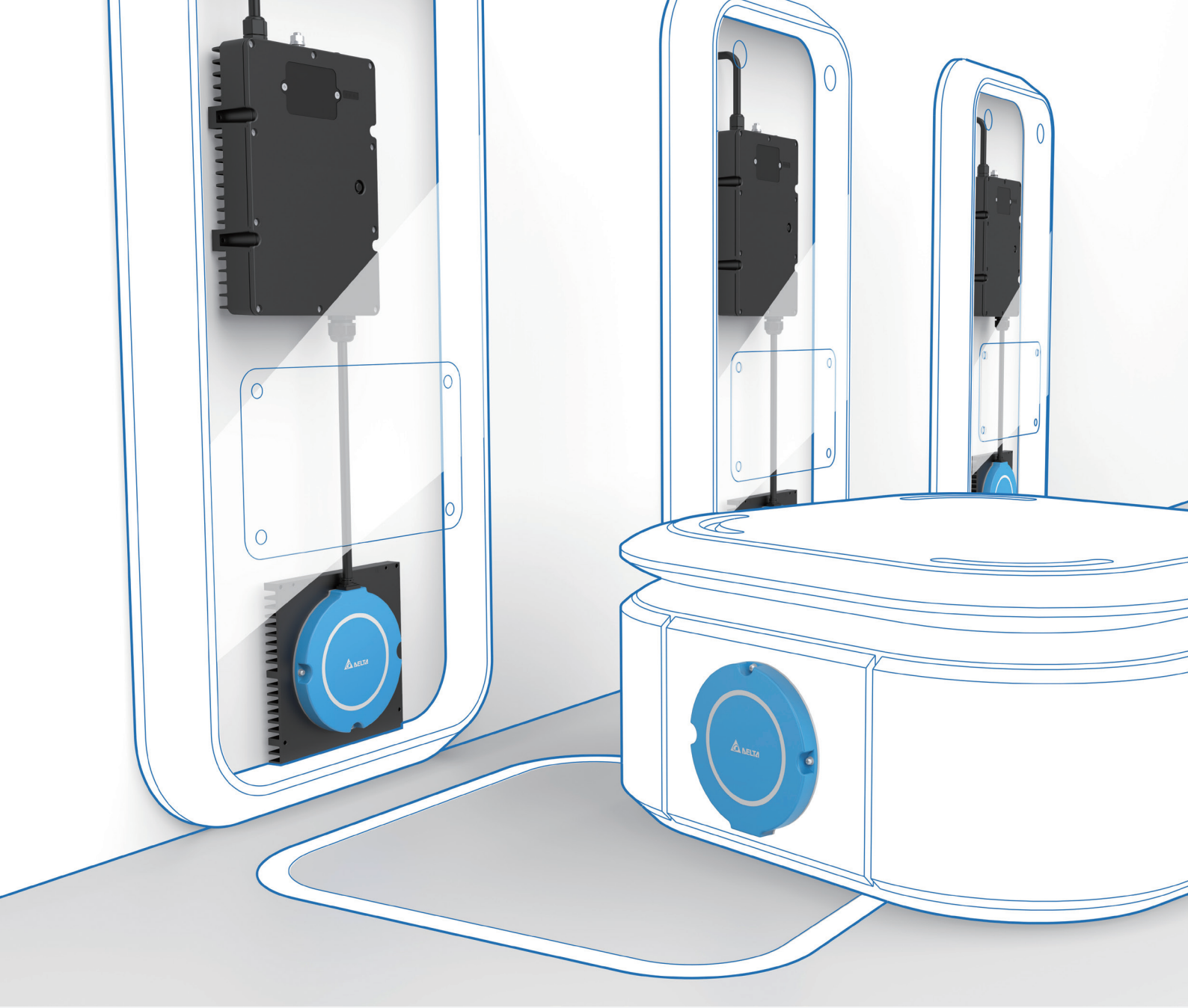


1 kW Wireless Charging System
MOOV air

Application Notes

Wireless Power Transfer
Battery Charging
Industrial

DELTA

1 About this document

1.1 Purpose of this document

This document is to provide information that will allow the wireless charger system to be used safely and reliably when it is installed in another product such as an AGV. Whilst the document contains some information on how to use the charger system as a stand-alone product, this is only for evaluation purposes. The final application must use the charger system as a component in a system.

Read this document before working with the wireless charger system.

Always follow the safety instructions and guidance messages in this document. This will ensure that the charger can be safely installed, commissioned and operated.

Delta Energy Systems is not responsible for damage or harm resulting from failure to follow the safety and operating instructions set out in this document.

1.2 Target audience

This document is intended for qualified engineers who will be working on integrating the Delta wireless charger system into a larger system such as an AGV. The engineer must be trained and approved for working with electrical and electronic equipment. The engineer must also be experienced in how to apply safe working practices for connecting and charging batteries.

Although this documentation is not aimed at the end users of the wireless charging system, it does contain important information that must be provided to these users to ensure safe and effective use of the system after installation.

1.3 Products covered

WPU (Wireless Primary Unit), transmitter, TX:	WPU 1000 W 1 AC US
	WPU 1000 W 1 AC EU
WSU (Wireless Secondary Unit), receiver, RX:	WSU 1000 W 24 V
	WSU 1000 W 48 V

1.4 Warning notices and warning symbols

This document uses the following warning notices and symbols to describe potential dangers and the measures necessary for reducing these dangers.

1.4.1 Warning levels

⚠ DANGER

Indicates a dangerous situation that will always lead to death or severe injuries if not avoided.

⚠ WARNING

Indicates a dangerous situation that can lead to death or severe injuries if not avoided.

⚠ CAUTION

Indicates a dangerous situation that can lead to light or medium injuries if not avoided.

ATTENTION

Indicates possible material damage that can be caused to other objects by the charger system.

If necessary, the warning labels are also marked with warning symbols indicating the source of the danger.

 High electrical voltages or currents

 Hot surfaces

 General danger

 Electric and magnetic field (EMF)

 Sharp edges

2 General safety instructions

⚠ DANGER

Electric shock

Potentially fatal voltages are present in the charger system during operation.

- ► No item in the charging system contains user serviceable parts and enclosures should not be opened for any reason.

⚠ WARNING

Electric and magnetic field (EMF)

The WPP (transmitter, TX) produces a magnetic field

- ► People must be > 20 cm away from the WPP.
- ► People with medical devices such as metallic prostheses, cardiac pacemakers and cochlear implants, must be > 1 m from the WPP.
- ► Warning signs giving the above advice must be clearly displayed at the WPU installation.
- ► Operators must be trained to inform them of the EMF risk, and to keep enough distance from the WPP at all times, including when not charging.
- ► The wireless charging system is not suitable for use in location where children are likely to be present.
- ► Charging must take place in an area where the general public are forbidden to enter.

⚠ CAUTION

Hot surfaces

All parts of the charging system can become hot during operation.

- ► Always wear safety gloves before handling, or allow 30 minutes to allow the charger system to cool when not operating.

⚠ CAUTION

Sharp edges

The heatsink attached to the WPP has sharp edges.

- ► Protective gloves should be worn when handling the heatsink.

⚠ CAUTION

Material damage

No metallic objects are allowed between the pads during charging, as they may get heated and damage the plastic cover.

- ► Select the installation site where no metallic objects can go into the air-gap and stay on the plastic cover of the pads.
- ► The pads must be mounted vertically. If the user insists on mounting the pads horizontally, then they will take full responsibility to ensure there are no metallic objects between the pads during charging.
- ► Heated metallic objects could ignite combustible materials if also present.

2.1 EU declaration of conformity

Hereby, Delta Energy Systems (Germany) GmbH declares that the radio equipment types WPU 1000 W 1AC EU / WSU 1000 W 24 V / WSU 1000 W 48 V are in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address: https://filecenter.deltaww.com/Products/Download/21/2110/1kW%20Wireless%20Charging%20System_EU%20DoC_EN_20207.pdf

3 System description

The wireless charger system consists of two main assemblies:

1. The WPU: Wireless Primary Unit (transmitter, TX)

   a. WPB (Wireless Primary Box) connected to AC

   b. WPP (Wireless Primary Pad) that produces a magnetic field for transferring energy

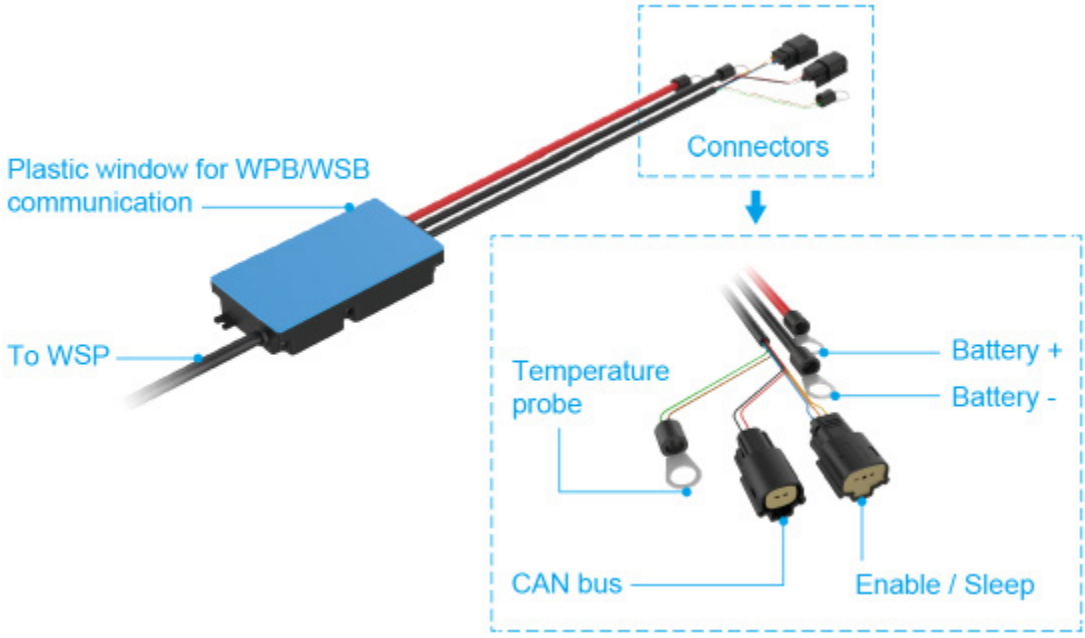
   The WPU is typically installed on the wall of the infrastructure.

