is recommended.
WSU	<ul style="list-style-type: none"><li>• Check for metallic foreign objects on the WSU, if present clear away with a soft brush or similar.</li><li>• Check the WSU on every vehicle for visible damage. If any damage is detected, discontinue the use of WSU.</li></ul>	Periodic inspection according to NFPA 70B, EN 50110 or regional/country equivalent is recommended.

## 6.2.1 General Cleaning

### 6.2.1.1 Materials

**Table. 7 Cleaning Agents**

Item	Material
1	Electrical Contact Cleaner
2	Kärcher VehiclePro Truck Cleaner, acidic RM 804
3	Kärcher Autoshampoo 3-IN-1 RM 610

**Note:**

- Use all cleaning solutions with care.
- Alternative equivalents are permitted.
- For plastic parts only use cleaning agents suitable for cleaning plastic.



Cleaning agents should be used with care. Make sure to follow the instructions (for example dilutions) provided in the datasheets of the cleaning agents.

### 6.2.1.2 Procedure

#### 6.2.1.2.1 Cleaning WPB



Make sure to follow the health and safety instructions. Refer to 2 Safety & Regulations.

1. Put clean PVC or polythene gloves on your hands to protect your hands from cleaning agents.
2. Wipe off any dirt with a clean dry cloth or soft brush. Use a microfiber or a soft lint-free cloth only. Do not use abrasive cloths, towels, paper towels or similar items.
3. Dirt, oil and grease may require a solvent to be removed. If this is required use an alcohol solution consisting of 70% isopropyl alcohol and 30% water. Keep liquids away from the WPB. Moisten (not wet) a microfiber or soft lint-free cloth with the cleaning agent and wipe clean.
4. Dry all of the equipment before use.

### 6.2.2 Cleaning WPP & WSU

 <b>WARNING:</b>	Make sure to follow the health and safety instructions. Refer to 2 Safety & Regulations.
 <b>CAUTION:</b>	Do not use heated pressure washer or a steam cleaner on WPP and WSU.

1. Put clean PVC or polythene gloves on your hands to protect your hands from cleaning agents.
2. Wipe off any dirt with a clean dry cloth or soft brush. Use a microfiber or a soft lint-free cloth only. Do not use abrasive cloths, towels, paper towels or similar items.
3. Dirt, oil and grease may require a solvent to be removed. If this is required use an alcohol solution consisting of 70% isopropyl alcohol and 30% water. Keep liquids away from the WPB. Moisten (not wet) a microfiber or soft lint-free cloth with the cleaning agent and wipe clean.
4. For cleaning by cold water pressure washer, either clean without cleaning agent or use a cleaning agent as referred in Table. 7, items 2 & 3 with a dosage of up to 3%. Pressure washer suitability as follows:
  - Flow rate: 15 l/m max
  - Impact force: 1.2 N max

### 6.2.3 Cleaning Fans of WPB

Item	Special Tool	Specification
1	Vacuum cleaner	-
2	Standard toolkit	-

 <b>DANGER:</b>	<b>Electric Shock</b> Make sure to disconnect the main power supply and wait for 30 min before opening WPB, as it may lead to death of Personnel.
---	--

1. Make sure to power off the system and wait for 30 minutes until the WPB cools down.
2. Remove the four screws M6 (2) and remove the front cover (3). See Figure. 31.
3. Remove the four screws (4) and remove Fan Panel Assembly (5).
4. Clean the fans (7) with a dry cotton cloth or with a vacuum cleaner.

5. Do not use any cleaning agents or solvents to clean the fans, this may damage the fans.
6. Once cleaning is complete, install the fan panel assembly (5) with screws (4).
7. Install the front cover (3) with the four screws M6 (2).
8. Make sure that everything is installed and connected. Now turn on the power supply to the WPB.

