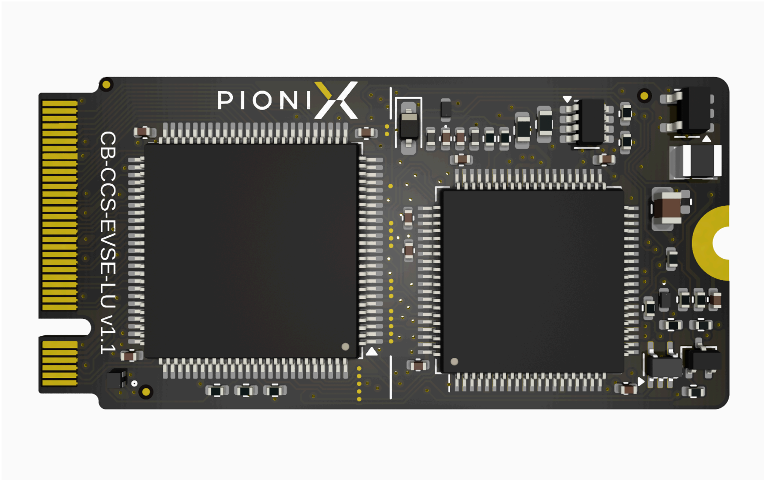
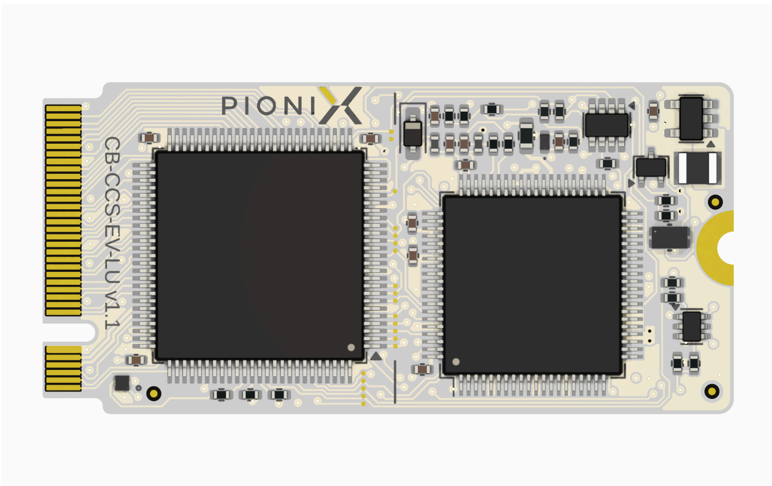
ChargeBridge Datasheet



CB-CCS-EVSE-LU



CB-CCS-EV-LU

Preliminary specifications for prototype series v1.2
January 2026

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Overview

This datasheet outlines the technical specifications of the ChargeBridge module family and provides all necessary information for seamless integration into a baseboard.

ChargeBridge serves as a complete charging frontend for a single charging port, and can be integrated with off-the-shelf solutions, open reference designs, or used in the development of custom controllers.

Controllers can be designed with pin-compatible ChargeBridge modules, enabling support for multiple charging standards by simply exchanging the module. For example, switching from CCS1/2 to MCS is possible without redesigning the baseboard—only the ChargeBridge module needs to be replaced.

While the primary application is for charging stations (EVSE side), EV-side modules are also available. These are ideal for bench testing, development, or HIL (Hardware-in-the-Loop) test setups.

All core charging logic and safety-relevant control is executed by the MCU on the ChargeBridge module, effectively decoupling it from the high-level host system (e.g., Linux). The firmware running on the MCU ensures full compliance with all relevant standards and comes pre-certified.

The ChargeBridge EVSE variant is certified for functional safety according to IEC 61805 SIL-2.

Communication with external components is routed through a transparent Ethernet or USB bridge, enabling modular system designs and a wide range of possible topologies.

Support for additional charging standards is planned, including MCS, CHAdeMO, GB/T, and ChaoJi.

Software

The firmware of the ChargeBridge module is proprietary and is bundled with Linux support software that manages all communication between the host system and the module. This support software bridges the ChargeBridge's hardware interfaces—including CAN, RS485, PLC, and UART—to native virtual devices within Linux, enabling seamless integration.

Key hardware functions such as Control Pilot (CP), Proximity Pilot (PP), relays, and GPIOs are exposed via a simple MQTT API in Linux, making them easy to control and monitor from user-space applications.

EVerest, a reliable and future-ready Linux-based operating system for EV charging stations, integrates directly with this API without additional customization.

Fully Supported in combination with EVerest

- IEC 61851-1 – PWM Basic Charging
- ISO 15118-2:2014 – AC & DC, TLS 1.2 / PnC

- DIN SPEC 70121:2014 – DC

Technical Preview

- ISO 15118-20:2022
  - TLS 1.3 (with optional support for TLS 1.2 or no encryption)
  - Dynamic Mode
  - Scheduled Mode
  - DC and DC_BPT (Bidirectional Power Transfer)
  - AC and AC_BPT (Bidirectional Power Transfer)

Supported Connector Types

This version of the ChargeBridge module supports CCS Type 1 and 2 for AC and DC.
Future modules will support additional standards including:

- MCS (Megawatt Charging System)
- GB/T
- CHAdeMO
- ChaoJi

Supported plug types

- Type 1 (J1772)
- Type 2
- CCS Combo Type 1
- CCS Combo Type 2
- NACS / Tesla

Future modules will support additional plug types.

Backend Communication

- OCPP 1.6J – Including most standard profiles plus additional optional extensions
- OCPP 2.0.1 – Core, Advanced Security, Local Authorization List Management, etc.
- OCPP 2.1 – Core supported; full use-case coverage coming soon
- Plug & Charge
- Eichrecht (German calibration law support)

EVerest Hardware Integration

EVerest includes drivers for commonly used EVSE components, including:

- AC/DC power supplies
- Power meters (AC/DC)
- Insulation monitors

- RFID/NFC readers
- And more

More Information

For the complete and up-to-date list of features included in the current EVerest release, please refer to the EVerest open source project:

https://github.com/EVerest/everest-core

Typical Applications

ChargeBridge supports a wide range of applications and can be integrated into various hardware and system architectures. Its modular design allows it to scale from simple single-port chargers to complex multi-port, multi-standard systems. Example topologies include:

- **Single PCB with one charging port**
  A compact design integrating compute, power, and a single ChargeBridge module.

- **Single PCB with dual charging ports**
  Supports **AC/AC**, **DC/DC**, or mixed **AC/DC** configurations.

- **Single PCB with multiple charging ports (AC & DC)**
  For dense charging applications with shared compute and power resources.

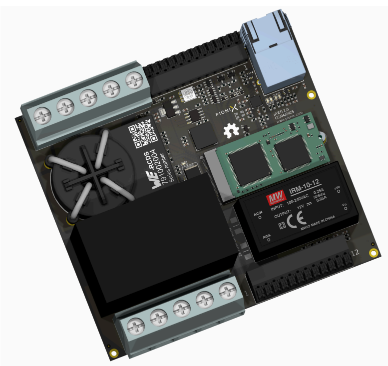
- **Single charging port with external compute (Satellite architecture)**
  The ChargeBridge is installed on a dedicated power-handling PCB, connected via **Ethernet or USB** to an external compute unit.

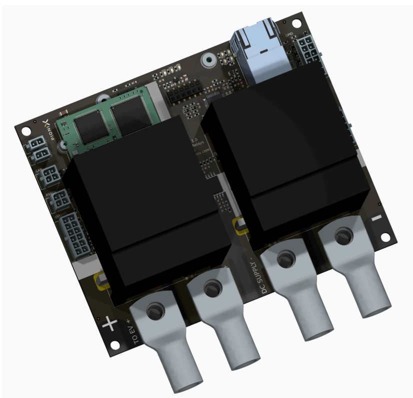
- **Multiple charging ports per station with external compute (Satellite architecture)**
  ChargeBridge modules interface with a centralized compute platform (via Ethernet/USB) and **shared power supplies**.

- **Modular controller board**
  Interchangeable ChargeBridge modules allow the same PCB to support different charging standards such as **CCS**, **MCS**, **CHAdeMO**, **GB/T**, and **ChaoJi**—depending on which module is installed.

