

Cludio User Manual

v. 2024-3

June 26, 2024



Figure 1: Cludio V631 device

Cludio is an IoT gateway device designed for integration and management of industrial machinery through advanced connectivity and data synchronization capabilities. It allows you to have a digital twin of industrial machineries for remote monitoring, management, and analytics.

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1 Introduction

Cludio is an IoT device designed for seamless integration and management of industrial machinery through advanced connectivity and data synchronization capabilities. It connects to industrial machinery through various protocols, such as RS485, RS422, Profinet, Modbus - RTU/TCP. It captures data, structures it, and transmits it to a Cloud or Edge server through WiFi on the SIP module. The power management for data collection and connectivity ensures power-efficient operations. Cludio has 1 x SPI, 1 x I2C, 2-4 x Digital I/O, and 2 x Analog I/O that can connect to third-party sensors or actuators. It has footprints for several energy harvesting functions and expansion interfaces, which can be used by clients to generate power-efficient and custom off-grid solutions.

2 Intended Use

Cludio is intended to be used as a gateway between machinery and cloud infrastructure such as AWS, Azure, Edge, or custom cloud or on-premise setups. It collects data using interfaces like RS485, RS422, Ethernet and transmits it securely. It can also be used to directly connect sensors or auxiliary devices via exposed I2C, SPI, and ADC interfaces for remote monitoring and management.

2.1 Applications

- Water quality monitoring
- Factory floor machine monitoring via RS485/422, MODBUS RTU/TCP, OPC-UA
- Retrofit production machinery without built-in cloud/edge data aggregator
- Integrated data collection, visualization, analytics, and alerts

3 Safety Precautions

Incorrect handling or installation of the Cludio unit may result in injury to personnel and damage to the unit or other associated equipment. Please read the manual carefully before connecting the unit and follow all installation and maintenance instructions.

3.1 General Safety Instructions

- Read the manual before use.
- Only qualified personnel should handle installation and repairs.
- Use the provided power supply.
- Operate within specified environmental conditions.
- Handle the device carefully to avoid damage.
- Use recommended batteries and follow safety guidelines.
- Ensure proper electrical grounding.
- Maintain ventilation to prevent overheating.

3.2 Operational Safety

- Familiarize yourself with emergency shutdown procedures.
- Respond promptly to device alerts and alarms.
- Perform regular inspections to ensure proper function.
- Regularly update the device's software to maintain security.

3.3 Installation Safety

- Install the device in a stable, level, and secure location.
- Route cables neatly to avoid tripping hazards.
- Ensure the device and its controls are easily accessible.

3.4 Maintenance and Repair Safety

- Implement lockout/tagout procedures before maintenance.
- Use only manufacturer-specified replacement parts.

- Dispose of the device and components in accordance with local regulations.

4 Technical Specifications

Detailed sensor and operation specifications can be downloaded from the manufacturer's website [1].

4.1 Device Ratings

Table 1: Device's Electrical Specifications

Parameter	Min	Typ	Max	Units
Supply voltage (DC adapter)	3.0	3.6	5.5	V
External Battery voltage (optional)	3.0	3.6	4.7	V
Supply current rating	0.024	28	600	mA
Continuous power rating	49 μ W	0.02 W	0.2 W	-
Ingress protection	IP66	IP68 ¹	IP69	-