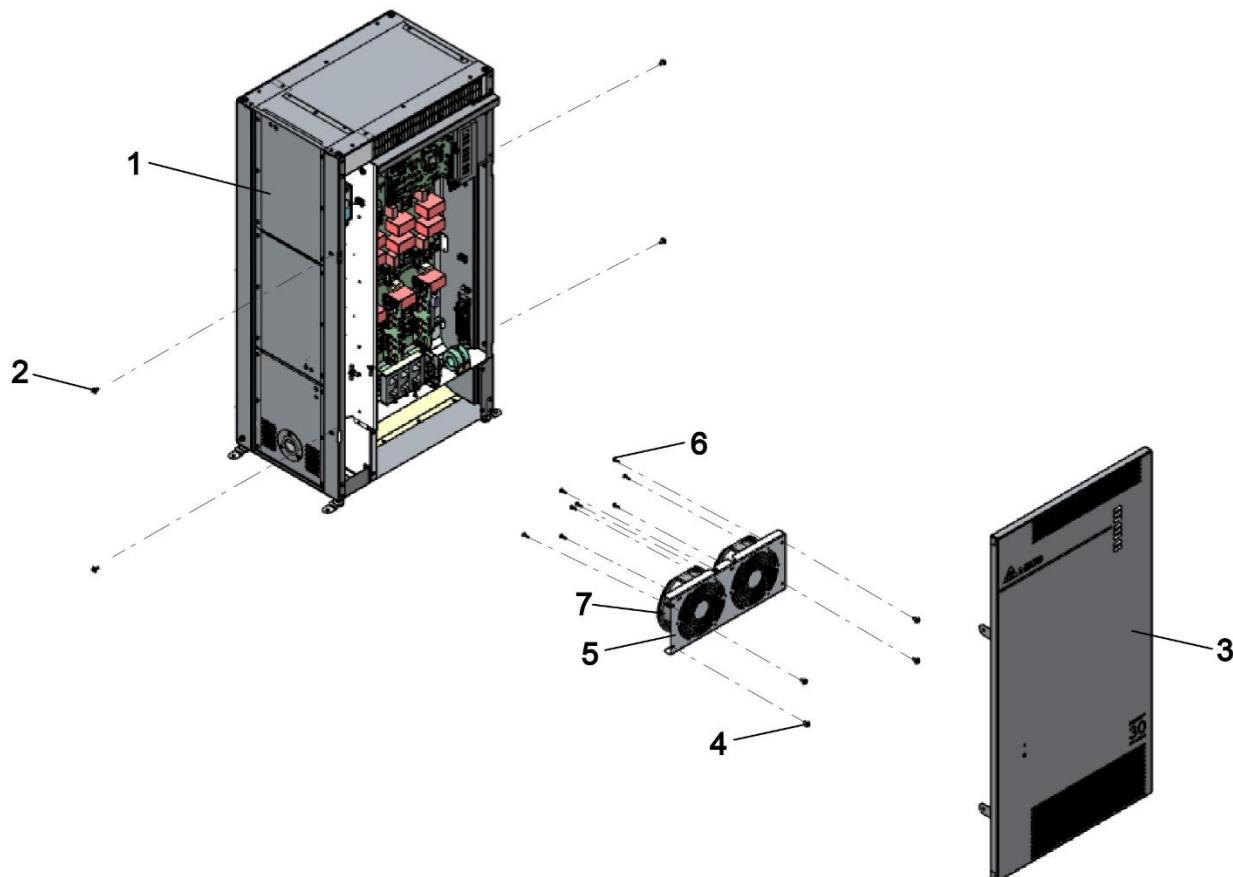


Figure. 31 WPB – Accessing Fan Panel Assembly WPB

Item	Description	Item	Description
1	WPB	5	Fan Panel Assembly
2	M6 Screws	6	Screws
3	Front Cover	7	Fans
4	Screws M M6*1*12 FPH TORX SUS		

## 6.3 Corrective Maintenance

### 6.3.1 Replacing Fans of WPB

	<b>Electric Shock</b> Make sure to disconnect the main power supply and wait for 30 min before opening WPB, as it may lead to death of Personnel.
---	--

1. Make sure to power off the system and wait for 30 minutes until the WPB cools down.
2. Remove the four screws M6 (2) and remove the front cover (3). See Figure. 31.
3. Remove four screws (4) and remove Fan Panel Assembly (5).
4. Remove the press button screws (6) and remove the fans (7).
5. Install the new fans (7) with press button screws (6).
6. Install the Fan Panel Assembly (5) with four screws (4).
7. Install the front cover (3) with the four screws M6 (2).
8. Make sure that everything is well installed and connected. Now turn on the power supply to WPB.