- **Custom or hybrid setups**
  Thanks to the modular architecture and unified communication model, ChargeBridge enables flexible and scalable system designs tailored to specific requirements.

ChargeBridge modules for **standards beyond CCS** (e.g., **MCS**, **CHAdeMO**, **GB/T**, **ChaoJi**) are on the roadmap and will be supported in the same modular infrastructure.





Example applications are available free of charge as open hardware on our GitHub:

Evaluation board (break out board) for AC and DC applications:
https://github.com/PionixPublic/cb-eval-board

CCS AC Satellite:
https://github.com/PionixPublic/cb-sat-ac

Features

Common features

The following features are available on all ChargeBridge models:

- **Single supply**
  - Single 3.3V supply
  - All other required voltages are generated on the module
- **Ethernet**
  - IEEE 802.3 100BASE-TX and 10BASE-Te
  - Auto Negotiation
  - Auto MDIX
  - Energy Efficient Ethernet (EEE) IEEE 802.3az
  - Globally unique MAC Address
  - Link/Traffic indication LED output
  - mDNS support
- **Secure communication**
  - Strong encryption and authentication of all communication to Linux host[1]
  - Non-encrypted option
- **USB 2.0 Full Speed Device**
  - For Host uplink when Linux SOM and ChargeBridge are on the same PCB (CDC-ECM)
- **CAN**
  - ISO 11898-2:2016 high-speed CAN up to 1 Mbps
  - CAN FD support up to 8 Mbps[2]
  - Ethernet to CAN bridge
- **RS485**
  - TIA/EIA-485 A standard
  - Half-duplex RS-485 up to 500kbps
  - Up to 256 bus nodes
  - Ethernet to RS485 bridge
- **UART1**
  - 3.3V TTL level, no HW flow control
  - Separate DE/#RE output to connect external RS485 PHY for second RS485

[1] Encryption/Authentication is not available on firmware version 1.0
[2] Feature is not available on firmware version 1.0. Use 1Mbps CAN.

- **UART2**[3]
    - 3.3V TTL level, no HW flow control
    - Defaults to debug UART
    - Can be configured to be used as regular UART
- **GPIOs**
    - 9 free to use GPIOs
- **Relay control**
    - Switch output for up to three relays
    - PWM option for coil output to reduce holding power[4]
    - Feedback / mirror contact input for up to three relays
- **I2C/I3C**
    - I2C or I3C mode selectable[5]
    - Enables baseboard extensions such as GPIO extenders
- **ADC**
    - 1 pseudo differential ADC input (typically used for HV overvoltage sensing)
    - 3 single ended ADC inputs (typically used for plug temperature measurement with PT1000/NTC/PTC, supply voltage monitoring etc).
- **Simple user interface**
    - RGB LED output to show charging status
    - Stop charging button input
- **Emergency I/O**
    - Emergency input. Can be wired-OR for multiple sources
    - Latched emergency output
- **Secure lockdown**[6]
    - Dedicated HW input to lock down security configuration
    - Prevents Root certificate and key pairs to be updated
- **Charging standard interface**
    - 7 pins for charging standard specific functions
    - Route directly to charging cable, no external components needed
    - Allows to use the same base board for multiple standards (e.g. CCS and MCS)
- **Safety and self-test features**
    - Supports an extensive list of safety features
    - IEC 61508 SIL-2 certification pending
    - Functional self test capabilities
    - Monitoring of 3.3V supply voltage
    - Monitoring of junction temperature
    - Monitoring of internal 1.1V, +12V, -12V (EVSE) / 5V (EV) supplies
    - See Safety Functions chapter for a detailed description

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[3] Only available as Debug UART on firmware version 1.0
[4] Feature not available on firmware version 1.0
[5] I2C only on firmware version 1.0
[6] Not available on firmware version 1.0

Charging standard specific features

The following features are available on the 7 specific pins and are different on the ChargeBridge models.

CB-CCS-EVSE-LU / CB-CCS-EV-LU

- **Control Pilot / Proximity Pilot**
  - IEC 61851-1:2019 compliant for CCS2
  - SAE J1772 2024 compliant for CCS1
  - BASIC and HLC charging modes
  - Supports up to 97% duty cycle for up to 80 A AC charging
  - EVSE: Proprietary cut-cable detection for DC Charging[7]
  - EVSE: ±12V supply on module, no external power supply needed
  - EV: 5V supply on module, no external power supply needed
  - EV: supports states B/C/E
  - EV: supports virtual disconnect to state A
  - Connects directly to the charging cable, no external components needed
- **PLC modem**
  - ISO 15118-3 compliant
  - Supports DIN SPEC 70121, ISO 15118-2/20 AC/DC TLS1.2/1.3 in combination with EVerest
  - Based on Lumissil CG5317
  - Firmware and configuration update over IP
  - EV and EVSE mode
  - PLC Debug UART over IP bridge
  - All coupling circuitry to CP line on module
  - ZC input (3.3V)

CB-MCS-EVSE-LU / CB-MCS-EV-LU[8]

- **Charge Enable / Insert detection**
  - IEC 61851-23-3 compliant
  - EVSE: 5V supply on module, no external power supply needed
  - Connects directly to the charging cable, no external components needed
- **Single pair Ethernet**
  - IEEE 802.03-2022 10BASE-T1S compliant
  - ISO 15118-10 compliant
  - Supports ISO 15118-20 AC/DC with mutually authenticated TLS 1.3 in combination with EVerest

Safety functions

The ChargeBridge module implements a set of safety functions using hardware-enforced isolation based on ARM TrustZone technology. This architecture ensures strict separation between safety-critical and non-safety operations through dedicated Flash/RAM regions, peripherals, and execution contexts.

[7] Not available on firmware version 1.0
[8] MCS support is planned and not yet available. Contact Pionix sales representative for further information.

All non-safety-related functions are executed in a separate application context outside the TrustZone-protected domain.

The hardware design is fault-tolerant to single component failures and is engineered to fail safely. The system continuously performs self-tests and validates critical measurements to ensure safety functions operate reliably while the system is energized.

The ChargeBridge module is responsible for a safety-related control function (SRCF) as defined by IEC 61805: it acts as the control authority for the output contactors that connect the EVSE's internal high-voltage circuitry to the external charging interface (e.g., the vehicle or charging cable).

This function is allocated to a Safety Integrity Level (SIL 2) system and is implemented within a safety function block isolated through ARM TrustZone technology. The ChargeBridge continuously monitors operating conditions and system health, and in the event of a detected fault, unsafe state, or loss of supervision, it transitions the system to a safe state by opening the output contactors.

In effect, ChargeBridge acts as a functional safety gatekeeper between the internal HV domain and the external world. No matter the internal voltage present, the ChargeBridge guarantees disconnection of high-voltage power under unsafe conditions, fulfilling the goal of preventing electrical shock hazard and fire risk as required by IEC 61805.

The safe state is explicitly defined as:
All output contactors open — ensuring galvanic isolation of high voltage from any accessible or externally connected components.

To reliably fulfill its role as the **functional safety gatekeeper** for the output contactors, the ChargeBridge module performs continuous monitoring of several **safety-critical parameters**. These measurements form the basis of a set of **Safety Functions (SFs)**, which enable the system to detect hazardous conditions and transition the EVSE to a **safe state** by opening the relays. The safety functions implemented within the TrustZone-isolated safety domain include:

- **Control Pilot (CP) Monitoring**: Validates signaling between the EVSE and EV per IEC 61851-1, detecting invalid, missing, or unexpected states.

- **Proximity Pilot (PP) Monitoring**: Detects plug insertion/removal, cable type, and mechanical disconnects, ensuring safe connector handling.

- **Temperature Monitoring**: Supervises onboard and connector pin temperature to detect overheating and trigger protective action if thermal thresholds are exceeded.

- **High-Voltage Overvoltage Detection**: Monitors the HV output to ensure compliance with voltage limits (per IEC 61851-23:2023 6.3.1.106.2 and 6.3.1.106.3); shutdown is triggered if thresholds are violated within required timings.

- **Relay Control and Feedback Monitoring**: Ensures safe operation of output contactors through direct control and verification via feedback lines, detecting faults such as welded or stuck relays.

