# uRADMonitor-A3

ADVANCED AIR QUALITY MONITORING STATION

Congratulations on purchasing this excellent environmental monitor! You are now part of an ambitious global effort named uRADMonitor. Some information to help you get started is provided in this manual and more is available online on http://www.uradmonitor.com , both on the Blog and the Forums.

## Summary

## The uRADMonitor network

The uRADMonitor project is a global array of network connected monitoring stations, focused on continuous Environmental Surveillance. Its purpose is to generate fully transparent open data, used to assert the quality of our environment and the impact of various pollutants on human health.

## uRADMonitor A3

uRADMonitor A3 is an automated, fixed monitoring station that tracks a total of 8 important air quality parameters. It comes in a compact, rugged aluminum enclosure with wall mounting support. The data is exported to the uRADMonitor network and can be accessed in real time using the cloud API interface or directly via the local network.

## Connectivity

There are 4 A3 variants, with the same sensors, but different connectivity options, one on cable using Ethernet and three wireless solutions including WLAN, GSM (Cellular) and the new LoRaWAN. The WLAN variant has built in antenna, while the GSM and the LoRaWAN have a SMA connector for an external antenna.
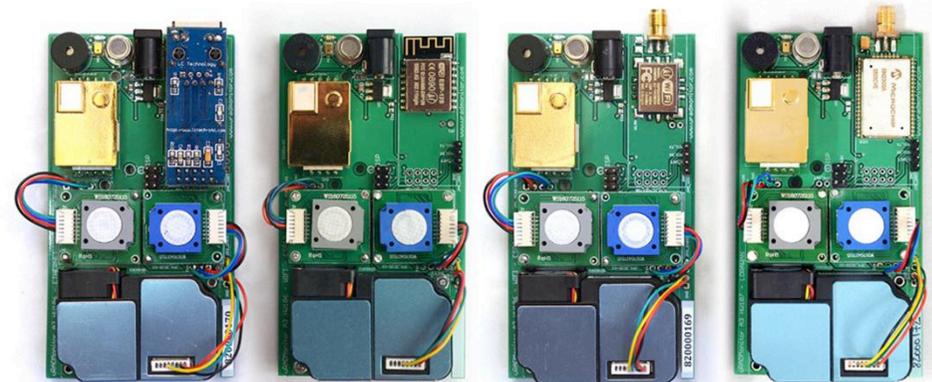


Picture 1: wired / wireless data connectivity options

Using the 4 available connectivity options and the low power consumption this device can be deployed for a large variety of field applications. Its versatility is combined with a convenient cloud based data access with an API interface to access the measurements directly from the uRADMonitor cloud.

## Sensors

uRADMonitor model A3 uses the Bosch BME280 sensor to measure air temperature, barometric pressure and humidity. A MOX VOC sensor measures volatile organic compounds. A high quality laser scattering sensor is used to detect the Particulate Matter PM1, PM2.5 and PM10 concentration in air. There are two electrochemical sensors, one for formaldehyde and another one for ozone and a non-dispersive infrared sensor for $CO_2$. A built in fan assures an active air flow stream across the sensing elements. There is also a noise level sensor since iteration v105.

| SENSOR | PARAMETER | MIN | MAX | RESOLUTION | ACCURACY | INTERVAL[1] | LIFE[2] |
|---|---|---|---|---|---|---|---|
| Bosch BME280 | Temperature | -40 °C | +85 °C | 0.5 °C | ± 1°C | -40..+100°C | 5 yrs |
| | Pressure | 300 hPa | 1100 hPa | 1 Pa | ± 0.25% | -40..+100°C | |
| | Humidity | 0% RH | 100% RH | 1% RH | ± 3% | -40..+100°C | |
| ZH03A | PM1 | 0 µg/m³ | 1000 µg/m³ | 1 µg/m³ | ±15% | -40..+100°C | 5 yrs |
| | PM2.5 | 0 µg/m³ | 1000 µg/m³ | 1 µg/m³ | ±15% | -40..+100°C | |
| | PM10 | 0 µg/m³ | 1000 µg/m³ | 1 µg/m³ | ±15% | -40..+100°C | |
| ZE08-CH2O | Formaldehyde | 0 ppm | 5 ppm | 10 ppb | ± 5% | 0..+50°C | 2 yrs |
| ZE25-O3 | Ozone | 0 ppm | 10 ppm | 10 ppb | ± % | -10..+55°C | 2 yrs |
| MH-Z19B | Carbon Dioxide | 400 ppm | 5000 ppm | 1 ppm | ± 5% | 0..+50°C | 5 yrs |
| MP503 | VOCs | 10 ppm[5] | 1000 ppm[3] | - | ± 15% | -40..+100°C | 2 yrs |
| SPU414 MAX4466 | Noise level | 30 dB | 130 dB | 1 dB | ± 10% | -40..+100°C | 2 yrs |