### 6.3.2 Replacing Fuses of WPB

	<b>Electric Shock</b> Make sure to disconnect the main power supply and wait for 30 min before opening WPB, as it may lead to death of Personnel.
---	--

1. Make sure to power off the system and wait for 30 minutes until the WPB cools down.
2. Remove six screws (4) and remove the middle cover (3) and lower cover (2). See Figure. 32
3. Disconnect all electrical connection around the fuses L1, L2 and L3 (5, 6, 7).
4. Replace all the three fuses with the new Fuses.
5. Reconnect all electrical connections around the fuses.
6. Install middle cover (3) with six screws (2).
7. Make sure that everything is installed and connected. Now turn on the power supply to WPB.

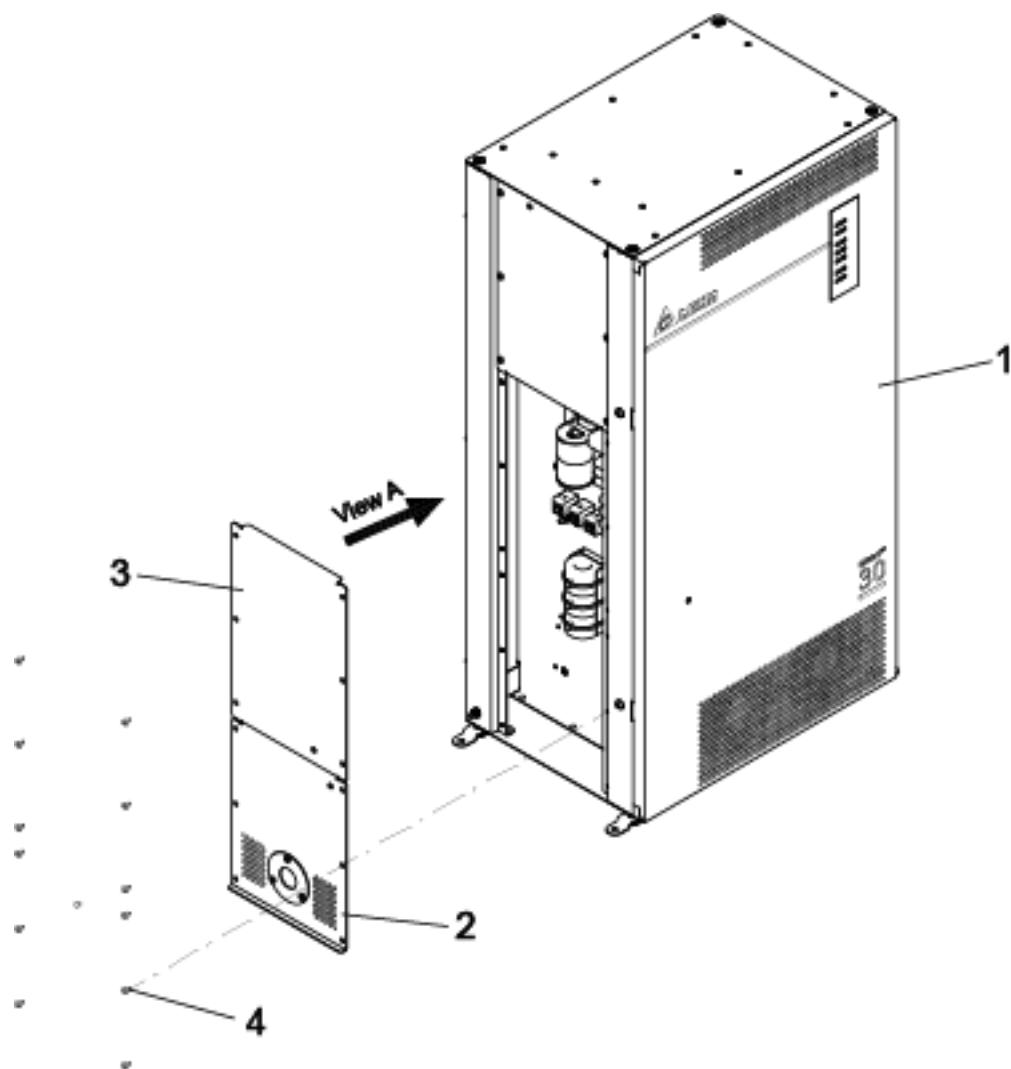
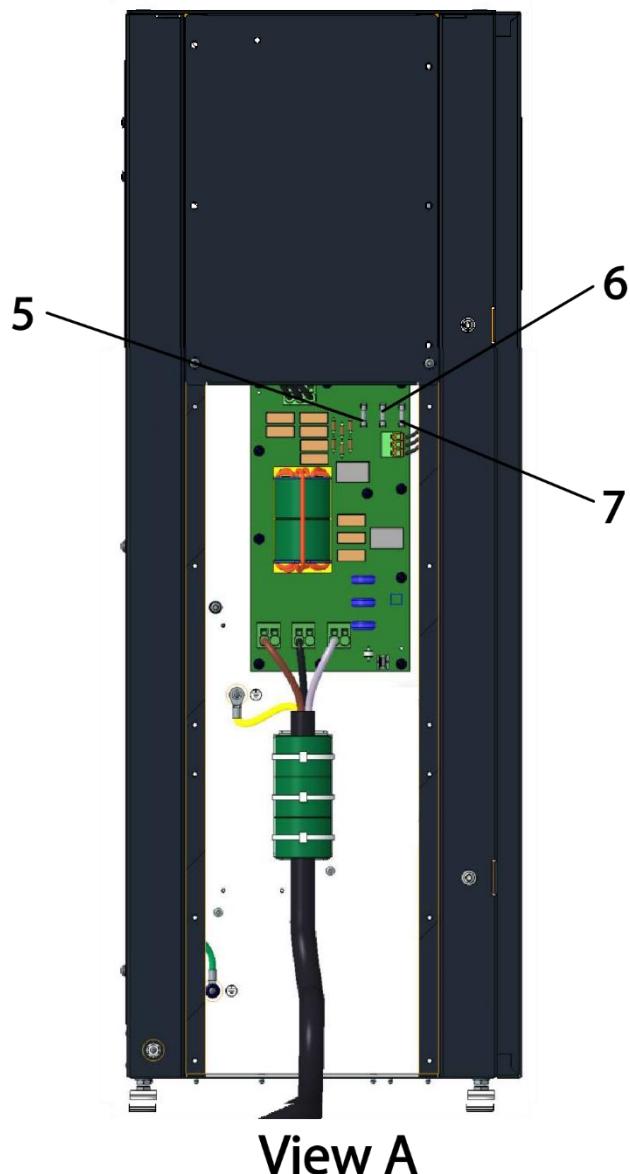