- **External Safety Input Monitoring**: Accepts emergency shutdown signals from **external safety components** such as **insulation monitors**, **RCDs**, **door lock sensors**, or **emergency stop buttons**. This input allows coordinated safety actions across subsystems through a **wired-OR configuration**, ensuring a unified system response in the event of a fault.

Together, these safety functions provide comprehensive supervision of the **electrical, thermal, and mechanical aspects** of the charging interface. The ChargeBridge module autonomously manages fault detection and enforces safe-state transitions, ensuring system-level safety and compliance with functional safety standards such as **IEC 61805 (SIL 2)**.

Functional safety certification is currently in progress and will be completed prior to the production release. Complete safety documentation and a safety manual for integration will be provided later.

Secure Communication

Firmware version 1.0 does not support encrypted communication to the CB module. This feature will be available as a firmware update in later versions.

Specifications

Absolute Maximum Ratings

Exceeding the Absolute Maximum Ratings can lead to permanent device damage. These ratings do not guarantee functional operation; for that, refer to the Recommended Operating Conditions. Operating the device outside the Recommended Operating Conditions but within the Absolute Maximum Ratings may compromise reliability, functionality, and performance, and could reduce the device's lifespan.

		MIN	MAX	UNIT
V_{input}	USER_GPIO[0..9]	-0.3	4.0 (TBD)	V
T_{stg}	Storage Temperature	-40	TBD	°C
	- exact maximum ratings will be defined later -			

Recommended Operating Conditions

		MIN	TYPICAL	MAX	UNIT
V_{supply}	Supply voltage	3.15	3.3	3.45	V

V_{input}	Input voltage on USR GPIO[0..8]	-0.3	0-3.3	3.6 (TBD)	V
I_{diode}	Maximum current through internal clamping diodes USR GPIO[0..8]			TBD	mA
$T_{ambient}$	Ambient temperature	-40		85	°C
V_{input}	ADCn input voltage range on any pin[9]	0		2.048	V
V_{ADC0_CM}	ADC0 Common Mode Voltage	0.922	1.024	1.126	V

ESD Ratings

PINS	TEST CONDITIONS	VALUE	UNIT
ETHERNET 20,22,26,28 Protection is sufficient for typical applications. For outdoor ethernet usage consider additional protection.	IEC 61000-4-2 contact discharge	±12000	V
	IEC 61000-4-2 air-gap discharge	±15000	V
	Human-body model (HBM), per AEC Q100-002	±8000	V
	Charged-device model (CDM), per AEC Q100-011	±1000	V
RS485 A/B 36,38 Protection is sufficient for typical applications. Consider additional protection / isolation when used for charger to charger connections.	IEC 61000-4-2 contact discharge	±12000	V
	IEC 61000-4-2 air-gap discharge	±15000	V
	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(	±16000	V
	Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002	±1500	V
CAN HI/LO	Human-body model (HBM), per AEC Q100-002	±10000	V
	Charged-device model (CDM), per AEC Q100-011	±750	V
	SAE J2962-2 per ISO 10605 Powered contact discharge	±8000	V
	SAE J2962-2 per ISO 10605 Powered air discharge	±15000	V
	IEC 62228-3 per ISO 10605	±8000	V

[9] Always keep ADC input voltage <3.3V, never exceed 2.048V in normal operation. If the input voltage can be higher than 2.048V e.g. in an error state, use 100kOhm series resistance to limit current leakage into the ADC reference.

	ISO 7637-2 Transient immunity/Pulse 1	–100	V
	ISO 7637-2 Transient immunity/Pulse 2a	75	V
	ISO 7637-2 Transient immunity/Pulse 3a	–150	V
	ISO 7637-2 Transient immunity/Pulse 3b	100	V
All other pins	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(	±2000	V
Protection needed on baseboard if signals leave the PCB	Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002	±500	V

Electrical Characteristics

Typical values represent the most likely parametric norm at TJ_ambient = 25°C, and are provided for reference purposes only. Unless otherwise stated, the following conditions apply: V_supply = 3.3V

PARAMETER	TEST CONDITIONS	MIN	TYPICAL	MAX	UNIT
Current consumption	Normal operation, Ethernet connected, CAN/RS485 idle(RX), PLC idle(RX)		270		mA
	Normal operation, Ethernet connected, CAN/RS485 idle(RX), PLC idle(RX), 85°C		285		mA
	Design Current for base board power supply		500		mA
Power dissipation	Power dissipation to air during active charging session for thermal design		1200		mW

Pin configuration and functions

NC: Do not connect, leave floating
O: Logic level 3.3V output, maximal 5mA
I: Logic level 3.3V input
IPU: Logic level 3.3V input with internal pull up. Pull up only when firmware is running.
IPD: Logic level 3.3V input with internal pull down. Pull down only when firmware is running.
I/O: Configurable GPIO
AI: ADC analog input. 0 - 2.048V range
PWR: Supply Voltage/Ground pin

PIN	NAME	TYPE	DESCRIPTION

1	RESERVED	NC	Do not connect
3	RELAY 3	O	Relay 3 on/off. HI: Relay ON, LO: Relay OFF
5	RESERVED	NC	Do not connect
7	USB D+		USB Positive Data Line
9	USB D-		USB Negative Data Line
11	3.3V Supply	PWR	
21	RELAY 2 FB	IPD	Relay 2 Feedback input. Default: HI: Relay open, LO: Relay closed. (The polarity can be configured)
23	RELAY 1 FB	IPD	Relay 1 Feedback input. Default: HI: Relay open, LO: Relay closed. (The polarity can be configured)
25	RELAY 3 FB	IPD	Relay 3 Feedback input. Default: HI: Relay open, LO: Relay closed. (The polarity can be configured)
27	RELAY 2	O	Relay 2 on/off. HI: Relay ON, LO: Relay OFF
29	RELAY 1	O	Relay 1 on/off. HI: Relay ON, LO: Relay OFF
31	UART 1 TX	O	UART TX/RS485_2 TX. External PHY is needed if RS485 is used on this pin.
33	UART 1 RX	I	UART RX/RS485_2 RX. External PHX is needed if RS485 is used on this pin.
35	LED B	O	Charging status LED BLUE output. Do not connect the LED directly to this pin, use a dedicated driver on the base board. Active Low.
37	LED G	O	Charging status LED GREEN output. Do not connect the LED directly to this pin, use a dedicated driver on the base board. Active Low.
39	LED R	O	Charging status LED RED output. Do not connect the LED directly to this pin, use a dedicated driver on the base board. Active Low.
41	EMGY OUT	O	Emergency Shutdown Output. LO: Normal operation. HI: Emergency shutdown currently active.
43	EMGY IN	IPD	Emergency shutdown Input. HI: Normal operation. LO: Trigger emergency shutdown. See section “Emergency input and output” for further details. Has internal 100kOhm pull down resistor, needs external pull up.
45	RS485_2_TXEN	O	If UART on pins 31/33 is used in RS485 mode, connect this pin to the external PHY’s DE/#RE pins. Can be configured for GPIO as well.
47	STOP CHRG	IPU	Stop charging input (normal shutdown). HI: Normal operation.

