

# Indoor Air Quality Sensor IAQ04



## Interfaces

WiFi

- MQTT
- HTTP
- Modbus TCP
- HTTP API

LoRaWAN (optional)

Modbus RTU

Analog output (*optional*)

## Measured quantities

Temperature

Air humidity

CO<sub>2</sub> concentration

VOC concentration

Ambient light (indicative value)

Particulate concentration (*optional*)

Noise (indicative value)



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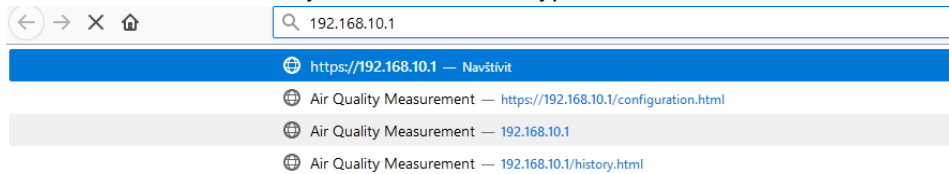
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## 1 Quick Start - First login to the sensor

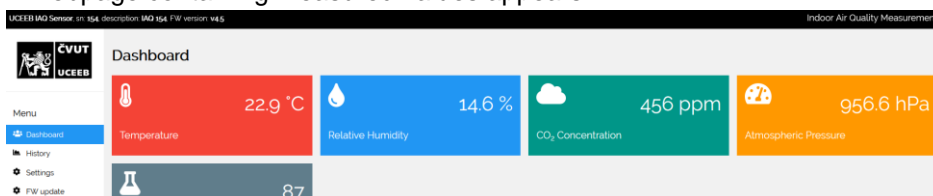
- Power on the sensor.
- The sensor creates a WiFi access point with SSID name **IAQ\_sens\_XXX**, where XXX is the serial number of the sensor. This mode is called AP mode or WiFi hotspot.
- Connect to this network from your laptop/tablet/phone. No password is required.



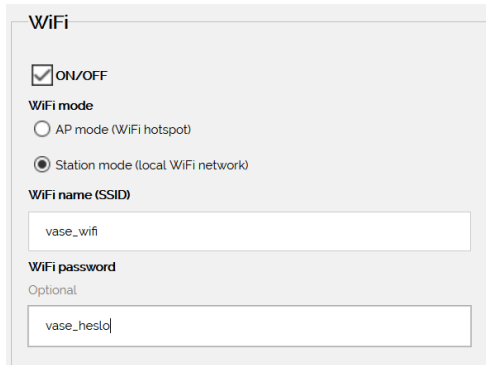
- In the address column of your web browser, type **192.168.10.1**.



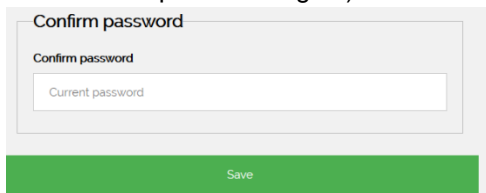
- A webpage containing measured values appears.



- Setting of the sensor can be modified (**Settings** item in the **Menu**, default login name: **admin**, password: **admin**).
- It is recommended to configure the sensor to connect to a local (home/business) WiFi network.



- Apply changes in the form by clicking **Save** button at the very end of the page (you need to fill in the admin password again).



- The sensor informs you that the setting has been saved correctly and you have to restart sensor.
- Connect your computer back to your home/business WiFi network.
- In your web browser type [iaq.uceeb.cz](http://iaq.uceeb.cz) in the address column. You should find all your sensors in the network – this verifies that the settings and connection to your WiFi network succeeded.

## 2 Basic information

This datasheet is valid for the IAQ04 sensor with firmware version **4.7** and higher until the release of the new datasheet.

<b>Measurement of indoor parameters</b>	Ambient temperature Relative humidity CO <sub>2</sub> concentration VOC concentration (volatile organic compounds) Ambient light Particulate matter <b>concentrations</b> ( <i>optional</i> )	
<b>Power</b>	12 to 24 V DC, 1 A USB 5 V DC, 1 A	
<b>Average power</b>	< 1 W	
<b>Measuring range</b>	Temperature Relative humidity CO <sub>2</sub> concentration VOC concentration Ambient light Particulate Matter concentration PM10, PM4, PM2,5 and PM1	-40–85 °C 0–90 %RH (non-condensing) 300–5000 ppm 300–5000 (dimensionless index) 0–7500 lx 0.0-999.9 µg/m3 ( <i>optional</i> )
<b>Measurement accuracy</b>	Temperature Relative humidity CO <sub>2</sub> concentration VOC concentration Ambient light Particulate Matter concentration PM10, PM4, PM2,5 and PM1	± 0,5 °C ± 2 % (in range 20-80 %) ± 30 ppm ± 3 % of the value indicative value indicative value ±10 µg/m3 (in range 0–100 µg/m3) ±10 % (in range 100-1000 µg/m3)
<b>Outputs</b>	Analog voltage output 0-10 V <i>or</i> Analog current output 0-20 mA, 4-20 mA ( <i>optional, available only with a supply voltage higher than 12 Vdc</i> )	
<b>Communication interface</b>	WiFi 802.11 b/g/n 2.4 GHz LoRaWAN – Class A, 14 dBm, SF 7-12, 868 MHz support for both ABP and OTAA device activation Modbus RTU (RS485)	
<b>Indication</b>	Multicolour LED to indicating CO <sub>2</sub> concentration and sensor status <i>or</i> LCD display with measured values	

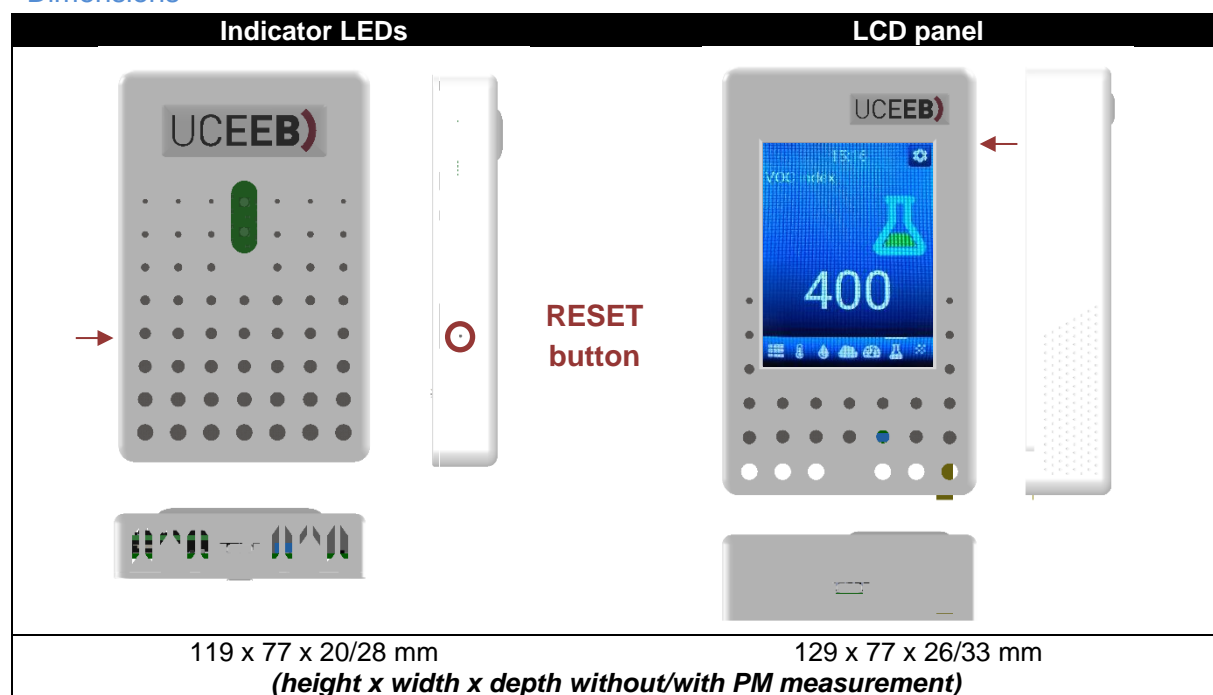
### Sensor version and marking

IAQ04 sensors can be manufactured in the following configurations.