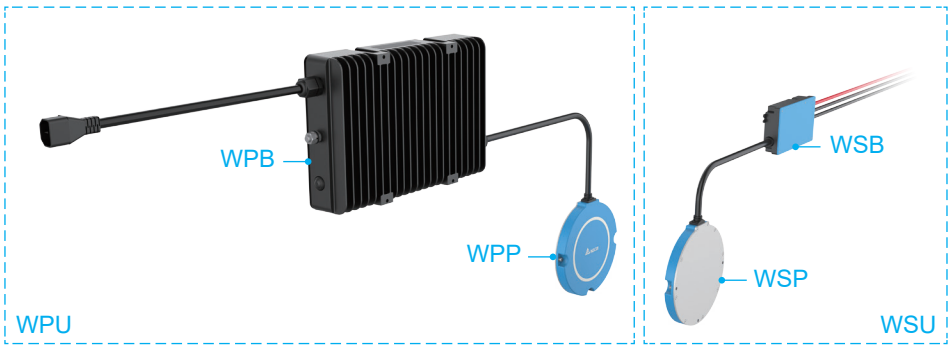
2. The WSU: Wireless Secondary Unit (receiver, RX)

   a. WSP (Wireless Secondary Pad) that accepts the magnetic field

   b. WSB (Wireless Secondary Box) that produces a DC output that is typically used to charge a battery. The output the WSB produces can be controlled via CAN bus, or via inbuilt charging profiles chosen specifically for the attached battery

   The WSU is typically installed on moving equipment containing a battery, such as an AGV or pallet jack. However the wireless charging system can be used in other applications where there is a need to transfer power over an air gap.





4 Functional description

Typically the WPB is permanently supplied with AC, and the WSB is permanently connected to the battery. Charging can commence when:

- The WPP and WSP are correctly aligned: face-to-face, parallel, and within the specified misalignment and air gap ranges
- and the charger system is instructed to start charging, either via CAN bus or by the charger system's ENABLE input
- The charger system does not detect any fault conditions.
- The WPB and WSB are able to communicate with each other.

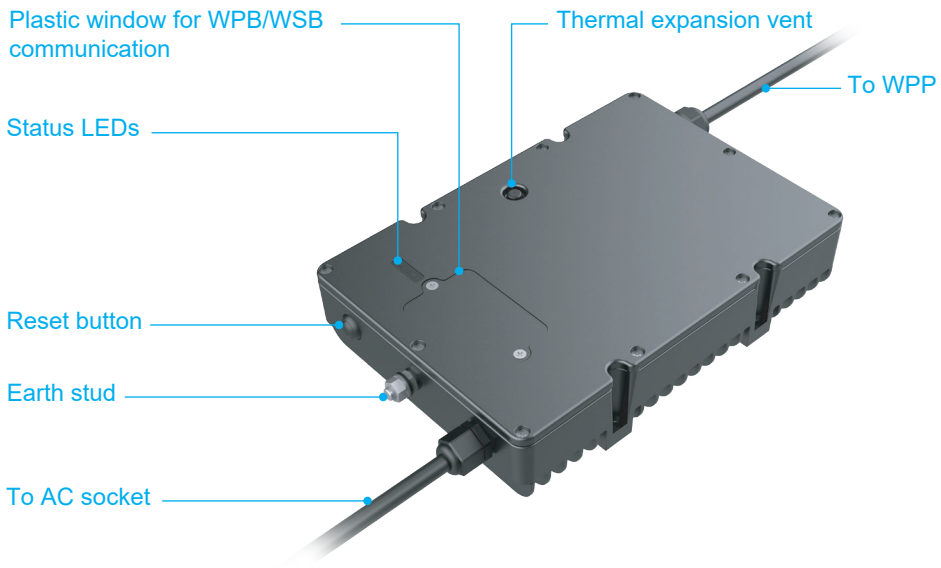
4.1 Wireless WPB - WSB communication

For internal system communication the WPB and WSB both contain a radio frequency transceiver module with integral antenna. The transceiver module is IEEE Std. 802.15.4 compliant and has Radio Regulation Certification for all countries and regions where the charger system may be used.

The transceiver module operates at ISM Band 2.405 to 2.480 GHz, with maximum RF transmit power as 2.09 dBm. The wireless communication WPB and WSB uses a proprietary protocol and cannot be accessed by the user.

4.2 Hardware features

4.2.1 WPB

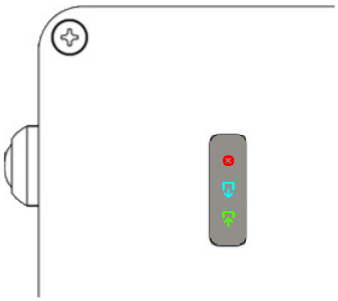


4.2.1.1 Reset button

The WPB has a non-latching push button that can be used to restart the charging process.

4.2.1.2 Status LED operation

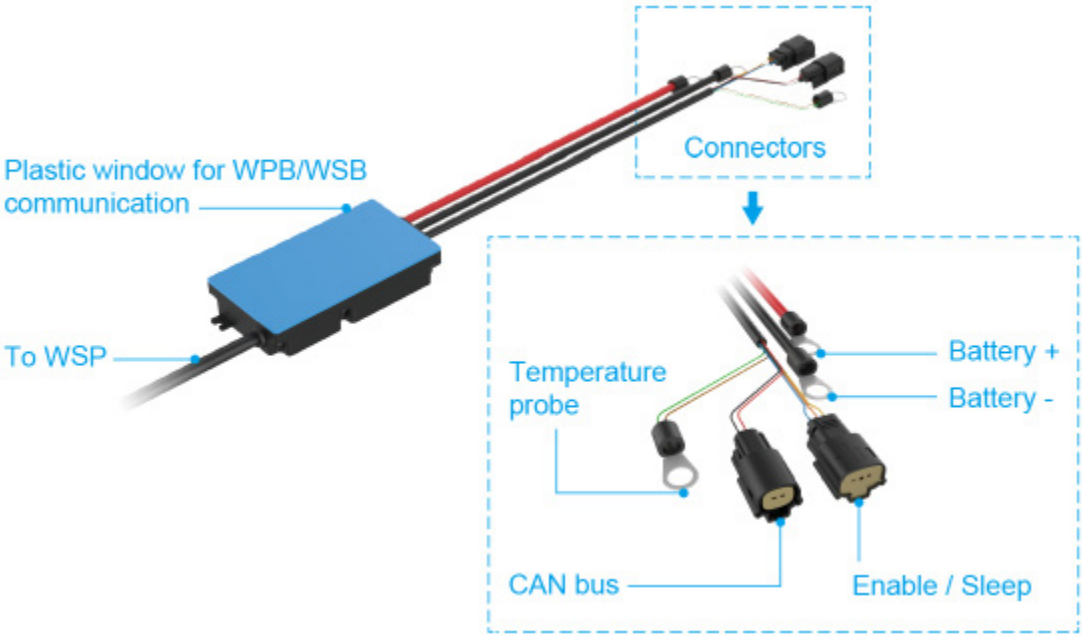
The WPB has three LEDs that show basic information about the charger system's status.



	AC present	Charging	Fault
			
No input	Off	Off	Off
Ready	On	Off	Off
Charging	On	Flash	Off
Charge complete[1]	On	On	Off
Fault	On	Off	Flash

1 Profile mode only

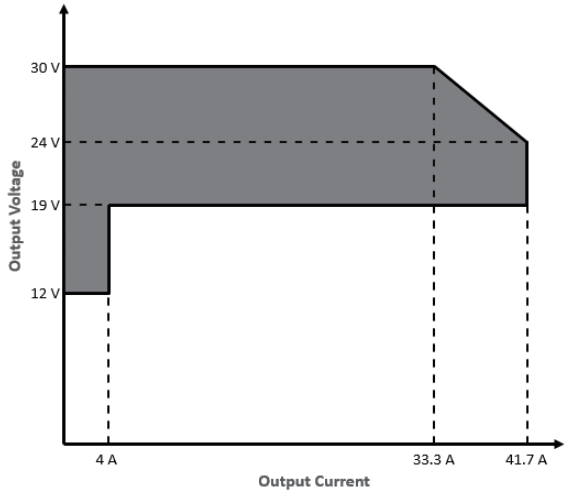
4.2.2 WSB



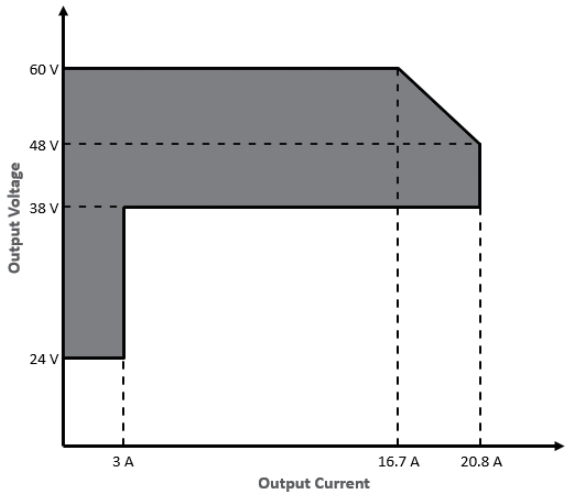
4.3 Output power and de-rating

4.3.1 Output operating area

The charger system can provide an output within the bounds of the graphs below.



24 V operating area



48V operating area

Using the 48 V charger system as an example:

- Between 24 V and 38 V the charger system can provide a maximum of 3 A
- Between 38 V and 48 V the charger system can provide up to 20.8 A
- Between 48 V and 60 V the charger system can provide a maximum of 1000 W, and will reduce the output current to achieve this

4.3.2 Power vs. input voltage

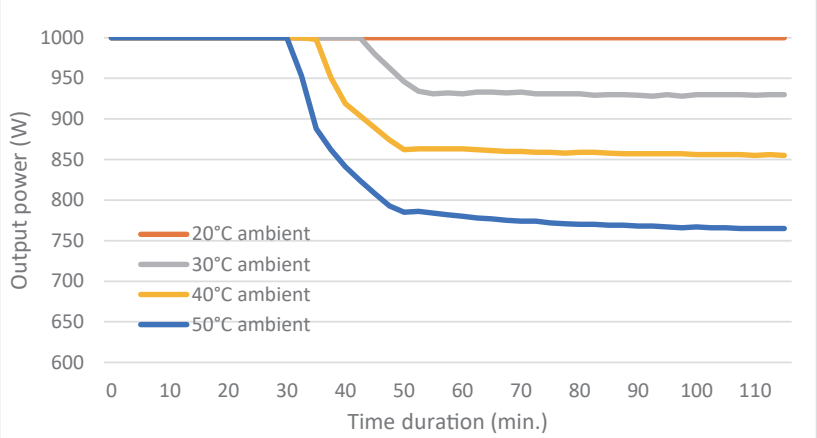
The charger system can operate from an AC supply of 85 to 265V_{AC}. However when input voltage is less than 100 V_{AC}, the output power is automatically reduced to avoid the input current exceeding 13 A.