4.2 Block Diagram

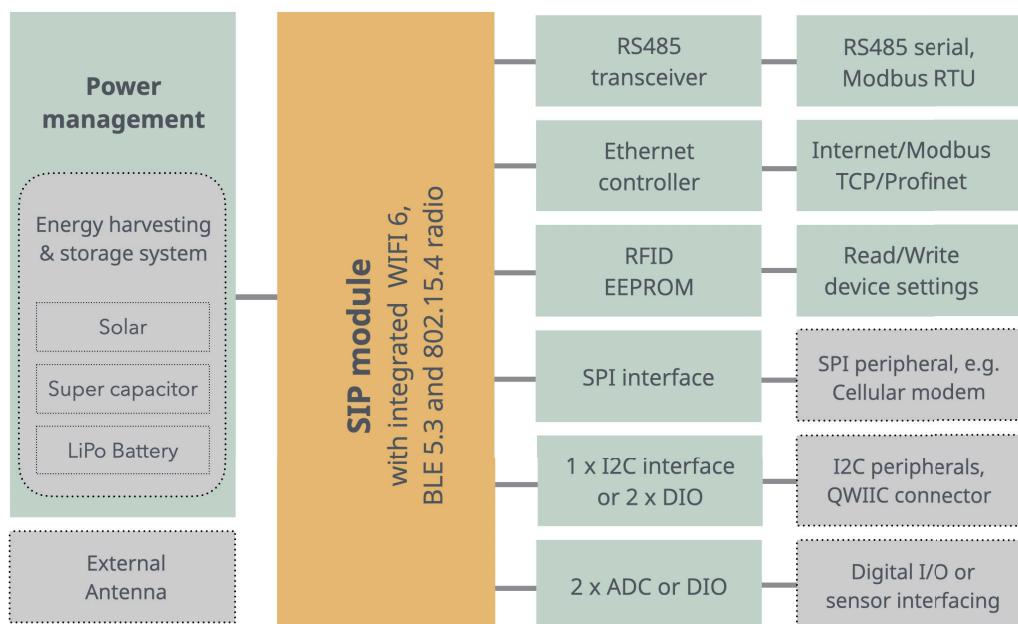


Figure 2: Device block diagram²

¹Refer to Section 4.7 for details on protection ratings.

4.3 Description

The block diagram of Cludio illustrates its core components and their interactions:

- **Power Management:** This section includes the energy harvesting and storage system utilizing solar power, super capacitors, and a LiPo battery. It ensures a continuous power supply to the device.
- **SIP Module:** The core module integrates WiFi 6, BLE 5.3, and 802.15.4 radio for connectivity. It handles communication and processing tasks.
- **RS485 Transceiver:** Facilitates serial communication with devices using RS485 and Modbus RTU protocols.
- **SPI Interfaces:** Exposed with an independent chip select so that additional SPI devices such as cellular modems or other SPI-enabled devices can be attached.
- **RFID EEPROM:** Used for storing and retrieving device settings via RFID.
- **I2C Interface:** Allows connection of I2C peripherals, such as sensors and other digital interfaces.
- **ADC/DIO:** Provides analog-to-digital conversion or digital I/O for sensor interfacing.
- **Ethernet:** Supports Ethernet communication, including Modbus TCP/Profinet for industrial network integration.
- **External Antenna:** Ensures optimal signal reception and transmission for wireless communication.

4.4 Interfaces and Connectivity

4.4.1 RS485 and RS422

ESD Protection: IEC 61000-4-2

EFT Protection: IEC 61000-4-4

ESD Ratings: 30kV (Air), 30kV (Contact)

²Functionalities in boxes are expandable by users.

4.4.2 Ethernet

Controller: DHCP-capable

Protocols: TCP/IP, Modbus TCP, Profinet

4.4.3 Dynamic NFC/RFID tag

Chip: ST25DV16KC at 13.56 MHz

Capacity: 16K

Function: Dynamically program the RFID with the device ID, configuration and may also hold recent measurements depending on device settings in the firmware.

4.4.4 WIFI 6

SSID Connection: Preset using RFID EEPROM data

Support: Power-efficient with WIFI 6, TWT

4.5 Expansion Options

Optional Modules: BLE 5.3, 802.15.4 radio

Interfaces: 1 x I2C, 1 x SPI, 2 x ADC

4.6 Power Options

Cludio is powered by a DC 5V power supply adapter, included with the device. Optionally, it supports a 4.7V 2500 mAh LiPo battery, a 5V solar panel, and energy harvesting with a supercapacitor. Customizing power options requires adjustment of jumpers on the PCB. Please contact the manufacturer for instructions.

Two modes of power are available on board:

- **VBUS & GND:** Supplies power through the supercapacitor and battery charging circuit before powering the MCU through LDO.
- **Batt & GND:** Bypasses the charging circuit and directly powers the MCU through LDO. Cludio is sent in this mode by default as this is a low power consumption mode.

Follow the safety guide for battery usage [2].