Type	WiFi	LoRa	RS485	T, RH	VOC	CO <sub>2</sub>	Light	Noise	PM	LED	LCD
IAQ04	✓		✓	✓	✓	✓	✓	✓		✓	
IAQ04_PM	✓		✓	✓	✓	✓	✓	✓	✓	✓	
IAQ04_LoRa	✓	✓	✓	✓	✓	✓	✓	✓		✓	
IAQ04_PM_LoRa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
IAQ04_LCD	✓		✓	✓	✓	✓	✓	✓			✓
IAQ04_LCD_PM	✓		✓	✓	✓	✓	✓	✓	✓		✓
IAQ04_LCD_LoRa	✓	✓	✓	✓	✓	✓	✓	✓			✓
IAQ04_LCD_PM_LoRa	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

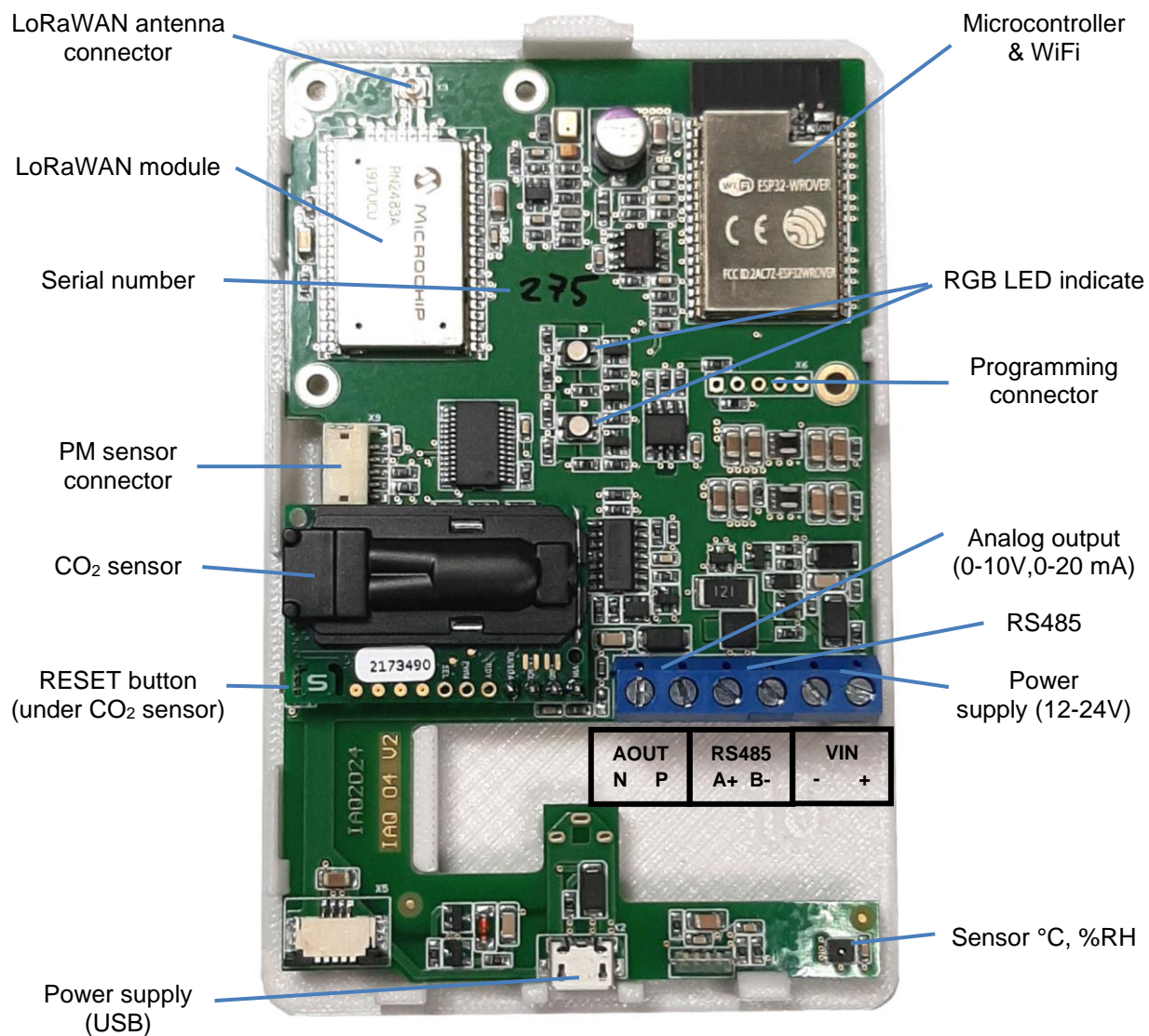
All designs have a WiFi module and a web interface for data presentation and configuration.

### Dimensions



### 3 Sensor connection and installation

To ensure the accuracy of the measurement of all quantities, the sensor must be placed in a vertical position (e.g. mounted on the wall). Horizontal orientation on flat surface will affect the measured values.



## 4 Measured quantities

To ensure accurate measurements, it is necessary to install sensor properly (see Chapter 3).

### 4.1 Averaging

Measured quantities can be averaged depending on the communication interface through which they are sent. For MQTT and LoRaWAN, the values are averaged over the transmitting period. For example, if the transmission period is 5 minutes, the value is an average of 5 minutes. For Modbus TCP/RTU, HTTP API and analog output, the averaging time can be set via the webserver for each interface separately or averaging is completely turned off (by setting the value zero). The values displayed in the web browser, LCD display and on the indicator RGB LED always have the same averaging period, which can also be set via the webserver. The default is not averaging. In all cases, averaging is moving average type filter.

### 4.2 Temperature

Ambient temperature (°C).

#### Temperature calibration

It is possible to set the temperature offset in the sensor's configuration, which is then added to the measured value.

### 4.3 Humidity

#### Relative humidity

Amount of dissolved water in space related to the saturated state (%). The most used humidity explanation.

#### Absolute humidity

Amount of water dissolved in the air in grams per cubic meters (g/m<sup>3</sup>).

#### Dew point

A temperature at which water starts condensate at the current humidity (°C).

### 4.4 CO<sub>2</sub> concentration

Carbon dioxide concentration (ppm). This informs how much the air is exhausted.

#### Manual CO<sub>2</sub> calibration

Sensor configuration section provides possibility to set the current CO<sub>2</sub> reference value measured by another calibrated instrument. After saving the setting, the CO<sub>2</sub> sensor is calibrated according to this value and the value zero will appear again in the setting. Manual calibration will be overridden in time by automatic calibration, if enabled.

#### Automatic CO<sub>2</sub> calibration

Factory-enabled automatic CO<sub>2</sub> calibration works on background and adjusts CO<sub>2</sub> calibration in seven-day cycles. Fresh air must be provided for at least one hour per day in order to make automatic calibration work. This calibrates the sensor according to the outdoor CO<sub>2</sub> concentration (the outdoor concentration is 400 ppm). When automatic calibration is enabled, the manual calibration value will be overridden no later than in seven days.



