URBAN AIR QUALITY MONITORING STATION

DATASHEET

Document Release Information

Persons in Charge		Document Information	
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EXECUTIVE SUMMARY

The Urban Air Quality Monitoring Station is a hardware solution that empowers cities sense accurate data for the air quality in the different parts of the city. It features a modular design, utilizing advanced sensor technologies that measure particulate matter and gas volumes for key air quality indicators, as defined by the European Environment Agency's (EEA) and the US Environmental Protection Agency's (EPA) directives.

The Station can measure both low gas concentrations (in ppb, used for environmental sensing), and high gas concentrations (in ppm, used for industrial sensing). The Station comes with a unique climatization feature: its gas sensors are mounted in a specialized, actively climatized Air Quality Sensors Enclosure Box that ensures consistent sensor measurements by actively compensating for negative temperature deviations (e.g. low ambient temperature during winter).

The following is the complete list of available measurement sensors:

- Nitrogen Dioxide (NO_2)
- Ozone (O_3)
- Carbon Monoxide (CO)
- Sulfur Dioxide (SO_2)
- Hydrogen Sulfide (H_2S)
- Ammonia (NH_3)
- Phosphine (PH_3)
- Chlorine (Cl_2)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Oxygen (O_2)
- Formaldehyde (CH_2O)
- Ethylene (C_2H_4)
- Benzene (C_6H_6)
- Hydrogen (H_2)
- Particulate Matter (PM10 and PM2.5)
- Temperature, Humidity, Pressure
- Noise Level
- Wind Speed
- Wind Directions
- Solar (UV) Radiation

The Station's modular design allows for different sensor configurations, upgrades, and add-ons. Developed with practicality in mind, the Station is easy to install, maintain, and support. Even when the city power grid fails, two standalone power sources ensure the Station's completely autonomous operation. The autonomy is further enhanced by the software's ability for remote configuration and hardware reset. Sensed data can be integrated effortlessly into multiple platforms using standard protocols. This complete solution is housed in an industrial-grade body, able to withstand all weather conditions.

For optimal results, a network of stations can be deployed at multiple locations around the city, reporting the air quality indicators in real-time. The network effect is crucial for developing a thorough understanding of the pollution generators in urban areas. By utilizing real-time machine learning, the network can track the movement of dust and gas clouds, thereby helping cities understand air flow phenomenon and patterns. Aggregated sensor data can be converted into an easily comprehendible air quality index, an easy to understand number outlining the air quality in the specific areas. The general purpose is to provide the city with the data needed to help identify measures to improve air quality and life standards for all city occupants accordingly.

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SPECIFICATION

General Data

Main Microcontroller

- Model: ESP32 & STM32 series embedded;
- Flash: 128 kB;
- SRAM: 64 kB;
- Operational temp range: -30 ~ +60°C;
- Clock: RTC 32 kHz;
- Wireless Connectivity Options: LoRaWAN / NBIoT / 2G / 5G;
- Wireless Connectivity Option for on-site update: WiFi;
- GPS module: latitude, longitude, altitude, speed, direction, date/time.

Inputs/Outputs

- UART; USB; SPI; I2C (up to 127 addressable end points/sensors).

Electrical Data

- Main battery (UPS): 12 VDC 12 Ah;
- Secondary battery: 4 000 mAh;
- Power Grid electrical connectivity: 110/220 VAC;
- Solar panel charging - 15 W.

Secondary (Autonomous) Microcontroller

- Model: STM32L0;
- Inputs/outputs: 2 digitals (I/O);
- Built-in temperature sensor;
- Electrical data: battery voltage 3 VDC;
- Autonomous/operational time: up to 60 000 messages;
- Wireless Connectivity Options: LoRaWAN / NBIoT

Certifications:

- CE (Europe) (undergoing).

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Mechanics

Main Box

- Metal, robust, water proof in accordance with IP65;

Dimensions

- Main body: 400/300/150 mm;
- Minimum required space for installation on mast: 730/300/300 mm.

Installation

- Fast deployment – equipped with special holders designed for outdoor installations – street lights, masts, building fronts, etc.