4.7 Enclosure Durability Ratings

Table 2: Device Enclosure Protection Specifications

Specification	Details
Ambient temperature, operating	-40 to 100°C
UL 94 flammability rating	V0
Material	Polycarbonate
Degree of protection	IP66/67/69
NEMA 250 enclosure rating	6
Conformance	UL 746C, IEC 60068 (Vibration, Shock), EN 50102 (Impact), IEC 60068 (Salt fog)

4.8 Contact Details for Technical Assistance

For detailed device specifications and technical assistance, contact the manufacturer:

Vaiota UG

Gleimstr. 36,
10437 Berlin,
Germany
support@vaiota.com
<https://vaiota.com/>

4.9 Installation

Please carefully follow this installation guide before using the equipment. A quick start instruction to install and use the equipment is provided by the manufacturer, which can be downloaded from this web-link.

4.10 Installation site

4.10.1 Network

To ensure optimal functionality the following conditions must be met:

1. Internet access over WIFI or LAN-Cable is required for operation and configuration of the equipment.
2. Low noise, high quality WIFI network ($\text{RSSI} \geq -70 \text{ dBm}$) access is available. If unsure, contact the device vendor and the network provider for the location of intended operation.
3. The WIFI network should have WPA2 or newer access security and the SSID should be visible
4. Please ensure that your WIFI router is not using noisy WIFI channel
5. Cludio provisioning does not support additional web-based authentication
6. If the WIFI router has MAC address based authentication, the MAC address of Cludio should be added before provisioning
7. Do not place the device directly under or fully enclosed in metallic or electrically conductive structures.
8. If WIFI network is not available please use RJ-45 LAN cable for internet connectivity.

4.10.2 Power

Cludio is supplied with its own DC 5V power supply adapter.

Optionally, it supports a 4.7V 2500 mAh LiPo battery, a 5V solar panel, and energy harvesting with a supercapacitor. See the connectors in Figure 5. Customizing power options requires adjustments to Cludio, please contact manufacturer for instructions.

4.11 Mounting

Use screws 3 or zip ties 4 to mount the device on a clean, dry surface. Connect communication cables. Follow the steps shown in Figures carefully.

