Indoor Air Quality sensor

RLW-THC
RW-THC
RLW-TH
RW-TH

unipi technology

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1 What is the Unipi Indoor Air Quality sensor and what does it serve for?

It is a device designed to monitor a range of physical quantities affecting live organisms located within the monitored areas. The individual models differ from each other by the number/type of measured quantities and communication interfaces.

	RW-TH	RLW-TH	RW-THC	RLW-THC
Communication interface				
Wi-Fi AP	⊕	⊕	⊕	⊕
Wi-Fi client	⊕	⊕	⊕	⊕
Modus TCP + MQTT + HTTP/REST	⊕	⊕	⊕	⊕
Modbus RTU via RS485	⊕	⊕	⊕	⊕
LoRaWAN 868 MHz	⊗	⊕	⊗	⊕
Binary output	⊕	⊕	⊕	⊕
Measured quantities				
Temperature + humidity	⊕	⊕	⊕	⊕
Ambient light intensity	⊕	⊕	⊕	⊕
VOC	⊕	⊕	⊕	⊕
CO_2	⊗	⊗	⊕	⊕
Power supply				
5V power supply (MicroUSB)	⊕	⊕	⊕	⊕
24V power supply (screw terminals)	⊕	⊕	⊕	⊕

The sensor is designed primarily as a source of data for the control system in „smart" buildings to provide an optimal environment in households, factory buildings or office spaces. The data can be used to effectively regulate heating, cooling, heat recovery, lighting etc.

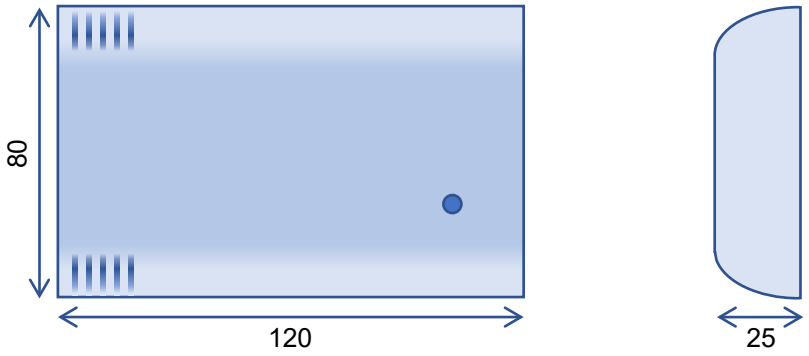
2 Parameters

Measured parameters of indoor environments*	Air temperature Air humidity CO_2 concentration VOC (volatile organic compound) concentration – air quality index Barometric pressure Ambient light intensity	
Power supply	5-24 V DC, 0.6 W average consumption micro USB 5 V DC, max. 1 A (typ. 120 mA), long tip cable required	
Measuring range	Air temperature Relative air humidity CO_2 concentration VOC concentration Barometric pressure Ambient light intensity	-40 až +85 °C 0–90 % non-condensing 300–5000 ppm AQ index 0–500 300–1100 hPa 0–7500 lx
Measurement accuracy	Air temperature Relative air humidity CO_2 concentration VOC concentration Barometric pressure Ambient light intensity	± 0,5 °C ± 2 % (in range of 20–80 %) ± 30 ppm and ± 3 % from the value indicative value ± 5 hPa indicative value
Communication interfaces*	Wi-Fi LoRaWAN RS-485	802.11 b/g/n 2,4 GHz Class A, 14 dBm, SF 7-12, 868 MHz ABP support and OTAA activation
Communication protocols	Wi-Fi RS485	MQTT, HTTP/REST, Modbus TCP Modbus RTU
Digital output	Galv. isolated open collector, max 20 mA / 24 V	
Indication and visualisation	RGB LED for indication of indoor air quality and device status	
Internal storage	Up to 7 days with 5 quantities values at a 5-minute interval. Power supply outage results in a loss of the data.	
Comply with	EN 300 328; EN 300 220; EN 301 489 EN 60730; EN 60950; EN 62311; EN 62479 RoHS; WEEE	

** Available measured quantities and communication interfaces depends on the particular sensor variant*

3 Size and installation

The sensor's cover is made from white ABS plastics. Dimensions are shown in millimetres.