[1] Using the sensor outside the recommended temperature interval can shorten its lifespan
[2] Estimated for normal usage conditions. Device maintenance is recommended after the shortest sensor lifespan interval (2 years).
[3] Estimated for alcohol.
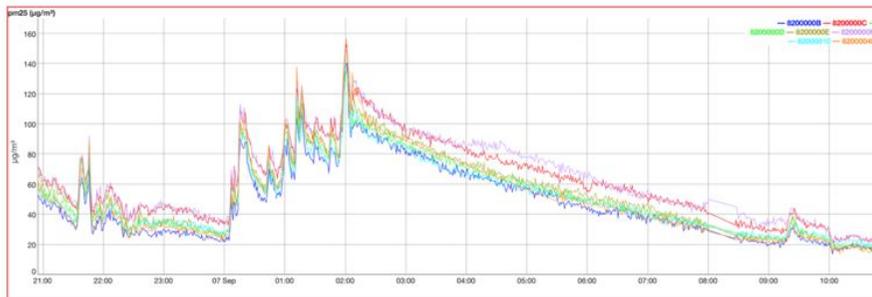


Picture 2: uRADMonitor units on the test bench

## Dosimeter vs. Monitor

Automated monitoring provides more options over using handheld units occasionally. Mapping data trends becomes possible thanks to continuous surveillance and a permanent data flux. We have a higher detection capability for small variations and can trigger automated  alarms if predefined thresholds are reached, improving reaction time while lowering costs.

## Health impact



Picture 3: uRADMonitor fights pollution to improve our health

The purpose of the model A3 detector and of the entire uRADMonitor network is to monitor chemical and physical factors that can have a negative impact on our health or on the environment. Using its advanced sensors, the model A3 monitors against the following potentially hazardous parameters:

**VOC or volatile organic compounds** are a class of substances that evaporate at room temperature. Being different substances may be responsible for a broad category of disorders, including respiratory problems, allergic or weakening immunity in children. Some VOC 's are responsible for the formation of smog, irritation of eyes, nose and throat, headaches and concentration problems. In extreme circumstances, more severe complications can occur, such as damage to liver, kidney and central nervous system or cancer [1]

**Particulate matter PM2.5** refers to small particles with a diameter of up to 2.5 microns. These particles can penetrate deep into the lungs , causing allergies, respiratory and cardiovascular diseases [2]

**Formaldehyde** is a toxic colorless gas with a pungent smell, that results from the burning of carbon based materials. It can be found in forest fires, in automobile exhaust and cigarette smoke. It is an allergenic and a known carcinogenic compound that can cause serious health effects, depending on concentration and exposure. Even in tiny quantities just above 0.1ppm it can irritate the eyes and nose, and can worsen asthma symptoms [3]

**Carbon dioxide** is a gas heavier than air. In small quantities of up to 5000ppm (0.5% ) can cause headaches, lethargy, slowing of intellectual ability, irritability, sleep disturbance. In larger quantities can cause dizziness, loss of sight, hearing or knowledge. The fresh air contains between 360ppm and 410 ppm of CO2 [4]

**Ozone** can cause the muscles in the airways to constrict, trapping air in the alveoli. This leads to wheezing and shortness of breath. Long-term exposure to ozone is linked to aggravation of asthma, and can cause asthma development. Long-term exposures to higher concentrations of ozone may also be linked to permanent lung damage, such as abnormal lung development in children. [5]