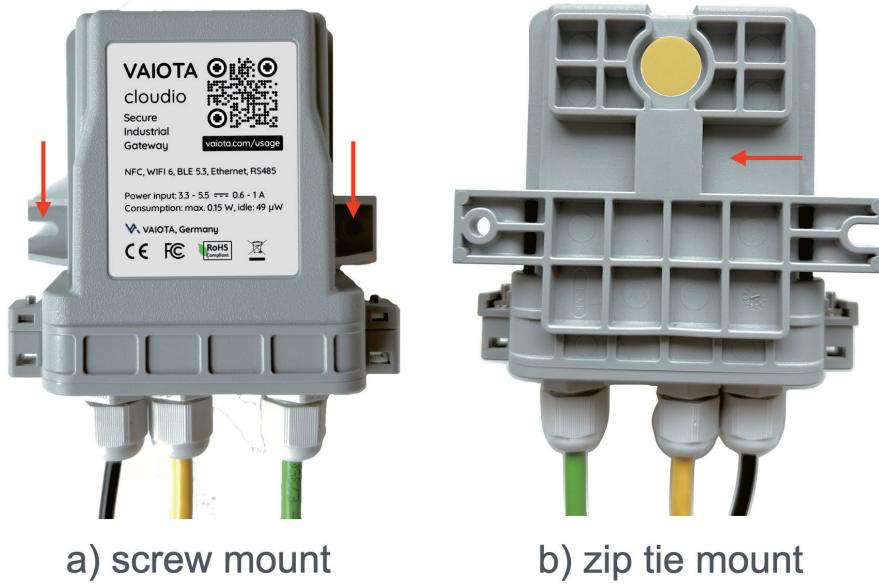


Figure 3: Mounting using screws. Use a 3.5 mm flat screwdriver to mount

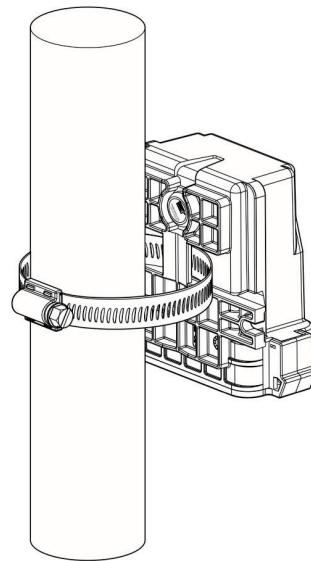


Figure 4: Zip tie mount on poles

5 Operation

5.1 Device Symbols and Parts

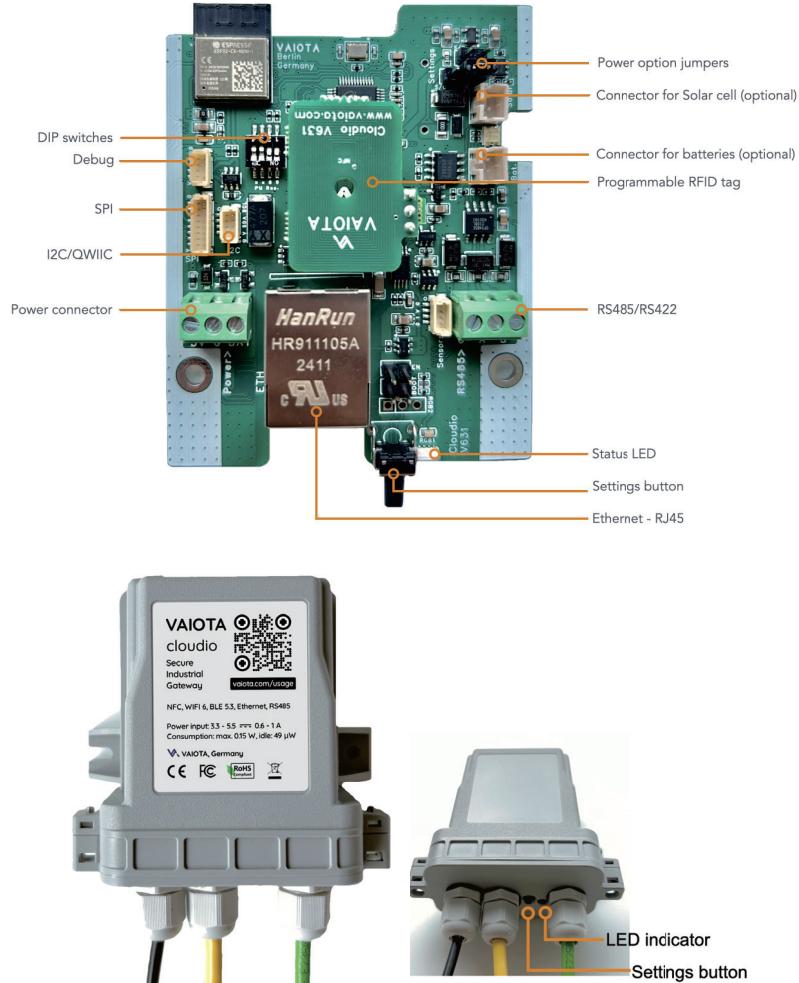


Figure 5: Parts and symbols on the device. Up: Description of functional parts of the PCB. Lower left: Left most cable is power cable, center is Ethernet cable, right cable from the cable gland is RS485/RS422 cable. Lower right: Led indicator shows the state of operational state of the device. And Settings button allows one to restart, and factory reset a device

- 1. Power Connector:** Cludio comes with a 5V (>600mA) power adapter already connected through the cable gland.
- 2. Programmable RFID Tag:** Device serial ID and configurations can be obtained by touching the Vaiota logo at the center of the front label using an NFC-enabled smartphone.
- 3. Status LED:** LED indication details are elaborated in section 5.2.

4. **Settings Button:** For resetting and setup of Cludio. For details, see section 5.3.5.
5. **RS485/RS422:** Serial communication connector to read UART data over RS485, and MODBUS RTU data acquisition.
6. **Ethernet - RJ45:** RJ45 connector for Ethernet, Profinet, Modbus TCP communication.