Sensors

List of Available Sensors:

- Low concentration gas detection and monitoring sensors (environmental sensors, in ppb) – CO, NO_2, SO_2, O_3, H_2S;
- High concentration gas detection and monitoring sensors (industrial sensors, in ppm) – CO, NO_2, SO_2, O_3, NH_3, H_2S, PH_3, CL_2, HCL, HF, O_2, CH_2O, C_2H_4, C_6H_6, H_2, etc.;
- Particulate matter – PM2.5, PM10;
- Temperature, humidity, pressure;
- Noise Level;
- Solar Radiation / UV Index;
- Wind speed;
- Wind direction.

Technical Details of the Sensors

- High sensitivity and resolution;
- Low energy consumption;
- Communication interface (UART) and analog output.

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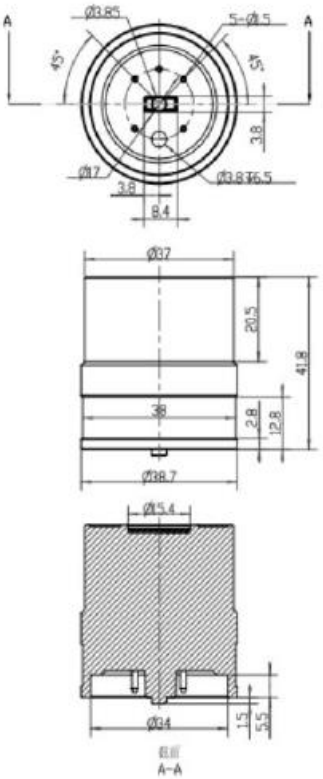
Technical Data: Low concentration gas detection and monitoring sensors (environmental sensors, in ppb)



Technical data for low concentration NO_2 sensor

Parameters	Values/Data
Target gas	NO_2
Working voltage	DC 5V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -20 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 39 mm x 42 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 2 ppm
Resolution	< 10 ppb
Response time	< 30 sec
Output graph	Linear
Deviation from zero (-20℃ ~ 50°C)	≤5 ppb

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Technical data for low concentration CO sensor

Parameters	Values/Data
Target gas	CO
Working voltage	DC 5V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -20 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 39 mm x 42 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 12.5 ppm
Resolution	< 10 ppb
Response time	< 30 sec
Output graph	Linear
Deviation from zero (-20°C ~ 50°C)	≤5 ppb

Technical data for low concentration SO_2 sensor

Parameters	Values/Data
Target gas	SO_2
Working voltage	DC 5V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -20 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 39 mm x 42 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 2 ppm
Resolution	< 10 ppb
Response time	< 30 sec
Output graph	Linear
Deviation from zero (-20°C ~ 50°C)	≤5 ppb

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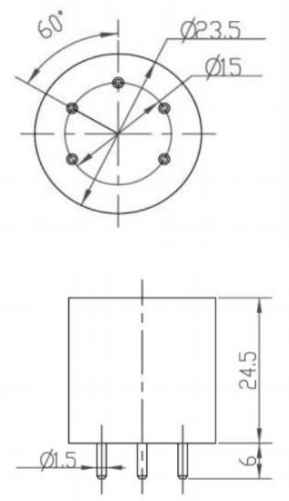
Technical data for low concentration O_3 sensor

Parameters	Values/Data
Target gas	O_3
Working voltage	DC 5V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -20 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 39 mm x 42 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 2 ppm
Resolution	< 10 ppb
Response time	< 30 sec
Output graph	Linear
Deviation from zero (-20°C ~ 50°C)	≤5 ppb

Technical Data: High concentration gas detection and monitoring sensors (industrial sensors, in ppm)



Technical data for high concentration NO_2 Sensor

Parameters	Values/Data
Target gas	NO_2
Working voltage	DC 4 ~ 9V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -30 ~ +50°C

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	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 23.5 mm x 24.5 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 20 ppm
Resolution	0.1 ppm
Response time	< 30 sec
Output graph	Linear
Deviation from zero (-20°C ~ 50°C)	0.2 ppm