**Noise** Induced Hearing Loss (NIHL) is the most common and often discussed health effect, but research has shown that exposure to constant or high levels of noise can cause countless adverse health affects. [6]

[1] Volatile Organic Compounds' Impact on Indoor Air Quality, US Environmental Protection Agency
[2] Health and Environmental Effects of Particulate Matter (PM), US Environmental Protection Agency
[3] ToxFAQs™ for Formaldehyde, Agency for Toxic Substances and Disease Registry
[4] Health Risk Evaluation for Carbon Dioxide, US Bureau of land management
[5] Health Effects of Ozone Pollution, US Environmental Protection Agency
[6] Noise Pollution, US Environmental Protection Agency

## Product features
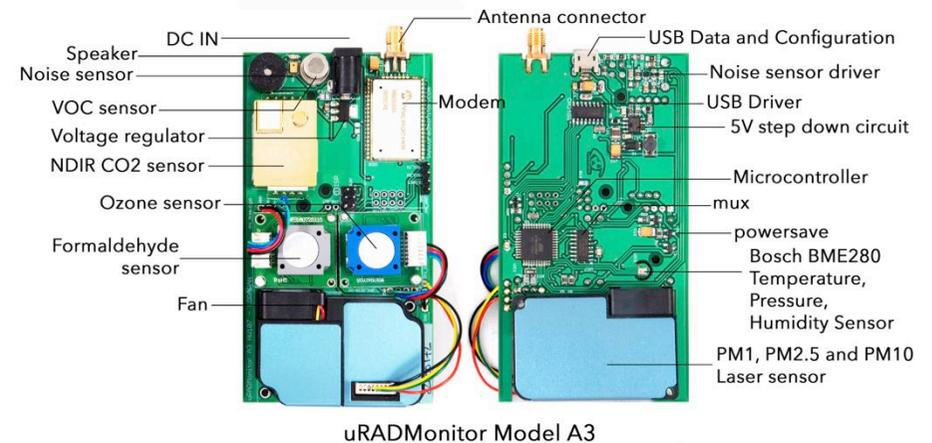


Picture 4: uRADMonitor A3 motherboard front and bottom view

| Parameter | uRADMonitor A3.LAN | uRADMonitor A3.Wifi | uRADMonitor A3.GSM | uRADMonitor A3.LoRaWAN |
|---|---|---|---|---|
| Internet connection | Ethernet RJ45 10/100/1000 Base-T Networks | Wifi 2.4GHz | Cellular GPRS over GSM GPRS multi-slot class 10/12 | Compliant with multiple international LoRaWAN bands |
| Wireless frequencies | n/a | 2400-2483.5MHz | 850MHz/900MHz/ 1800MHz/1900MHz | IN865, EU868, US915, AU915, IL915, KR920, AS923 |
| Modem Chip | Microchip enc28j60 | Espressif ESP8266 | SIMCom SIM800L | Microchip RN2482 / RN2903 |
| Antenna connector | n/a | SMA male | SMA female | SMA female |
| Protection | IP30 | IP30 | IP30 | IP30 |
| Supply Voltage | 6 - 28 V | 6 - 28 V | 6 - 28 V | 6 - 28 V |
| Sizes | 110x65x25 mm (excl.sup) | 110x65x25 mm (excl. sup) | 110x65x25 mm (excl. sup) | 110x65x25 mm (excl. sup) |
| Weight | 175g | 170g | 170g | 170g |
| Mounting | mounting support provided | mounting support provided | mounting support provided | mounting support provided |
| Ratings | Temperature: -20°C to +65°C          Humidity: 0RH to 95RH | | | |
| Certifications | CE / ROHS 2017 | | | |

## Connecting and starting your A3

If you have a radio variant, connect the antenna first. If it is the wired variant, connect it to the Internet Router using the Ethernet cable. Next, connect the uRADMonitor to the power source using a DC adapter with voltage between 6V and 28V or with a 5V USB Adapter via the USB connector. Both options are ok.

- **The Ethernet variant**

Make sure the device is connected to the Internet router using the Ethernet cable. Use a longer cable if needed. The Internet router must have DHCP enabled. When powered, the uRADMonitor gets an IP automatically, via DHCP, and will show up on the map automatically.