5.2 LED indicator

The LED indicator blinks in a certain pattern which indicates the device status. Description of the codes is as follows:

1. **Continuous blue blink:** The NFC module is switched on to receive connectivity settings, such as WiFi SSID & Password. This is the status of the device when it boots for the first time or is reset using the settings button shown in Figure 5. Refer to section 5.3.3 for details on device setup.
2. **Continuous green blink:** Attempting to connect to WiFi using the saved WiFi credentials.
3. **Continuous red/green blink:** WiFi is connected, attempting to synchronize time with the configured timeservers.
4. **Static short green:** First indication after boot, time synchronization successful. Connection to the cloud follows. Second indication, data acquisition is successful. Third indication, data sent to the cloud is successful.
5. **Static short blue:** A peripheral setup is successful, for example, settings button initialized and active. Network peripherals initialized and active.
6. **Static short red:** First indication: cloud connection successful, data acquisitions started but failed. Second indication: new device configuration received from the cloud.
7. **Static green:** The settings button is pressed for more than 6 seconds continuously. The device will restart when the button is released after continuous green.
8. **Static red:** The settings button is pressed for more than 11 seconds. Network

configuration is reset on the device. This is useful when the network credentials change at the location or the device is moved to a new location with new credentials.

5.3 Device onboarding

5.3.1 Commissioning

Cludio comes pre-commissioned. It only needs connectivity settings, such as the WiFi credentials at the installation site. It automatically downloads the device configuration data frame from the server to start operating. The credentials can be transferred to Cludio using **NFC Connectivity** along with the Vaiota App. Please see section 5.3.3 for details.

5.3.2 Activation

The device activates automatically as soon as the power adapter is connected to AC mains. The device connects to the configured network and starts operating normally, performing data acquisition and sending as configured by the configuration data frame.

Operation status of the device is indicated by the LED (Figure 5). Wait 10 seconds after powering the device and observe the LED status. LED color and blink codes are explained below in section 5.2. When activating Cludio for the first time or at a new location, the device needs to be set up. Here is a setup guide.

5.3.3 Setup

Please follow the setup process by observing the LED status indicator 5.2. Cludio in setup mode will constantly blink blue.

Note!

If Cludio has been provisioned before, and you need to re-configure it to a new location/network or adapt credentials, please refer to section 5.3.5 to set up the device at a new location or with new network credentials.

1. You will need an NFC read/write app on an NFC-enabled smartphone. You can use Vaiota App [3] for it.
2. Uploading connection credentials to Cludio via NFC:



Figure 6: Vaiota's App for provisioning Cludio

WiFi setup using Vaiota's App:

You can download the APK of our app from this link. How to connect Cludio to any 2.4 GHz WiFi:

1. Go to **Settings** > **Authentication code**: "nfcconfpass" > **SSID**: "YOUR WIFI NAME" > **Password**: "YOUR WIFI PASSWORD" > **Device Configuration**: "na" > press **Save** > press **Upload** button > touch Cludio as shown in Figure 6. You can also see and confirm your inputs in the Write Preview box (only on the testing app).
1. Make sure that Cludio is in setup mode - Blue LED is blinking continuously. Reset Cludio if it is not in setup mode 5.3.5.
2. Press the "Write to NFC" button or similar depending on your app to activate the NFC module on your phone with your connectivity credentials.
3. Place your smartphone on Cludio around the logo on the front label, which is at the center of the device.
4. Wait for a confirmation sound on your phone and see if the LED stops blinking blue and starts blinking green.
5. You have provisioned your Cludio. Reset and begin again if it fails.
6. As soon as Cludio is connected to the internet, it downloads the data acqui-

sition configurations from a cloud or edge server.

7. Cludio is now fully operational and sending data periodically as configured remotely.

5.3.4 Internal Alarm Wakeup

Cludio wakes up periodically to perform scheduled tasks, collect data via interfaces, timestamp them, get device status, pack them in a data frame and send to the server. The alarm activation and period can be configured by user using *“publish_interval”* key of the configuration dataframes 6.

5.3.5 Reset

1. To restart Cludio press the settings button and hold it until the LED indicator glows steadily green (approximately 6 seconds). Ignore any blinks that may happen while you are holding the button.
2. To reset connectivity credentials press the settings button and hold it until the LED indicator glows steadily red (approximately 12 seconds). Ignore any blinks that may happen while you are holding the button.
3. To factory reset all settings press the settings button and hold it until the LED indicator glows steadily orange (approximately 16 seconds). Ignore any blinks that may happen while you are holding the button.

The NFC module on Cludio is an I2C interfaced EEPROM module connected to an RFID antenna based on the ST25DV16KC chip. The EEPROM reading is only active when the device is in setup mode. At all other times, Cludio behaves as a passive RFID. The I2C, and EEPROM is powered down.

