

PIONIX

BelayBox

User manual and setup and assembly instructions
for the BelayBox DevKit

The **BelayBox** is a reference platform specifically designed for development and testing of the open source software **EVERest**. More details about how EVERest is embedded on the hardware can be found in the dedicated sections about EVERest cross-compilation.

EVERest is part of LinuxFoundation Energy and the BelayBox is powered by Raspberry Pi.



The **BelayBox** is a development kit, which has to be assembled following the instructions in this documentation, and can be utilized by individuals, research facilities and companies alike to

- Parallelize HW and SW developments for new charger projects
- Explore new charging algorithms without the need do all the groundwork
- Rapid integration of EV charging with other applications

.... and anything else you want to quickly do without building your own EVERest compatible charger first.

BelayBox is not meant to be used for private usage or outdoor charging,

Disclaimer: *The descriptions and specifications of this product are preliminary and subject to change without further notice. Final product specifications may differ. As PIONIX cannot control or anticipate the conditions under which this product may be used, each user should review the information in the specific context of the planned use. To the maximum extent permitted by law, PIONIX will not be responsible for damages of any nature resulting from the use or reliance upon the information contained in this document.*

Revision History

Date	Revision	Changes
2023-08-16	1.0	
2024-04-23	1.1	Clarification: Software simulation is not possible with BelayBox out of the box. EV or hardware EV simulator is needed.
2024-08-06	1.2	Removed notes regarding derating, the option of a GNSS receiver and dependency of charge rate from ambient temperature. Clarification of BelayBox being a development to be assembled. Clarification for support contact: Purchased support quota only is for hardware-related issues. Changed standard credentials for SSH access. Updated Pionix headquarter's address.
2024-08-23	2.0	Multiple changes regarding the new Yocto-based Yak image.

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1. Introduction

This "Installation and user manual" describes how to install the charging station and make it ready to use. You must carefully read the safety information before you start.

1.1. Scope of the manual

The installation and commissioning instructions in this manual are intended for qualified installers who can assess the work and identify potential danger.

The user instructions are intended for users of the charging station.

Retain all documentation delivered with the charging station in a safe place for the entire life cycle of the product.

Forward all documentation to any subsequent owners or users of the product.

This manual gives an overview of the functionality and technical specifications of the BelayBox. To dive right into the setup and assembly procedure, see https://everest.github.io/nightly/hardware/pionix_belay_box.html

Disclaimer

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1.2. Target group

The document is intended for these groups:

- Academia and laboratories developing EVSE / charging stations
- Installation engineer

Required qualifications for the installation engineer:

- The qualified installation engineer fully knows the EVSE and its safe installation.
- The installation engineer is qualified according to the applicable local rules to do the work.
- The qualified installation engineer obeys all local rules and the instructions in the installation manual.
- It is the responsibility of the owner of the EVSE to make sure that all qualified installation engineers obey the local rules, the installation instructions, and the specifications of the EVSE.

1.3 Symbols used in this manual

Symbols are used according to the standards of ISO 3864-2:

▲ DANGER
DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.
▲ WARNING
WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.
▲ CAUTION
CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE
NOTICE is used to address practices not related to physical injury. The safety alert symbol shall not be used with this signal word.

1.4. Icons used in this manual

The following icons are used on illustrations in this manual or on the product.



Danger of electric shocks:

When the device is not correctly installed and / or parts or the DevKit are ruptured like cables, plugs or interfaces, high voltages and with it hazards to persons (e.g. electric shocks, burns) and systems (e.g. overload) may occur.

If water enters the product, it may result in fire, electric shock or a problem with the product or the charged product.

1.5 Certification and compliance



The BelayBox is **not** yet CE-certified. A list of standards that have been used during the design process will be listed in the Appendix.



Electrical and Electronic appliances must be disposed of separately from the general municipal solid waste.



The product was developed with components only that meet the regulation 2011/65/EU

2. Safety

2.1 Safety precautions

⚠ DANGER

Not following the installation and user instructions given in this manual will result in the risk of electric shock, which will cause severe injury or death.

- Read this manual before installing or using the charging station.

⚠ DANGER

Installation, servicing, repair and relocation of this charging station by a non-qualified person will result in the risk of electric shock, which will cause severe injury or death.

- Only a qualified electrician is permitted to install, service, repair, and relocate the charging station.
- The user must not attempt to service or repair the charging station as it does not contain user-serviceable parts.
- Local regulations may be applicable and may vary depending on your region or country of use. The qualified electrician must always ensure that the charging station is installed according to the local regulations.

⚠ DANGER

Working on electric installations without proper precautions will result in the risk of electric shock, which will cause severe injury or death.

- Switch off the input power before installing the charging station.
- Do not switch on the charging station if it is not fully installed or not secure.
- Do not install a charging station that is faulty or has a noticeable issue.

⚠ DANGER

Operating the charging station when it is damaged or worn will result in the risk of electric shock, which will cause severe injury or death.