Figure. 32 Replacement of Fuses – Part 1

Item	Description	Item	Description
1	WPB	3	Middle Cover
2	Lower Cover	4	Screws

**View A****Figure. 33 Replacement of Fuses – Part 2**

Item	Description	Item	Description
5	Fuse L1	7	Fuse L3
6	Fuse L2		

## 6.4 Firmware Updates

### 6.4.1 WPU

Info yet to be added

### 6.4.2 WSU

Info yet to be added

## 7 Troubleshooting

This section provides information for identification and correction of malfunctions and faults of the WCS.

### 7.1 Identifying Subsystems to Troubleshoot

The following are different ways to identify a faulty subsystem:

- Stack Light (if fitted)
- Status LED panel
- CANopen® and Ethernet (Not Implemented)

10-30kW WCS - Status LEDs							
Category	WPB / WPP		POSITIONING			WSU	
Symbol							
Description	AC IN	Fault	Too Close	OK	Too Far	Fault	Charge
AC Not OK							
AC OK							
AC OK, Position OK, Charging							
AC OK, Position Suboptimal-Far, Charging							
AC OK, Position Suboptimal-Close, Charging							
AC OK, Position too far, not charging							
AC OK, Position too close, not charging							
AC OK, Charge Complete							
AC OK, WPB / WPP Fault							
AC OK, WSU Fault							
AC OK, WPB / WPP & WSU Fault							

Figure. 34 Possible Status LED Panel Scenarios

**Note:** Positioning LED status is only available when the output power is  $\geq 3.5\text{kW}$ .

**Note:** Further diagnostics for troubleshooting can be acquired from the Ethernet webpage (Not Implemented) and/or CANopen® interface e.g. PPL Connection Status, detailed Positioning Status etc.