## 4.5 Concentration of volatile substances VOC

### VOC index

The Indoor Environment Quality Index (dimensionless index) indicates relative changes in the measured concentration of volatile organic compounds (VOC). A value of 300 corresponds to clean air and 5000 very polluted air. Evaluation algorithm adapts to the typical ambient conditions in which the sensor is located (home, office, car, ...) during the measurement. Thus, value of 500 corresponds to typically clean air and 2000 typically polluted air in each environment.

The range of VOC index values is determined in such way that the scale is comparable to scale of CO<sub>2</sub> concentration. Sometimes this VOC index is called CO<sub>2</sub> equivalent, although it has nothing to do with CO<sub>2</sub> measurement.

## 4.6 Ambient indirect lighting

IAQ sensors are equipped with an ambient light sensor (lux) that is used for dimming the indicating LED or LCD panel. The illumination intensity in lux is sent via MQTT, LoRaWAN or Modbus TCP/RTU. This value must be taken only as indicative, since the light sensor is located in the box and therefore does not receive as much light as in ambient space.

## 4.7 Concentration of PM10, PM4, PM2.5 and PM1 particulate matter (PM versions only)

PM sensor measures concentration of dust particles in the air in four size classes 10 µm, 4 µm, 2.5 µm and 1 µm in micrograms per cubic meter (µg/m<sup>3</sup>). The sensor does not sort the particulates into classes, it counts all the particulates that are smaller than the size of class is. E.g. the concentration for a size 10 µm represents all particulates of size 10 µm and smaller.

## 4.8 Noise measurement

The sensor allows you to measure the average noise intensity in the range of 25-80 dB. Value sent over MQTT, LoRaWAN, or Modbus TCP/RTU is the average over the sampling period. In addition to the average intensity, the sensor also measures the time during which noise exceeds adjustable noise intensity threshold (as a percentage of the measured interval). The default threshold value is 40 dB, which corresponds to the detection of normal speech in the room. You can change the threshold using webserver or by LoRaWAN downlink settings frame.

## 5 IAQ sensor with RGB LED indication

The following part of the document is divided by sensor type. This chapter describes sensor with LED indicator and the following chapter 0 display. Chapter 0 describing web interface is already the same for both variants.

The sensor is equipped with a RGB LED indicator. Its primary function is indication of CO<sub>2</sub> concentration. In addition, it serves to indicate unconnected WiFi and gives the user feedback when resetting the settings using RESET button.

### 5.1 Basic features

After powering or restarting the sensor, the LED flashes shortly in red or cyan colour (depending on the HW version). Then the purple colour lights up, which indicates that all sensors are not yet initialized, and the measured values are not valid. This state lasts approximately 30 seconds. After all sensors have been initialized, the LED will light up in colour according to the measured CO<sub>2</sub> concentration and will remain on until it is switched off or restarted.

#### Colour range of CO<sub>2</sub> concentration

The colour of the LED varies depending on the CO<sub>2</sub> concentration from green through yellow to red. Green colour corresponds to 500 ppm and less, red 2000 ppm and more. The colour gradient between these two values is smooth. The CO<sub>2</sub> value indicated by the LED can be averaged see 4.1 Averaging.

#### Feedback when resetting settings with the button

After powering or restarting the sensor, while the LED is purple, it is possible to reset the sensor via the RESET button to the factory settings or to the AP mode. This process is described below in 5.2 Reset the WiFi sensor connection.

#### Unconnected WiFi indication

If the sensor is set up to connect to your local WiFi network and the network connection fails, the LED will flash. The LED colour remains its function, which is indicating the CO<sub>2</sub> concentration. There may be more reasons why the connection to WiFi failed (e.g. wrong password or network name, weak a signal). When troubleshooting problems with WiFi connection, you can follow the instructions in the chapter 5.2 Reset the WiFi sensor connection.

### 5.2 Reset the WiFi sensor connection

The following chapters describe setting up sensors without an LCD display. If you have a sensor with an LCD display, continue to 6.2 Reset to factory settings.

#### Set WiFi to AP mode

In case the sensor is not in AP mode (WiFi hotspot) or connects to the local WiFi network (for example, due to a change in WiFi network settings), the AP mode can be temporarily turned on for 15 minutes. AP mode turns off automatically after 15 minutes or with sensor restart (power off and on).

#### Procedure

1) Turning the temporary AP mode on can only be only done shortly after switching on the sensor when the indicator LED is still purple.

2) Press and hold the RESET button for about 1 second. The LED signal colour changes to blue and flashes. The reset button is located on the left side of the sensor (see 2 Basic information). It is recommended to use paper clip for pushing the button.

- 3) At this time, the button have to be released and the sensor will automatically go into AP mode. It is now possible to connect to the WiFi sensor. The SSID name of the WiFi network is **IAQ\_sens\_XXX**.
- 4) The username and password for the administration will also be reset to the default **admin** name and **admin** password.
- 5) Set everything you need in the web configuration. Save the form and wait for confirmation.
- 6) Restart the sensor. After restart, the new settings are applied, and the temporary AP mode is terminated. If you want to set-up the AP mode permanently, you have to do it in the webserver in the configuration.

#### Reset to factory settings

This reset will set the WiFi AP mode on and returns all settings to the factory defaults. Any changes made by this procedure are permanent and can't be recovered.

#### Procedure

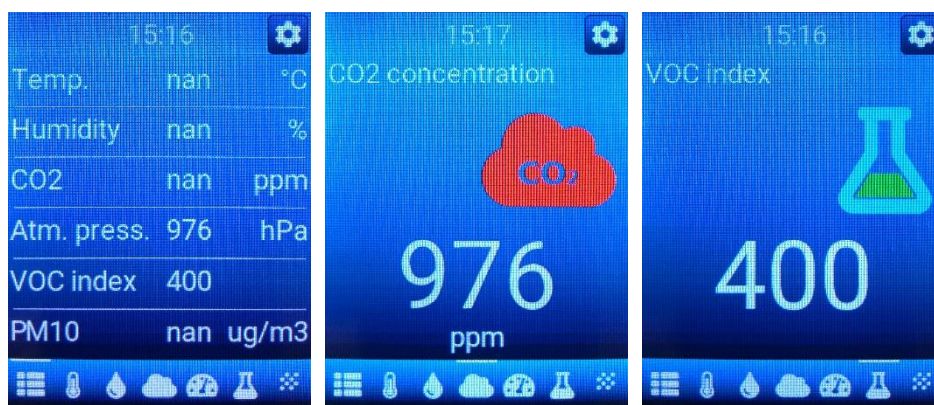
- 1) Reset to factory settings can only be done after switching on the sensor when the LED is still purple.
- 2) Press and hold the RESET button. The LED signal colour changes to blue and flashes.
- 3) Hold the button for approximately 8 seconds until the LED stops flashing, then release the button.
- 4) It is now possible to connect to the WiFi sensor. The name of the WiFi network is **IAQ\_sens\_XXX**.
- 5) The username and password for the administration will be reset to the default **admin** name and **admin** password.

## 6 IAQ sensor with LCD touch display

The sensor with LCD and capacitive touch screen version allows direct display of measured values and sensor configuration. The resolution is 240 x 320 pixels.

### 6.1 Measured values view

After switching on the sensor, the initial screen appears on the display, where all measured quantities are presented. The user interface consists of multiple screens. Their order and designation of the currently selected screen is indicated by an icon bar at the bottom. You can switch between screens, either by swiping your finger right / left in the middle area of the screen, or by tapping directly on the selected icon at the bottom of the screen. The current time is also displayed on each screen.