- Do not operate the charging station if the power supply, the enclosure or an EV connector is broken, cracked, open, or shows any other indication of damage.
- Do not operate the charging station if a charging cable is frayed, has broken insulation, or shows any other indication of damage.
- In the event of danger and/or an accident, have the electrical supply to the charging station disconnected immediately.
- Contact your installer if you suspect that the charging station is damaged.

⚠ DANGER

Extensive exposure of the charging station to water will result in the risk of electric shock, which will cause severe injury or death.

- Do not direct powerful jets of water toward or onto the charging station.
- Do not put the charging plug into any liquid.

⚠ WARNING

Installing the charging station during wet environmental conditions (for example, rain or fog) can result in the risk of electric shock and damage to the product, which can cause severe injuries or death.

- Do not install or open the charging station during wet environmental conditions (for example, rain or fog).

⚠ WARNING

Incorrect use of the charging station will result in the risk of electric shock, which may cause injury or death.

- Make sure that the contact area of the charging plug is free from dirt and moisture before starting a charging session.
- Make sure that the charging cable is positioned so that it will not be stepped on, tripped over, driven over, or otherwise subjected to excessive force or damage. Where applicable, make sure that the charging cable is correctly stowed when it is not in use, making sure that the charging plug does not touch the ground.
- Only pull on the charging plug hand grip and never on the charging cable itself.

- Keep the charging station, charging cable and charging plug away from heat sources, dirt, and water.
- Do not use explosive or readily flammable substances near the charging station.

⚠ WARNING

Using adapters, conversion adapters, or cord extensions with the charging station may result in technical incompatibilities and can result in damage to the charging station, which will cause injury or death.

- Use this charging station to charge compatible electric vehicles only. Refer to the charging station specifications in the charging station installation manual for details.
- Refer to your vehicle user manual to check if your vehicle is compatible.

⚠ WARNING

Exposure of the charging station or the charging cable to heat or flammable substances can result in damage to the charging station, which will cause injury or death.

- Make sure that the charging station or the charging cable never comes into contact with heat.

⚠ WARNING

Using the charging station under conditions not specified in this manual may result in damage to the charging station, which may cause injury or death.

- Use the charging station only under the operating conditions specified in this manual.

⚠ WARNING

Working on electrical installations without using personal protective equipment will result in the risk of injury.

- Use personal protective equipment such as eye protection, cut-resistant gloves, and non-slip safety shoes to prevent personal injuries.

⚠ WARNING

Fire safety:

- When safe to do so, have the electrical supply to the equipment that is burning or endangered by fire disconnected.
- Do not use water to extinguish electrical installations and equipment that have a live power supply.
- To extinguish a charging station, use an extinguisher that is specified for use on electrical equipment with a rating of up to 1 kV.

⚠ CAUTION

Charging a vehicle with the charging cable not completely extended may result in overheating of the cable, which can damage the charging station.

- Before you connect the charging cable to the vehicle, fully unwind the cable. Make sure that the charging cable has no overlapping loops.

⚠ CAUTION

Putting fingers into or leaving other objects inside the plug port (for example, during cleaning) may cause injury or can damage the charging station.

- Do not put your fingers into the plug port.
- Do not leave objects inside the plug port.

⚠ CAUTION

Not taking precautions against ESD (Electrostatic discharge) can damage electronic components in the charging station.

- Take the necessary precautions against ESD before touching electronic components. Ask your electrician which local requirements apply.

⚠ CAUTION

Not enabling firmware updates for this charging station, or disabling, opting out of, or otherwise failing to install available firmware updates, may cause the charging

station to encounter problems, function with errors, and be more prone to safety or security risks.

⚠ CAUTION

New releases of firmware will be identified automatically. As soon as the updates are downloaded and installed the BelayBox reboots automatically. This may cause interruptions of a charging process. Do not power off the device during the update process.

⚠ CAUTION

Cybersecurity note:

This topic is valid for all network connections, wired or wireless. This product is designed to be connected to and to communicate information and data via a network interface. It is the owner's sole responsibility to provide and continuously ensure a secure connection between the product and owner's network or any other network (as the case may be). The owner shall establish and maintain any appropriate measures (such as, but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. PIONIX is not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

2.2. Moving and storage precautions

Obey the following guidelines when moving and storing the charging station:

- Disconnect the input power before removing the charging station for storage or relocation.
- Transport and store the charging station only in its original packaging. No liability can be accepted for damage incurred when the product is transported in non-standard packaging.
- Store the charging station in a dry environment in the temperature and humidity ranges given in the technical specifications.

3. Technical Specifications

3.1 Intended use

The PIONIX BelayBox is an electric vehicle charging station development kit. The intended use thereby is to do **SW development** and fast integration projects and test real charging sessions on test vehicles.

It is not meant to be used as a private or public charging station for regular charging procedures. It is not approved for outdoor usage.