4.3.3 Power vs. ambient temperature

The maximum temperature the case of the WSB can reach is limited to ensure user safety. The charger system will limit its output power when required so the maximum case temperature of 90 °C is not exceeded. The graph below shows test results of the charger system attempting to provide full power at different ambient temperatures. No additional means were used to cool the charger system.

For example:

- At 20 °C ambient the charger system can run continuously at full power
- At 30 °C the charger system will run at full power for approximately 42 minutes and then eventually reduce its output power to 930 W



Mounting the metal surface of the WSB to a heatsink or other large metal item such as an AGV chassis will improve its thermal performance.

The WSB installation location can affect its thermal performance:

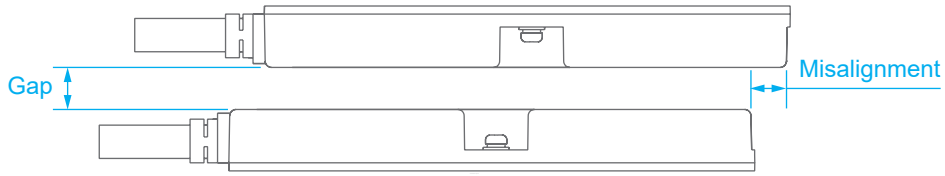
- Volume of air surrounding the WSB
- The ability of hot air to escape the vicinity of the WSB
- The ability of cool air to enter the WSB installation
- The proximity of the WSB to other hot components
- Emissivity of surrounding materials

The WPU can run continuously at full power in an ambient temperature of up to 40°C.

The WSB should be validated in the final application to determine whether any additional heatsinking is required.

4.3.4 WPP & WSP Physical Positioning

Misalignment is the distance the pads are offset laterally and air gap is the distance between the pad faces as shown below.



At the charger system's nominal output voltage, the full 1000 W can be delivered in all combinations of gap and misalignment up to 20 mm. However, when the output voltage is above nominal value the gap and misalignment does have an impact on the amount of power that can be delivered, with the worst case being at the charger system's maximum working voltage, and is shown in the following table:

Air-gap	Max. misalignment for 1000 W
0 - 6 mm	20 mm
8 mm	18 mm
10 mm	17 mm
12 mm	16 mm
14 mm	15 mm
16 mm	10 mm
18 - 20 mm	5 mm

For example

- If the gap is 10 mm, 1000 W can be delivered if the misalignment is 17 mm or less
- If the misalignment is 5 mm, 1000 W can be delivered if the gap is 20 mm or less

4.4 Efficiency and losses

Input: 230 V_{AC}, Output: 24 V at 41.7 A (1000 W), Misalignment: 0 mm, Gap: 10 mm

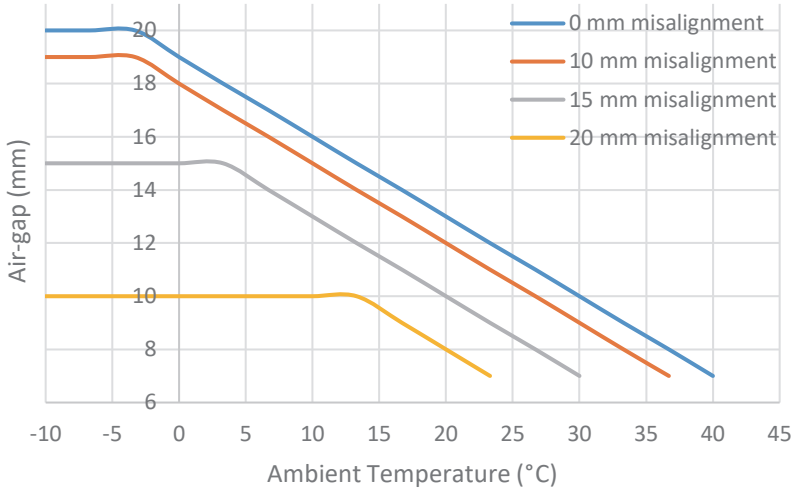
Item	Loss	Efficiency
WPB	53 W	95%
WPP	15 W	98%
WSP	7 W	99%
WSB	20 W	98%
Total	95 W	91%

4.4.1 Factors that influence losses

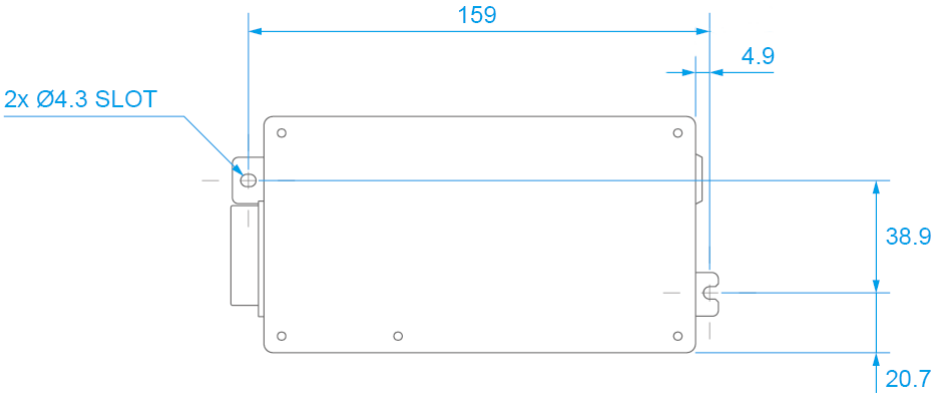
Criteria	Losses per component			
	WPB	WPP	WSP	WSB
Input voltage ↑	↓	-	-	-
Output voltage ↑	↑	↑	-	-
Output power ↑	↑	↑	↑	↑
Misalignment ↑	↑	↑	-	-
Gap ↑	↑	↑	-	-

4.4.2 Temperature of the WPP

As well as the ambient temperature, four other factors can cause the primary pad to become hot: gap, misalignment, output power, and output voltage. The WPP has a heatsink attached by default to ensure operation over a wide range of conditions. If the user wishes to remove the heatsink then they must ensure the pad temperature can be kept low by using the charger system at low gap and misalignment, or by only using the charger system in environments where the ambient temperature is not high.
The user may consider removing the heatsink if their operating conditions lie below the lines on the following graph for maximum power and maximum output voltage.



If the WPP becomes too hot, the charger system will self-protect by stopping operation until the temperature drops to an acceptable level.



4.5 Operating limits

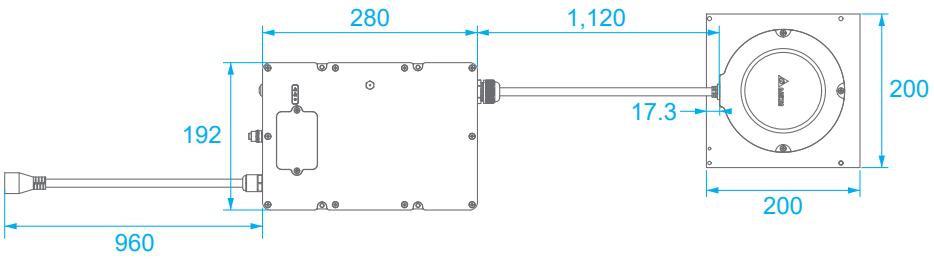
- Operation in ambient above 50 °C not recommended
- Operation at gaps of larger than 20 mm is not guaranteed
- Operation at misalignment of larger than 20 mm is not guaranteed
- 20 mm misalignment will not work at above 10 mm gap regardless of temperature or heatsink
- 15 mm misalignment will not work at above 15 mm gap regardless of temperature or heatsink
- 10 mm misalignment will not work at above 19 mm gap regardless of temperature or heatsink

4.6 Physical dimensions

To aid integration into an end system, Delta can make the wireless charging system CAD files available on request.

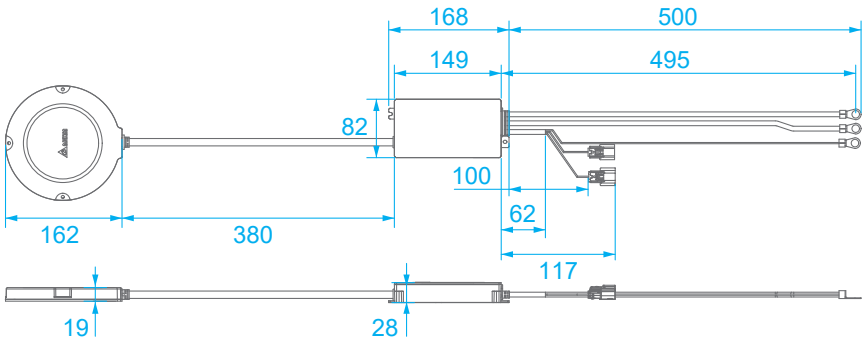
None of the cables can be altered by the user. Please contact Delta if different cable lengths are required.

4.6.1 WPU



See section 4.4.2 for details on the conditions that allow the pad heatsink to be removed.