6 Data Frame Formats

6.1 Device Configuration Data Frames

These frames synchronize device settings between the device and the cloud configuration server. They allow users to remotely change the functionalities of Cludio. The device configuration includes communication settings, query strings, sending interval, and device modes of operation.

Clients can add or remove settings parameters here based on their needs and in consultation with the manufacturer. Here is a typical configuration data frame in JSON:

```
"cfg": {  
    "publish_interval": 60,  
    "facility_id": "factory02-sec2",  
    "led": 1,  
    "wifi_RST": 0,  
    "dbg_mode": 0,  
    "sensor_read_interval": 60,  
    "radar_read_interval": 30,  
    "radar_publish_interval": 60,  
    "bdrt": 38400,  
    "qry_str": "31valueKey\n\r"  
}
```

Description of the Device Configuration Data Frames

- **publish_interval:** Time interval (in minutes) between consecutive data publishes.
- **facility_id:** Identifier for the facility where the device is deployed.
- **led:** LED status indicator (1 for on, 0 for off).
- **wifi_RST:** WiFi reset flag (1 to reset, 0 to maintain current state).
- **dbg_mode:** Debug mode status (1 for enabled, 0 for disabled).
- **sensor_read_interval:** Time interval (in minutes) between consecutive sensor readings.
- **radar_read_interval:** Time interval (in minutes) between consecutive radar readings.
- **radar_publish_interval:** Time interval (in minutes) between consecutive radar data publishes. Allows setting different sending intervals for add-on sensors.
- **bdrt:** Baud rate for serial communication.

- **qry_str:** Query string sent to the connected device for data retrieval.

6.2 Acquisition Data Frame (Uplink frames)

Uplink frames send data from the device to the server. The full content and structure of the data frame may vary depending on the user configuration set by the Device Configuration Data Frame on the server. Here is a typical example in JSON:

```
{  
    "ts": 1717548868,  
    "app_ver": "vcloudiofw_2_1_1",  
    "device_id": "cld-404xxxxxxxx",  
    "facility_id": "factory02-sec2",  
    "data_packet_nr": 1026,  
    "ph": "7.4",  
    "conductivity": "302",  
    "temperature_board": "20",  
    "rawdat": "7.4#302#xx#xxx#xxxx#xxxxx",  
    "raw_vsens": "nan",  
    "wifich": 6,  
    "power_volts": 1357.5625,  
    "power_raw": 3377,  
    "reset_reasons": 1,  
    "WiFiAccessPoints": [  
        {  
            "MacAddress": "04:B4:FE:27:1B:F6",  
            "Rss": -46  
        }  
    ]  
}
```

Description of the Acquisition Data Frame

- **ts:** Timestamp of the data frame.
- **app_ver:** Application firmware version.
- **device_id:** Unique identifier for the device.

- **facility_id:** Identifier for the facility where the device is deployed.
- **data_packet_nr:** Sequential number of the data packet.
- **ph:** Measured pH value.
- **conductivity:** Measured conductivity value.
- **temperature_board:** Temperature of the device board in degrees Celsius.
- **rawdat:** Raw data string from sensors.
- **raw_vsens:** Raw voltage sensor data.
- **wifich:** WiFi channel being used.
- **power_volts:** Measured power supply voltage.
- **power_raw:** Raw power measurement data.
- **reset_reasons:** Reason codes for device resets.
- **WiFiAccessPoints:** List of detected WiFi access points with their MAC addresses and signal strengths.

7 Quality Management System

7.1 Quality Control Procedures

The QMS covers all stages from design and development to manufacturing and after-sales support. Procedures include detailed design reviews, simulation and prototyping, in-process inspections, and final product testing.

7.2 Continuous Improvement

Vaiota UG commits to continuous improvement through regular audits, management reviews, and customer feedback.

8 Troubleshooting

8.1 Common Issues and Solutions

- **Issue:** Device not powering on. **Solution:** Check power connections and ensure the power adapter is functioning.
- **Issue:** Unable to connect to the network. **Solution:** Verify network credentials and ensure proper configuration.
- **Issue:** Device not responding to NFC. **Solution:** Ensure NFC antennas are properly aligned and try again.

8.2 Device status

Device status can be read from the LED indicator blink codes. See details in section 5.2.