- **The WIFI variant**

Use a smartphone or a computer with WLAN capabilities to connect to the local hotspot spawned by your A3 unit. The SSID is uRADMonitor-XX, where XX are the last two digits of the Device ID number. The key is the Device ID, in uppercase, as printed on the enclosure. Open 192.168.4.1 in your browser, and click the "WIFI" link to setup the Internet connection. Enter the SSID and key of your Internet Access Point. If the connection fails, you will see the status message, and three consecutive beeps will indicated the problem. You can configure it via USB too.

- **The LORAWAN variant**

Your device must be pre-provisioned with the LoraWAN credentials or configured via USB.

- **The GSM variant**

A data SIM card must be inserted in your A3 unit before it can connect over Internet. You can change the APN settings via USB.

Starting with hardware version HW106, the LoRaWAN, Wifi and GSM settings can be customized via the USB connection. See the USB commands section, page 13.

## The watchdog

When used as a monitoring station, it is likely that the unit will run unattended. There is a watchdog mechanism that automatically reboots the unit in case of any lockdown. This approach is a proven technique that allowed uRADMonitor units to operate unattended for long periods of time, while providing valuable automated measurements.

## Upgrading the firmware

Periodically we release new firmware versions. When such a software package becomes available, you have the option of upgrading your firmware manually. To write the new firmware you will need the following:

1. **usbAsp or compatible AVR programmer** configured for 3.3V with a 10to 6pin adapter. These are available on many online stores, including Ebay or Amazon. If you still can't find it, do a search for usbAsp or Avr Programmer. MacOS and Linux will recognise the device out of the box, for Windows install the driver on http://www.fischl.de/usbasp/
2. **the new firmware** compiled for each uRADMonitor unit that needs to be programmed. Contact us for this file.
3. **the toolchain**, used to read the firmware .hex file and send it over the programmer to download it into your unit, in this case avrdude, available on:
http://savannah.nongnu.org/forum/forum.php?forum_id=7719
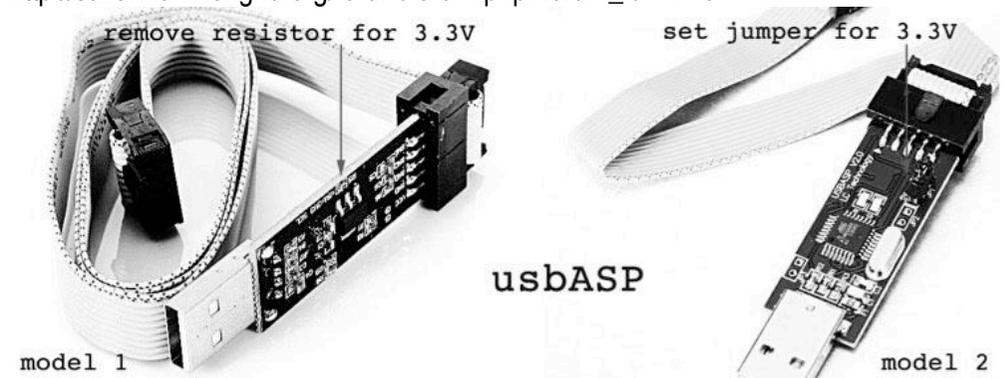


Picture 5: usbASP Programmer configured for 3.3V

To verify that your usbASP programmer is using the correct voltage, use a Multimeter to measure the voltage between the VCC and GND leads connecting to the flat wire cable. It should read at 3.3v. Using higher voltage will damage the uRADMonitor circuit.

Having the usbAsp AVR Programmer connected to your computer (on Windows you'll also need the driver) and the avrdude software installed, you are ready to go. Connect the programmer to the uRADMonitor PCB. GND must connect to PIN6 on the PCB. Make sure to match the header pins correctly.