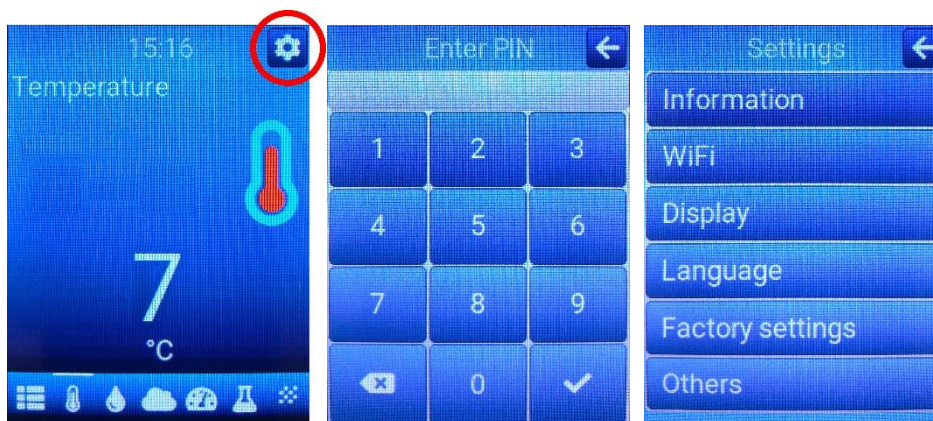
Screens showing the individual measured quantities in a large format together with the corresponding graphic icon, which in some cases changes colour according to the measured value. Green indicates standard values, orange the limit values and red unsatisfactory.

The colour scaling follows the following table:

Size	All right (green)	Limit (orange)	Over limit (red)
CO <sub>2</sub> concentration (ppm)	400–800	800–2000	2000
VOC index	400–800	800–2000	2000

## 6.2 Sensor settings

It is also possible to perform basic sensor settings via the touchscreen. To enter the settings menu, you need to tap the settings icon in the upper right corner and then enter the PIN (default PIN **1234**). It is recommended to change the PIN code.

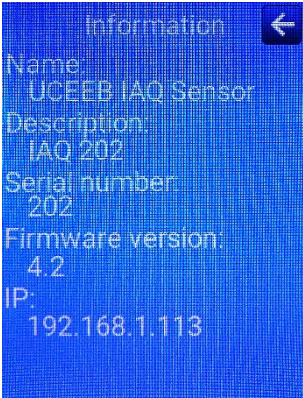


To return to the basic user interface, click on the arrow icon in the upper-right corner of the display.

### Basic information

Click the **Information** button in the Settings menu to see basic sensor information.

ITEM NAME		Description
<b>Name</b>	Sensor name	
<b>Description</b>	Description/location of the sensor	
<b>Serial number</b>	Sensor serial number	
<b>Firmware version</b>	Firmware version installed	
<b>IP</b>	Current device IP address	





### WiFi / AP mode settings

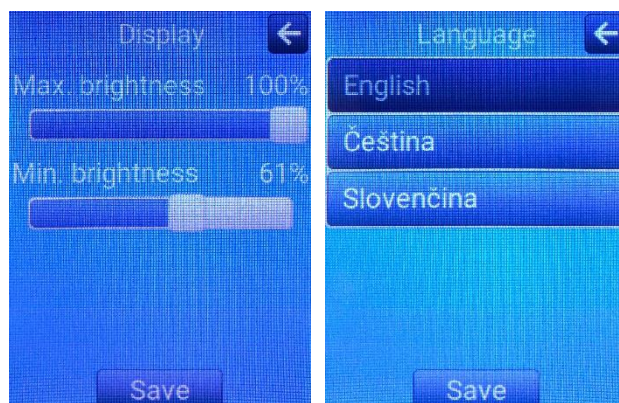
Click the **WiFi** button in the settings menu to see WiFi connection settings. To apply the changes, you have to confirm it clicking the **Save** button. The sensor then restarts.

ITEM NAME	Description
<b>ON/OFF</b>	Turn WiFi on or off
<b>WiFi mode</b>	Specifies how WiFi is connected: <b>Hotspot</b> – the sensor creates its own WiFi, which can be connected to by computer or mobile phone <b>Local network</b> – sensor connects to local (home/business) WiFi network
<b>WiFi name (SSID)</b>	The name of the WiFi network that the sensor creates (AP mode) or to connect to (Station mode)
<b>WiFi password</b>	WiFi network password. You can also connect to networks without a password or create networks without a password. Leave the field blank for use without a password.



### Adjust the brightness of the display

Click the **Display** button in the Settings menu to adjust the brightness range. You can set the maximum and minimum intensities of the backlight of the display. The maximum intensity is used in daylight, the minimum at low ambient light intensity. If you want the display to be on at night, set the minimum intensity value to at least 5%. Otherwise, the display will be turned off at night. You must confirm the settings with the **Save** button.

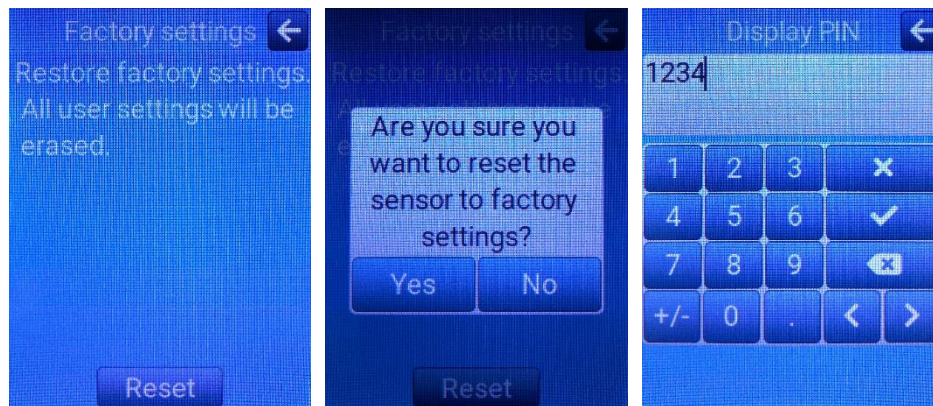


### Language settings

Click the **Language** button in the Settings menu to see a selection of possible interface languages (this option sets only the text on the display, it has no effect on the language of the web interface). To activate the settings, you must press **Save**. The sensor then restarts.

### Reset to factory settings

Click the **Factory settings** button in the Settings menu to see the option to restart the sensor to factory settings. WARNING - all user settings will be permanently deleted if you confirm.



### Other settings

Click **Others** in the Settings menu to see the option to set the **PIN** used to access the settings through the display. You have confirm the settings pressing the **Save** button.

## 6.3 Thermostat

The LCD version of IAQ sensor supports the thermostat functionality (to be more specific - the input user panel for temperature adjustment). The function is available when using Modbus RTU/TCP communication only.

### Principle of transmission of the temperature set point

Sensor provides the desired temperature value over Modbus RTU/TCP interface in one of the input registers (address 100). However, it is possible to overwrite that value from a superior control system by writing in a Modbus holding register (address 5020).



The sensor in the system acts as a subordinate device. Therefore, the superior system must take care of maintaining the set value. When the sensor is started, the temperature setting value is not initialized and the superior system must take care of initializing it.

### Reading cycle and writing value to sensor

1. Read the input registry at the desired temperature.
2. If the temperature has changed since the last reading, the superior system will make an action.

3. Writing the current temperature setting from the superior system to the holding register of the sensor (this step must always be done – even if no change has occurred – this maintains the consistency of the settings in the sensor and the parent system).
4. Optional communication delay.
5. Repeat over from step 1.