Technical data for high concentration CO Sensor

Parameters	Values/Data
Target gas	CO
Working voltage	DC 4 ~ 9V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -30 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 23.5 mm x 24.5 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 1000 ppm
Resolution	0.5 ppm
Response time	< 25 sec
Output graph	Linear
Deviation from zero (-20°C ~ 40°C)	9 ppm

Technical data for high concentration SO_2 Sensor

Parameters	Values/Data
Target gas	SO_2
Working voltage	DC 4 ~ 9V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -30 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 23.5 mm x 24.5 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)

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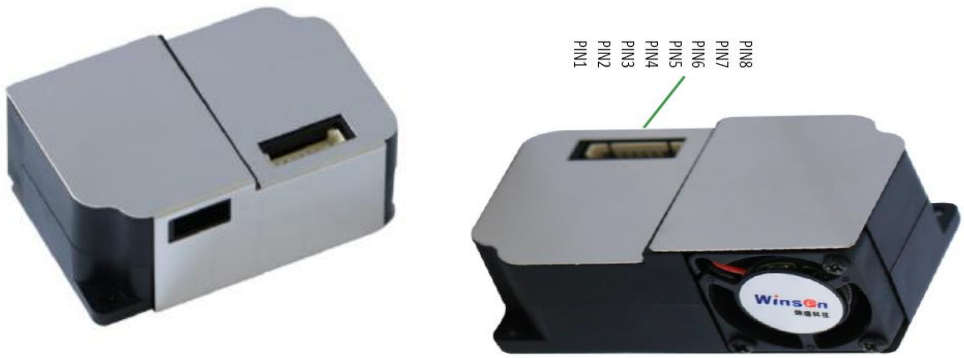
Detection range	0 ~ 20 ppm
Resolution	0.1 ppm
Response time	< 3 sec
Output graph	Linear
Deviation from zero (-20°C ~ 40°C)	0.2 ppm

Technical data for high concentration O_3 Sensor

Parameters	Values/Data
Target gas	O_3
Working voltage	DC 4 ~ 9V
Current (consumption)	< 5 mA
Output data	UART (TTL, voltage level – up to 3 V)
	Analogue output
Operating environment	Temperature: -30 ~ +50°C
	Humidity: 15% RH – 90% RH (no condensation)
Size	Ø 23.5 mm x 24.5 mm
Working pressure	Standard ±10%
Lifespan	24 months (in air)
	12 months (in use)
Detection range	0 ~ 18 ppm
Resolution	0.02 ppm
Response time	< 60 sec
Output graph	Linear

Technical Data: Particulate Matter (PM2.5, PM10) Sensor

The laser dust sensor module is a common type, small size sensor, using a laser scattering principle to detect the dust particles in the air, with good selectivity and stability. Contains serial port and PWM outputs.



Parameters	Values/Data
Detection particles	PM2.5, PM10
Detection Range	0 ~ 1000 μg/m^3

Response time	< 45 sec
Operating environment	Temperature: -10°C ~ +50°C
	Humidity: ≤85% RH (no condensation)
	86 KPa ~ 110 KPa

Technical Data: Sensor for Temperature, Humidity and Pressure

Parameters	Values/Data
Digital interface	I2C and SPI
Power supply	V_{DD} main supply voltage: 1.71 ~ 3.6 V;
	V_{DDIO} interface voltage range: 1.2 ~ 3.6 V;
Current consumption	1.8 µA @ 1 Hz, humidity and temperature;
	2.8 µA @ 1 Hz, pressure and temperature;
	3.6 µA @ 1 Hz, humidity, pressure and temperature;
	0.1 µA in sleep mode;
Operating range	-40°C ~ +85°C
	0 ~ 100% rel. humidity
	300 ~ 1100 hPa
Response time ($\tau_{63\,\%}$)	1 sec
Accuracy tolerance	± 3% relative humidity
Hysteresis	± 1% relative humidity
RMS noise	0.2 Pa, equiv. to 1,7 cm
Offset temperature coefficient	± 1.5 Pa/K, equiv. to ±12.6 cm at 1°C temperature range

- Humidity sensor and pressure sensor can be independently enabled/disabled;
- RoHS compliant, halogen-free, MSL1.

