



Outdoor Air Quality 2nd Gen. Library Documentation

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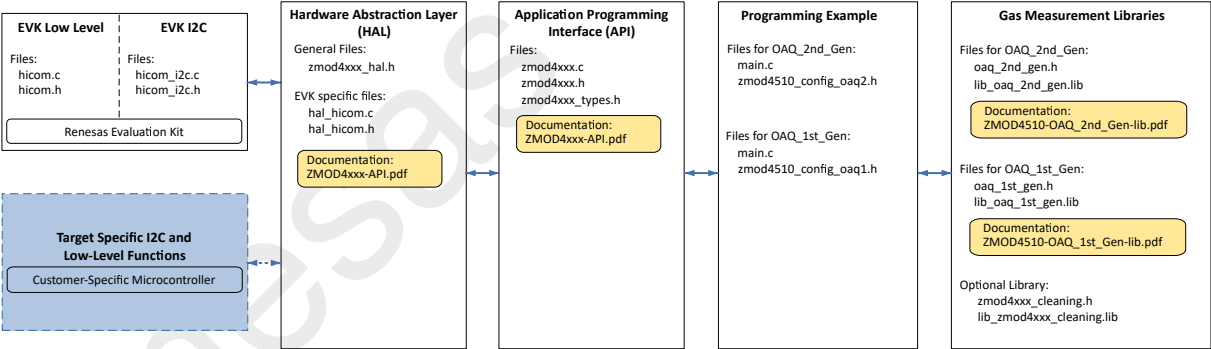
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Chapter 1

ZMOD4510 Application Programming Interface Overview

This document describes the libraries for the ZMOD4510 gas sensor module using the second-generation algorithms for outdoor air quality measurements (OAQ 2nd Gen) in ultra-low power mode (ULP). This algorithm is recommended for accurate and consistent Air Quality Index (AQI) measurement. Refer to the ZMOD4510 Programming Manual - Read Me for further information regarding sample code. The figure below shows an overview of the ZMOD4xxx API, programming example and libraries. Custom microcontrollers can be used to establish I2C communication. Using the user's own microcontroller requires implementing the user's own target-specific I2C and low-level functions (highlighted in blue). The following sections describe in detail the OAQ 2nd Gen algorithm libraries for ultra-low power and an optional cleaning procedure after product assembly.



Chapter 2

How to Work with the Renesas Gas Algorithm Libraries

- Include the intended header file in the user's program for gas sensor module control; for example:
`#include "oaq_2nd_gen.h"`
- Copy the library file into user's project folder
- Call the intended function in the user's program

Example for OAQ:

```
#include "oaq_2nd_gen.h"

int main() {
    int8_t ret;
    oaq_2nd_gen_handle_t algo_handle;
    oaq_2nd_gen_results_t algo_results;
    zmod4xxx_dev_t dev;
    uint8_t adc_result[ZMOD4510_ADC_DATA_LEN];

    /* The ambient compensation needs humidity and temperature measurements! */
    float humidity_pct;
    float temperature_degC;
    ...
    // User's functionality
    ...
    // Hardware initialization
    ...

    ret = init_oaq_2nd_gen(&algo_handle, &dev);

    // User's functionality
    while(1) {
        /* Read the adc value */
        ret = zmod4xxx_read_adc_result(&dev, adc_result);
        /* Humidity and temperature measurements are needed for ambient compensation.
        * It is highly recommended to have a real humidity and temperature sensor
        * for these values! */
        humidity_pct = 50.0; // 50% RH
        temperature_degC = 20.0; // 20 degC
        ...
        // get sensor results with API
        ret = calc_oaq_2nd_gen(&algo_handle, &dev, adc_result, humidity_pct,
                             temperature_degC, &algo_results);
    }

    return 0;
}
```

Chapter 3

Example for zmod4xxx_cleaning:

- Include the intended header file in the user's program for cleaning;
`#include "zmod4xxx_cleaning.h"`
- Copy the library file into user's project folder
- Call the `zmod4xxx_cleaning_run` function in the user's program
- IMPORTANT NOTE : The cleaning procedure can be run only once during the modules lifetime and takes 10 minutes.

```
#include "zmod4xxx_cleaning.h"

int main() {
    // initialization of the device structure(dev)
    zmod4xxx_dev_t dev;

    // User's functionality

    zmod4xxx_cleaning_run(&dev);

    // User's functionality

    return 0;
}
```

Chapter 4

Module Index

4.1 Modules

Here is a list of all modules:

Return codes of the algorithm functions. 7

Chapter 5

Data Structure Index

5.1 Data Structures

Here are the data structures with brief descriptions:

algorithm_version	Variables that describe the library version	8
oaq_2nd_gen_handle_t	Variables that describe the sensor or the algorithm state	8
oaq_2nd_gen_results_t	Variables that receive the algorithm outputs	9

Chapter 6

File Index

6.1 File List

Here is a list of all documented files with brief descriptions:

oaq_2nd_gen.h	This file contains the data structure definitions and the function definitions for the 2nd generation	
OAQ algorithm	11
zmod4xxx_cleaning.h	This file contains the cleaning function definition for ZMOD4xxx	13

Chapter 7

Module Documentation

7.1 Return codes of the algorithm functions.

Macros

- `#define OAQ_2ND_GEN_OK (0)`
- `#define OAQ_2ND_GEN_STABILIZATION (1)`

7.1.1 Detailed Description

7.1.2 Macro Definition Documentation

7.1.2.1 OAQ_2ND_GEN_OK

```
#define OAQ_2ND_GEN_OK (0)
```

everything okay

7.1.2.2 OAQ_2ND_GEN_STABILIZATION

```
#define OAQ_2ND_GEN_STABILIZATION (1)
```

sensor in stabilization

Chapter 8

Data Structure Documentation

8.1 algorithm_version Struct Reference

Variables that describe the library version.

```
#include <oaq_2nd_gen.h>
```

Data Fields

- uint8_t **major**
- uint8_t **minor**
- uint8_t **patch**

8.1.1 Detailed Description

Variables that describe the library version.

The documentation for this struct was generated from the following file:

- [oaq_2nd_gen.h](#)

8.2 oaq_2nd_gen_handle_t Struct Reference

Variables that describe the sensor or the algorithm state.

```
#include <oaq_2nd_gen.h>
```

Data Fields

- uint16_t [stabilization_sample](#)
- float [gcda](#) [8]
- float **log_ra**
- float **log_b**
- float **beta2**
- float **O3_conc_ppb**
- float **o3_1h_ppb**
- float **o3_8h_ppb**

8.2.1 Detailed Description

Variables that describe the sensor or the algorithm state.

8.2.2 Field Documentation

8.2.2.1 gcda

```
float gcda[8]
```

baseline conductances.

8.2.2.2 stabilization_sample

```
uint16_t stabilization_sample
```

Number of samples still needed for stabilization.

The documentation for this struct was generated from the following file:

- [oaq_2nd_gen.h](#)

8.3 oaq_2nd_gen_results_t Struct Reference

Variables that receive the algorithm outputs.

```
#include <oaq_2nd_gen.h>
```

Data Fields

- float [rmox](#) [8]
- float [O3_conc_ppb](#)
- uint16_t [FAST_AQI](#)
- uint16_t [EPA_AQI](#)

8.3.1 Detailed Description

Variables that receive the algorithm outputs.

8.3.2 Field Documentation

8.3.2.1 EPA_AQI

```
uint16_t EPA_AQI
```

EPA_AQI stands for the Air Quality Index according to the EPA standard based on ozone.

8.3.2.2 FAST_AQI

```
uint16_t FAST_AQI
```

FAST_AQI stands for a 1-minute average of the Air Quality Index according to the EPA standard based on ozone

8.3.2.3 O3_conc_ppb

```
float O3_conc_ppb
```

O3_conc_ppb stands for the ozone concentration in part-per-billion

8.3.2.4 rmox

```
float rmox[8]
```

MOx resistance.