Reading and writing value should be done with a care. First read the input registry (step 1), then write the holding register (step 3) and finally there is an optional communication delay (step 4). Reading and writing to the sensor (steps 1-3) must be done as quickly as possible with a maximum delay 5 seconds. This is necessary due to user's possible entering a new value via LCD at any time. This new value must first be read from the sensor (step 1) before setting a new value from the superior system (step 3).

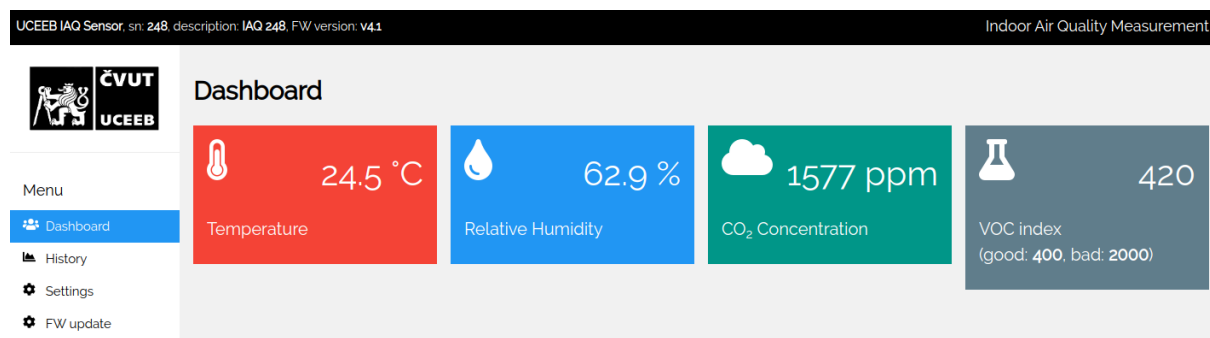
To resolve a situation where user changed the value in the meantime between reading and writing (between steps 1 and 3), the sensor has a protective 7 second period, when it is possible to write to the holding registry, but the written value is not set in the sensor. The protection 7 second period starts running from the temperature change on the sensor display.



## 7 Configuration of IAQ sensor using web interface

### 7.1 Web

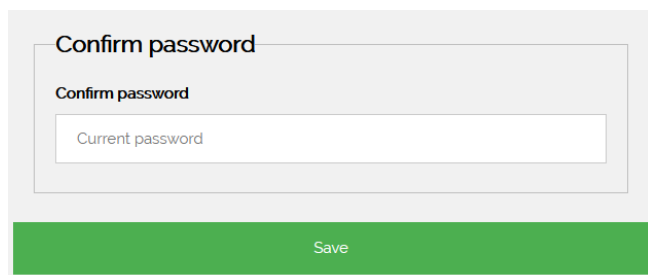
The default sensor address in AP mode (WiFi hotspot) is **192.168.10.1**. When you enter this address, the following page appears in web browser with currently measured values without using averaging.



### 7.2 Settings

The **Settings** section allows you to set up the sensor and communication with the superior system, cloud or database. In order to access this section, use menu on the left side of web page. To configure the sensor, you must confirm by entering the name **admin** and password **admin** (default factory settings). We recommend that you change your password after you log on for the first time.

The following chapters describe each block of the Settings section one at a time. Everything is set up on one long page and then everything needs to be confirmed at the end of the page by entering an admin password and the **Save** button.



The screenshot shows a "Confirm password" form. It has a title "Confirm password" and a label "Confirm password" above a text input field. The input field contains the placeholder text "Current password". Below the input field is a green "Save" button.

## 7.3 Login

ITEM NAME	Description
Admin username	name for administrator access to configuration
New password	new password for administrator access to configuration

**Login**

**Admin username**

**New password**

## 7.4 General sensor settings

ITEM NAME	Description
Serial number	sensor serial number - cannot be changed
Sensor name	sensor name (type) – cannot be changed
Sensor description (location)	a description of the sensor used to identify it, e.g. its location

**Sensor**

**Serial number**

**Sensor name**

**Sensor description (location)**

## 7.5 WiFi settings

ITEM NAME	Description
ON/OFF	WiFi can be completely deactivated. To activate it later, you have to reset it by pressing the button into AP mode or factory settings.
WiFi mode	Specifies how WiFi is connected: <b>AP mode</b> – the sensor creates its own WiFi, which can be connected to by computer or mobile phone <b>Station mode</b> – sensor connects to local (home/business) WiFi network
WiFi name (SSID)	The SSID name of the WiFi network that sensor creates (AP mode) or is connecting to (Station mode)
WiFi password	WiFi network password. You can also connect to networks without a password or create networks without a password. Leave the field blank for use without a password.

### Example of settings

#### WiFi

☒ ON/OFF

WiFi mode

☒ AP mode (WiFi hotspot)

☐ Station mode (local WiFi network)

WiFi name (SSID)

Default SSID for AP mode: IAQ\_sens\_101

IAQ\_sens\_101

WiFi password

## 8 Communication interfaces

The sensor allows you to display currently measured values as well as its history using the webpage. At the same time it can send measured values using WiFi (MQTT, HTTP API, Modbus TCP), LoRaWAN, RS485 (Modbus RTU) interfaces. The sensor also supports an online search service on your local network.

### 8.1 Local Area Network Sensor Search Service - Discovery service

Usually the DHCP service running in the router creating WiFi network assigns IP address automatically without knowing the user. This IP address is needed to access the web page, but sometimes it cannot be revealed easily.

Discovery service is an online service that makes it easy to find sensors in the local network. If you turn on the service, the sensor will send its serial number, description and your local IP address to our server. The service is not used for accessing sensors, but only for finding them and showing their list. All communication with the sensor webserver then takes place directly in the local network only.

Displaying a list of sensors can be password protected. The password is not necessary because you can only view sensors with the same public IP address, which in most cases will be sensors just in your local WiFi network. However, under certain circumstances, multiple WiFi networks may share the same public IP address, and therefore someone else could see the names of your sensors. The password is not used to restrict access to sensors on the local network. Sensors will always be accessible in the local network to anyone who knows their IP address.

When you open the [iaq.uceeb.cz](http://iaq.uceeb.cz), you will see a list of sensors in the WiFi network to which these are currently connected.

#### Settings

ITEM NAME	Description
ON/OFF	Turns ON or OFF the discovery service.
Password	Optional short password or PIN to access the sensor list.

#### Example of settings

#### Online discovery service

Find sensors in your local network: [iaq.uceeb.cz](http://iaq.uceeb.cz)  
If you enable this service, the sensor will send its name, serial number and your IP address to our server.

☒ ON/OFF

**Password**  
Short password or PIN to access your sensor list. The password is not necessary because you only have access to the list of sensors in your local network.

## 8.2 MQTT

To send data via MQTT, it is first necessary to enable this option in the Settings menu (see below). MQTT only works with WiFi in Station mode. The sensor sends data in preset periods in JSON format, which is also used with the HTTP API and is described below.

MQTT enables encrypted and unencrypted connections. We highly recommend using encrypted connection (by default on port 8883). It is also recommended to use the authentication options using username and password.

After switching on the sensor, sensor waits for all quantities to be initialized first. After that, periodical data sending begins.