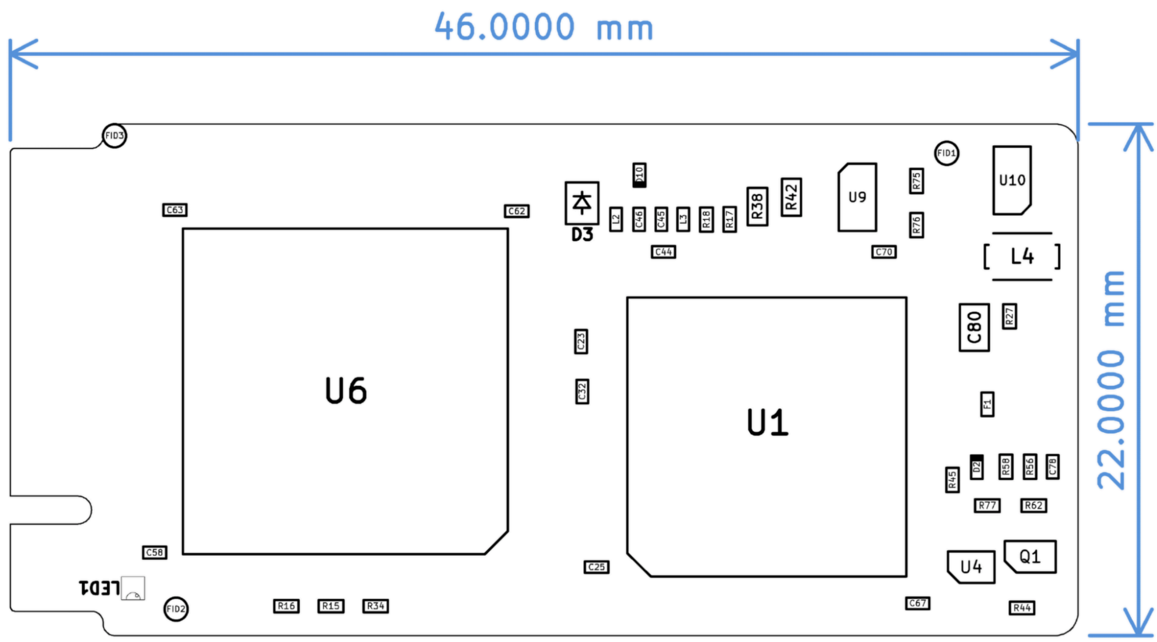
			Pulse low for at least XX ms to stop charging.
49	USR GPIO 4	I/O	User GPIO 4 (PWM)
51	USR GPIO 5	I/O	User GPIO 5 (PWM)
53	USR GPIO 3	I/O	User GPIO 3
55	USR GPIO 2	I/O	User GPIO 2 (PWM)
57	USR GPIO 1	I/O	User GPIO 1
59	USR GPIO 0	I/O	User GPIO 0 (PWM)
61	3.3V Supply	PWR	
63	UART 2 TX	O	Debug UART TX. Can be configured to normal UART if debug is disabled.
65	UART 2 RX	I	Debug UART RX. Can be configured to normal UART if debug is disabled.
67	ADC0_P	AI	Pseudo differential positive input for CH0 (0-2.048V on each pin, 4.096V differential). Typically used for HV over voltage measurement.
69	ADC0_N	AI	Pseudo differential positive input for CH0 (0-2.048V on each pin, 4.096V differential total range) Typically used for HV over voltage measurement.
71	ADC1	AI	Single ended ADC (0-2.048V). Typically used for temperature sensing of plug contacts
73	ADC3	AI	Single ended ADC (0-2.048V). Typically used for board specific voltage measurement (e.g. 24V supply monitoring)
75	GND	PWR	
2	CAN LO		CAN Bus LO Signal (PHY is included in ChargeBridge), not terminated
4	CAN HI		CAN Bus HI Signal (PHY is included in ChargeBridge), not terminated
6	GND	PWR	
8	I3C SDA		I2C or I3C SDA line for base board extensions
10	I3C SCL		I2C or I3C SCL line for base board extensions
20	ETH TXN		Ethernet TX negative line. See Ethernet chapter on how to use
22	ETH TXP		Ethernet TX positive line. See Ethernet chapter on how to use
24	GND	PWR	

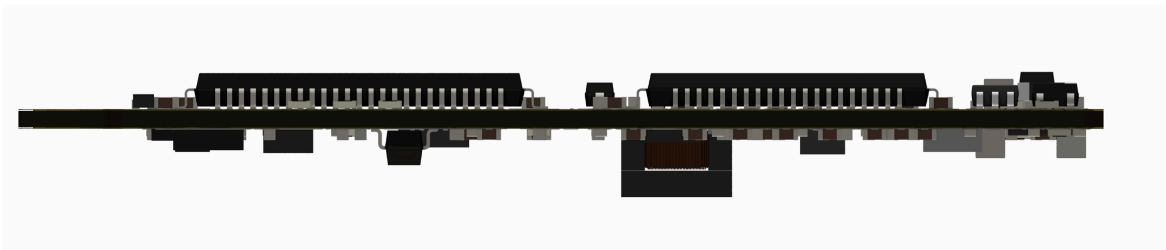
26	ETH RXN		Ethernet RX negative line. See Ethernet chapter on how to use
28	ETH RXP		Ethernet RX positive line. See Ethernet chapter on how to use
30	SECURE MODULE	IPD	HI: Module is security unlocked (Allows installation of new root certificates and key pairs), LO: Root certificates and keys cannot be installed. Connect to GND on production boards. Only pull high when installing custom root certificates in the manufacturing process.
32	ETH LED	O	Ethernet LED. Steady on: Network link detected. Blinking: Traffic. Active high output. Can be directly connected to an LED (internal 470Ω series resistor)
34	GND	PWR	
36	RS485 A		RS485 line A. Integrated non-isolated PHY on ChargeBridge, not terminated
38	RS485 B		RS485 line B. Integrated non-isolated PHY on ChargeBridge, not terminated
40	3.3V supply	PWR	
42	RESET	IPU	Reset Chargebridge. HI: Normal operation, LO: Reset. Pull high or leave unconnected (internal 10kΩ pull up)
44	ADC2	AI	Single ended ADC (0-2.048V). Typically used for temperature sensing of plug contacts
46	3.3V supply	PWR	
48	3.3V supply	PWR	
50	GND	PWR	
52	GND	PWR	
54	USR GPIO 8	I/O	User GPIO 8 (PWM)
56	USR GPIO 7	I/O	User GPIO 7
58	USR GPIO 6	I/O	User GPIO 6
60	CONN RES		Charging standard specific pin RESERVED (NC)
62	CONN PIN5		Charging standard specific pin 5: CB-CCS-EVSE-LU: NC CB-CCS-EV-LU: NC
64	GND	PWR	
66	CONN PIN4		Charging standard specific pin 4: CB-CCS-EVSE-LU: PLC DBG UART RX CB-CCS-EV-LU: PLC DBG UART RX

68	CONN PIN3		Charging standard specific pin 3: CB-CCS-EVSE-LU: PLC DBG UART TX CB-CCS-EV-LU: PLC DBG UART TX CB-MCS-EVSE-T1S: Ethernet Data- (DA-) CB-MCS-EV-T1S: Ethernet Data- (DA-)
70	CONN PIN2		Charging standard specific pin 2: CB-CCS-EVSE-LU: ZC (Zero Cross Input 3.3V) CB-CCS-EV-LU: ZC (Zero Cross Input 3.3V) CB-MCS-EVSE-T1S: Ethernet Data+ (DA+) CB-MCS-EV-T1S: Ethernet Data+ (DA+)
72	CONN PIN1		Charging standard specific pin 1: CB-CCS-EVSE-LU: Proximity Pilot (PP) CB-CCS-EV-LU: Proximity Pilot (PP) CB-MCS-EVSE-T1S: Insertion Detection (ID) CB-MCS-EV-T1S: Insertion Detection (ID)
74	CONN PIN0		Charging standard specific pin 0: CB-CCS-EVSE-LU: Control Pilot (CP) CB-CCS-EV-LU: Control Pilot (CP) CB-MCS-EVSE-T1S: Charge Enable (CE) CB-MCS-EV-T1S: Charge Enable (CE)

Mechanical specifications

- M.2 Connector (B key)
- Width: 22mm
- Height: 46mm
- Weight: 4.5g
- Clearance to the base board (stacking height): >5mm due to high components on the bottom side. Standard 3mm M.2 connectors do not have enough stacking height.
- Recommended part on the base board: Amphenol 10128796-001RLF (8.5mm height, B key)





Recommended symbols/footprint

Symbol, footprint and 3D model for KiCAD will be made available.

Functional blocks

This chapter contains detailed description and application information of the individual functional blocks.