Note: While it is possible to run charging simulations with the open-source software EVerest, the BelayBox is not configured to run a software simulation without a connected car or a hardware EV simulator. More sophisticated modifications in the BelayBox-integrated EVerest would be necessary for such a scenario without any connected EV hardware.

3.2 Technical specifications BelayBox

Main parts of the BelayBox are the **Yeti board**, an AC charger for electric vehicles (EV) supporting IEC-61851-1 and SAE J1772, and the **Yak board**, which is a high-level control board for EV charging stations.

Feature	Description
Electrical properties	
Maximum charge rate	Up to 11 kW (3-phase, 16 A) The charge rate depends on factors such as the demand from the EV and the available power supply.
Charging mode	Mode 3 (IEC 61851)
Input capacity	EU: 1-phase, 230 V $\pm 10\%$, maximum of 16 A $\pm 6\%$, 50/60 Hz. 3-phase, 400 V $\pm 10\%$, maximum of 16 A $\pm 6\%$, 50/60 Hz. US: 3-phase 240 V delta $\pm 10\%$, maximum 16 A $\pm 6\%$, 50/60 Hz

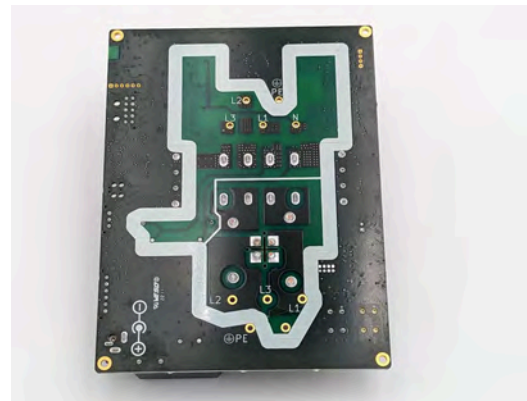
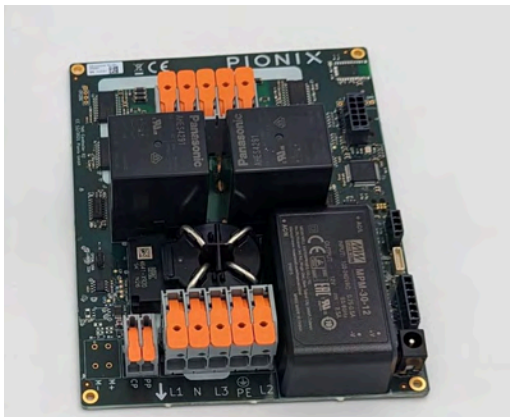
Power cable	Fixed cable with 16A CE plug
Charging cable	Permanently connected cable with Type 2 plug for electric vehicles (approx. 5m length)
Metering	Non-MID conform metering included, current metering, voltage and line frequency on all phases
Ground leakage detection	Electronic RCD 6mA DC/30mA AC. <i>Does not replace the RCD type A in the installation, this must still be present electromechanically / as part of the house installation.</i>
Measurements	Current, voltage and line frequency on all phases
Operating temperature range	0 °C to +45 °C (+40 °F to +113 °F)
Maximum operating humidity (non-regulating)	85% RH (non-condensing)
Maximum installation altitude	1.000 m above sea level
Connectivity + User interface	
Authorization device	RFID included
Communication standards	2.4 GHz and 5.0 GHz IEEE 802.11ac WLAN, Bluetooth 5.0, BLE Gigabit Ethernet USB RS 485 CAN UART
Powerline Modem	Homeplug GreenPHY QCA7005
Display	5 inch IPS Display with capacitive touch, 1000 nits sunlight readable
Physical information	

Dimensions	435 x 245,2 x 151,2 mm (L x W x D) see 6. Technical Drawings
Weight	<5kg
Housing	
Plastic cover over high voltage parts	
Double insulation on power PCBs	

3.3 Yeti PowerBoard

As both Yeti & Yak Board are also released as Open Hardware under CERN Open Hardware Licence Version 2 - Permissive, more information as well as the schematics, design files and the 3D files for printing the BelayBox case components are available here:

<https://github.com/PionixPublic/reference-hardware>



The Yeti board manages the high voltage path.

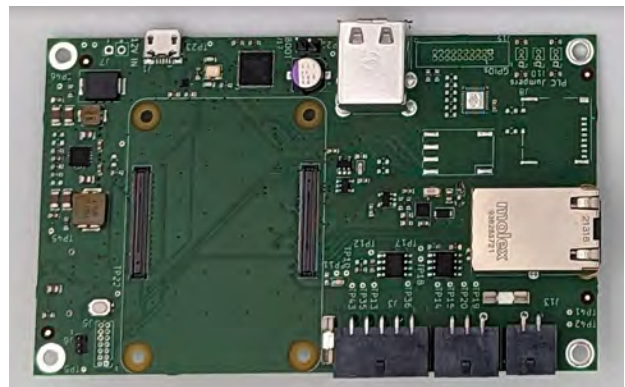
Electrical

A CAUTION

The Yeti board can work with 32 A but the PIONIX cable set will only work with 16 A. The default configuration sets the limit of the amperage to 16 A. Please make sure to not change the configuration to higher values.