Installation

Air quality sensors are intended for installation on interior walls of residential buildings. To ensure maximum measurement accuracy it is necessary to place the sensor correctly to allow for an optimal airflow inside the case.

Within individual rooms, the sensor should be installed ideally at 100-150 cm height from the floor (eg. in places where occupants of the building spend most of the time – in bedrooms the sensor can be placed lower). In any case, WE DO NOT RECOMMEND installing the sensor too low (floor level) or too high (ceiling level), as some measurements (especially temperature and CO_2) could be distorted.

Connection

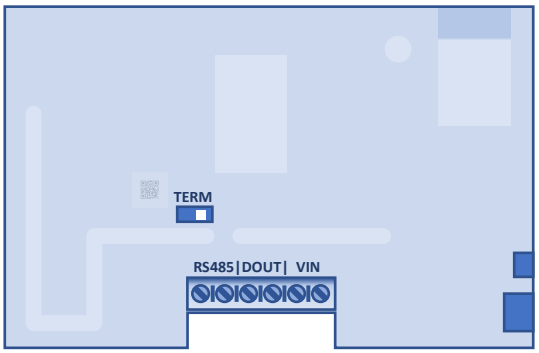
Before the connection, it is necessary to disassemble the sensor's plastic cover and remove the circuit board. Perform this operation carefully, ideally using a small flat screwdriver. Take special care to not damage the cable connecting the circuit board to the antenna mounted in the upper part of the case (applies only for the corresponding variants).

The sensor can be powered either by 5-24 V voltage connected to the screw terminal or by 5 V input with MicroUSB connector placed on the sensor's side – in this case, make sure to use a suitable power supply (adapter) able to supply at least 1 A current at 5 V voltage. Connect the power source with a short cable featuring a sufficient gauge and **long tip**. The device is not designed for being powered by batteries or accumulators

The sensor features the following connectors:

- **Screw terminal with paired pins:**
  - **RS485** – communication bus
  - **DOUT** – binary output (**N**egative, **P**ositive)
  - **VIN** – 12-24 V DC power input
- **MicroUSB** connector – 5 V DC voltage input

The **TERM** switch in **ON** position is used for connecting a 120 Ω terminal resistor to the RS485 bus.



4 Measured quantities

Quantity	Description	Note
Temperature	Ambient temperature in °C	A temperature offset can be configured in the sensor settings. The offset is added to the measured value.
Rel. humidity	Air humidity expressed in degrees (%). The most frequently used value related to air humidity.	
Abs. humidity	An amount of water dissolved in the air. Expressed in grams per cubic meter (g/m^3).	
Dew point	Represents the temperature at which condensation would start on the current level of humidity (°C)	
CO_2 concentration	CO_2 concentration value (ppm).	Upon powering the sensor, it is necessary to wait for several minutes until the sensor initialises.
Atmospheric pressure	Atmospheric pressure (hPa) with the option to recalculate to sea level pressure	
Ambient indirect lighting		The value is indicative and depends on the sensor variant and its placement.
VOC index	Volatile compound concentration.	You need to take VOC accuracy into account, representing the accuracy of the measured value. Upon powering the sensor, the value is 0 (invalid value). Stabilisation and reaching the maximum accuracy are indicated by the value of 3.
CO_2 VOC equivalent	Relates to the VOC index and is scaled to match the CO_2 concentration, eg. it does not represent the CO_2 concentration and only interprets VOC values on a comparable scale.	

CO_2 calibration

Manual calibration

In the web configuration interface, you can set current CO_2 concentration detected by a different calibrated sensor, using either normal or by placing the sensor in the open air. After saving the value the CO_2 uses it to calibrate itself (the value in configuration interface is simultaneously reset). When calibrating the sensor in fresh air (ie. on a windowsill) you need to set the reference value to 400 ppm. Manual calibration should be performed only on a calibrated sensor, eg. no sooner than 15 minutes after powering up.

CO_2 automatic calibration

Runs on the background and adjusts the CO_2. calibration constant automatically every seven days. For proper function, you need to ensure free airflow for at least an hour each day (typically by airing out the room). If the automatic calibration is enabled, values entered via manual calibration are overwritten after seven days at the latest. Automatic calibration is enabled by default.