## 7.2 Troubleshooting on WPB

**Table. 8 Troubleshooting of WPB**

Symptom	Probable Cause	Corrective Action
No power to WPB	WPB is not connected properly to grid	Check the connection between WPB and grid.
	Supplementary Fuses (supply line fuses) are blown OFF.	Check the supplementary fuses (supply line fuses) and if necessary replace them. (63 A for Europe and 50 A for US and Canada).
	Fuses to Auxiliary supply are blown OFF.	Check the fuses to Auxiliary supply and replace them if necessary.
	One phase connection is missing.	Check for any missing grid connection (Phase 1, 2 and 3) to WPB or improper connection. In this case charging starts but B6 voltage drops and WCS shuts down
	WPB Internal defect	Confirm with Delta and request for replacement if it is within the Warranty period

## 7.3 Troubleshooting on WPP

**Table. 9 Troubleshooting of WPP**

Symptom	Probable Cause	Corrective Action
No power to WPP	WPP is not connected properly to WPB.	Check the connection between WPB and WPP (power connector and signal connector).
	WPP Internal defect	Confirm with Delta and request for replacement if it is within the Warranty period.
WPP LED's not lit up	Signal connector is not connected properly.	Make sure to connect the signal connector firmly to WPB.
	WPP internal defect	Confirm with Delta and request for replacement if it is within the Warranty period.

## 7.4 Troubleshooting on WSU

Table. 10 Troubleshooting of WSU

Symptom	Probable Cause	Corrective Action
No power to WSU	WSU is not installed properly and is not connected to battery.	Check the installation of WSU and make sure all connections to battery are right.
	WSU internal defect	Confirm with Delta and request for replacement if it is within the Warranty period.
Charging not happening	Battery connection to WSU is incorrect.	<ol style="list-style-type: none"><li>Make sure to securely connect both the red and black cables to the battery terminals.</li><li>Make sure that the polarity is not reversed.</li></ol>
	Wrong battery	Check the voltage range of the battery, correct voltage range is (72V to 120V). Below or above this range is not accepted.
	Pad to pad positioning is wrong.	Check the position of both the pads and correct it as referenced in section 3.3.1.3.
	Misalignment is too big.	Check the alignment between WPP and WSU, it must be within the range. Refer to sections 3.3.1.3.1 and 3.3.1.3.2.
	Battery is Full	Charging does not happen when battery is full, User should know this information via BMS or vehicle SoC gauge.

## 8 Accessories & Spare Parts

### 8.1 Parts List

Item	Part	Description	Qty
1	EOE18010815	WPB	1
2	EOE18010851	WPP	1
3	EOE18010850	WSU	1
4	3486388501	WPP Mounting Bracket	1
5	3620174611	Single Fans	2
6	0809010602	Single Fuses(for L1, L2,L3)	3