4.6.2 WSU



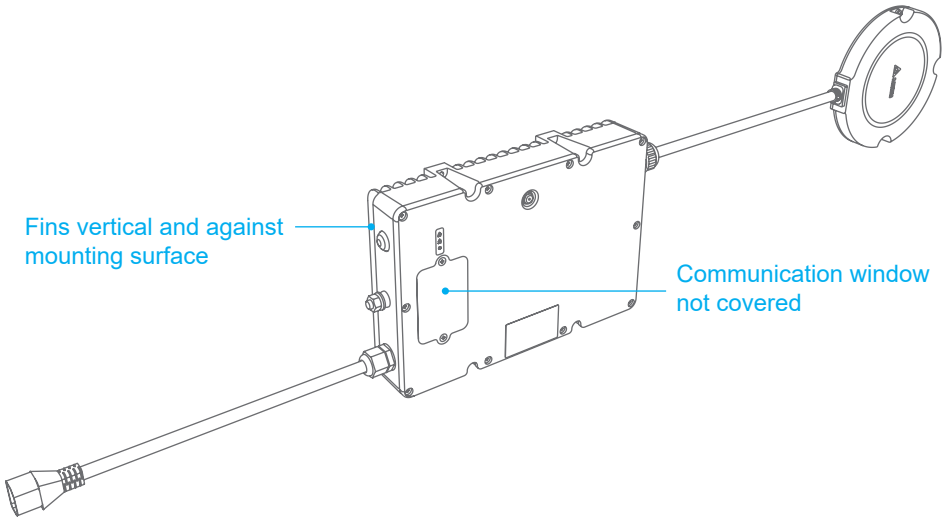
5 Installation

5.1 WPB

5.1.1 Description

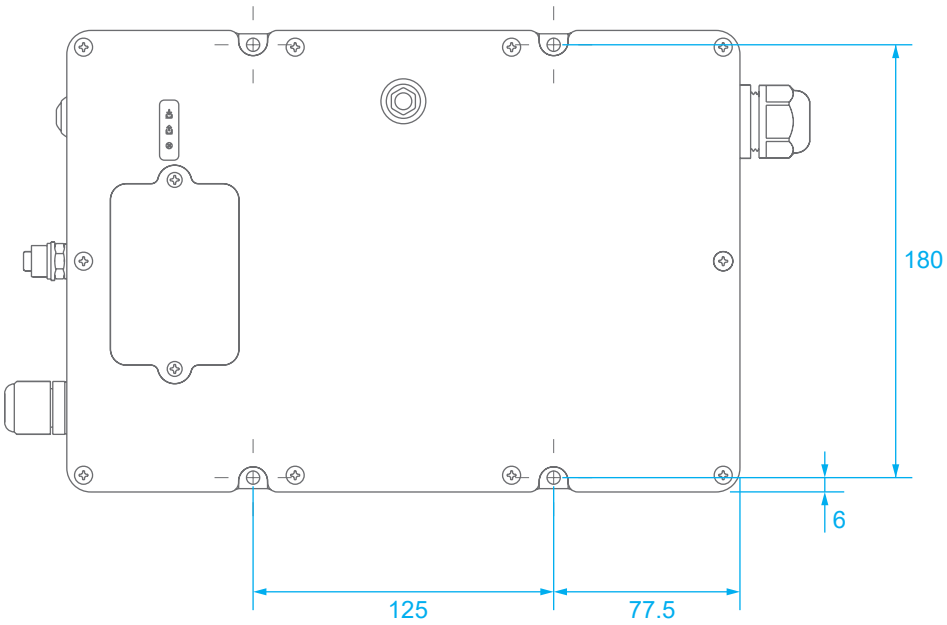
The WPB should have its fins against the mounting surface, and for optimal thermal performance, the fins should be vertical. Take care not to cover the plastic communication window with metal.

The WPB has an ingress protection rating of IP65: it is completely dust proof, and can be exposed to water jets from all angles. However, it should not be submerged or exposed to high-pressure water jets.



5.1.2 Mounting pattern

The WPB should be secured with M4 screws.



5.2 WSB

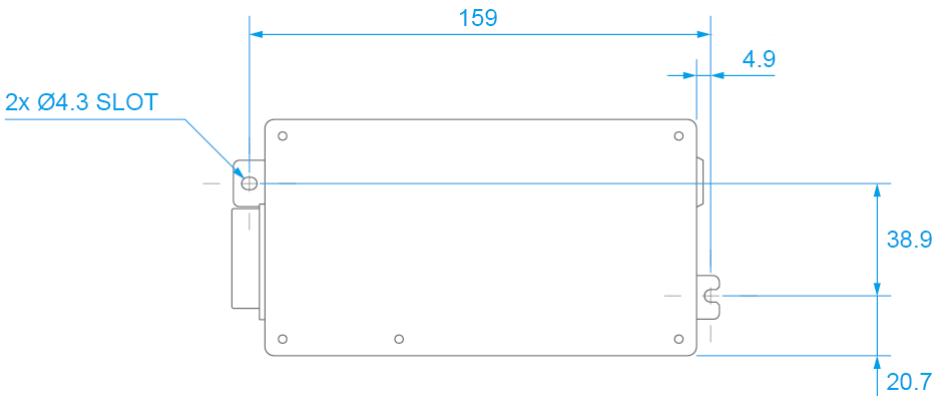
It is intended that the WSB be mounted inside the equipment to be charged. Delta's testing has verified that the WSB is protected against ingress to IP40 and therefore must be protected from water. The other parts of the wireless charging system have been verified by Delta as meeting IP65.

As previously mentioned in section 4.3.3 (Power vs. ambient temperature), it is recommended that the WSB is mounted to a metal surface that can provide heatsinking. This will allow the continuous operation in a wider range of operating conditions.

The plastic cover of the WSB should not be covered, especially by metal. Similarly, the vehicle housing should have a non-metallic area that will allow the WPB and WSB to communicate.

5.2.1 Mounting pattern

The WSB should be secured with M4 screws.



5.3 WPP and WSP

The two pads are the key components used for the wireless power transfer and the following items are important for safe and reliable operation:

- The plastic covers of the Primary Pad and the Secondary Pad must be face-to-face during charging.
- Pad gap and misalignment must be within acceptable the ranges during charging.
- Metallic objects are not allowed between the pads during charging.

System operation is not influenced by pad rotation and the pads may be mated at any angle with respect to each other.

The recommended minimum bend radius of the pad cables is as follows:

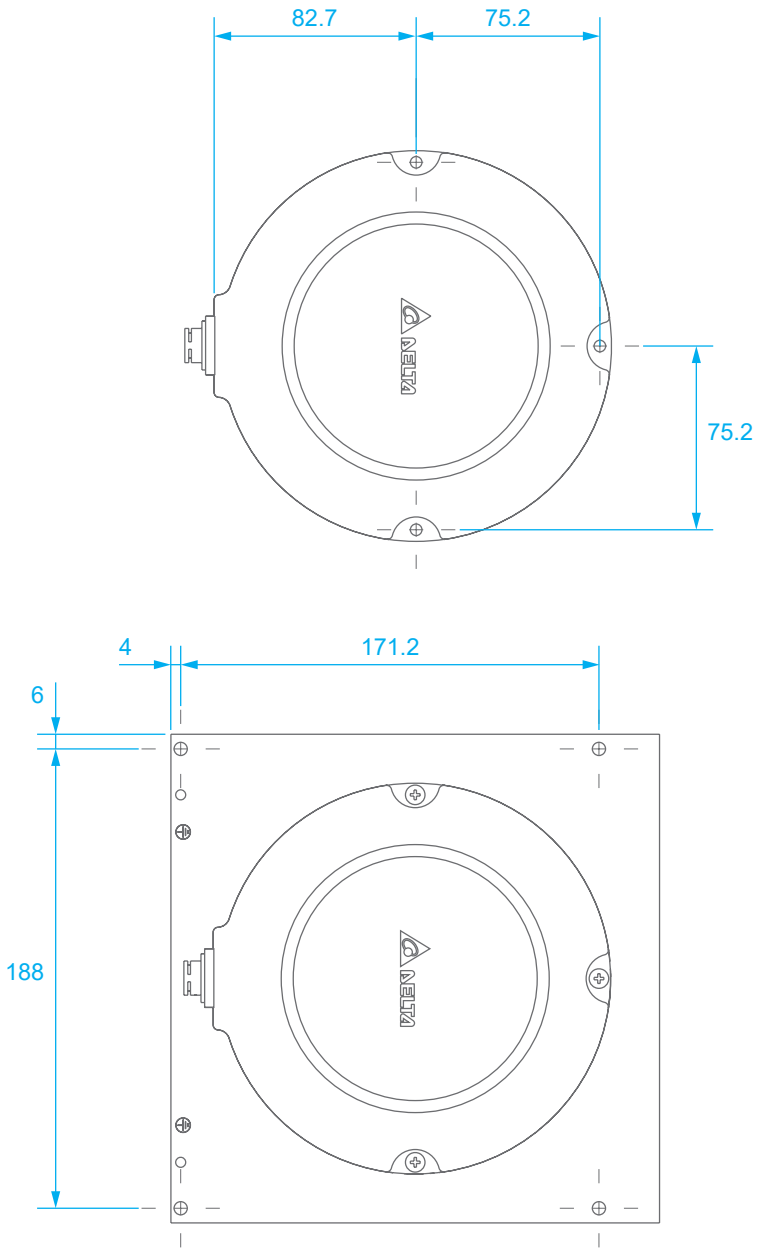
- Primary cable 110 mm
- Secondary cable 80 mm

Important: The charger system is certified as safe only when the pads are mounted vertically. If the user insists on mounting the pads horizontally, then they will take full responsibility to ensure there are no metallic objects present between the pads during charging.

The pads have an ingress protection rating of IP65: they are completely dust proof, and can be exposed to water jets from all angles. However, they should not be submerged or exposed to high-pressure water jets.

5.3.1 Mounting pattern

Both pads have the same dimensions and physical appearance, and should be secured with M4 screws. If the WPP heatsink is used, it should also be secured using M4 screws.



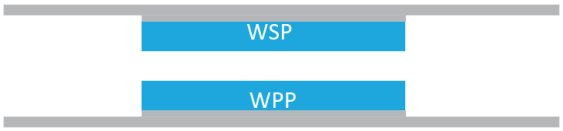
5.4 Metal near the pads

There are no issues when mounting the base of the pads to non-metallic surfaces such as plastic. The active surfaces of the pads can be completely covered by non-metallic material, but the thickness of the material should be taken into account when considering the “gap” when aligning the pads.

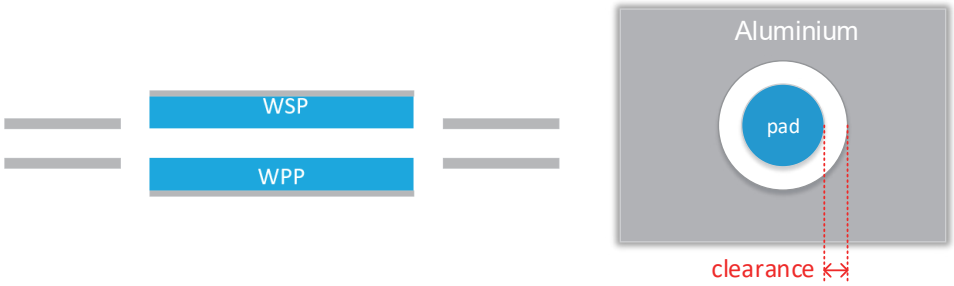
When mounting to metal, the misalignment must be no worse than 20 mm and the guidance in following sections must be followed otherwise unacceptable heat will be generated which will damage the charger system and possibly create a hazardous situation.

5.4.1 Mounting to aluminium

- The base of the pads can be installed directly onto aluminium.