- AC 1-3 phase, 16 A each, 230 V (11kW) with neutral (IEC 61851) or 3 phase Delta 240V for USA.
- N/L1/L2/L3 switched by relay
- Electronic RCD 6mA DC/30mA AC.
Does not replace the RCD type A in the installation, this must still be present electromechanically / as part of the house installation.
- Measurement of current, voltage and line frequency on all phases.

3.4 Yak HighLevel Board



The Yak board is the highlevel compute board designed for running EVerest / BaseCamp. For more information on EVerest and BaseCamp, see the "SW Start-up" section below.

Compute & Radio

- Raspberry Pi Compute Module 4 - 2 or 4GB RAM, 8-32GB eMMC. Exact model depending on availability.
- 2.4 GHz and 5.0 GHz IEEE 802.11ac WLAN, Bluetooth 5.0, BLE

- Gigabit Ethernet, USB, RS 485, CAN, UART
- RFID+NFC transceiver 13.56 MHz

3.4 Internal Interfaces

- 5x3.3V GPIO or PTC input (e.g. for connector temperature monitoring)
- ISO 15118 / PowerLine HomePlug GreenPHY communication with vehicle via CP pin

3.6 Outbound connectors:

- Permanently connected cable with **Type 2** plug for electric vehicles (approx. 5m)



- Supply line: L1,L2,L3,N,PE, by means of terminals in the DevBox housing



- Housing (without cable):
 - Metal cable hook (optional)
 - Vacuum molded casing
- Designed for:
 - EMI: IEC/EN61851-21-2