The first calibration cycle is always performed during the sensor's assembly – that said, you do not need to wait 7 days for a relevant value after purchasing the sensor.

VOC (volatile compound concentration)

VOC represents internal environment air quality (value range 0-500). It expresses relative changes in the measured volatile organic compound (VOC) concentration. Zero value corresponds to clear air, maximum value indicates a heavily polluted environment. During the measurement, an evaluation algorithm adapts to ambient conditions in which the sensors are placed (household, office, car interior, ...). Value calculation considers measuring history for the last 4 days, where an approximate value of 25 indicates clean air, while the value of 250 marks polluted air.

VOC index is defined according to measurements of concentrations of the following compound:

- Ethane
- Isoprene
- Ethanol
- Acetone
- Carbon monoxide

Averaging

Measured values can be averaged separately for each communication interface. For synchronous MQTT messages and LoRaWAN, the averaging period is fixed and always matches the interval of messages sending. For Modbus TCP/RTU, HTTP API and web interface you can configure the averaging independently or disable it by setting it to zero value. In any case, it is always represented as a moving average.

5 LED indication

The sensor features multipurpose LED with the primary purpose of indicating the CO_2 concentration (or VOC on models lacking the CO_2 sensor) in the surrounding space by changing its colour.

The secondary function of the LED is to indicate Wi-Fi connection status and to provide feedback when resetting the sensor via the reset button.

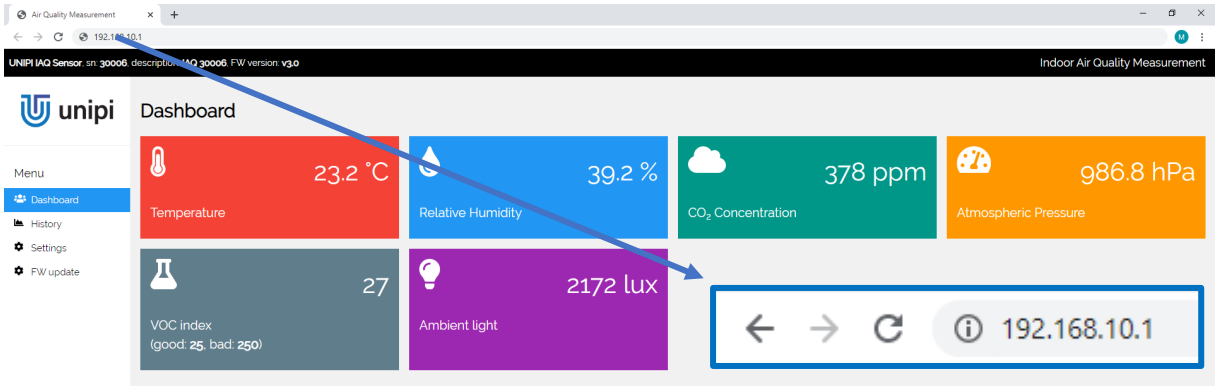
LED state	Meaning
Purple	Initialisation phase after the device's power-up.
Green **Yellow** **Red**	CO_2 concentration green ≈ <450 ppm red ≈ >2000 ppm The transition between these thresholds is linear according to the current concentration.
Blue **Red**	Feedback for manipulation with the button: Wi-Fi AP activation Factory reset, see the Device reset chapter
Periodic blinking (disregarding the colour)	Wi-Fi connection is set but is unavailable (ie. wrong password or weak signal).

6 Communication

The primary communication channel used for managing the sensor's parameters is Wi-Fi.

Initial login and configuration

Before the integration of the sensor into your project, you may need to configure it first. Configurations are performed via an integrated web interface displayed directly in your web browser. After the first start-up (or after pressing the corresponding button – see Device reset) the Wi-Fi is set to access point (AP) mode with the network name (SSID) being in the *Unipi <model> <serial number>* format. The password is **iaqsensor.** After connecting to the network enter ***192.168.10.1.*** address into the address tab.



All available parameters can be configured in the *Settings* section. Access to the section is protected by login and password. We strongly recommend changing both after the initial configuration.