- **Continuous Blue Blink:** NFC module is ready to receive settings.
- **Continuous Green Blink:** Attempting to connect to WIFI.
- **Continuous Red/Green Blink:** WIFI connected, synchronizing time.
- **Static Short Green:** Time synchronization successful, data acquisition, and data sent to the cloud.
- **Static Short Blue:** Peripheral setup successful.
- **Static Short Red:** Cloud connection successful, data acquisition failed.
- **Static Green:** Settings button pressed for more than 6 seconds.
- **Static Red:** Settings button pressed for more than 11 seconds, network configuration reset.
- **Static orange:** Settings button pressed for more than 16 seconds, resets the full factory reset.

9 Maintenance and Technical Service

- **Battery Replacement:** Performed by the manufacturer. Contact Vaiota technical support for assistance.
- **Firmware Update:** Instructions provided by Vaiota technical support. Ensure the device is connected to a stable network during the update process.

9.1 Regular Maintenance Tasks

- **Visual Inspection:** Regularly inspect the device for signs of damage or wear.
- **Cleaning:** Clean the device with a dry microfiber cloth. Avoid using water or solvents.

10 Technical Features

10.1 Electrical Specifications

- **Supply Voltage (DC Adapter):** 3.0V to 5.5V DC
- **External Battery Voltage (optional):** 3.0V to 4.7V DC
- **Power Consumption:** Realistic power consumption depends on sending interval and mode
 - **Fulltime mode:** 0.1W, e.g. 1 min. sending interval. (Device never sleeps)
 - **Intermittent mode:** 0.01W, 10 min. interval in between sending data frames
 - **Deep sleep Mode:** 49 μ W, Avg. 14.8 μ A @3.3 V

10.2 Connectivity

- WIFI 6 (802.11ax), BLE 5.3
- Zigbee (802.15.4)
- Ethernet: DHCP-capable controller for TCP/IP, Modbus TCP, and Profinet

10.3 Security

- TPM for keys and FW, and TLS v1.2, TLS v1.3 for MQTT communication with the server.

10.4 Microcontroller

- 160MHz RISC-V

10.5 Enclosure Specifications

- **Material:** Polycarbonate
- **Degree of Protection:** IP66/IP68
- **Ambient Temperature (Operating):** -40 to 100°C
- **Flammability Rating:** UL 94 V0
- **Conformance:** UL 746C, IEC 60068 (Vibration, Shock), EN 50102 (Impact), IEC 60068 (Salt fog)

11 Product Regulations

Cludio complies with FCC and CE regulations. Ensure compliance with local laws and guidelines when deploying the device.

11.1 FCC Compliance

- **Contains FCC ID:** 2AC7Z-ESPC6MINI1
- **FCC ID:** 2BG4Q-CV63
- This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
 1. This device may not cause harmful interference.
 2. This device must accept any interference received, including interference that may cause undesired operation.

11.2 CE Compliance

- **CE Marking:** Conforms to EU Directives.
- Ensure the device is used in accordance with the instructions provided to maintain compliance.

12 Guarantee

Vaiota guarantees the quality and performance of Cludio. Refer to the warranty terms for detailed information.

12.1 Warranty Terms

- **Coverage:** The warranty covers manufacturing defects and performance issues.
- **Duration:** 2 years from the date of purchase.
- **Exclusions:** The warranty does not cover damage caused by improper use, unauthorized modifications, or external factors.

13 Document History

- **Version 1.0** - Initial release.

14 Contact Information

For technical support and inquiries:

Vaiota UG

Gleimstr. 36,
10437 Berlin,
Germany
support@vaiota.com
<https://vaiota.com/>

15 FCC Warning

FCC WARNING

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

To maintain compliance with FCC's RF Exposure guidelines, this equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body. Use only the supplied antenna.

References

- [1] <https://vaiota.com/support>
- [2] <https://www.iata.org/contentassets/05e6d8742b0047259bf3a700bc9d42b9/lithium-battery-guidance-document-2021.pdf>
- [3] <https://www.dropbox.com/scl/fi/bh8ard86o93sjy3iatmde/app-release.apk?rlkey=iy1cj3hzlycocr0osvwx6sujk&st=cr06hqiq&dl=0>
- [4] <https://apps.apple.com/us/app/nfc-tools/id1252962749>
- [5] https://play.google.com/store/apps/details?id=com.wakdev.wdnfc&pcampaignid=web_share