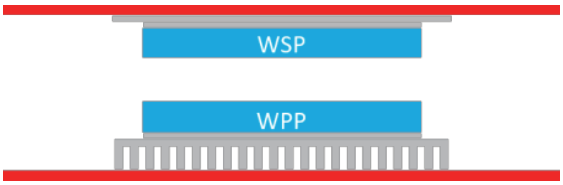


- The top if the pads can be mounted flush with aluminium so long as there is a clearance of 15 mm to the edge of the pad.

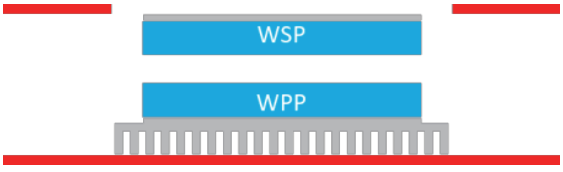


5.4.2 Mounting to ferrous metal

- If the WPP is to be mounted to ferrous metal e.g. steel, the pad heatsink must be used.
- Steel must not be placed near the flat plastic surface of the WPP
- The base of the WSP can be mounted directly to steel if a ≥2 mm thick aluminium shield is placed between the pad and the steel. The shield should extend at least 20 mm beyond the pad in all directions.



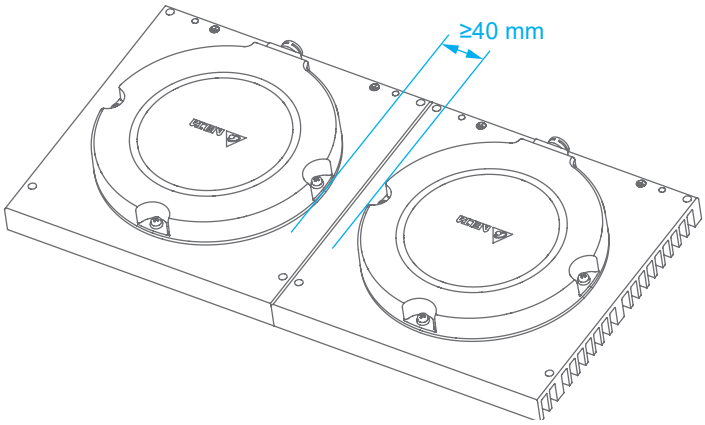
- The base of the WSP can be mounted flush with steel if there is a gap of 15 mm to the edge of the pad.



5.5 Installation of multiple pads

Two or more WPP can be installed in the same area but must be separated as follows:

- If the heatsinks are used on the WPPs then the heatsinks can be touching
- If the heatsinks are not used then the pad edges must be separated by at least 40 mm



5.6 User safety considerations

During charging there will be electric and magnetic fields between the pads. The charger system has been designed to minimise any stray fields. Testing shows conformity to the following human exposure standards:

- EN 62311:2008
- ISED RSS-102 Issue 5
- FCC 47 CFR part 2.1091

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

- Users must be > 20 cm away from the pads. To help ensure this the side of the WSP should be > 20 cm from the edges of the vehicle.
- 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.
- Users with medical devices, such as metallic prostheses, cardiac pacemakers, implanted defibrillators, and cochlear implants, must stay at least 1 m away from the pads.

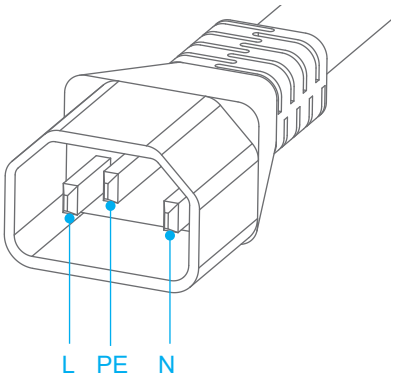
It is the responsibility of the installer of the system to provide adequate training and to place associated warning signs. Also see section 2 for user safety.

5.7 Description of connections

5.7.1 WPU: AC Input

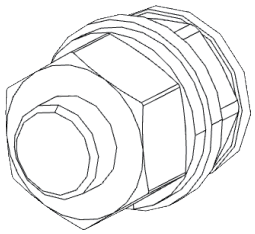
The WPB is supplied with AC via its cable containing a standard IEC C14 connector. The installer should plug in a commonly available IEC C13 power cord.

If the charger system is to provide full power at 100 to 120 V_{AC}, the AC supply including the cord should be rated as suitable for at least 13A.



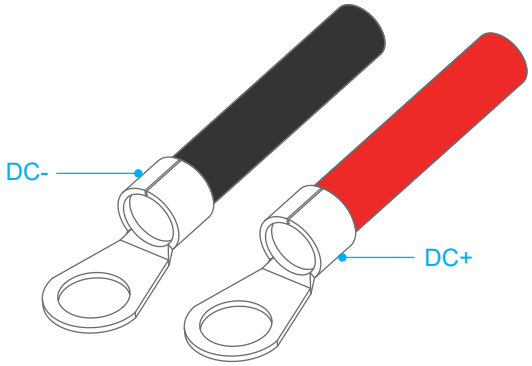
5.7.2 WPU: Earth stud

The WPB has an M8 stud. The installer must firmly attach an earth (PE) cable using the nut and spring washer provided. This is required for the correct EMI performance.



5.7.3 WSU: DC Output

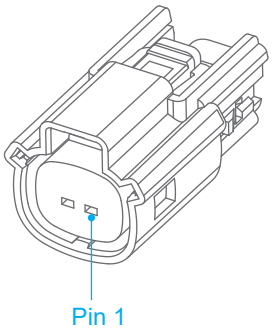
The WSB provides its DC output via red and black AWG #8 cables terminated with M10 ring terminals



5.7.4 WSU: CAN bus connector

The WSB can communicate status and be controlled by CAN bus, allowing connection to BMS or smart vehicle systems. A bootloader function is also implemented allowing the charger system firmware to be field updated. See section 7.10 for details. The use of CAN bus in the end application is optional.

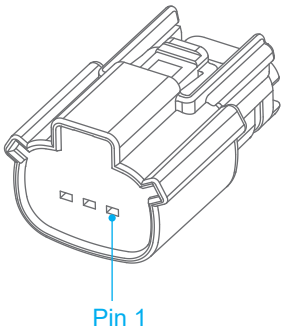
Molex MX150 series. Part number 33471-0201,
mating connector part number 33481-0201:



Pin	Assignment
1	CAN_HIGH
2	CAN_LOW

5.7.5 WSU: External control connector

Molex MX150 series. Part number 33471-3301,
mating connector part number 33481-0301:



Pin	Assignment
1	EXT_Enable
2	Sleep
3	EXT_Signal_GND

5.7.5.1 Sleep

When the WSU is not in use, Sleep mode can be used to reduce the current the WSU draws from the battery. See 6.3 for details. **The use of Sleep mode is optional, and if not required this pin can be left unconnected**.

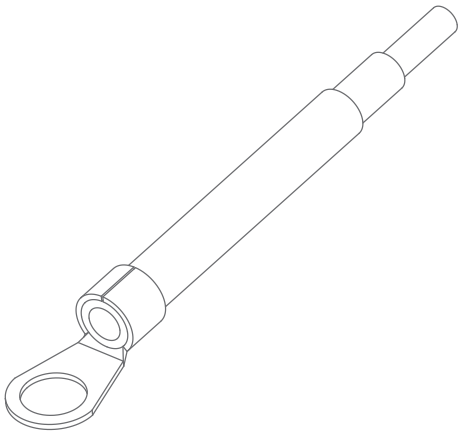
5.7.5.2 Enable

Enable is only used when the WSU is in Profile mode, ie, not under CAN bus control. The purpose of the signal it to initiate the charge process once the vehicle has determined that it is correctly docked and ready for charging. See the flowchart in 8.2 for details.

If the WSU is operating in CAN mode, the EXT_Enable signal pin can left unconnected.

5.7.6 WSU: Battery temperature probe

The WSU is equipped with a temperature probe that can be attached to one of the battery posts using the M10 ring terminal. When in Profile Mode the WSU can use the battery temperature to adjust the charging characteristics or even disable charging in extreme conditions.



The posts in lead acid batteries continue deep inside the battery. Therefore, the temperature of the post is a good indicator of the battery temperature. If the temperature probe is attached to a battery post, the charger system can use the battery temperature to adjust several charging parameters. Care must be taken to avoid any forced airflow directed at the probe as this could lead to the WSU misreading the temperature and therefore not charging optimally.

The battery profiles stored on the WSB will use the information from the temperature probe to adjust the charge to follow the battery manufacturer's recommendations and thereby maximise the life of the battery.

Use of the temperature probe is recommended but not required. If the probe is not being used it should be placed in a location that best represents the battery ambient temperature i.e. in close vicinity to the battery. Avoid placing the sensor close to the WSB.

6 Charge modes

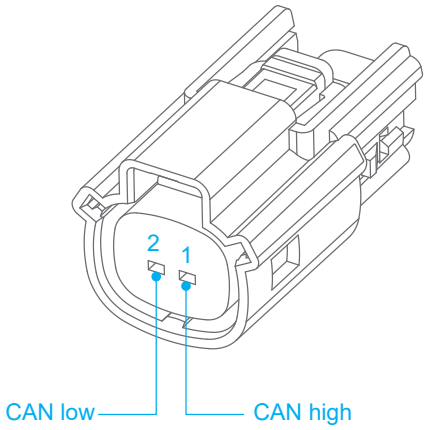
The WSU has two working modes: CAN bus mode and profile mode.

Unless otherwise agreed the WSU will be preconfigured for CAN bus mode. Please contact Delta to discuss how the factory should preconfigure WSU when purchasing in volume.

6.1 CAN bus mode

► **Caution:** When using CAN bus mode it is the responsibility of the user to charge the battery correctly according to the battery manufacturer's recommendations.