Settings and FW update section	Default login	admin
	Default password	admin
Default Wi-Fi password		iaqsensor

Detecting sensors on a local network

Sensors with an unknown IP address can be detected on LAN easily using an integrated tool. For the tool to work properly you need to enable it first in the *Settings->Online discovery service* menu and enable access from the LAN to the internet (the service runs on manufacturer's servers, the device sends its local + public IP addresses and its identification).

This service DOES NOT ALLOW remote access to the sensor and is designed only for listing all sensors within the subnet from which the request was sent. The access to this service can be optionally secured by a PIN code to display only sensors assigned to the same group (eg. sharing the same PIN code) and using the same public IP address or local address.
The service is available on the following link:

https://iaq.unipi.technology/

MQTT

MQTT can be used only via Wi-Fi in the *Station* mode, eg. the sensor acts as a client device connected to an already existing network. Measured data are periodically sent in the form of JSON messages – the format is used also by HTTP API and is described in the following subchapter.

MQTT supports both ciphered (recommended, default port 8883) and unciphered connection (default port 1883). We also strongly recommend using the optional authentication by login and password. Message sending is blocked during the CO_2 sensor initialisation. After that the messages are sent in a configured period – the same period is also used for moving value averaging (see Averaging section).

HTTP

REST API is accessible through GET on the following address (endpoint):

http://<IP>/api/v1/data.json

The IP address depends on the configured Wi-Fi mode. In AP mode the address is 192.168.10.1, In *Station* mode the address is usually dynamically assigned by the DHCP protocol. The required values are averaged by a moving average with adjustable period (see Averaging). Response messages can be formatted for better readability and/or complemented by metadata using optional *format* and *meta* parameters. An example:

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

An example of data in JSON format:

```
{
    "meta": {
        "sn": 30004, /* Sensor serial number */
        "ip": "10.208.249.210", /* Local network IP address */
        "name": "IAQ Sensor", /* Sensor name (type) */
        "desc": "Living room", /* Sensor description */
        "uptime": 64 /* Sensor uptime/restart time (s) */
        "wifi_rssi": -72.29067993 /* Wi-Fi signal strength (dBm) */

    },
    "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) */
    "atm_pressure": 977.82, /* Atmospheric pressure (hPa) */
    "ambient_light": 482.94, /* Ambient light (lux)*/
    "VOC_index": 70.85, /* VOC index (0-500) */
    "VOC_equiv_CO2": 681.67, /* VOC CO2 equivalent (ppm) */
    "VOC_accuracy": 3, /* VOC measurement accuracy (0-3) */
}
```

If any of the measured values are not initialized, its value is *null*. Example:

```
    ...
    "dew_point": 11.2, /* Dew point (°C) */
    "CO2": null, /* CO2 concentration (ppm) */
    "atm_pressure": 977.82, /* Atmospheric pressure (hPa) */
    ...
```

LoRaWAN

A bidirectional energy-saving radio connection allowing to transmit measured values at a distance of several kilometres. Message sending period can be configured in the service web interface or remotely using a downlink LoRaWAN messages addressed to the sensor. To save up bandwidth all outgoing data are encoded – see the following section.

Activation

Before the first use of LoRaWAN interface the sensor must be activated, eg. registered to a public provider or in a database of a private LoRaWAN gateway. Two activation methods are supported (your provided may support only one of them):

1. Over-the-Air Activation (OTAA) – **preferred**
2. Activation by Personalization (ABP)

OTAA method requires joining a LoRaWAN network first (*Join*). The process is started each time the sensor is powered – in case of an unsuccessful connection the process is repeated over a randomly generated period (about 3 minutes).

Device EUI serves as identification within the LoRaWAN network and is displayed in the corresponding section of settings. The parameter is set by default to ensure its value is unique, its change is not recommended.

The meaning of other parameters (Application EUI, Application Key) depends on the selected activation method. The parameters' description is available in LoRaWAN network documentation or from your operator.

Measured values formatting (uplink)

Message section carrying measured values (referred to as *payload*) contains up to 16 bytes in which up to 10 different quantities or information can be encoded depending on the specific sensor model. Information can be a single byte, 2-byte, or multi-byte. All transmitted values are expressed in integers. Decimals and negative numbers can be calculated using the calculation below. An example of such calculation is available in the attachment.