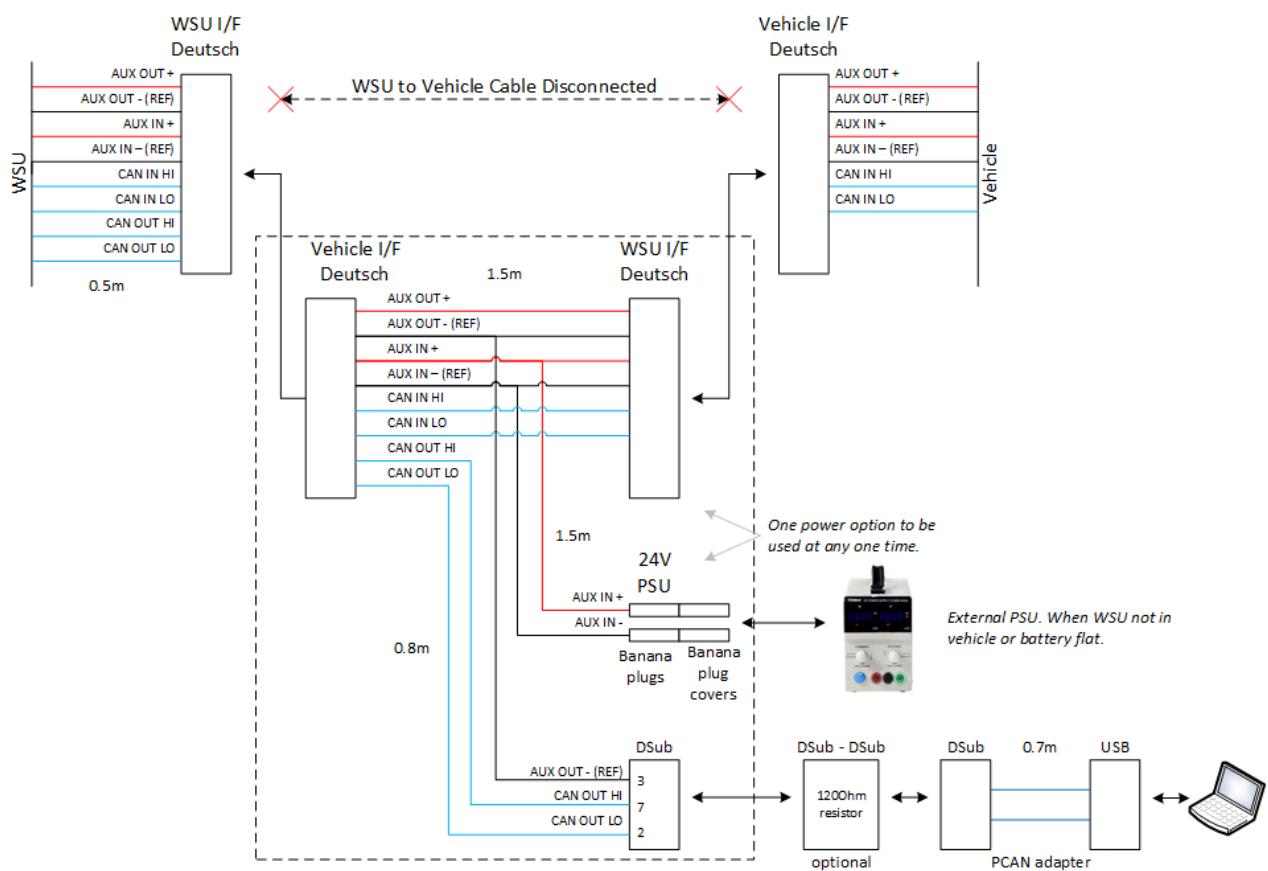
**Note:** WPP mounting bracket is included within the WPP packaging.

### 8.2 Accessories

Item	Part	Description	Qty
1	TBD	WSU Deutsch Mating Half (DT04-12PA-C015)	1
2	TBD	WPB Mounting Bracket (Not Implemented)	1

### 8.3 Development Kit

Item	Part	Description	Qty
1	EOE99001072	- WSU Cable Harness - CAN Bus Termination; D-Sub to D-Sub - PCAN Adapter; D-Sub to USB	1



**Figure. 35 Development Kit Connections**

## 9 **Warranty**

The following section provides the information regarding warranty and non-warranty conditions. Make sure to go through these conditions before approaching Delta for warranty service.

### 9.1 **Warranty Conditions**

The limited warranty is applicable for physical goods/products purchased from Delta and covers the following conditions.

- The limited warranty applies only to material and production defects under normal use and maintenance during the warranty period.
- Delta repairs or exchange the defective parts under normal use and maintenance during the warranty period.
- The warranty period for the physical goods/products purchased from Delta is valid for 24 months from the date of manufacturing.

### 9.2 **Non-Warranty Conditions**

The limited warranty does not cover the following conditions:

- Any defects which is not resulting from material and production.
- Failed to obey the safety instructions and guidance given in this document.
- Scratches and wear due to improper handling or installation of the physical goods/products.
- Any indication that the enclosure for WPP and WSU has been opened.
- Cables or connectors has been removed or changed.
- Firmware being loaded is of an older version than the one indicated on the product label.
- Accidental damage or damage caused by other devices.