Technical Data: Noise Level Sensor

Noise pollution, also known as environmental noise or sound pollution, is the propagation of noise with harmful impact on the activity of human or animal life. The source of outdoor noise worldwide is mainly caused by machines, transport, and propagation systems. The World Health Organization guidelines for night noise recommend less than 40 dB(A) of annual average (Lnight) to prevent adverse health effects from night noise.

Parameters	Values/Data
Operating Range	30 dB ~ 120 dB
Frequency Range	20 Hz ~ 12.5 kHz
Resolution	0.1 dB
Accuracy	±0.5 dB (94dB @ 1 kHz)
Response time	< 3 sec

Technical Data: Solar Radiation / UV Index Sensor

The UV Index is a number linearly related to the intensity of sunlight reaching the earth and is weighted according to the CIE Erythemal Action Spectrum. The UV Index has been standardized by the World Health Organization and includes a simplified consumer UV exposure level. Index reported by the sensor: from 1 (low level) to 11+ (extreme).

Parameters	Values/Data
Detection range (wavelength, nm)	UV-B; UV-A; (280 nm ~ 400 nm)
Detection range (UV Index)	1 ~ 11+
Operating environment	Temperature: -40°C ~ +85°C
	Humidity: ≤100% RH

Technical Data: Wind Speed Sensor

Wind speed sensor adopts the traditional three-wind cup wind speed sensor's structure. The wind cup is produced of ABS material with very high strength. The wind speed detection starts from very low air masses movement. The sensor's built-in signal processing unit can output the corresponding wind speed signal according to the user's requirements.

Parameters	Values/Data
Detection range	0 ~ 45 m/s
Resolution	0.1 m/s
Accuracy	< 0.5 m/s
Minimum detection range	< 0.5 m/s
IP Rating	IP54
Operating environment	Temperature: -20°C ~ +60°C
	Humidity: ≤100% RH

Technical Data: Wind Direction Sensor

The wind direction sensor uses a precise internal angle sensor and low inertia ABS vane response for wind direction.

Parameters	Values/Data
Detection range	0 ~ 359°
Resolution	1°
Accuracy	±3°
IP Rating	IP54
Operating environment	Temperature: -20°C ~ +60°C
	Humidity: ≤100% RH

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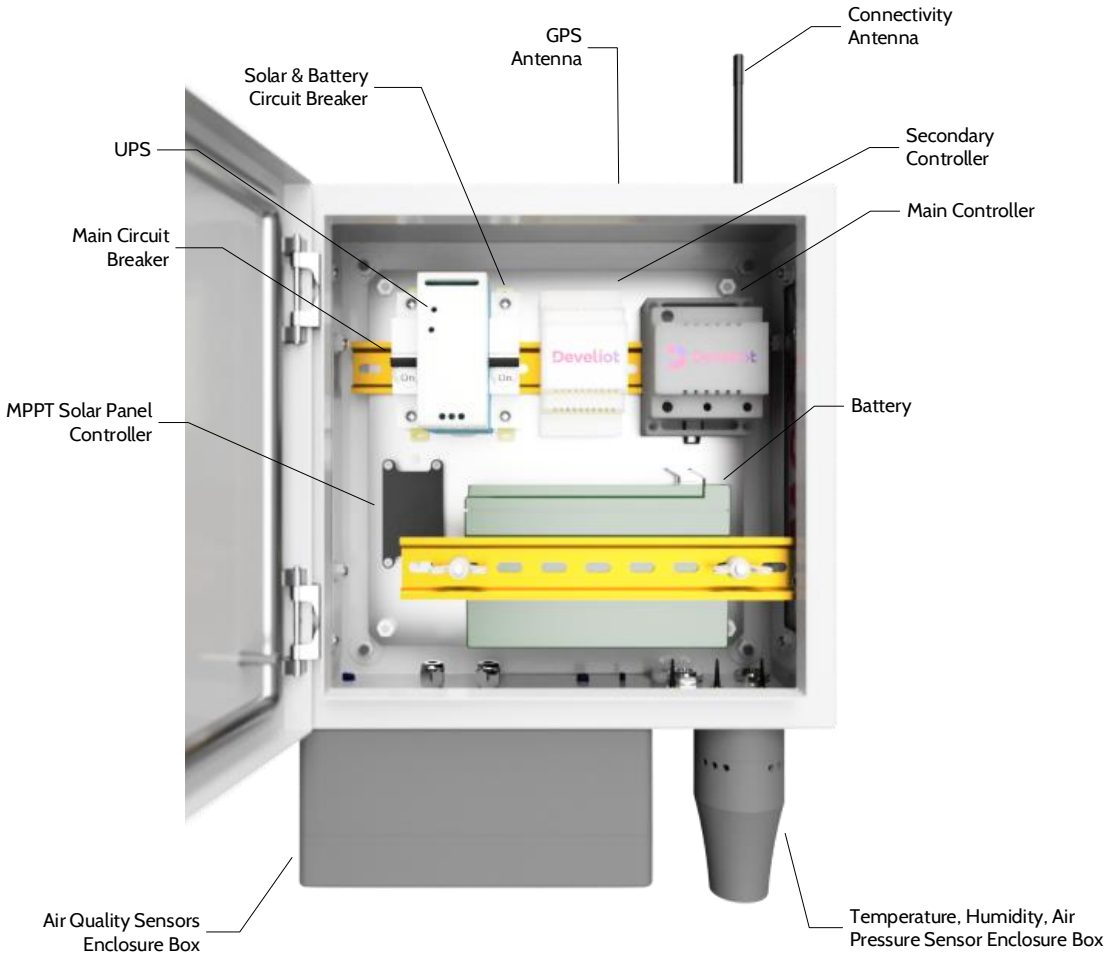
URBAN AIR QUALITY MONITORING STATION MAIN COMPONENTS