- Safety: IEC/EN61851-1

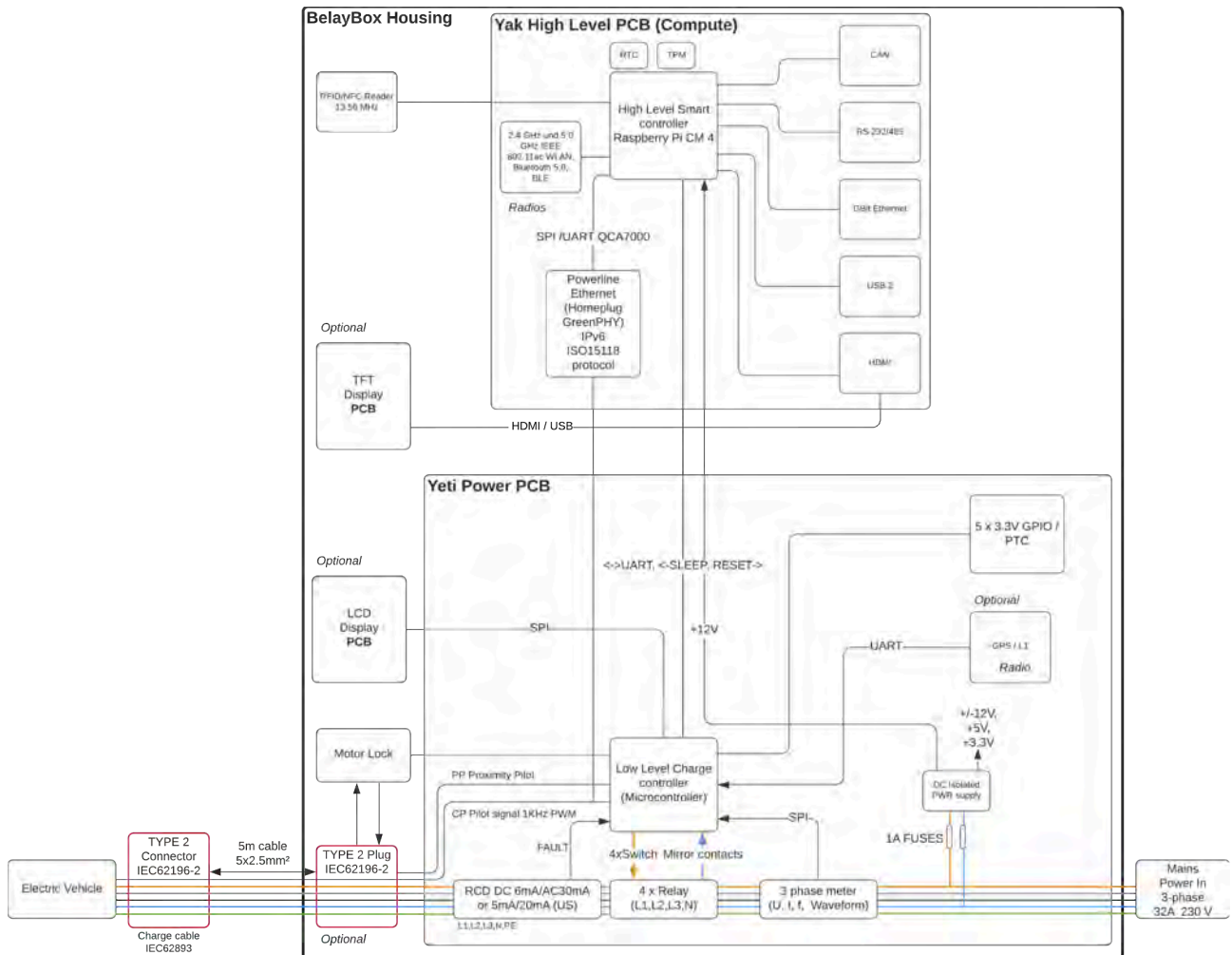
3. 7 Microcontroller Firmware

- Control AC charge signals (PWM, CP)
- Control energy metering etc.
- Perspective: Encapsulation of calibration law

Open source code, contains all electrical safety relevant software, available on GitHub:

<https://github.com/PionixPublic/yeti-firmware>

4. Electrical Block Diagram



5. Housing

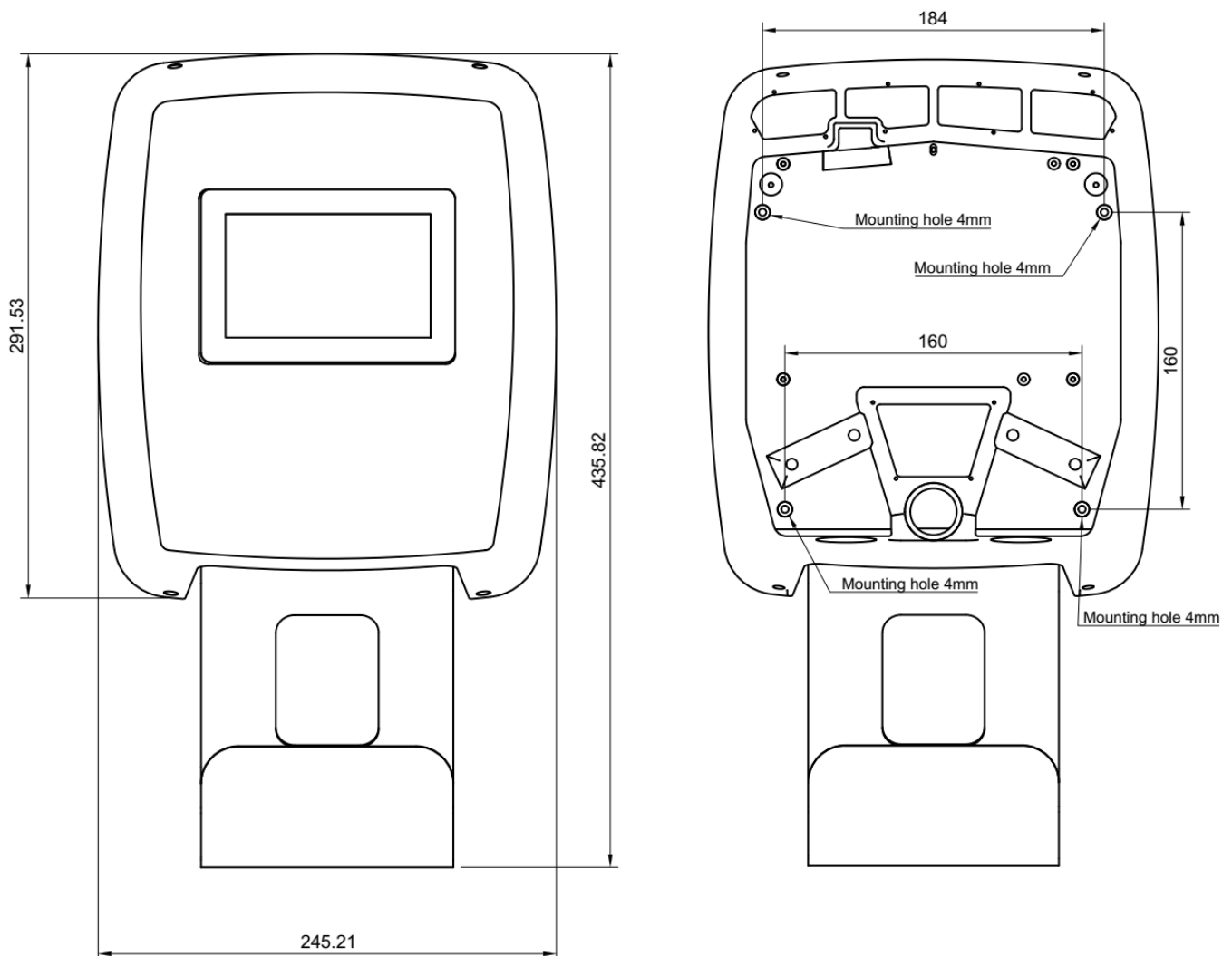
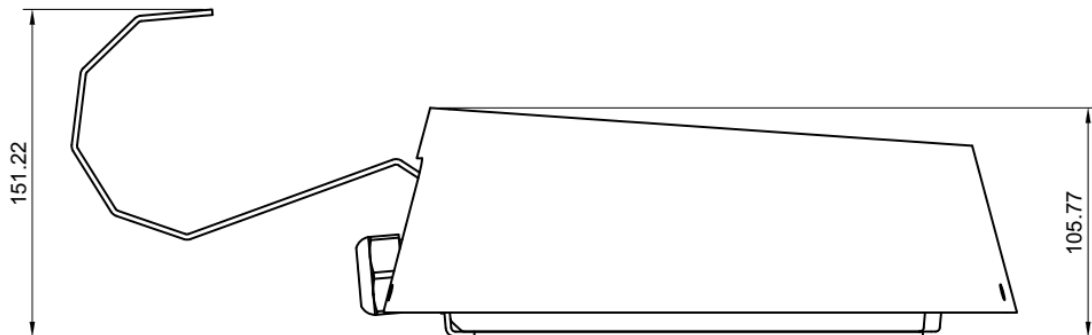
Housing only