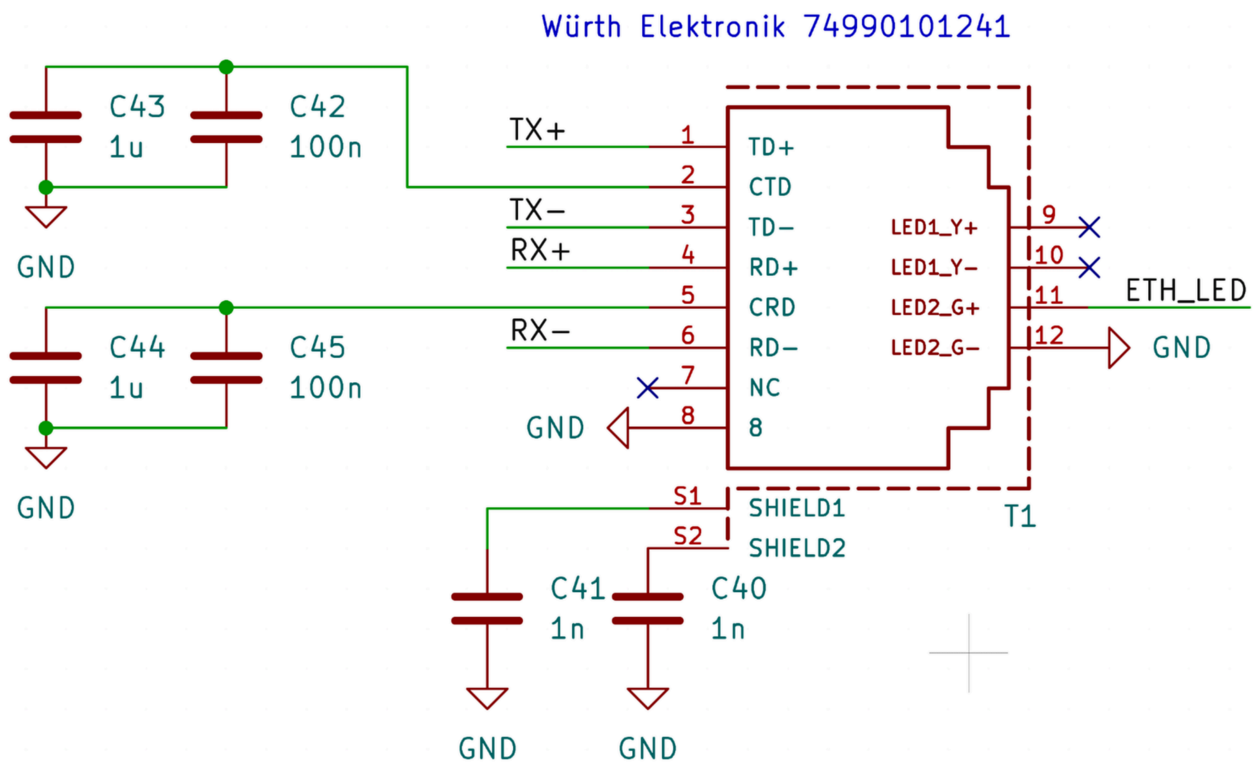
Ethernet

ChargeBridge contains a 100BASE-TX and 10BASE-Te Ethernet port with integrated PHY for host uplink.
ESD protection is included on the module.
External magnetics need to be added on the base board. Center taps need to be AC coupled to GND, do not connect them to 3.3V. Do not use pull ups on any of the data lines.
Separate magnetics and connectors are possible for cost constrained designs, Pionix recommends connectors with integrated magnetics for simplicity.

The ETH_LED pin can be connected directly to one of the LEDs. It contains an internal 470Ω series resistor. The second LED is not supported. LED states as follows:

- LED OFF: No link
- LED ON: link detected, autonegotiation complete
- LED BLINKING: traffic indication

Refer to the following reference schematics with integrated magnetics:



Ethernet and USB should not both be used at the same time. Only one uplink to host is supported by firmware. If USB is connected, Ethernet will be disabled.

ChargeBridge is configured for IPv4 DHCP. If it is connected directly to a Linux host, use a simple DHCP server such as *dnsmasq* or *udhcpd*:

Shell
```
sudo dnsmasq --no-daemon --interface=eth0 --bind-interfaces --dhcp-range=192.168.50.100,192.168.50.150,12h
```

Fixed MAC addresses are used, allowing DHCP to assign fixed IP addresses based on the MAC addresses defined in the DHCP configuration file.

This approach enables the assignment of consistent IP addresses to specific modules - for example, those of charging port 0 and charging port 1 - when using multiple ChargeBridges within a single charger. If a module needs to be replaced later, such as during a repair, only the DHCP configuration file needs to be updated. All other system configuration files that reference the ChargeBridge IP addresses can remain unchanged.

An alternative and more elegant method for managing IP addresses is mDNS. In this case, DHCP still assigns IP addresses, but it does so dynamically, while mDNS provides a convenient way to resolve device names to their current IP addresses.

On Linux, all ChargeBridges can be detected with *avahi-browse*:

Shell
```
avahi-browse _chargebridge._udp -tr
```

```
+   eth0 IPv4 PionixChargeBridge                               _chargebridge._udp    local
+ wlp0s20f3 IPv4 PionixChargeBridge                               _chargebridge._udp    local
=   eth0 IPv4 PionixChargeBridge                               _chargebridge._udp    local
   hostname = [chargebridge-44b7d0d1372f.local]
   address = [10.10.10.64]
   port = [6000]
   txt = ["board_type=CB-CCS-EVSE-LU"]
```

By default the mDNS name includes the MAC address of the module. When exchanging the module (e.g. during repair of a charger), this name changes and configuration files would need to be updated.

There are alternatives available to configure persistent names. Contact Pionix for options.

USB

The USB+ and USB– data lines can be connected to a USB host for uplink to a Linux system. The ChargeBridge module functions as a USB 2.0 Full-Speed device (12 Mbps). However, the module does not include any built-in filtering or protection on the USB lines. Depending on your application - especially if the USB traces extend beyond the baseboard PCB - it is recommended to add ESD protection and a common-mode choke for signal filtering.

Important: Ethernet and USB uplink should not be used simultaneously. The firmware supports only one host uplink at a time. If a USB connection is detected, Ethernet will be automatically disabled.

On the Linux side, the ChargeBridge is recognized as a **CDC-ECM USB-to-Ethernet adapter**, and can be used just like a standard Ethernet interface.

During start up of the module, it samples the USB data lines. If both are pulled low, USB mode is used and ethernet is disabled. In any other case, ethernet is used and USB is disabled. Normally USB controllers should pull down the data lines and the auto detection works fine. If your USB controller does not, add pull downs externally to both USB data lines.

ADC0 HV overvoltage measurement

ADC0 is configured as a pseudo-differential input. Each of its two analog input pins supports a voltage range of 0–2.048 V, with the ADC measuring the differential voltage between them. This provides a total measurement span of ±2.048 V (i.e., a differential range of 4.096 V). The required common-mode voltage for proper operation is 1.024 V ±10%.

On the EVSE side, ADC0 is typically used for high-voltage (HV) overvoltage detection, as defined in sections 6.3.1.106.2 and 6.3.1.106.3 of IEC 61851-23:2023. The EVerest and ChargeBridge systems fully implement the logic needed to support these shutdown mechanisms in compliance with the standard.

Important: The voltage conversion from >1000 V down to the ±2.048 V ADC input range, including galvanic isolation, must be implemented externally.

Thresholds and Measurement Requirements

- For CCS, the highest specified overvoltage threshold is 1100 V, so the external voltage measurement and conversion stage should support a range slightly above that, e.g., up to 1150 V,
- For MCS, the highest threshold is 1375 V.

The emergency shutdown described in IEC 61851-23:2023, section 6.3.1.106.2 is the most critical use case. If the HV remains above the specified threshold for more than 9 consecutive milliseconds, the system must initiate an immediate shutdown, including opening relays under load if necessary.

The required measurement accuracy is specified as ±10 V absolute, without a relative accuracy requirement. This tight constraint—combined with the short averaging window—makes the design of the measurement and signal chain particularly challenging. Poor signal integrity or inadequate design can result in false emergency shutdowns, especially due to electrical noise between the HV measurement point and the ChargeBridge ADC input.