When the connection is successful, you will hear the starting beep. Open a terminal and type the following command to configure the fuses for 8MHz and write the firmware:

*avrdude -p atmega1284p -c usbasp U lfuse:w:0xdc:m -U hfuse:w:0xd7:m -U efuse:w:0xFf:m -U lock:w:0xFF:m  -U flash:w:uradmonitor-A3-ID.hex:i*

If everything is properly configured, you will see a text-mode animation showing a progress indicator. Wait for the download to finish, it shouldn't take more than a few seconds.

The download shows a confirmation message when done. When complete, your unit will go online with the new firmware.

Alternatively, the firmware can be updated via USB if the bootloader is installed. Contact us for more help and details at support@uradmonitor.com or use the info available on the uRADMonitor Forums, www.uradmonitor.com/forum .

## The alarm

There's a built in alarm system and you can configure the threshold values in the Dashboard, on http://www.uradmonitor.com/dashboard . The device can also be muted if needed to prevent any beeps or alarms. See the USB configuration.
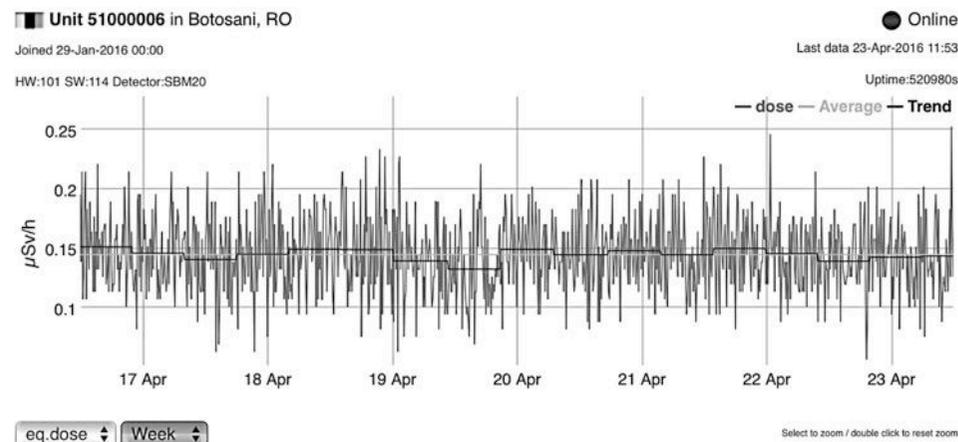


Picture 6: firmware update

## Accessing the data

You can access the data collected by your unit in multiple ways. You can see the readings online, on the uRADMonitor webpage, via:

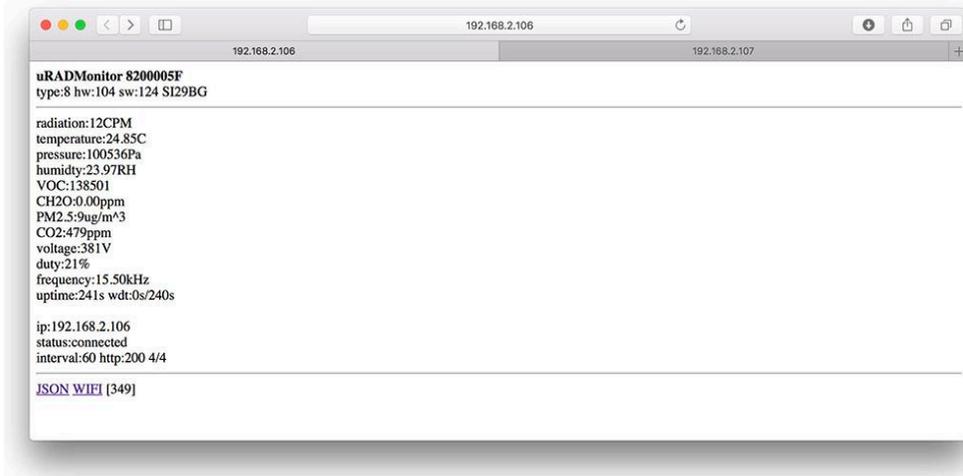http://www.uradmonitor.com/?open=ID

Where ID is your unit's ID (82XXXXXX), please replace accordingly.