In CAN bus mode the WSU's output is controlled by the vehicle or battery management system (BMS) which must be aware of when a charge should happen, what the target voltage of the battery is, what maximum current should be applied, and if any charge parameters should be altered during the course of the charge. The charger system CAN bus protocol is proprietary and can be made available as a .dbc file with accompanying documentation. Please contact Delta for further details

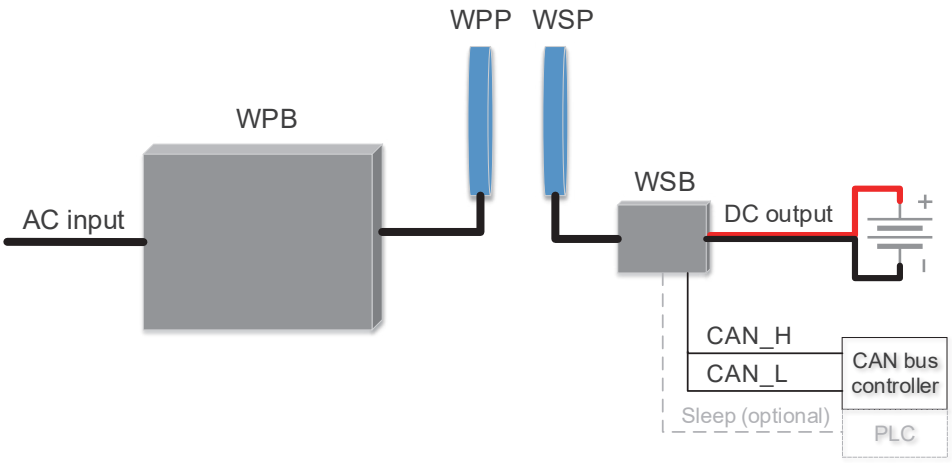


6.1.1 CAN bus hardware specification

- ISO 11898-1 & ISO 11898-2 (CAN 2.0A)
- ID Bits: 11
- Bit rate: 1 Mbit/s (user configurable to 125k, 250k, 500k, 800k)

The WSU is configured as a CAN bus stub node.

6.1.2 System configuration



6.1.3 Basic protocol commands

The following table details the essential commands used to control the WSU. The full protocol includes many more messages, is capable of controlling multiple WSUs on the same bus, and gives detailed fault and status information.

Message Name	Message ID	Signal name	Start bit	Length	Factor	Unit	Description
ControlModule	0x190	Demand_V	0	20	0.001	V	The target voltage the WCS is to achieve by providing current to the battery. When the battery terminal voltage reaches this value, the charging current will reduce (eventually to 0), to maintain the voltage.
		Demand_ PowerStage1	20	1	1		1 = Turn on 0 = Turn off
		Demand_ ClearFaults	21	1	1		1 = Clear Faults If the fault condition no longer exists, charging will resume
		Demand_I	32	18	0.001	A	The maximum current used to reach or maintain the target voltage.

Note: ClearFaults will not clear over voltage protection (OVP) and over current protection (OCP). Instead a “Turn off” command then a “Turn on” command should be sent using Demand_PowerStage1

6.1.4 CAN bus watchdog

If the WSU is under CAN bus control it must receive frequent messages on ID 0x190, otherwise it will disable its output and indicate “Fault_WD_Comms”. This is an important safety feature as when the WSU is being controlled by CAN bus, it is the responsibility of the system to ensure safe operation of the WSU. Without this feature, if the system lost control of the WSU perhaps due to a broken cable, the charger system would continue doing the last thing it was instructed to and would do so indefinitely resulting in a potentially hazardous situation.

It is recommended that the 0x190 message be sent to the WSU every 100 ms.

6.2 Profile mode

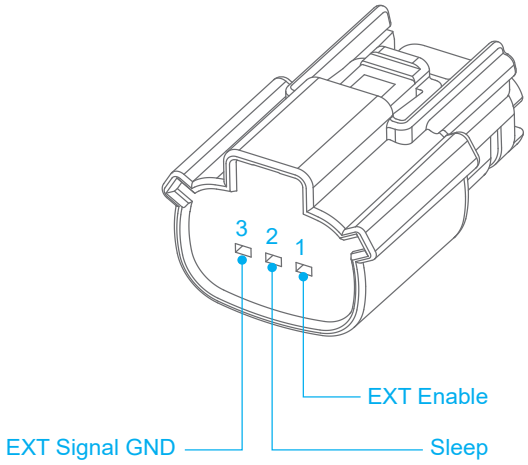
► **Caution:** When using profile mode, only charge the battery with an appropriate profile. Contact Delta for further advice.

In this mode, the WSU uses an inbuilt profile to charge the battery according to the manufacturer's recommendations. The profile will be specific to the battery and Delta have profiles for many manufacturers covering a range of battery constructions, e.g., lithium and lead acid (AGM, gel, TPPL). The WSU can store four of these profiles and new profiles can be created on request.

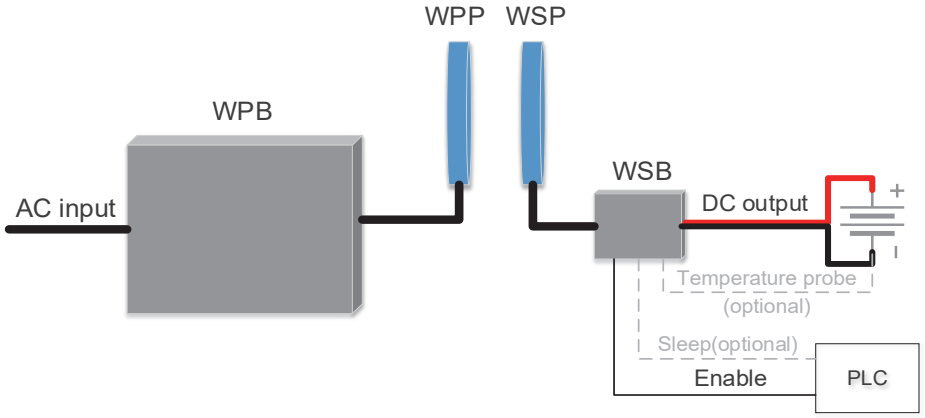
When the WSU is operating in profile mode, the vehicle controller's GPIO must provide high and low logic levels to start and stop the charging process.

A high voltage level presented between pin 1 (“EXT_Enable”) and pin 3 (“EXT_Signal_GND”) of the connector instructs the charger system to start charging following the pre-set profile. Conversely, a low voltage level will stop the charging process. A high voltage level is defined to be a nominal 3.3 V or 5 V (range 2.7 V to 5.5 V), and a low voltage level should be less than 0.3 V or NC (not connected). The flowchart in appendix section 8.2 shows the correct sequence of events.

When the WSU is in profile mode, CAN bus control commands have no effect, but the WSU can still report status via CAN bus.



6.2.1 System configuration



6.3 Sleep mode

The purpose of Sleep Mode is to lower the current the WSU takes from the battery when not charging. If the WSU is connected to a small capacity battery, or if charging does not occur frequently, this current draw could be significant, and if this is the case then Sleep Mode should be used.

If Sleep Mode is not used the WSU will typically draw an average of 70 mA (24 V version) or 40 mA (48 V version) from the battery. Sleep mode would reduce this to approximately 2 mA.

A high voltage level presented between pin 2 (“Sleep”) and pin 3 (“EXT_Signal_GND”) of the connector instructs the WSU to enter Sleep Mode. Conversely, a low voltage level will deactivate Sleep Mode. A high voltage level is defined to be a nominal 3.3 V or 5V (range 2.7 V to 5.5 V), and a low voltage level should be less than 0.3 V or NC (not connected). It will take the WSU less than one second to change mode as instructed by the Sleep signal.

The use of Sleep is optional, and if it is not require this pin can be left unconnected.

When Sleep Mode is active, charging cannot take place and CAN bus communication with the WSU is not possible. Sleep must only be activated when the WSU is in Standby, ie, not charging. The flowchart in appendix section 8.2 shows the correct sequence of events.

7 Graphical user interface (GUI) for PC

The GUI is primarily a means to demonstrate the charger system's CAN bus capabilities as all data transmitted and received by the GUI is done via CAN bus. It allows evaluation of the wireless charger system before the CAN bus protocol is incorporated into the AGV system controller.

CAN bus mode	Control	Set target voltage and maximum currrent
		Enable or disable the charging process
	Configuration	CAN bus baud rate
		Assinging CAN bus node ID
Profile mode	Selecting the charging profile to be used	
Both Profile and CAN bus mode	Monitoring the charger system	Status including graphing of the output voltage and current
		Faults
		Data logging for export to Excel
	Update firmware	

7.1 Requirements

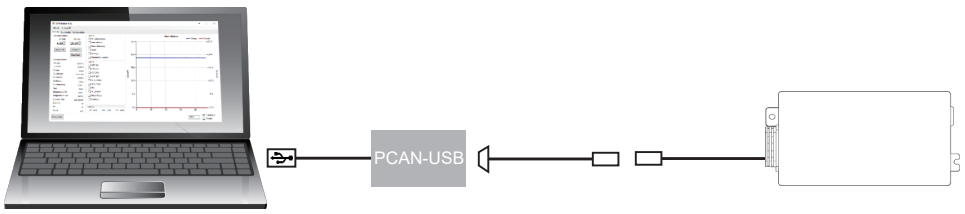
- PC with a USB port, and Windows 10 operating system.
- Peak-System PCAN-USB adapter
- 2-pin Molex to DB9 cable (Delta can make available on request)
- GUI software for PC (Delta can make available on request)

7.2 Installing PCAN-USB drivers

The GUI requires that the drivers for the PCAN-USB are installed. The drivers can be downloaded from support section of the the Peak-System website.

7.3 Connecting the WSU to the PC

The WSU CAN bus cable is connected to the PC using a PCAN-USB and an adapter cable as follows.

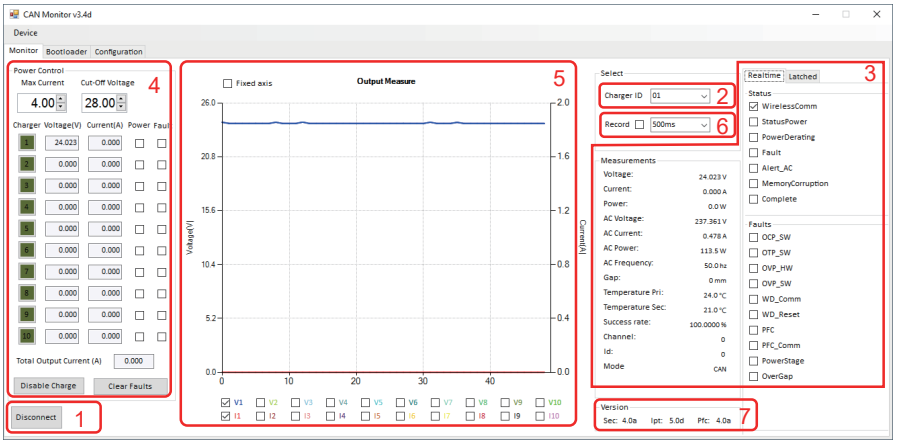


Additionally, the WSU DC output terminals must be connected to a voltage source of between 12 V and 30 V (24 V model) / 60 V (48 V model) to be able to communicate via CAN bus.

7.4 Installing the GUI

The GUI files are available as a zip to be downloaded via FTP. Please contact Delta for details. Preferably, the zip file should be extracted to the hard disk of the PC, but extracting to a network location is also possible. The following shows the contents of the GUI folder when the zip is extracted to the desktop. Double click “CanMonitor.exe” to run the GUI.