with **Yeti** PowerBoard mounted (on backplate), **Yak** & display mounted on front plate



6. Technical Drawings



7. Mechanical Installation

Preliminary requirements - Installation engineer:

- Make sure that there is no voltage on the AC input cables during the complete installation procedure.
- Keep unqualified personnel at a safe distance during installation.
- Make sure that water cannot enter the cabinet.
- Protect the EVSE with safety devices and measures that the local rules specify.
- If it is necessary to remove safety devices, immediately install the safety devices after the work.

As the BelayBox is only meant to be a development kit it is not certified for outdoor usage. In case you want to mount the BelayBox, install it on a wall or flat surface that is protected from any influence of dust, water, chemicals or air pollution.

The surface needs to be able to withstand the mechanical load of the BelayBox and the cable handling.

For installing, please follow these steps:

1. Mark the position of the 4 mounting holes on the surface according to the technical drawings above.
2. Drill 4 holes into the surface.
3. Open the BelayBox by unscrewing the outer 4 screws fixed in the housing.
4. Secure the BelayBox with screws through the mounting holes according to the technical drawing.
5. Close the BelayBox housing by fixing the housing screws.

Make sure the Box is properly secured and fixed to the surface.

8. Electrical Installation

Preliminary requirements

Installation engineer:

- Make sure that there is no voltage on the AC input cables during the complete installation procedure.
- Keep unqualified personnel at a safe distance during installation.
- Make sure that water cannot enter the cabinet.
- Protect the EVSE with safety devices and measures that the local rules specify.
- If it is necessary to remove safety devices, immediately install the safety devices after the work.
- Only use electrical wires of sufficient gauge and insulation to handle the rated current and voltage demand.
- Make sure that the load capacity of the grid is in accordance with the EVSE.
- Earth the EVSE correctly. Make sure that the EVSE is connected to a grounded, metal, permanent wiring system, or an equipment-grounding conductor must be run with the circuit conductors and connected to the equipment grounding terminal or lead on the product.
- Make sure that the connections to the EVSE comply with all applicable local rules.
- Make sure that the wiring inside the EVSE is protected from damage and cannot get trapped when you open or close the cabinet.

There are three options to supply power:

1. 16A CEE plug in
2. 3-phase 16A CEE socket to 1-phase Schuko adapter
3. An external 12V power supply that can deliver at least 2.5A. Open the BelayBox to reach the barrel connector with 5.5mm outer and 2.5mm inner diameter (no AC power for charging applications).

9. SW Start-up

The software of the BelayBox is divided into an open source hardware specific microcontroller firmware and a Linux-based open source SW stack containing the main charging controller and its various interfaces (EVerest / BaseCamp - see next section).

9.1 Project EVerest and BaseCamp

EVerest is a full open source stack for EV charge points under a [commercial-friendly license \(Apache 2.0 license\)](#). Allows modifications and commercial products based on it, without publication obligation of the source code. It is governed by the [Linux Foundation](#) / Linux Foundation Energy and maintained by a growing community.

BaseCamp is a commercial wrapper around EVerest to provide long-term support and standard APIs which make development of production-ready chargers easier.