Picture 7: data chart example

If you have a Ethernet or a Wifi A3, you can also access the unit directly, by opening its DHCP assigned LAN IP in your Internet browser:



Picture 8: direct access to A3 data via LAN

The JSON link can be used to read the data via various automated scripts. Here are a few examples developed by the community:
http://www.uradmonitor.com/weather-vs-radiation-readings/
http://www.uradmonitor.com/howto-upgrade-uradmonitor-graph-local-statistics/
http://www.uradmonitor.com/topic/new-firmware-enables-rrdtool-graphing/
http://www.uradmonitor.com/topic/include-uradmonitor-in-monitoring-software/
http://www.uradmonitor.com/topic/setup-local-graphs-for-your-uradmonitor/
http://www.uradmonitor.com/topic/uradmonitorx/

## uRADMonitor API
You can access the data using the uRADMonitor API. A complete description is available on http://www.uradmonitor.com/dashboard .

**Get devices list**
http://data.uradmonitor.com/api/v1/devices

**Get device sensors list**
http://data.uradmonitor.com/api/v1/devices/[ID]

**Get device data**
http://data.uradmonitor.com/api/v1/devices/[ID]/[sensor]/[interval]

**Method:** GET

**Authentification:** All calls must be authenticated with user-id and user-key sent in the headers section of the GET call as key-value pairs of the following format: X-User-id:[numeric id], X-User-hash:[hash]
**Response:** JSON formatted answer, containing error message in case of failure or the requested data.

## The mobile application
At the time of writing this article, there is a mobile application for Android OS, that can be used to access environmental data worldwide. Go on Google play and search for uRADMonitor to download your copy.
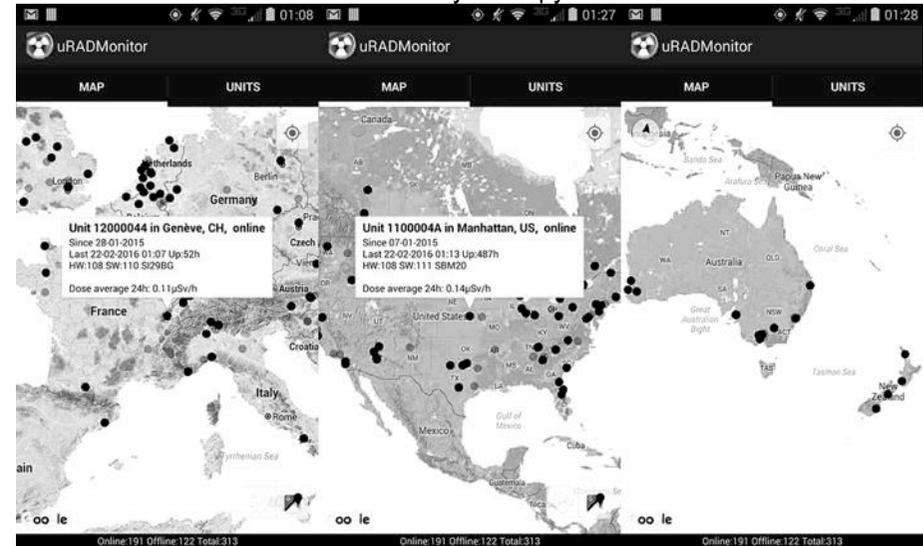


Picture 9: the mobile application

## USB Serial connection setup

Use a standard USB data cable to connect your computer to the uRADMonitor unit using its USB port:



Figure 10. The USB port is marked with a white label and is located below the round power jack

On your computer open the serial terminal software and set it to 9600bps. Select the appropriate serial port then open the connection. The device will display a greeting and will enter powersave mode, where the sensors, the communication module and the data transmission are all stopped.



Figure 11. Serial connection is established

Now the device is ready to take commands over the serial link.

## USB Configuration commands

The current firmware implements commands for configuration, debugging and data access. Each command must be issued between double quotation marks and any following parameters are separated by a comma. No spacing should be added between the elements in double quotation marks and the comma. This format was derived from machine to machine communication (server to device) and it is therefore rigid and inflexible in regards to any typos. However simple commands with no parameters can be send without the double quotation marks. First command you should start with is "help" (or simply just help):

- help , returns a brief list of the supported commands



Figure 12. Device response to the help command, showing the list of supported commands

The list of supported commands:

**setid**
Format: "setid","id"
Call example: "setid","14000045"
*Description*: changes the devide ID to the new specified ID. This command is restricted and cannot be used in normal operation.