A wide selection of low-noise isolated amplifiers is available from Texas Instruments. A particularly suitable option for high-voltage sensing is the AMC3311, which offers the following features:

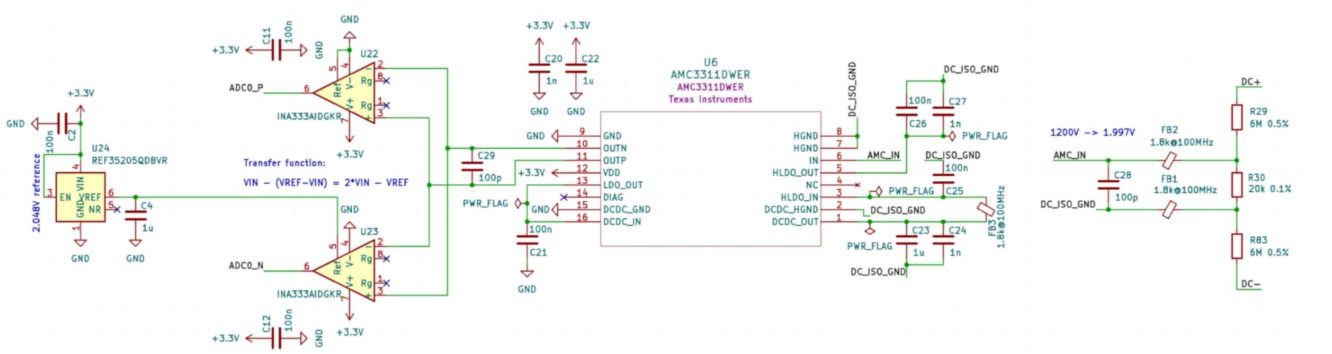
- Integrated isolated power supply
- 2 V input and 2 V pseudo-differential output voltage range
- Reinforced isolation with 8 mm clearance and creepage
- May require conformal coating to meet creepage requirements
- Output common-mode voltage range: 1.39 V to 1.49 V

The AMC3311's output common-mode voltage does not match the 1.024 V ±10% required by the ChargeBridge's ADC0 input. This mismatch must be corrected to ensure proper ADC operation. Ensure that clearance and creepage requirements are in accordance with the standard that applies for your product.

The recommended solution is to shift the common-mode voltage while preserving the full-scale range (±2.048 V) of the ADC. This can be achieved by inserting two additional instrumentation amplifiers between the AMC3311 outputs and the ADC inputs. The amplifiers should be configured to both scale and shift the signal appropriately to match the ADC input requirements.

Scaling coefficients to calculate actual HV voltage from the ADC reading can be adjusted during calibration.

Here is a full example schematics:



When using a cable between the measurement PCB (with the AMC amplifier) and the PCB that houses the ChargeBridge module, it's important to ensure low-impedance differential signaling for reliable and noise-resistant transmission. To maintain signal integrity:

- Use twisted-pair wiring to carry the differential output from the AMC chip.
- Keep the signal path short and avoid routing it near high-voltage or high-current lines.
- Place the offset adaptation circuitry—used to adjust the common-mode voltage to match the ChargeBridge ADC input—on the same PCB as the ChargeBridge module.
- Add proper protection for the ADC inputs to the ChargeBridge module - the ADC inputs are unprotected.

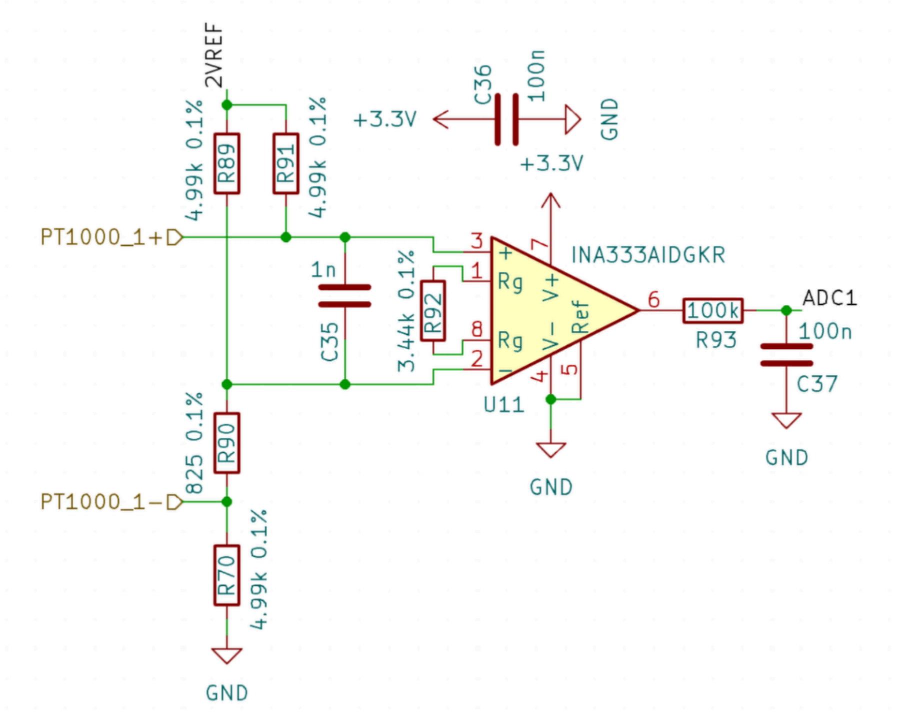
This setup helps maintain measurement accuracy and reduces the risk of noise interference, which is especially important in high-voltage EVSE environments.

ADC1/2 PT1000 temperature measurement

ADC1 and ADC2 are single-ended ADC inputs referenced to 2.048 V. These inputs can be used for temperature measurement.

In a typical DC application, the plug includes two PT1000 sensors integrated into the contact pins. For AC applications, PTCs or NTCs are commonly used instead.

A typical measurement circuit for a PT1000 sensor is shown in the example below. The resulting ADC voltage can be converted to temperature using scaling coefficients, which can be configured during calibration.



ADC generic

ADC1/2/3 can also be used for other applications. A common example would be to monitor 24 V input voltage to the base board etc.

PLC

The CB-CCS-EVSE-LU and CB-CCS-EV-LU modules include a Lumissil CG5317 PLC modem. An external EEPROM is connected to the CG5317 to store both the firmware and chip configuration, eliminating the need for a host-based loading tool.

In a Linux environment, the PLC device appears as a virtual Ethernet interface, allowing seamless integration as if it were a locally connected Ethernet device.

Firmware updates can be performed using Lumissil's official update tool, which works out of the box with the virtual Ethernet interface on Linux. No additional configuration or drivers are needed.

Signal level calibration can also be performed with Lumissil's official tooling.

All necessary coupling circuitry to inject the PLC signal into the Control Pilot (CP) line is already integrated into the module. No external components are required, check the chapter about Control Pilot. The CP line from the module can be connected directly to the charging cable.

CAN

ChargeBridge includes a CAN bus interface for communication with local devices such as DC power supplies, power meters, or isolation monitors.

Note: The CAN bus is not internally terminated. Proper termination resistors must be added on the baseboard, depending on the specific application. Without termination, the CAN bus will not function reliably.

Basic ESD protection is integrated into the module and should be sufficient for most typical use cases. However, for longer CAN bus runs that exit the charger enclosure, additional ESD and surge protection may be necessary to ensure robustness and compliance with EMC requirements.

In Linux, the CAN bus appears as a virtual SocketCAN interface, and all standard tools work as expected. For example, you can use candump to monitor CAN traffic. The tunneling over Ethernet is fully transparent to the user—no special configuration or drivers are required beyond standard SocketCAN support.

Both standard and extended CAN frame formats are supported. CAN FD is not yet supported but will be added in a future firmware release.

RS485

ChargeBridge includes an RS485 interface for communication with local devices such as power meters or isolation monitors.

Basic ESD protection is built into the module and is generally sufficient for typical applications. However, for long RS485 bus runs that extend outside the charger enclosure, additional ESD protection, surge suppression, and galvanic isolation may be necessary to ensure signal integrity and compliance with EMC standards.

In Linux, the RS485 interface appears as a virtual serial port using pseudo-terminal emulation. All standard tools work as expected—for example, you can use minicom to monitor the RS485 communication on /dev/cbserial0.

Control Pilot

The CB-CCS-EVSE-LU and CB-CCS-EV-LU modules feature a Control Pilot (CP) implementation compliant with IEC 61851-1 and SAE J1772—on the EVSE side and EV side respectively.

The full duty cycle range from 5.0% to 97% is supported, enabling compatibility with both AC/DC High-Level Communication (HLC) charging and basic AC charging up to 80 A.