### MQTT settings

ITEM NAME	Description
ON/OFF	Turns ON or OFF data transfer using MQTT. The transfer should only be activated when connected via WiFi (Station mode only).
MQTT publish period (seconds)	The period of sending data in seconds. The data you send is the average for the entire period.
MQTT TLS encryption	Encrypting data and credentials: <ul style="list-style-type: none"><li>• Unencrypted</li><li>• Encrypted – recommended</li></ul>
MQTT server	Server's domain name or IP address
MQTT port	Server port. Do not forget changing port when changing the encryption.
MQTT username MQTT password	User login and password to MQTT server. Optional but highly recommended.
MQTT topic	MQTT topic

### Example of settings

#### MQTT

☒ ON/OFF

**MQTT publish period (seconds)**  
Valid range 10 - 3600 seconds, default 120 seconds

**MQTT TLS encryption**  
☐ Unencrypted (default port 1883)  
☒ Encrypted (default port 8883) recommended

**MQTT server**

**MQTT port**

**MQTT username**  
Optional but highly recommended

**MQTT password**  
Optional but highly recommended

**MQTT topic**

## 8.3 HTTP API

The API website is available at <http://192.168.10.1/api/v1/data.json> in the case of WiFi AP mode (WiFi hotspot). If the sensor is connected to local WiFi, you must change the IP address.

The measured values are averaged. The averaging time can be set in **Settings** on the webserver (in seconds).

You can add format and meta parameters to an address to determine whether the output will be formatted, for better readability, and whether it will contain metadata. Example of URLs with parameters:

<http://192.168.10.1/api/v1/data.json?format=0&meta=0>

<http://192.168.10.1/api/v1/data.json?format=1&meta=1>

## 8.4 JSON data format

```
{
  "meta": {
    "dream": 127, /* Sensor serial number */
    "ip": "192.168.0.53", /* IP address in the local network */
    "name": "IAQ Sensor", /* Name (type) sensor */
    "desc": "Living room", /* Sensor description */
    "uptime": 64 /* Time from sensor start/restart (s) */
  },
  "temperature": 22.57, /* Temperature (°C) */
  "relative_humidity": 48.64, /* Relative humidity (%) */
  "absolute_humidity": 9.73, /* Absolute humidity (g/m3) */
  "dew_point": 11.2, /* Dew point (°C) */
  "CO2": 518.46, /* CO2 concentration (ppm) */
  "ambient_light": 482.94, /* Ambient lighting (lux) */
  "VOC_index": 681.67, /* VOC index */
  "VOC_equiv_CO2": 681.67, /* VOC equivalent CO2 (ppm) */
  "PM10": 10.5, /* Particulates concentration 10 um (ug/m3) */
  "PM4": 10.1, /* Particulates concentration 4 um (ug/m3) */
  "PM2_5": 9.7, /* Particulates concentration 2.5 um (ug/m3) */
  "PM1": 8.7 /* Particulates concentration 1 um (ug/m3) */
}
```

If a value is not initialized yet, there is a **null** value instead of a number. For example:

```
...
"dew_point": 11.2, /* Dew point (°C) */
"CO2": null, /* Concentration CO2 (ppm) */
"ambient_light": 482.94, /* Ambient lighting (lux) */
...
```

## 8.5 LoRaWAN

### LoRaWAN settings

ITEM	Description
ON/OFF	Turns LoRaWAN data transfer ON and OFF. Only some versions support this option.
LoRaWAN TX period (minutes)	<p>The period of transmitting data in <b>minutes</b>. The data you send is average for that period.</p> <p>Due to the limitation of the transmission time, it is not recommended to set a period shorter than 5 minutes. Minimum period 1 minute is suitable for short-term testing.</p> <p>The sending period is not fixed but has <math>\pm 10</math> seconds variance. This is protection against interferences between multiple sensors in case these are turned on simultaneously.</p>
LoRaWAN activation method	<p>Sensor activation method</p> <p><b>OTAA activation</b> – Over-the-Air Activation – <b>recommended</b></p> <p><b>ABP activation</b> – Activation by Personalization</p>
LoRaWAN Device EUI	Device EUI (or DevEUI) is factory-preset and is not recommended to be changed.
LoRaWAN EUI Application LoRaWAN Application Key	<p>Set additional LoRaWAN parameters. For more details see LoRaWAN documentation.</p> <p>All data have a simple validity check (amount of characters and its correctness – 0-9 and A-F upper case allowed only).</p> <p>Clicking on the "random" button can be set a random value for a given field (this is not recommended for Device EUI).</p>



### Example of LoRa settings

LoRa

☒ ON/OFF

LoRa TX period (minutes)  
 Valid range 1 - 180 minutes, default 5 minutes

LoRa activation method  
☒ OTAA activation recommended  
☐ ABP activation

LoRa Device EUI random 16/16  
 Default DevEUI: 0004A30B00E86801

LoRa Application EUI random 16/16

LoRa Application Key random 32/32

### Payload - uplink

Uplink payload contains up to 18 bytes (depending on the version) in which up to 12 different quantities/information are encoded. The information is single-byte, double byte or multi-byte. All transmitted values are positive integers. Decimal and negative numbers are obtained by the calculation described below.

### Payload options

The tables below show all the values that can be transferred in the payload. The actual number of values varies depending on the version of the sensor (payload version). The basic values are temperature (T), air humidity (RH), atmospheric pressure (p), VOC concentration index (VOC), ambient indirect lighting intensity (Ambient\_light). Furthermore, some versions may include CO<sub>2</sub> concentration (CO<sub>2</sub>), particulate matter concentration (PM), noise measurement (Noise\_duration, Noise\_intensity).

### Payload content

The first byte of payload indicates its content. It is conceived as a bit field where each bit corresponds to one quantity or group of quantities (if payload contains a certain quantity, its corresponding bit is set high).

Bit	Binary representation	Importance
0	0000 0001	T, RH (temperature and relative humidity)
1	0000 0010	p (atmospheric pressure)
2	0000 0100	VOC index
3	0000 1000	Ambient_light (ambient lighting)
4	0001 0000	CO <sub>2</sub>
5	0010 0000	PM10, PM2.5, PM4, PM1 (dust particulates)

Bit	Binary representation	Importance
6	0100 0000	Noise_duration, Noise_intensity (noise measurement) (in this FW version is not supported)
7	1000 0000	Reserved

#### Payload format

The following table shows values in payload byte by byte. If a value is omitted in the payload, another value moves in its place.

Byte	Byte order	Name	Meaning
0	-		Payload content
1	LO	T_x	Temperature (°C)
2	HI		
3	-	RH_x	Relative humidity (%)
4	LO	p_x	Atmospheric pressure (hPa)
5	HI		
6	LO	VOC_x	VOC index
7	HI		
8	-	Ambient_light_x	Ambient illuminance (lux)
9	LO	CO2_x	CO <sub>2</sub> concentration (ppm)
10	HI		
(11)	LO	PM_x	Concentration of PM10 and PM2.5 particulates (µg/m <sup>3</sup> )
(12)	MID		
(13)	HI	PM_y	Concentration of PM4 and PM1 particulates (µg/m <sup>3</sup> )
(14)	LO		
(15)	MID		
(16)	HI		
(17)*	-	Noise_duration_x	Noise duration (%)
(18)*	-	Noise_intensity_x	Average noise level (dB)

\* If there is no PM functionality, 17 & 18 becomes 11 & 12.