**encrypt**
Format: "encrypt","1|0"
Call example: "encrypt","1"
*Description:* toggles the payload encryption on (1) or off (0). If the device talks to the uRADMonitor data server the payload must be encrypted (default option). Instead if you want to access the payloads via a proprietary LoRaWAN Network Server, you need to disable encryption.

**sendint**
Format: "sendint","interval"
Call example: "sendint","300"
*Description:* sets the data reporting frequency, in seconds. By default, Ethernet, Wifi and GSM units report the measurements every minute, while LoRaWAN units send every 5minutes.

**morse**
Format: "morse","message"
Call example: "morse","alert"
*Description:* uses the internal speaker to transmit the message as audible morse encoded.

**reset**
Format: "reset"
Call example: "reset"
*Description:* will reboot the uRADMonitor device

**powersave**
Format: "powersave","1|0"
Call example: "powersave","1"
*Description:* toggles the powersave mode on (1) or off (0). Default is off. If enabled, the device will send measurements data then go to sleep immediately, for the "sendint" interval, to conserve power. A LoRaWAN INDUSTRIAL device comes about 500mW in normal mode and an average of 10mW with sleep mode enabled. This feature is useful when running on limited power.

**key2**
Format: "key2","value"
Call example: "key2","WLAN-KEY"
*Description:* this is a multipurpose parameter depending on uRADMonitor device type:
- WIFI: it holds the key of the Wifi network the device should connect to.
- LoRaWAN with ABP join: it holds the NWKSKEY.
- LoRaWAN with OTAA join: it holds the APPEUI.
- GSM: it holds the GPRS user (if any).

This command allows you to configure the key2 value. Maximum key length is 64 characters.

**beep**
Format: "beep"
Call example: "beep" or beep
*Description:* if mute is off, will produce a short beep on the speaker

**setmute**
Format: "setmute","1|0"
Call example: "setmute","1"
*Description:* toggles the speaker on (0) or off (1). Default value is 0, so the speaker is active by default.

**key1**
Format: "key1","value"
Call example: "key2","WLAN-SSID"
*Description:* this is a multipurpose parameter depending on uRADMonitor device type:
- WIFI: it holds the SSID of the Wifi network the device should connect to.
- LoRaWAN with ABP join: it holds the DEVADDR.
- GSM: it holds the GPRS APN .

This command allows you to configure the key1 value. Maximum key length is 64 characters.

**key3**
Format: "key3","value"
Call example: "key3","APPSKEY"
*Description:* this is a multipurpose parameter depending on uRADMonitor device type:
- LoRaWAN with ABP join: it holds the APPSKEY.
- LoRaWAN with OTAA join: it holds the APPKEY.
- GSM: it holds the GPRS password (if any) .

This command allows you to configure the key3 value. Maximum key length is 64 characters.

**alarm**
Format: "alarm"
Call example: "alarm"
*Description:* if mute is off, will activate the sound alarm for about a minute or until the command is called the second time.

**key4**
Format: "key4","value"
Call example: "key4","PINCODE"
*Description:* this is a multipurpose parameter depending on uRADMonitor device type. Currently it is only used by GSM devices, where the value represents the SIM CARD PIN code (if any).
This command allows you to configure the key4 value. Maximum key length is 64 characters.

**script**
Format: "script","value"
Call example: "script"," /api/v1/upload/e7/"
*Description:* on devices with Ethernet, WIFI or GSM, this command sets the script the payload should be sent to. This powerful command allows to redirect payloads to other destinations then the default uRADMonitor data server. Please do not change unless you know what you are doing. Max length is 64 characters.

**lorajoin**
Format: "lorajoin","1|2"
Call example: "lorajoin","1"
*Description:* sets the LoRaWAN JOIN mode, where 1 is OTAA and 2 is ABP.

**loraadr**
Format: "loraadr","value"
Call example: "loradr","0|1|255"
*Description:* Toggles the LoRaWAN adaptive data rate at device startup, 1 to enable ADR, 0 to disable ADR. Use 255 for no change (ADR remains on previous setting).