All necessary coupling circuitry to inject the PLC signal into the Control Pilot (CP) line is already integrated into the module. No external components are required. The CP line from the module can be connected directly to the charging cable.

The module contains an internal protection diode. If an additional external protection diode is added, note the following:

- The internal capacitance on the CP line is 300pF + about 1pF parasitic capacitance of the protection diode
- Make sure to stay below the IEC 61851-1 maximum limit of 1600pF in total (including parasitic capacitance of additional protection and module internal capacitance)
- Excessive capacity on the CP line can degrade the PLC signal significantly.
- The additional protection diode may cap the CP voltage too much during conducted immunity testing for CE certification and lead to a loss of connection of the PLC signal in the band of 2-30MHz.
- Ensure compatibility with other charging standards that reuse the same pin for a different signal

In Linux, the Control Pilot (CP) signal state and PWM control commands are exposed through a simple MQTT API, following the EVerest evse_board_support_API specification. This allows external services or applications to monitor and control the CP signal over standard MQTT messaging.

Proximity Pilot

The CB-CCS-EVSE-LU and CB-CCS-EV-LU modules include a Proximity Pilot (PP) implementation compliant with IEC 61851-1 and SAE J1772, on the EVSE and EV sides respectively.

The PP interface supports three modes of operation:

1. CCS-2 AC socket
2. CCS-1 AC/DC attached cable, with detection of the unlock button event
3. CCS-2 DC, using a proprietary method to detect a cut cable condition

The PP signal should be connected directly to the charging cable. No additional protection circuitry is required.

If an additional external protection diode is added, note the following:

- For cut cable detection mode, the EV applies some voltage to measure the resistor. For CCS-2 the voltage to be used is not defined in the standard, but typically voltages in the range of 3.3V to battery voltage is being used (12V/24V) by the EV. The internal protection has a breakdown voltage of at least 26.5V.
- Input R/C filter of the module is 100kOhm/10nF.
- Ensure compatibility with other charging standards that reuse the same pin for a different signal

In Linux, the PP signal state is exposed through a simple MQTT API, following the EVerest evse_board_support_API specification. This allows external services or applications to monitor and control the PP signal over standard MQTT messaging.

Stop charging input

This input can be used to trigger a graceful shutdown to end the charging session. For example, it can be connected to a push button that allows the user to manually stop charging.

The signal is active-low:

- Pull high for normal operation
- Short to GND to trigger shutdown (e.g. when the button is pressed)

Add debouncing circuitry as needed to avoid false triggers from mechanical noise or signal instability.

AC motor lock

For CCS2 AC socket configurations, a motor lock may be required. The available USR GPIOs can be used to control the lock mechanism, as the specific requirements vary depending on the motor lock model and vendor.

Please contact Pionix to add support for your specific motor lock type or to discuss integration options.

USR GPIOs

USR GPIOs can be used to add functionality not covered by the dedicated functional blocks.

In Linux, they are exposed via an MQTT API. Some GPIOs can be configured for PWM as well.

Secure lockdown

Note: This functionality is not implemented in firmware version 1.0.

This pin is a 3.3 V input with an internal pull-down. It is used to control the certificate update mode for secure communication.

When secure communication is required, the ChargeBridge module must have a trusted root certificate and a certificate/private key pair installed. These are used for mutual authentication and encryption of all communications.

Certificates and keys should be installed during manufacturing, and should be non-expiring.

Pulling this pin high during manufacturing enables certificate and key installation.

On final production PCBs, this pin should be pulled low. This disables the ability to update certificates or keys after deployment, ensuring security and integrity in the field.

I2C/I3C

ChargeBridge includes both an I2C and an I3C controller, sharing the same physical pins. The controller can be configured to operate in either mode. This interface is intended for local functionality on the same PCB, such as GPIO expanders or sensor ICs, it is not transparently bridged to Linux.

Important guidelines:

- I2C traces should never leave the PCB. Keep trace lengths short to ensure signal integrity and reliability.
- The following slave address range is reserved internally: 1010xxx
- The lower three bits are don't care, so avoid using any devices that conflict with the four most significant bits (1010) to prevent address collisions.
- The I2C/I3C bus is not forwarded to Linux. It is handled entirely within the ChargeBridge firmware.
- The ChargeBridge module has internal pull-ups. Do not add additional pull-ups on the base board.

If you plan to add devices to the I2C/I3C bus, please contact Pionix in advance to discuss firmware integration. Support for common GPIO expander ICs will be added over time, as this is one of the most typical use cases.

Relay control

Electrical Characteristics

- Outputs and inputs operate at 3.3 V logic level and are not protected.
  External driver circuitry and protection must be added on the baseboard for both outputs and inputs.

- Relay control outputs are active-high. In the simplest implementation, they can drive an NFET directly.
  Be sure to include a pull-down resistor on the gate to ensure the relay switches off safely in the event of a ChargeBridge reset.

Feedback Behavior

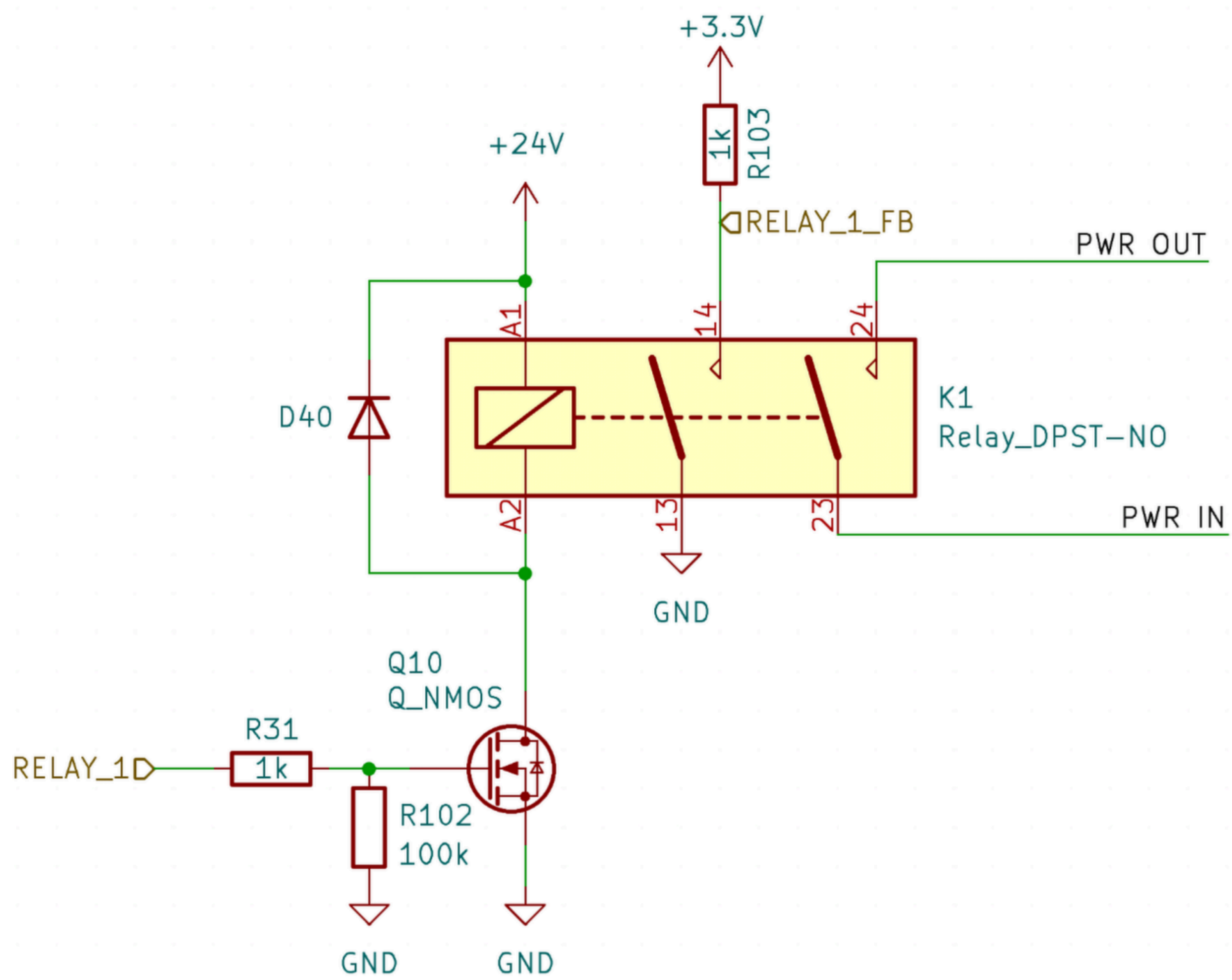
- When the relay is closed, the feedback input should read LOW.
- When the relay is open, the feedback input should read HIGH.
- The logic ensures that relay state can be verified independently through feedback monitoring.
- The polarity of the feedback signal can be configured if it is reversed in your application.