Byte	0	1	2	3	4	5	6	7	8	9	10
	-	Lo	Hi	-	Lo	Hi	Lo	Hi	-	Lo	Hi
Field	CONT	T_x		RH_x	p_x		VOC_x		AL_x	CO_2_x	

Field name	Meaning		
CONT	A bitmask for the following fields. If the corresponding bit is at LOG1, the given field is included in the payload.		
	Bit	Binary representation	Meaning
	0	0000 0001	T, RH – temperature and rel. humidity
	1	0000 0010	p – atmospheric pressure
	2	0000 0100	VOC index
	3	0000 1000	AL – Ambient light
	4	0001 0000	CO_2
	5-7	1110 0000	Reserved

	Quantity	Calculation method
T_x	Temperature (°C)	T = (T_x / 100) - 100
RH_x	Relative air humidity (%)	RH = RH_x / 2.5
p_x	Atmospheric pressure (hPa)	p = (p_x / 100) + 800
VOC_x	VOC index, VOC accuracy	VOC_index = VOC_x & 0x01FF VOC_accuracy = (VOC_x >> 9) & 0x0003

AL_x	Indirect ambient light (lux)	Ambient_light = exp(Ambient_light_x / 20) - 1
CO_2_x	CO_2 concentration (ppm)	CO_2 = CO_2_x

Sensor command format (downlink)

Only a single type of downlink payload, intended to set the sending period for LoRaWAN messages, is supported. The payload type number is 1. The minute value must be set within 1 – 180 range. See Attachments for an example.

Byte	0	1
Field	P_TYPE	PERIOD

Field name	Meaning	
P_TYPE	Payload name	Always equal to 1
PERIOD	Message sending period in minutes	Integer, range 1-180

Modbus RTU / TCP

The sensor works as a Modbus slave (eg. server). Register map (containing addresses and formats of all registers) is shared between TCP and RTU. All quantities can be read at once as a single block. However, any values outside the registers have a non-defined state (eg. the control system should discard them).

Both serial line parameters and TCP listening port (502 by default) can be configured – see Configurable parameters description. The sensor supports only a single open TCP connection at once.

Register map of input registers

Register	Meaning	Units	Format
0	Temperature	°C	float (32 bits)
6	Relative air humidity	%	float (32 bits)
8	Dew point	°C	float (32 bits)
10	Absolute humidity	g/m^3	float (32 bits)
18	CO_2	ppm	float (32 bits)
26	VOC index (0-500)	-	float (32 bits)
28	VOC accuracy (0-3)	-	float (32 bits)
34	VOC CO_2 equivalent	ppm	float (32 bits)
42	Ambient light	lux	float (32 bits)
76	Atmospheric pressure	hPa	float (32 bits)
84	Sensor uptime	s	float (32 bits)

Register map of configuration (holding) registers

Register	Meaning	Units	Format
5000	LED intensity; range 1-100	%	integer (16 bitů)
5001	Digital output state	-	0 – OFF Other value - ON

7 Device reset

By pressing the sensor's button **during the initialisation phase after power-up** (the LED is purple) you can perform one of the following operations:

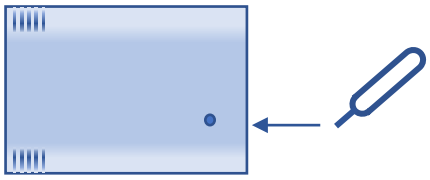
1. **Switching Wi-Fi to access point (AP) mode (press the button for approx. 2 seconds)**

The sensor creates a Wi-Fi network (SSID: *Unipi <model> <serial number>*. This network is open, eg. without any login or password. This operation **does not** delete or reset device parameters.

To change any settings, you need to know the *Settings* section password. If you do not know the password or it was already changed (eg. is not set to default – see the Initial login and configuration chapter), the only option left is to perform a factory reset (see below)-

2. **Factory reset (press the button for approx. 8 seconds until the LED stops flashing blue)**

All parameters are set back to their factory default. Login and password needed for device configuration are also reset (login: admin, password: admin).



A simple tool for pressing the button comfortably is included in the sensor's package. Alternatively, you can use a needle or any other suitable sharp object.