**getsettings**
Format: "getsettings"
Call example: "getsettings" or getsettings
*Description:* returns the device configuration in JSON format

**server**
Format: "server","value"
Call example: "server","data.uradmonitor.com"
*Description:* on devices with Ethernet, WIFI or GSM, this command sets the server the payload should be sent to. This powerful command allows to redirect payloads to other destinations then the default uRADMonitor data server. Please do not change unless you know what you are doing. Maximum length is 64 characters.

**rx1delay**
Format: "rx1delay","value"
Call example: "rx1delay","4000"
*Description:* sets the LoRaWAN RX1 window, in miliseconds. RX2 will be automatically set to RX1 + 1000ms.

**loradr**
Format: "loradr","value|255"
Call example: "loradr","0"
*Description:* sets the LoRaWAN data rate at device startup. Use 255 for no change (DR remains on previous setting). Value interval is from 5 (SF7) to 0 (SF12).

**loraupctr**
Format: "loraupctr","value"
Call example: "loraupctr","1055"
*Description:* Sets the UP Counter used with LoRaWAN ABP. the next message sent to the Gateway will have the counter value+1.

**getdata**
Format: "getdata"
Call example: "getdata" or getdata
*Description:* returns the last device data in JSON format. Please note that while USB is connected, the device is in powersave mode and all sensors are disabled.

# Frequently asked questions

Here are a few hints on fixing various issues when using your A3 dosimeter.

## How to add my A3 to my dashboard account?

If both the unit and your computer as in the same network and share the same external IP you'll see the unit listed in the dashboard, and you'll have a button to add it to your account. If it's a LoRaWAN or GSM unit, or if for some reason you cannot see it in the dashboard, contact us for help.

## The unit is not visible online, nor can I access it via LAN

If it is an Ethernet or a Wifi variant, open your router's admin page and make sure the A3 received a valid IP via DHCP. Try pinging the IP to make sure the connection is properly setup. It it is a GSM/Cellular A3 unit, make sure you've inserted a valid data sim, and the APN is correctly set. If it is a LoraWAN unit, you'll need to double check the NWKSKey, the APPSKey, the DEVEUI and the DEVADDR settings in the network server you are using.

## Can I use it outdoors?

Yes, but only taking precautions not to expose it to rain or sun. The device, like other electronics, is sensitive to the elements, and reasonable care must be taken to protect it.

## What is the privacy policy if the unit sends data online?

We only retain your email address needed for the system to register your account online. Other than that we retain no personal information associated with your unit's data online, and the location on the map can be customized for better accuracy or better privacy, according to your requirements. You have access to these coordinates yourself, by using the Dashboard, on http://www.uradmonitor.com/dashboard

## Air quality index worldwide thresholds

You can read more on international pollutants legal limits by visiting https://en.wikipedia.org/wiki/Air_quality_index

## Disclaimer

Magnasci SRL deems the data generated by the uRADMonitor detectors as factual, and the opinions expressed above are those of qualified experts based on the results of tests conducted. The uRADMonitor data can not be used as a warranty provision or representation for which Magnasci SRL assumes legal responsibility. The data are offered solely for consideration, investigation and verification. Any use of this information is subject to federal, state and local laws and regulations.

## Warranty and support

Your A3 comes with a warranty that covers any defects in material or workmanship under normal use during the warranty period. During the Warranty period, your A3 will be repaired or replaced, at no charge if it proves defective because of improper material or workmanship under normal use and maintenance. The warranty period is one year (12 months) from the date of purchase.

The warranty does not cover any problem caused by conditions, malfunctions or damage not resulting from defects in material or workmanship.

To obtain the warranty service, you must first contact us to determine the problem and the most appropriate solution for you.

Support email: support@uradmonitor.com

## Contact

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*"Thank you for participating in World's first global open source environmental surveillance program and for helping the uRADMonitor project move forward! This work has a direct impact on the quality of our environment and implicitly, on the quality of our lives."*

Radu Motisan
Founder and CEO
Magnasci SRL