Mirror/Auxiliary Contact Considerations

Most relays require a minimum voltage and current across the mirror or auxiliary contact to prevent contact degradation over time. This requirement must be addressed on the baseboard, and it may differ from the example schematics provided.

PWM Support

All relay outputs support PWM control to reduce coil power dissipation.
The activation delay (after triggering the relay) and the PWM duty cycle can be configured in the module configuration file to suit the specific relay characteristics.



RGB LED

ChargeBridge has 3 individual outputs to connect a RGB LED for a simple user interface. It reflects the charging state or error conditions.

Do not drive an LED directly with the pins. Add dedicated drivers on the base board. The output is active LOW.

UART

ChargeBridge includes two UART interfaces:

- UART1 can operate either as a 3.3 V UART or in RS485 mode.
  If a second RS485 interface is required, an external (isolated) RS485 PHY can be implemented on the baseboard. A dedicated DE/#RE pin is available to control the Driver Enable and Receiver Enable signals of the transceiver.

- UART2 is a 3.3 V UART only and does not support RS485 mode.
  By default, UART2 is used as a debug output for the ChargeBridge module. However, its function can be changed in the configuration file if needed.

In Linux, both UARTs appear as virtual serial ports, allowing access through standard terminal tools and applications.

Emergency input and output

The emergency input on ChargeBridge is active-low and can be used in a wired-OR configuration, allowing multiple external components to trigger an emergency shutdown.

Electrical Characteristics

- The input operates at 3.3 V logic level.
- If external devices are connected, driver and protection circuitry must be added on the baseboard.
- The emergency condition can be latched with a short pulse—the line may be released after being pulled low.

Example Application

In a typical application, three or more devices might be connected to a shared emergency line:

- A red push-button
- An isolation monitor
- A door lock sensor

On the baseboard:

- The shared emergency line is pulled up to 24 V.
- Each device can pull the line low to signal an emergency.

- The signal is then level-shifted and passed to the 3.3 V emergency input on the ChargeBridge.

For instance:

- The isolation monitor detects a ground fault and closes a fault relay, pulling the line low.
- The door lock sensor triggers when the cabinet is opened during charging, also pulling the line low.
- The emergency button provides a manual shutdown option.

ChargeBridge Behavior on Emergency

- Once the emergency input is detected (pulled low), ChargeBridge will:
  - Immediately set the emergency output pin HIGH.
  - Latch the shutdown for the remainder of the charging session—charging will not resume until the vehicle is unplugged.
  - The emergency output can be used to disable systems such as ACDC power supplies, ensuring rapid power-down.
- After triggering the emergency state:
  - ChargeBridge waits for a configurable delay (e.g. 15 ms) before opening the output relays.
  - This delay allows the power supplies to ramp down current, reducing relay wear and extending relay life.
  - Note: The power supply ramp-down is not a safety mechanism—safety is ensured solely by relay disconnection.

Glossary

BASIC charging

Refers to conventional AC charging of electric vehicles without the use of high-level communication (HLC). It relies on simple control signals over the control pilot (CP) and proximity pilot (PP) lines to coordinate charging between the EV and EVSE.

CCS1 (Combined Charging System Type 1)

A DC fast-charging connector primarily used in North America and Korea. It combines a Type 1 (AC) connector with two additional DC pins to enable both AC and DC charging.

CCS2 (Combined Charging System Type 2)

The European and international version of CCS. It builds upon the Type 2 connector, adding two extra DC pins for fast DC charging. Widely used in Europe and supported by ISO 15118 and IEC 61851 standards.

Charge Enable (MCS)

A control signal or internal status used by the EVSE to permit or block the flow of power to the vehicle. It’s usually set once the EV and EVSE agree on the charging parameters and safety conditions are met.

CP (Control Pilot)

A signaling line used in CCS1/2 EV charging (defined in IEC 61851-1) to facilitate communication between the EV and EVSE. It carries PWM signals to negotiate charging current, signal the presence of the EV, and support basic control logic.

EV (Electric Vehicle)

A road vehicle powered entirely or partially by electricity, equipped with on-board systems to receive energy from an external charger (EVSE).

EVSE (Electric Vehicle Supply Equipment)

The hardware that supplies electrical power to EVs. It includes the connectors, control systems, protection mechanisms, and sometimes communication interfaces with the grid and backends.

Functional Safety Gatekeeper

In the context of this document, this refers to a dedicated safety control element—such as the **ChargeBridge module**—that ensures the output power from the EVSE is only enabled when all required safety conditions are met. The gatekeeper typically controls the **output relay** of the EVSE, acting as the final authority in permitting or interrupting the power supply to the EV. This role is critical in enforcing **safe state transitions** and implementing **Safety Functions (SFs)** as defined by functional safety standards like IEC 61508.

HLC (High-Level Communication)

A communication protocol (typically over Power Line Communication – PLC) used during advanced charging sessions (e.g., CCS with ISO 15118). Enables features like user authentication, dynamic power management, and Plug & Charge.

ID (Insertion Detection)

In the context of **Megawatt Charging System (MCS)** connectors, **ID** refers to the **Insertion Detection signal**. It is an electrical signal present on a dedicated pin in the MCS plug, used to detect when the connector is physically inserted into the EV inlet. This signal is essential for initiating the safety and communication sequences defined in **IEC 61851-23-2** and helps coordinate safe connection handling between the EV and EVSE.

MCS (Megawatt Charging System)

A high-power DC fast-charging standard under development (IEC 61851-23-2, IEC 63379), targeting commercial and heavy-duty EVs. Allows charging at megawatt-level power levels (above 1 MW), requiring special connectors and cooling systems.

PLC (Power Line Communication)

A communication method used in ISO 15118-based EV charging to transmit data over the CP line between the EV and EVSE. Enables HLC, Plug & Charge, smart charging, and V2G (vehicle-to-grid) features.

PP (Proximity Pilot)

A pin in Type 1 and Type 2 connectors that signals the physical presence of a connected plug and provides plug-in status and cable current capacity information to the EVSE.

RCD (Residual Current Device)

A safety device in the EVSE that disconnects the power supply if it detects a leakage current (typically to ground), helping to protect users from electric shock.

Safe State

A predefined system condition in which the risk is reduced to an acceptable level in case of faults or unexpected behavior. In functional safety, entering a safe state often means shutting off power or disabling motion. In the context of ChargeBridge, it is defined as “output relays open”.

Safety Functions (SFs)

Functions implemented in hardware or software that help ensure a system remains in or transitions to a safe state under hazardous conditions. Defined and validated as part of functional safety design according to standards like IEC 61508.

Type1 Connector

An AC charging connector primarily used in North America and Japan. Also known as SAE J1772. It supports single-phase AC charging and includes CP and PP lines for signaling.

Type2 Connector

A European-standard AC charging connector (IEC 62196-2), supporting single-phase and three-phase charging. It forms the basis for CCS2 and includes CP and PP signaling lines.

Ordering Information

The ChargeBridge family uses the following order codes:

CB-CCS-EVSE-LU

- ChargeBridge
- Charging standard:
  CCS: CCS1 and CCS2
  MCS: MCS
  GBT (GB/T)
  CHJ (ChaoJi)
- EVSE: Charging station
  EV: Vehicle side
- LU: Lummisil PLC chip option
  T1S: T1S Ethernet

Packaging

TBD

Further Information

For more details, documentation, and support resources, feel free to contact us via email:
contact@pionix.de

Additional company and product information is available at:
www.pionix.com