#### Conversion method

Quantity	Data in payload	Conversion
Content	-	Content = bit field corresponding to quantities contained in payload
T	T_x	$T = (T\_x / 100) - 100$
RH	RH_x	$RH = RH\_x / 2.5$
p	p_x	$p = (p\_x / 100) + 800$
VOC_index	VOC_x	$VOC\_index = VOC\_x$
Ambient_light	Ambient_light_x	$Ambient\_light = \exp(Ambient\_light\_x / 20) - 1$
CO <sub>2</sub>	CO2_x	$CO2 = CO2\_x$
PM10	PM_x	$PM10 = ((PM\_x \gg 12) \& 0x000FFF) / 4$
PM2.5	PM_x	$PM2.5 = (PM\_x \& 0x000FFF) / 4$
PM4	PM_y	$PM4 = ((PM\_y \gg 12) \& 0x000FFF) / 4$
PM1	PM_y	$PM1 = (PM\_y \& 0x000FFF) / 4$
Noise_duration	Noise_duration_x	$Noise\_duration = Noise\_duration\_x / 2$
Noise_intensity	Noise_intensity_x	$Noise\_intensity = (Noise\_intensity\_x / 5) + 25$

#### Example of payload

Payload in hexadecimal notation: 7f932f871046ab0265c80168f00768f0074d37

Division into individual values: 7f 932f 87 1046 ab02 65 c801 68f007 68f007 4d 37

Change in endianness: 7f 2f93 87 4610 02ab 65 01c8 07f068 07f068 4d 37

## Decoding payload

Content	Hexadecimal representation	Decimal representation	Conversion	Result
Content	0x1f	-	0x1f (hexa) = 0001 1111 (binary)	T, RH, p, VOC, CO <sub>2</sub> , Ambient_light, PM
T	0x2f93	12179	$T = 12179 / 100 - 100$	21,79 °C
RH	0x87	135	$RH = 135 / 2,5$	54 %
p	0x4610	17936	$p = 17936 / 100 + 800$	979,36 hPa
VOC_index	0x02off	683	VOC_index = 683	683
Ambient_light	0x65	101	$\exp(101 / 20) - 1$	155 lux
CO <sub>2</sub>	0x01c8	456	CO <sub>2</sub> = 456	456 ppm

Content	Hexadecimal representation	Shifting and masking	Result
PM10	0x07f068	$((0x07f068 \gg 12) \& 0x000fff) / 4 = 0x7f / 4 = 127 / 4 = 31,75$	31,75 µg/m <sup>3</sup>
PM2.5	0x07f068	$(0x07f068 \& 0x000fff) / 4 = 0x68 / 4 = 104 / 4 = 26$	26 µg/m <sup>3</sup>
PM4	0x07f068	$((0x07f068 \gg 12) \& 0x000fff) / 4 = 0x7f / 4 = 127 / 4 = 31,75$	31,75 µg/m <sup>3</sup>
PM1	0x07f068	$(0x07f068 \& 0x000fff) / 4 = 0x68 / 4 = 104 / 4 = 26$	26 µg/m <sup>3</sup>

Content	Hexadecimal representation	Decimal representation	Conversion	Result
Noise_duration	0x4d	77	$77 / 2$	38,5 %
Noise_intensity	0x37	55	$55 / 5 + 25$	36 dB

## Payload – downlink

## Setting sending period

Downlink payload type 1 contains 2 bytes and is used to set the LoRaWAN messaging period. The first byte indicates a payload number (must always be 0x01), and the second byte indicates new period of messaging in minutes. Valid range is 1-180 minutes.

## Setting noise detection threshold

Downlink payload type 2 contains 2 bytes and is used to set the noise detection threshold. The first byte indicates a payload type number (must always be 0x02), and the second byte indicates a new value for the noise detection threshold in dB. Valid range is 25-70 dB.

## Payload examples

Request	Hex downlink payload
Setting uplink period 5 minutes	01 05
Setting uplink period 10 minutes	01 0A
Setting noise detection threshold 40 dB	02 28

## 8.6 Modbus RTU slave and Modbus TCP server

Some versions of the sensors include interface for communication using Modbus RTU protocol over RS485 communication bus. Transmission parameters (address, speed, parity, ...) are set via webpage (see below).

All sensors have the option to enable Modbus TCP (via WiFi) in the settings. The default port for communication is 502 and can be changed in the settings. The Modbus TCP server supports only one active incoming TCP connection.

All measured values and information from the sensor (input registers) are transmitted as 32-bit float numbers (single precision according to IEEE 754). Each data occupies two Modbus registers. Holding registers for sensor settings contain 16bit numbers by default.

### Settings for Modbus RTU slave

ITEM NAME	Description
<b>ON/OFF</b>	Switching data Modbus RTU transfer on and off
<b>Modbus device address</b> <b>Modbus baud rate</b> <b>Modbus parity</b> <b>Modbus stopbits</b>	Setting Modbus RTU communication parameters.

### Example of settings

#### Modbus RTU

☒ ON/OFF

Modbus device address

Modbus baud rate

Modbus parity

Modbus stopbits

### Settings for Modbus TCP server

ITEM NAME	Description
<b>ON/OFF</b>	Switching data Modbus TCP transfer on and off . It makes sense to activate the transfer only when connected via WiFi (AP and Station mode).
<b>Modbus TCP port</b>	Set Modbus TCP server port parameters.

### Example of settings

**Modbus TCP**

☒ ON/OFF

Modbus TCP port

502

### List of input registers

The table below shows the list of input registers used. Space in the address space leaves space for possible future extensions for measured values. Missing registers can be read (so you can read the entire input block of registers at once), but the values in them are not defined. The values are always in two consecutive registers (4 bytes in total) and are float 32 bits data type (single precision according to IEEE 754).

If a measured quantity is not yet initialized, the float value in the float registry is a NaN value.

Register	Meaning	Units	Datatype
0	Temperature	°C	float (32bit)
6	Relative humidity	%	float (32bit)
8	Dew point	°C	float (32bit)
10	Absolute humidity	g/m <sup>3</sup>	float (32bit)
18	CO <sub>2</sub>	ppm	float (32bit)
26	VOC index (0-500)	-	float (32bit)
28	VOC accuracy (0-3)	-	float (32bit)
34	VOC equivalent CO <sub>2</sub>	ppm	float (32bit)
42	Ambient illuminance	lx	float (32bit)
60	PM10	µg/m <sup>3</sup>	float (32bit)
62	PM4	µg/m <sup>3</sup>	float (32bit)
64	PM2.5	µg/m <sup>3</sup>	float (32bit)
66	PM1	µg/m <sup>3</sup>	float (32bit)
76	Atmospheric pressure	hPa	float (32bit)
84	Time since the sensor is turned on	s	float (32bit)
100	Thermostat (set required temperature from LCD display)	°C	float (32bit)

### List of holding registers

The table below contains a list of the holding registers used. Values are integer 16 bits data type. Only the Modbus function Write single register (function number 06) can be used for writing holding registers. The multiplier column indicates a shift of the decimal point in the number. For example, a multiplier of

1/100 for temperature means that a temperature of 24.5 °C will be stored in the registry as 2450 integer, thus you need to multiply the number in the registry by 1/100 to get real value in °C.

Registry	Importance	Units	Form	Multiplier
5000	Adjust the LED intensity (manual mode only)	%	int (16bit)	1
5001	Digital output settings (logical 0/1)	-	int (16bit)	-
5020	Thermostat settings from the superior system	°C	int (16bit)	1/100

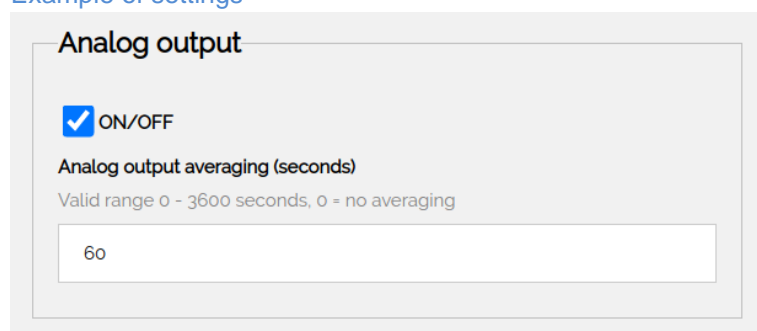
## 8.7 Analog output

The sensor contains current (0-20 mA) and voltage (0-10 V) analog output. A minimum of 12 V power supply is required for the correct operation of the analog output.