7.5 Areas of the monitor tab



1. Connect/disconnect button
2. Selects the CAN node address of the WSU to have its status shown in [3] or recorded in [6]. Also used to select the node address of the WSU to have its settings changed in the Configuration tab. If only one WSU is used then this can be ignored.
3. Status of the charger system who's node address is currently selected
4. Set voltage target and maximum current (i.e., setpoints). If multiple WSUs of the same variant are used with their outputs in parallel, then the current entered is the current per WSU. The numbers 1-10 down the left side refer to CAN node IDs. Each number can be clicked to toggle that WSU on or off.
5. Area for graphing the WSU outputs. The I and V numbers at the bottom can be used to show or hide each WSU.
6. Record button plus how often each recording is made.
7. Firmware revisions of each charger system part correctly aligned and powered.

7.6 Basic operation

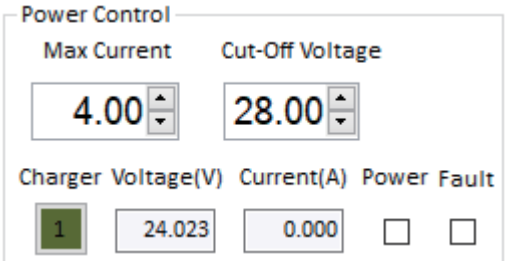
Click the “Connect” button to start communicating with the WSB. If everything is set up correctly the GUI will report live data from the WSB, for example:

- "Measurements" area [3] will show the voltage present on its terminals, temperature, etc
- "Output Measure" area [5] will start graphing the WSU output
- "Version" area [7] will show firmware revision

If the WPB has power and the pads are correctly aligned, the GUI will also show its live data.

7.7 Using the GUI with the WSU in CAN bus mode

Use “Cut-off Voltage” and “Max Current” to enter the target voltage the WSU should attempt to reach and maintain, and the maximum current it should use to reach the target voltage. When “Power On” number (#1 shown) is clicked the charger system will use the current that is chosen to charge the battery until it achieves the target voltage. Please note that the WSU will only give current if the target voltage is above the measured voltage. When the target voltage is reached, the current will automatically reduce to avoid the target voltage being exceeded. When the WSU is under CAN bus control, it is the CAN bus system controller that must decide when the battery is full and the charge should be stopped. In this case it will be the user of the GUI who decides then toggles the "Power on” button to the off position. If the charge is not stopped the current will decrease further and approach zero, but the target voltage will never be exceeded.



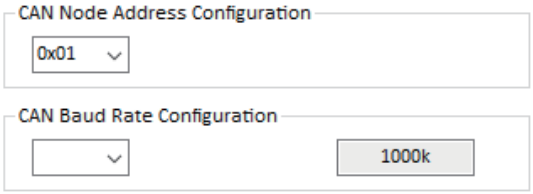
If any charger system encounters a fault condition then its Fault status will show a tick and details of the fault will be shown in the status area [3]. If the source of the fault is eliminated, the charge system may auto-clear the fault, but if not the “Clear Faults button can be clicked. If the fault is still present charging will not continue.

7.7.1 CAN bus configuration

If the WSU is used on the same bus as other items it may be necessary to change the WSU's CAN bus node address. This is done in the Configuration tab of the GUI. It is possible to control two or more WSUs of the same variant on the same bus with their outputs separate or in parallel, so long as the WSUs have different node addresses.

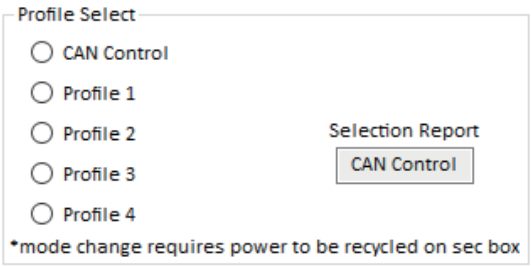
Unless otherwise agreed, the WSUs will have a CAN bus baud rate of 1 Mbps. The configuration tab can be used to set the baud rate to one of the following: 125 kbps, 250 kbps, 500 kbps, 800 kbps, 1 Mbps.

The configuration tab only effects the WSU selected in area [2] (Charger ID) of the Monitor tab.



7.8 Using the GUI with the WSU in Profile mode

The WSU can be loaded with up to four different charging profiles. The Configuration tab is used to select which profile to use, or to change back to CAN bus mode if already in profile mode. Simply click the circle next to the profile to be used. The Selection Report will show the Delta profile number (the picture below shows the WSU is still in CAN mode). The power must be recycled on the WSB in order for the profile change to take effect, i.e., disconnect it from the battery and then reconnect. When the new profile is active it will be reported in the Mode line at the bottom of area [3] on the Monitor tab.



When in Profile mode the WSU will not respond to GUI inputs for voltage and current setpoints, Power on/off, or Clear faults. However, the GUI will continue to report live status, faults and graph the output.

7.8.1 Loading a new profile

The secondary box should be powered and connected to a PC as shown in section 7.3

Delta will provide a batch file to automatically load the profile(s) to the WSU. The user only needs to run the batch file. Further details will be given should there be a need to add a profile to the WSU.

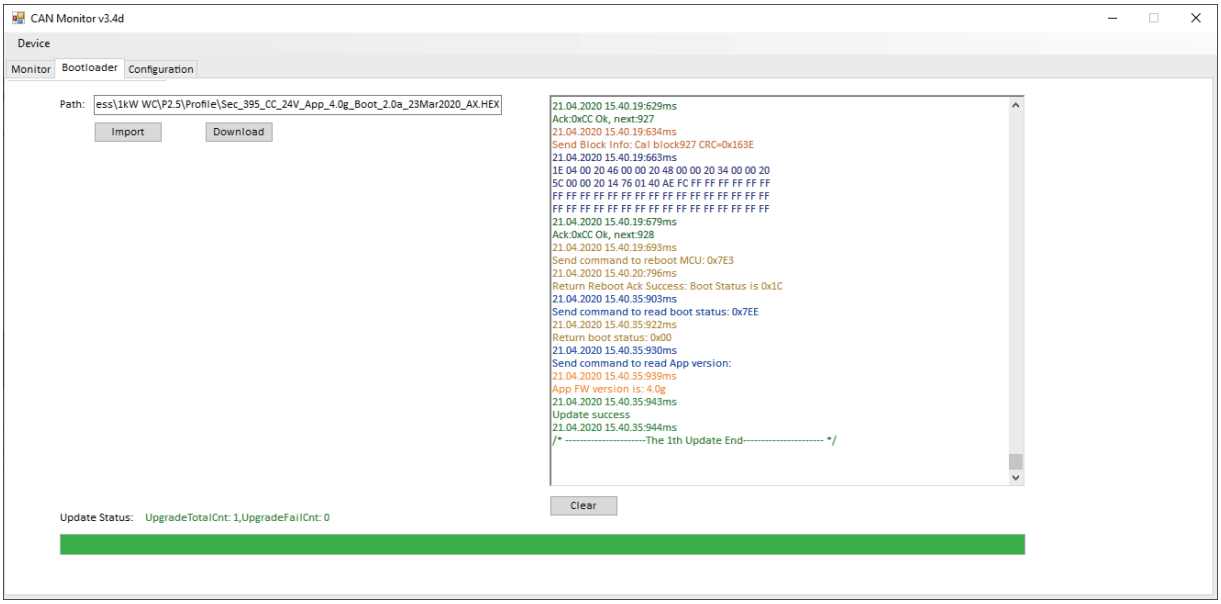
7.9 Data logging

The “Record” checkbox in area [6] will enable data logging. If the box is ticked a CSV file will be created in the same folder as the GUI exe file. The dropdown next to the record button sets the frequency of recording. The name of the CSV file will consist of the date and time when the file was created, e.g.,“17.04.2020 12.34.18.csv”. The CSV includes information for each timestamp such as input voltage and current, output voltage and current, primary and secondary temperatures, and fault/status information.

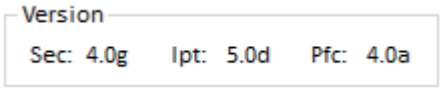
Please note that the CSV file can only be imported to Excel after the GUI has been closed.

7.10 Updating firmware

Should Delta make new firmware available for either the WPU or WSU, the Bootloader tab is used to upload it to the charger system. Click on Import and select the firmware update, then click download to send it to the charger system. The update process will take several seconds and should conclude with a message of success. Do not interrupt the process by disconnecting power or closing the GUI.



The new firmware version (secondary firmware version 4.0g in this example) is shown in area [7] of the monitor tab.



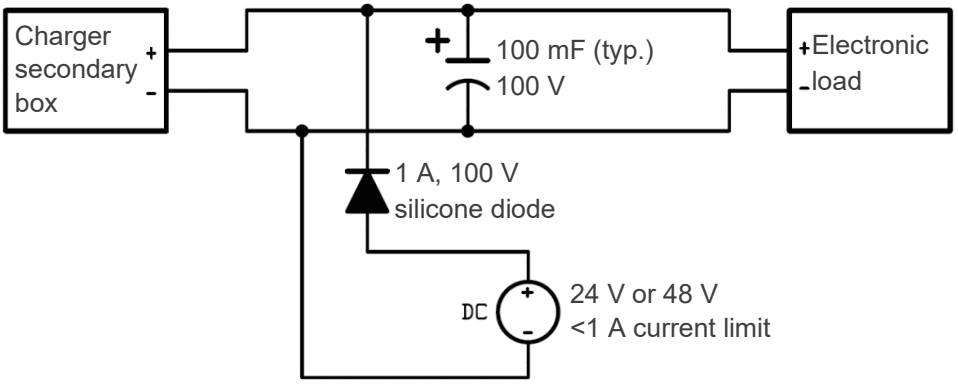
To update the WPU firmware the same process is followed but the WPU should be connected to AC and the pads should be mated and connected using the Connect button [1].