The documentation for this struct was generated from the following file:

- [oaq_2nd_gen.h](#)

Chapter 9

File Documentation

9.1 oaq_2nd_gen.h File Reference

This file contains the data structure definitions and the function definitions for the 2nd generation OAQ algorithm.

```
#include <stdint.h>
#include <math.h>
#include "zmod4xxx_types.h"
```

Data Structures

- struct [algorithm_version](#)
Variables that describe the library version.
- struct [oaq_2nd_gen_handle_t](#)
Variables that describe the sensor or the algorithm state.
- struct [oaq_2nd_gen_results_t](#)
Variables that receive the algorithm outputs.

Macros

- #define [OAQ_2ND_GEN_OK](#) (0)
- #define [OAQ_2ND_GEN_STABILIZATION](#) (1)

Functions

- [int8_t init_oaq_2nd_gen](#) ([oaq_2nd_gen_handle_t](#) *handle, [zmod4xxx_dev_t](#) *dev)
Initializes the OAQ algorithm.
- [int8_t calc_oaq_2nd_gen](#) ([oaq_2nd_gen_handle_t](#) *handle, [zmod4xxx_dev_t](#) *dev, const [uint8_t](#) *sensor_↵
results_table, const float humidity_pct, const float temperature_degc, [oaq_2nd_gen_results_t](#) *results)
calculates OAQ results from present sample.

9.1.1 Detailed Description

This file contains the data structure definitions and the function definitions for the 2nd generation OAQ algorithm.

Author

Renesas Electronics Corporation

Version

3.0.0

The library contains an algorithm to calculate an ozone concentration and various air quality index values from the ZMOD4510 measurements.

9.1.2 Function Documentation

9.1.2.1 calc_oaq_2nd_gen()

```
int8_t calc_oaq_2nd_gen (
    oaq_2nd_gen_handle_t * handle,
    zmod4xxx_dev_t * dev,
    const uint8_t * sensor_results_table,
    const float humidity_pct,
    const float temperature_degc,
    oaq_2nd_gen_results_t * results )
```

calculates OAQ results from present sample.

Parameters

in	<i>handle</i>	Pointer to algorithm state variable.
in	<i>dev</i>	pointer to the device
in	<i>sensor_results_table</i>	array of 18 bytes with the values from the sensor results table.
in	<i>humidity_pct</i>	relative ambient humidity (%)
in	<i>temperature_degc</i>	ambient temperature (degC)
out	<i>results</i>	Pointer for storing the algorithm results.

Returns

error code.

9.1.2.2 init_oaq_2nd_gen()

```
int8_t init_oaq_2nd_gen (
    oaq_2nd_gen_handle_t * handle,
    zmod4xxx_dev_t * dev )
```

Initializes the OAQ algorithm.

Parameters

out	<i>handle</i>	Pointer to algorithm state variable.
in	<i>dev</i>	pointer to the device

Returns

error code.

9.2 zmod4xxx_cleaning.h File Reference

This file contains the cleaning function definition for ZMOD4xxx.

```
#include "zmod4xxx.h"
```

Functions

- int8_t [zmod4xxx_cleaning_run](#) (zmod4xxx_dev_t *dev)
Start a cleaning procedure.

9.2.1 Detailed Description

This file contains the cleaning function definition for ZMOD4xxx.

Version

2.4.1

Author

Renesas Electronics Corporation

The library contains the function that starts the cleaning procedure. **The procedure takes 10 minutes.** After successful cleaning, the function returns 0. **The procedure can be run only once.**

9.2.2 Function Documentation

9.2.2.1 zmod4xxx_cleaning_run()

```
int8_t zmod4xxx_cleaning_run (
    zmod4xxx_dev_t * dev )
```

Start a cleaning procedure.

Parameters

<code>in</code>	<code>dev</code>	pointer to the device
-----------------	------------------	-----------------------

Returns

Error code

Return values

<code>0</code>	Success
<code>!= 0</code>	Error

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