Kindly contact Delta to determine the problem and to provide with a most appropriate solution.

### 9.3 **Return Procedure**

In case of repair or return under limited warranty period, kindly contact your Delta sales representative who would assign a RMA number and provide packing and shipping details.

# Appendix A - Electromagnetic Field Distribution

This Appendix provides more detailed information on the WCS EMF. It does not replace section 2.4.2 EMF Safety Instructions.

Wireless charging creates a magnetic field in and around the pads and extends in all directions, of which exposure to this can pose a health risk. The measured values of the Electric Field (E), Magnetic Field (H) and Magnetic Flux Density (T) - for the wireless power transfer – used in certification for the relevant regions are listed below. Guidance reference limits from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) are also listed for information only.

All measurements are in free space, meaning that the field (E, H & B) characteristics will be different when there is metal in the area such as with a forklift truck.

## A.1 EU Results

Frequency (kHz)	Side of the EUT and its distance to the measuring probe	Maximum obtained value			Limit	
		E-field (V/m)	B-field (µT)	H-field (A/m)	E-field (V/m)	B-field (µT)
55 – 65	Left of WPP at 180 mm distance <sup>1)</sup>	38.4	39.0	31.0	170	100
55 – 65	Right of WPP at 380 mm distance <sup>1)</sup>	65.8	38.0	30.2	170	100
55 – 65	Back of WPP at 260 mm distance <sup>3)</sup>	67.8	60.2	47.9	170	100
55 – 65	Back of WSU at 280 mm distance <sup>1)</sup>	15.5	43.2	34.4	170	100
55 – 65	Below WPP at 347 mm distance <sup>2)</sup>	75.7	41.6	33.1	170	100
55 – 65	Above WPP at 347 mm distance <sup>2)</sup>	37.8	23.2	18.5	170	100

<sup>1)</sup>entire height was scanned

<sup>2)</sup>entire length was scanned

<sup>3)</sup>entire length and height were scanned

Measurements presented are worst case

## A.2 US Results

Frequency (kHz)	Side of the EUT and its distance to the measuring probe	Maximum obtained value			Limit	
		E-field (V/m)	B-field (µT)	H-field (A/m)	E-field (V/m)	B-field (µT)
55 – 65	Left of WPP at 180 mm distance <sup>1)</sup>	38.4	39.0	31.0	83	90
55 – 65	Right of WPP at 380 mm distance <sup>1)</sup>	65.8	38.0	30.2	83	90
55 – 65	Back of WPP at 260 mm distance <sup>3)</sup>	67.8	60.2	47.9	83	90
55 – 65	Back of WSU at 280 mm distance <sup>1)</sup>	15.5	43.2	34.4	83	90
55 – 65	Below WPP at 347 mm distance <sup>2)</sup>	75.7	41.6	33.1	83	90
55 – 65	Above WPP at 347 mm distance <sup>2)</sup>	37.8	23.2	18.5	83	90

<sup>1)</sup>entire height was scanned

<sup>2)</sup>entire length was scanned

<sup>3)</sup>entire length and height were scanned

Measurements presented are worst case

Measurement performed in initial testing 2022-07-05 to 2022-11-28

### A.3 ICNIRP (information only)

ICNIRP Guidelines are readily available online, which contains information on the effects of EMF exposure and provides reference levels.

#### ICNIRP 1998 Reference Levels for 55-65 kHz:

- General Public Exposure
  - E Field: 87 V/m, H Field: 5 A/m, B Field: 6.25  $\mu$ T
- Occupational Exposure
  - E Field: 610 V/m, H Field: 24.4 A/m, B Field: 30.7  $\mu$ T

#### ICNIRP 2010 Reference Levels for 55-65 kHz:

- General Public Exposure
  - E Field: 83 V/m, H Field: 21 A/m, B Field: 27  $\mu$ T
- Occupational Exposure
  - E Field: 170 V/m, H Field: 80 A/m, B Field: 100  $\mu$ T

**Note:** H and B Fields have a constant; 1.2566371 approx.

### A.4 B Field Distribution

The following diagram provides a visual representation of the magnetic field emitting from the WPP when the pads are at maximum misalignment and charging:

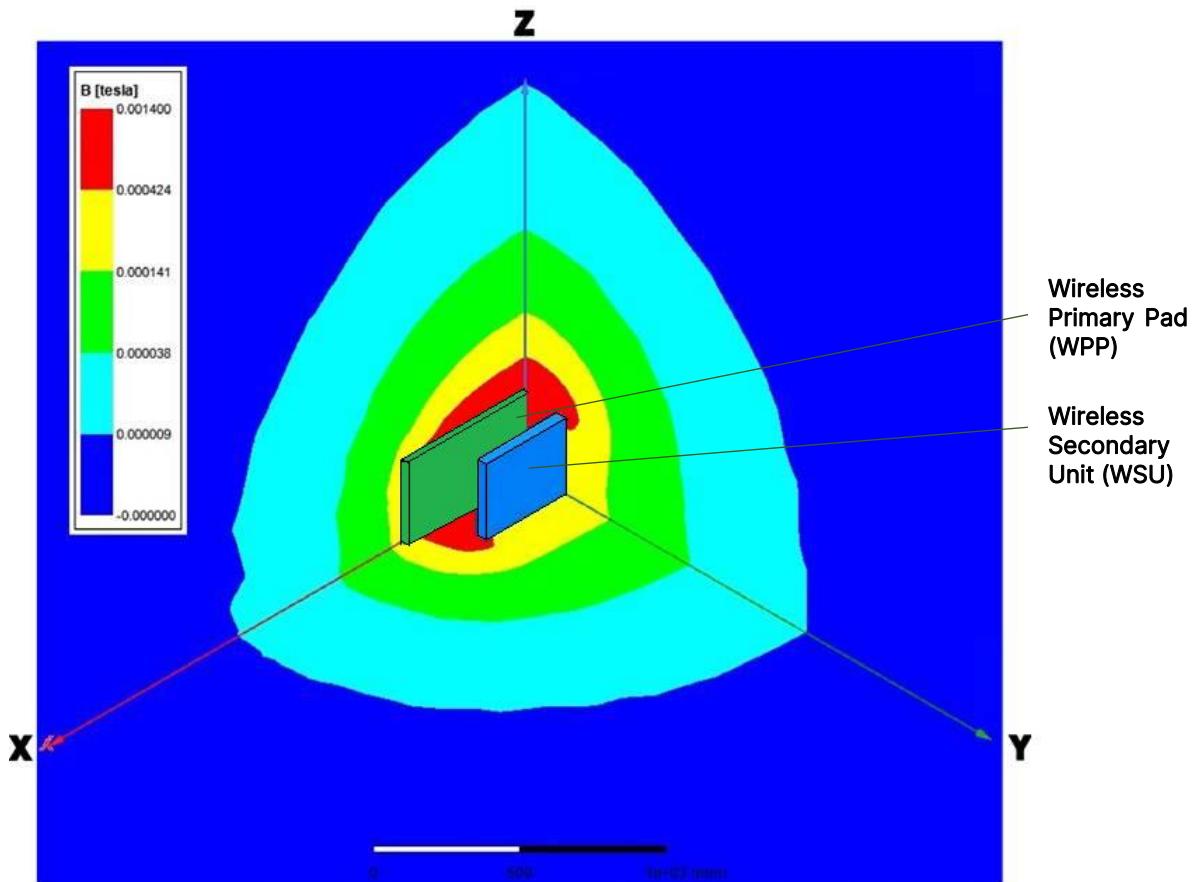


Figure. 36 Magnetic Field Distribution During Charging Process

- Red to Yellow: 300  $\mu$ T RMS
- Yellow to Green: 100  $\mu$ T RMS
- Green to Light Blue: 27  $\mu$ T RMS
- Light Blue to Blue: 6.25  $\mu$ T RMS

## Appendix B - Product Disposal

### Disposal of system and subsystems

The WCS and its subsystems constitute industrial electronic equipment. Disposal must be in accordance with applicable local regulations.

### Disposal of packaging materials

Packaging materials must be disposed of in accordance with applicable local regulations.



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More information