### Set up analog output

Item	Description
ON/OFF	Turns analog output on and off.
Analog output averaging	Sets averaging values for analog output in seconds. To switch off averaging, enter zero.

### Example of settings



### Analog output control

The analog output is controlled either according to the CO<sub>2</sub> value or according to the time schedule. Alternatively, combination of both can be used, the output always shows a higher value. The setting is done in Settings on the web page of sensor.

The entire form for setting analog output parameters is interactive and after each change you can see a preview of the control curve in chart. After you enter a new value, you have to always click outside the form or in another form window to see the changes.

To save the changes, you have to confirm clicking **Save** button.

### Quickly set up multiple sensors

The first large field in the analog output settings page is used to copy settings between sensors if you want to set multiple sensors in the same way. First set one sensor (see below) and then copy and paste the entire text in the box into another device. Then click outside the text box to see the new settings in the charts.

## Copy settings to/from another device

```
[{"value_co2":1,"x":500,"y":10}, {"x":1000,"y":40}, {"x":2000,"y":50}, {"x":3000,"y":80}], [{"time_hour":1,"x":0,"y":0}, {"x":6,"y":100}, {"x":7.75,"y":20}, {"x":9.6666666984558105,"y":80}, {"x":10,"y":20}, {"x":12.75,"y":0}]
```

## Set up a single sensor

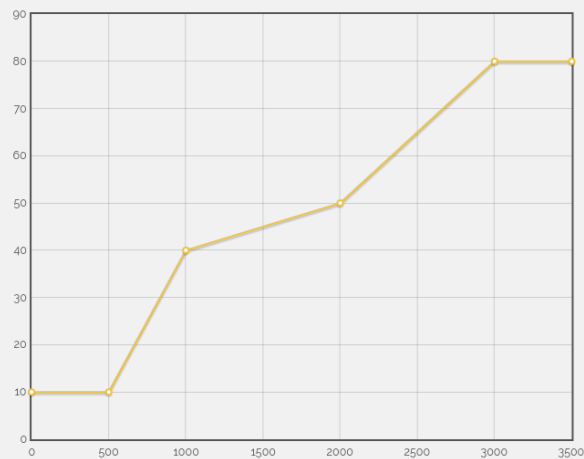
Analog output values are set as a percentage of the maximum output value. Therefore 100 % needs to be set for full output 10 V / 20 mA, 60 % for output 6 V / 12 mA, and 20 % for output 2 V / 4 mA etc. You can add or remove individual rows in a table. In total, you can set up to 50 values in each table. If you do not want to use one of the tables, it is possible to leave it either blank or leave only one row in it with the Output setting to 0%.

Control according to CO<sub>2</sub> values

The conversion characteristic (curve) from CO<sub>2</sub> value to analog output is set in table Control based on CO<sub>2</sub> value. The first Value (ppm) column is set to CO<sub>2</sub> levels, the second column Output (%) corresponds to the desired output levels. The transition in between the points is linear, as shown in the graph. For CO<sub>2</sub> values lower than the first row of the table and higher than the last row of the table, the analog output value is constant. Care should be taken to ensure that the first column of the table (CO<sub>2</sub> values) is constantly increasing. The output values can both increase and decrease with increasing CO<sub>2</sub> values.

Control based on CO<sub>2</sub> value

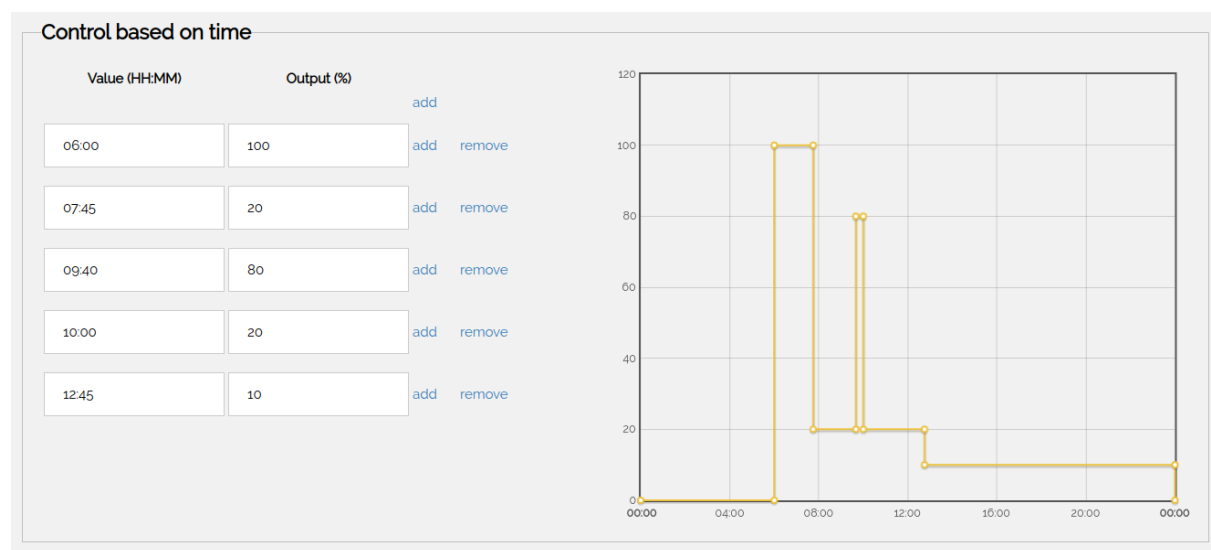
Value (ppm)	Output (%)		
500	10	add	remove
1000	40	add	remove
2000	50	add	remove
3000	80	add	remove



## Time-based regulation

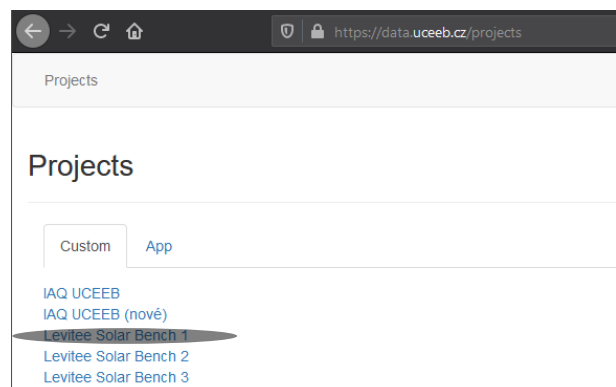
The Control based on timetable is used to set the time schedule. The values specified in the first Value (HH:MM) column are indicating start of the interval at which the corresponding output value is set, as specified in the second Output (%) column. The output value is constant until the beginning of the next interval or until midnight that day. Every day at midnight, the output is always set to 0%. You can track this property in an interactive chart.





## 9 Account in UCEEB database

For long-term monitoring of data, it is possible to use the MQTT sensor configuration to send data to the UCEEB MQTT server. CTU UCEEB provides this service at [data.uceeb.cz](https://data.uceeb.cz). After you open an account, you will receive instructions to set password on the registered email. After logging into the web server interface, select your project from the list on the left.



You will then see your data in the following graphical form, where the selected time period can be viewed, or the data downloaded in the preferred format.



## Notes