8 Appendix

8.1 Evaluating the charger system without a battery

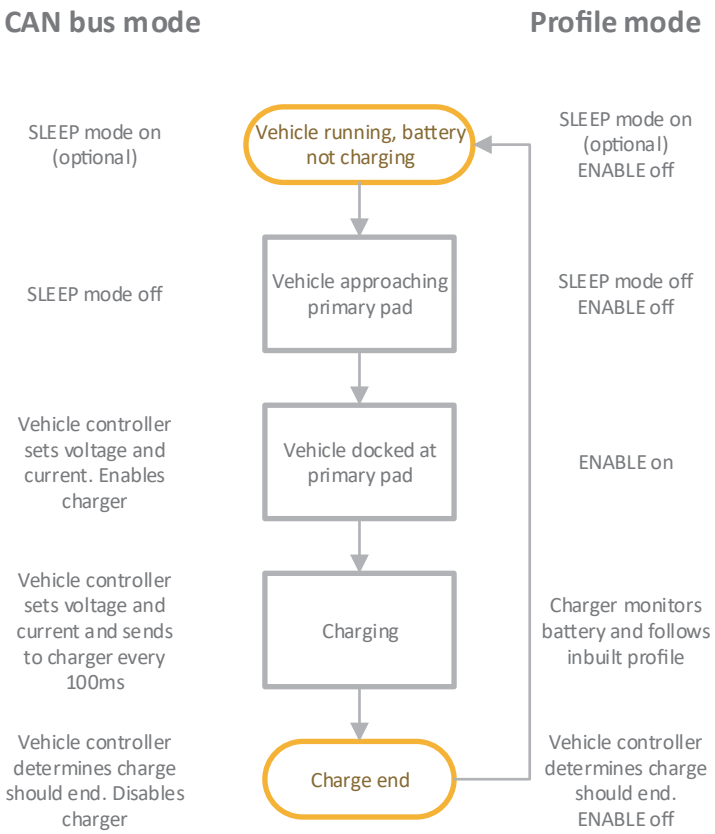
The best way to see an accurate representation of the charger system performance is to charge a real battery. However it is possible to evaluate the charger system using an electronic load set to Constant Voltage mode.

System block diagram in this condition is shown as below. In the test system, to simulate the battery, an 100 mF capacitor need to be connected in parallel at DC output bus, and a pre-charging circuit (including DC source, diode) is necessary to charge the capacitor to a reasonable voltage value (e.g. 24 V for 24 V variant, 48 V for 48 V variant) before turning on the wireless charger system.



The charger system performance is not guaranteed when operating with an electronic load.

8.2 Flow chart



8.3 Troubleshooting

The safety advice in this document must be followed before attempting to troubleshoot.

If charging does not start when commanded please follow the steps below:

1. If the Green AC Present LED is not lit
   - Check that input cable is securely inserted.
   - Check that the input voltage is within the WPU's operating range (85 V_{AC} to 265 V_{AC})

If the green LED is lit but the red LED is flashing, the charger system has detected a fault and has disabled its output. Please check the following:

2. Charger system output.
   - Check that output power cables are firmly connected to the battery.
   - Check the battery is connected to the WSU with the correct polarity.
   - Measure the battery voltage and check that it is within the acceptable range for the WSU variant. See section 4.3.1 for the acceptable voltage ranges.
   - Check that the signal cables are connected securely to the vehicle controller.
   - For using Profile Mode, check that “EXT_Enable” signal is activated. Refer to section 6.2
   - Check that “Sleep Mode” is not active. Refer to section 6.3
3. Air gap and misalignment.
   - Check that the pad gap and alignment is within the acceptable range. Refer to section 4.5
4. CAN bus mode.
   - Check that the baud rate is correct. The default baud rate of the WSU is 1 Mbps. Refer to the CAN bus .dbc file regarding how to configure the WSU for other baud rates.
   - The WSU must receive charging commands regularly via message 0x19x otherwise, the CAN bus watchdog will register Fault_WD_Comms as mentioned in 6.1.4. It is recommended that these messages are sent to the WSU every 100 ms. Sending the message more frequently runs the risk of overloading the bus, and sending less frequently could mean that one or two dropped messages trigger a fault when there was no real danger.
   - If the voltage setpoint sent to the WSU is lower than the battery voltage then no current will be delivered.
5. Whether the WSU is operated in CAN bus Mode or Profile Mode, status and faults will be reported live via CAN bus.
   - Useful debug information is sent on the following messages:

     0x31x (ModulePowerMeasurementsSlowT)

     0x32x (ModuleStatusReportT)

     0x3Ex (WirelessStatusMeasurementsT)

     0x5Fx (WirelessStatusReportT)

     0x77x (Control_ReportCommInfo_T)

     Further details are available in the .dbc file.
   - Comprehensive status and fault information are displayed in the Delta GUI, as shown in area [3] of the Monitor tab as shown section 7.5.
   - Most faults can be cleared by sending a Demand_ClearFaults message 0x19x. However OVP and OCP faults require the WSU to be turned off and then on again using Demand_PowerStage1.

If further support is required, please provide Delta with the following information:

- The serial numbers shown on the labels of both the WPU and the WSU
- Photographs of the charger system setup showing pad positions and cabling
- What the LEDs on the WPB are indicating
- Most useful of all is a screengrab showing the monitor tab of the GUI taken when the fault has occurred.

8.4 Charger system fault and status messages

The charger system will report faults and status via CAN bus, even if working in Profile Mode

8.4.1 Faults

All faults result in the WSU disabling its output and flashing the red fault LED on the WPB. In Profile Mode the WSU will attempt to automatically clear faults 5 times before latching them and turning permanently off. To recover from this state the DC power on the WSU must be recycled. The fault counter will reset after 5 minutes of fault free operation.

Type	Fault/Status	CAN Report	Active	Deactive
General Fault	Fault	0x32x, bit12	Any fault has occurred	
General Fault	Fault_OCP_SW	0x32x, bit18	The output current has exceeded the OCP threshold	In CAN mode the WSU latches off. Power off/on command to clear. In profile mode the WSU will auto clear.
General Fault	Fault_OTP_SW	0x32x, bit20	Any part of the system has exceeded the OTP threshold	Auto clear when the temperature decreased to an acceptable level.
General Fault	Fault_OVP_HW	0x32x, bit21	The output voltage has exceeded the OVP threshold	In CAN mode the WSU latches off. Power off/on command to clear. In profile mode, the WSU will try to auto clear 5 times.
General Fault	Fault_OVP_SW	0x32x, bit22	The output voltage has exceeded the OVP threshold	In CAN mode the WSU latches off. Power off/on command to clear. In profile mode, the WSU will try to auto clear 5 times.
CANbus Fault	Fault_WD_Comms	0x32x, bit24	Can bus mode only - The WSU has not received control command within 1s	Send clear fault command with message 0x190
General Fault	Fault_WD_Reset	0x32x, bit25	WSU has reset due to an internal firmware fault	In CAN mode the WSU latches off. Power off/on command to clear. In profile mode, the WSU will try to auto clear 5 times.
General Fault	Fault_PFC	0x32x, bit26	Any fault occurs in the WPU	The fault will auto clear after approximately 3 seconds once the WPU returns to an operational state.
General Fault	Fault_PFC_Comms	0x32x, 0x27	This fault is set when the internal communication failed at WPU	Auto clear When the internal communication recovery.

Type	Fault/Status	CAN Report	Active	Deactive
General Fault	Fault_PowerStage	0x32x, bit28	During charging - The output voltage or current is larger than the demand value for 10 s Before charging - The output voltage larger than the demand value	Auto clear if the battery voltage is smaller than the set value.
General Fault	Fault_ MemoryCorruption	0x32x. Bit30	Read calibration data from EEPROM failed	CAN mode - send clear fault command. Profile mode - latched off. Return to Delta
Profile Fault	Chrgr_Flt_ InvalidProfile	0x5Bx, bit0	Profile mode only - The charge profile is invalid	The charge profile is OK
Profile Fault	Chrgr_Flt_ BattTempOutOfRange	0x5Bx, bit1	Profile mode only - The battery NTC temperature is too high or too low	The temperature is in normal range
Profile Fault	Chrgr_Flt_ ProfDetectBattIssue	0x5Bx, bit2	Profile mode only - Any profile fault has occurred	No faults are present
Profile Fault	Chrgr_Flt_ BattVoltOutOfRange	0x5Bx, bit3	Profile mode only - Battery voltage is out with the range allowed to start charging.	Auto clear

8.4.2 Status

Type	Fault/Status	CAN Report	Active	Deactive
General Status	Status_Derating	0x32x, bit6	When the WSU working in power derating mode	Auto clear when working in normal mode
General Status	Status_Power	0x32x, bit10	When the WSU is transmitting power	When the WSU is not transmitting power
General Status	Alert_Temperature	0x32x, bit14	WSU is hot and is approaching OTP threshold	Auto clear when temperature reduces
General Status	Alert_AC	0x32x, bit23	When the AC input voltage is abnormal	Auto clear when AC voltage is normal
General Status	Status_Over_Gap	0x5Fx, bit0	When the air gap between WSP and WPP is to large during charging.	Auto clear when the air-gap is normal
General Status	Status_OTP_Receiver	0x5Fx, bit1	Any OTP occurred at WSU	Auto clear when the temperature decreases low enough.
General Status	Status_OTP_ Transmitter	0x5Fx, bit2	Any OTP occurred at WPU	Auto clear when the temperature decreases low enough.
General Status	Status_Wireless_ Comms	0x5Fx, bit7	When the wireless communication established.	The wireless communication disconnected

The following profile status messages are only used by Delta for the creation of profiles, but may be useful for debug purposes.

Type	Fault/Status	CAN Report	Active	Deactive
Profile Status	Chrgr_Prof_ ChargeEnd	0x5Dx, bit8	Charge has ended due to profile complete or error	
Profile Status	Chrgr_Prof_Phase_ AhLim	0x5Dx, bit10	The number of amp hours returned to the battery is too high for the charging stage.	Remove source of fault and recycle DC on the WSB
Profile Status	Chrgr_Prof_Phase_ Imax	0x5Dx, bit11	Current has exceeded the maximum allowed by the profile stage.	
Profile Status	Chrgr_Prof_Phase_ Imin	0x5Dx, bit12	Current is below the minimum allowed by the profile stage.	
Profile Status	Chrgr_Prof_Phase_ Timeout	0x5Dx, bit13	The charge stage is taking too long.	Remove source of fault and recycle DC on the WSB
Profile Status	Chrgr_Prof_Phase_ Vmax	0x5Dx, bit14	Voltage has exceeded the maximum allowed by the profile stage.	
Profile Status	Chrgr_Prof_Phase_ Vmin	0x5Dx, bit15	Voltage is below the minimum allowed by the profile stage.	
Profile Status	Chrgr_Prof_ PhaseComplete	0x5Dx, bit16	Briefly activated when changing profile stages	
Profile Status	Chrgr_Prof_ PhaseError	0x5Dx, bit17	Any profile phase error has occurred	

Smarter. Greener. Together.

Delta Energy Systems (Germany) GmbH
Tscheulinstrasse 21, 79331 Teningen
E-mail: IEV.sales@deltaww.com

More information

www.deltaww.com

2021 / 06 Version 1.0