Key advantage of the Station is its modularity. Due to this approach the ease of support, upgrade, and installation of additional sensors are "standard" features.

The basic version of the Station consists of the following components:

Main box

A metal, robust, water proof IP65 box is shielding the following components: Main Controller, Secondary Controller, Power Grid Connection, Two Parallel Power Modules, Main Battery, Secondary Battery.



Additional information for the components is provided below:

Main Controller

- Runs on ESP32 and STM32 series 32bit high performance and energy efficient CPUs;

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- The communication module uses any of the following communication standards: LoRaWAN, NBIoT, 2G, 5G;
- The Main Controller embeds its own Li-Ion back-up battery;
- The Main Controller monitors various parameters related to the health status of the Station, such as temperature, battery capacity, etc. All parameters are regularly sent to the connected (cloud) platform or database;
- The Main Controller receives the values (measurements) from all sensors of the Station and transmits them wirelessly to the central platform or database. This includes:
    - GPS coordinates – altitude, latitude, longitude;
    - Date and time for synchronization and statistics;
    - Gas readings/values;
    - Temperature, humidity, pressure;
- The Main Controller has multiple communication interfaces, including I2C (which addresses up to 127 end nodes - each node can have one or many sensors in itself). USB and UART;
- Measurement interval: Once per minute. Good practice is to send measurements every 5 to 10 minutes.

Secondary Controller

- Fully autonomous and independent as it has no connectivity with the Main Controller and its operational status;
- The goal of the Secondary Controller is to independently monitor and send data concerning the health status of the Station;
- The controller has its own temperature sensor to monitor the health of the station;
- The most important function of the Secondary Controller is the ability for remote restart of the Station, if necessary.
- The Secondary Controller has its own power supply that in fully autonomous regime is capable of sending up to 60 000 messages (depending on the environmental conditions);
- For redundancy the wireless communication of the Secondary Controller is organized via independent transmission technology in comparison to the transmission technology used by the Main Controller. The Secondary Controller provides option to use either LoRaWAN or NBIoT.