8 Firmware update

The device allows the user to update the embedded software using built-in web interface accessible via Wi-Fi. This is done using the *FW update* item in the main menu, which is protected by name and password (see chapter Initial login and configuration for their default values).

The latest firmware as a .bin file is available for download at:

https://kb.unipi.technology/

This file is then loaded directly via the web form. After uploading it to the sensor, it is necessary to restart the device.

9 Attachments

9.1 Example of decoding a LoRaWAN uplink message

Payload in hexadecimal format: 1f932f87c8011046b10465

Trimmed to individual fields: 0f 932f 87 c801 1046 b104 65

Endianness change of multi-byte values: 0f 2f93 87 01c8 4610 04b1 65

Quantity	Hexadecimal representation	Decimal representation	Conversion	Result
CONT	0x1f	-	0x1f (hex) = 0001 1111 (binary)	T, RH, CO2, p, VOC, Ambient_light
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
Ambient_light	0x65	101	exp(101 / 20) - 1	155 lux
CO_2	0x01c8	456	CO_2 = 456	456 ppm

Quantity	Hex representation	Bit shift and masking	Result
VOC_index	0x04b1	0x04b1 & 0x01ff = 0x00b1	177
VOC_accuracy	0x04b1	(0x04b1 >> 9) & 0x0003 = 0x0002 & 0x0003 = 0x0002	2

9.2 Example of downlink LoRaWAN message

Request	Hex payload
Set the message sending period to 5 minutes	0x01 0x05
Set the message sending period to 10 minutes	0x01 0x0A

9.3 Configurable parameters meaning

Parameter	Meaning
Login	
New password	a new password to access configuration
Sensor name	sensor name (type), cannot be changed
Sensor	
Serial number	the serial number of the sensor
Admin username	username to access configuration
Sensor description (location)	user description of the sensor (ie. its location)
LED	
Led intensity control	LED intensity settings: • According to the ambient light • According to the time of day • Constant intensity
Max/Min LED intensity	min. and max. LED intensity level, expressed as % of the maximum intensity
Threshold for max/min intensity	values for min. and max. intensity (in lux).
Day/Night/Sleep LED intensity	LED settings for each part of the daytime, expressed as % of the maximum intensity.
Sleep time from/to	activation/deactivation of nighttime LED intensity, expressed in hours (24H format)
LED intensity	The LED intensity in the constant intensity mode, expressed as % of the maximum intensity
Wi-Fi	
ON/OFF	Wi-Fi on/off
Wi-Fi mode	Wi-Fi mode AP mode – sensor acts as an access point (IP address: 192.168.10.1) Station mode – sensor acts as a client connecting to an existing network (IP address assigned by DHCP)
Wi-Fi name (SSID), Wi-Fi password	Wi-Fi network access info, common for both modes

Online discovery service	
ON/OFF, Pin	enables/disables the "Sensor detection in local network" function. When enabled, it is possible to set a PIN code. See the relevant section for more info.
Webserver	
Dashboard/HTTP API averaging*	length of a moving average's time window (in seconds). Can be adjusted separately for the web interface and REST API.
MQTT	
MQTT publish period (seconds)	a data sending period (in seconds). The data sent are an average for the entire period.
MQTT TLS encryption	encryption of data and access login Unencrypted Encrypted (RECOMMENDED)
MQTT server	the server domain name or IP address
MQTT port	server port. If encryption is changed it is necessary to change the port manually.
MQTT username/password	user login and password for the MQTT server. Optional, but RECOMMENDED.
MQTT topic	MQTT topic
Modbus RTU	
Modbus device address	device address on the bus
Baud rate, parity, stop bits	RS485 serial line communication parameters
Modbus values averaging*	moving average time window length for Modbus (in seconds)
Modbus TCP	
Modbus TCP port	the port Modbus server uses to listen for incoming connections. Default port: 502.
Calibration ()	
Temperature offset	offset value permanently added to the measured temperature.
CO_2 calibration – set reference	CO_2 concentration reference value serves for manual calibration.
CO_2 calibration – on/off	activation of automatic calibration. See CO2 calibration for more info.

Revisions

Version	Changelog	Published
1.0	Initial release	07/2020