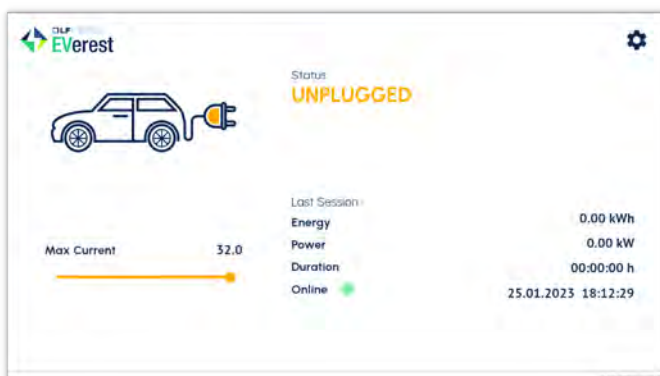
For more information about the product of BaseCamp, see <https://pionix.com/basecamp-os-for-ev-chargers>

The BelayBox is built to run a basic BaseCamp (which includes EVerest). Information on how to flash your Yak board with a ready-to-use BaseCamp image, see https://everest.github.io/nightly/hardware/pionix_belay_box.html

9.2 First booting

The BelayBox will boot up automatically.

1. After the very first boot, you will be asked if the BelayBox shall run in private or public mode. Tap the according option.
 - a. Private mode lets you change configuration and is for development purposes.
 - b. Public mode does not allow any changes on settings anymore via the UI on the display.
2. The following screen is shown on the display:



Connect to the WiFi:

1. Tap the "Settings" gear symbol in the upper right corner. You will see the settings menu:



2. Tap on "WiFi Setup". On the following screen, activate WiFi by tapping on the screen:



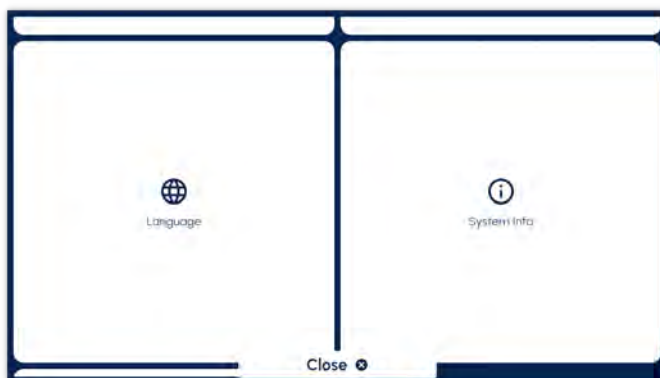
3. A list with accessible WiFi connections appears. Tap on the WiFi that you want to use for connecting.
4. To authenticate, tap on the text field on top of the screen. A on-screen keyboard will appear with which you can enter the WiFi password.

5. Tap on connect. If successful, you will see the connected WiFi flagged in green:

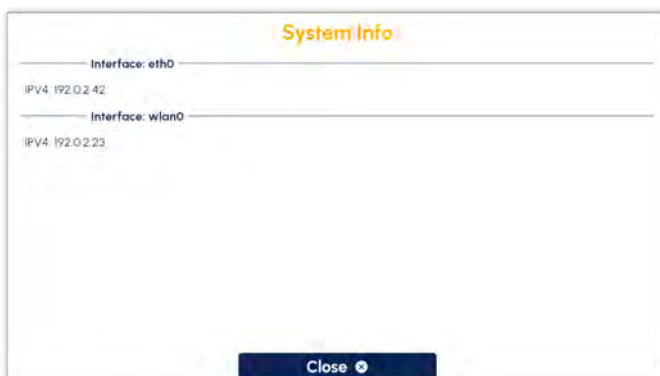


Get IP address of BelayBox:

1. Tap the "Settings" gear symbol in the upper right corner. Scroll / Drag down until you see the menu option "System Info":



2. Tap "System Info" and find the IP addresses for Ethernet and WiFi connections:



Note: eth0 is typically assigned to the GreenPHY PLC modem. In case a USB-to-Ethernet adapter is assigned to "eth0" by the OS, please make sure that you configure the correct network interface in the "device" section for the PLC in your EVerest config file.

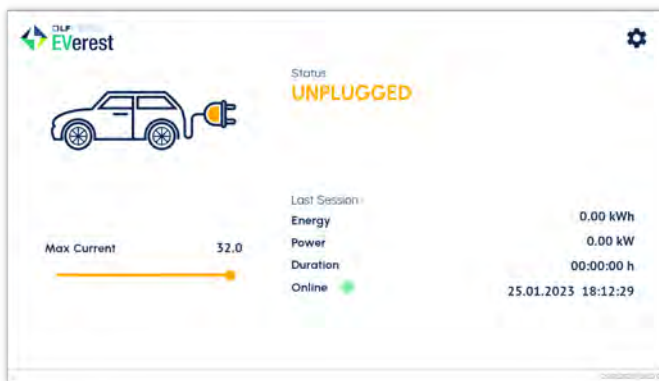
9.3 Car Charging

Important Information:

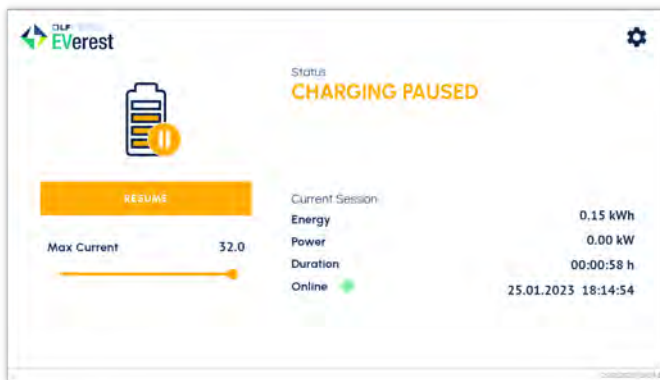
As soon as a new release of EVerest has been identified, downloaded and installed, the BelayBox reboots automatically - independent of a potential current charging process. This will be optimized in future releases.

A car charging process can be initiated after the BelayBox has started. See the display showing the status of the BelayBox:

- "Unplugged": This is the status without the BelayBox having a connection to a car.

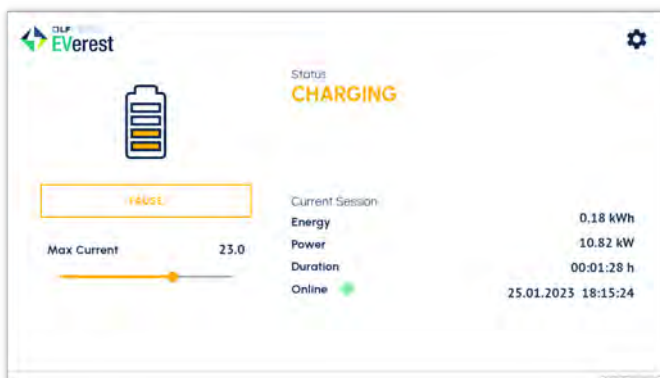


- "PluggedIn": Status right after the plug to the vehicle has been connected. If the charging process works, this status will switch to "Charging".
- "Charging": Status when actively charging
- "Charging Paused": Status after manually halting active charging. Charging can be manually paused by tapping on the PAUSE button. After that, the button will show the text RESUME like this:



- "Paused by car": This status is shown in case the car paused active charging.
- Further status names are "Auth Required" in case an authentication needs to be performed and "Permanent Fault" in case of an error that needs to be manually resolved.
- For more a full list of available states, see <https://github.com/PionixPublic/yeti-firmware/blob/main/Yeti/protobuf/lo2hib.h>

You can change the power level by adjusting the charge current with the slider button. The following picture shows a reduced power level:



For a user interface with more information, you can visit the following URL with a web browser on a computer in the same network as the BelayBox:

http://<IP_ADDRESS>:1880/ui

<IP_ADDRESS> is to be replaced by the actual IP address of the BelayBox (see section "First Boot And Gathering Network Information").

10. Developing With The BelayBox - SSH Access

For the most direct path to start developing follow these steps:

1. Startup the box, connect to a network and check your IP address (see chapter 7 - 9).
2. Establish an SSH connection from your computer that has to be in the same network as the BelayBox.
The standard credentials for user name and password are *root* / *basecamp*.
3. Refer to the software documentation of EVerest (<https://everest.github.io>) for information about EVerest details and how to create new modules.

For dedicated development use cases, see the corresponding section in the online BelayBox documentation here:

https://everest.github.io/nightly/hardware/pionix_belay_box.html

Support Contact

If you have any **hardware-related questions** regarding the BelayBox, you can contact us via our Support System: <https://support.pionix.com/>

For **software-related issues**, you can get help from the active EVerest community. You reach them best via the mailing list (<https://lists.lfenergy.org/g/everest>) or the Zulip instance at <https://lfenergy.zulipchat.com/>

Further Reading

Official EVerest documentation:

<http://everest.github.io>

Open hardware repository on GitHub:

<https://github.com/PionixPublic/reference-hardware>

Further EVerest resources

- Project page: <https://www.lfenergy.org/projects/everest/>
- Github project: <https://github.com/EVerest>
- Roadmap & [community meeting minutes](https://github.com/EVerest/everest/blob/main/tsc/README.md):
<https://github.com/EVerest/everest/blob/main/tsc/README.md>
- Full [documentation](https://everest.github.io/): <https://everest.github.io/>
- EVerest [YouTube Channel](https://www.youtube.com/channel/UCF0Mt88gmn7Hbx2fvaQPE4A) with webinars, meeting records, talks, ...
<https://www.youtube.com/channel/UCF0Mt88gmn7Hbx2fvaQPE4A>
- Developer [mailing list](https://lists.lfenergy.org/g/everest): <https://lists.lfenergy.org/g/everest>
- EVerest community exchange on Zulip:
<https://lfenergy.zulipchat.com/>

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See <https://shop.pionix.com/> for equipment related to BelayBox and our Micro-Mega-Watt-Charger.

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Get in touch!
contact@pionix.com