Power Supply Module

- The Power Supply Module uses different sources of power that on one hand, supplies the electronics, and on the other - charges the batteries;
- The primary energy source is the solar panel. In case the capacity of the main battery falls under 80%, the module connects to the power grid (110/220 VAC). If this source of energy is also unavailable, the Station continues to operate until its internal battery reaches 50% of the capacity. Below this level, the Station shuts down to preserve the battery from damages;
- The Station embeds a high capacity battery, similar to the one used in majority of UPSs – 12 VDC / 12 Ah. Such capacity allows Station to operate for long periods of time in a fully autonomous regime. While configured to send data once per hour, the Station would be operational for:
    - 7 (seven) days, in case of average daily temperature around 20°C;

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- 2 (two) days, in case of active use of the climatization system.

Solar Panel

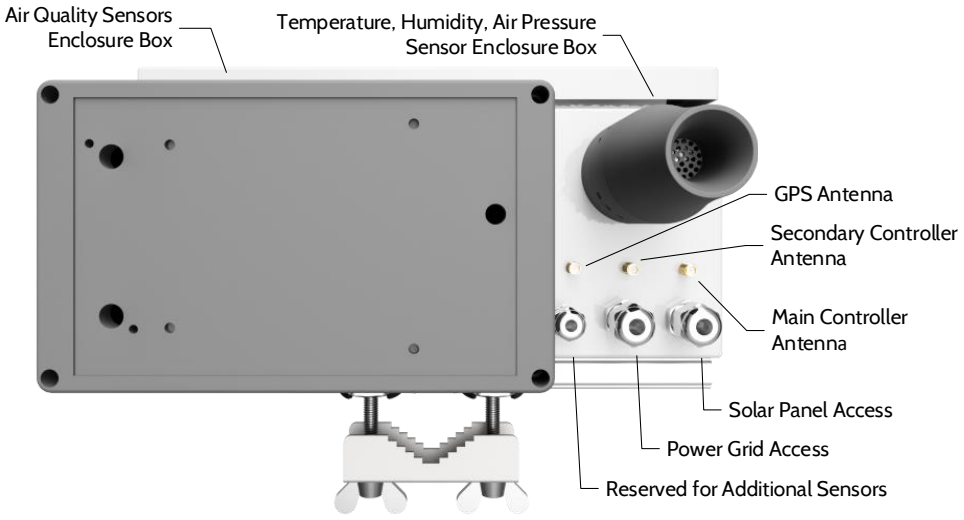
The Urban Air Quality Monitoring Station uses a renewable source of energy (a solar panel) as in most of the cases the sites where the Stations will be installed lack access to power-grid or power-grid access is available only during the night.

This feature also empowers for fast and easy displacement of the Station.

Air Quality Sensors Enclosure Box

The Sensors Enclosure Box protects the gas sensors (4 x low concentration, 4 x high concentration) and the particulate matter sensor.

The Station comes with a unique climatization feature: its gas sensors are mounted in a specialized, actively climatized Air Quality Sensors Enclosure Box that ensures consistent sensor measurements by actively compensating for negative temperature deviations (e.g. low ambient temperature during winter). The Main Controller constantly monitors the ambient temperature inside and outside the enclosure box and controls the intensity of a specially designed heater that guarantees optimal working temperature of the gas sensors and the passing air. This feature is predominantly used in cases of low temperatures and cold weather.



The design of the protective shield permits fast and easy access to the sensors. All sensors are mounted on sockets, which permit immediate access for servicing, support or sensor changing after their exploitation life is over. This operation could be executed by a technician without a risk of incorrect mounting.

The Air Quality Sensors Enclosure Box is designed specifically to assure constant air flow through the sensors and is protected against insects and particles above 500µm.

Temperature, Humidity, Air Pressure Sensor Enclosure Box

The Temperature, Humidity, Air Pressure Sensor (THAP Sensor) is situated in a separate enclosure box in order to avoid any interference by the heating of the Air Quality Sensors Enclosure

Box. In this way, the THAP Sensor is exposed to the effects of natural convection to assure consistent sensor readings of the ambient environment. The enclosure design ensures ease of access, maintenance, support, and sensor replacement.

Additional Sensor Modules

The Station can be equipped with additional sensors for noise level monitoring, wind speed, wind direction, and solar (UV) radiation. These sensors enable the end users to gain an even broader understanding of the pollutant sources in a city, to map the distribution of the pollutants, and to forecast expected pollution levels with more accuracy.

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