SGPC3 Driver Integration (for Dedicated I²C Hardware)
A Step-by-Step Guide

Preface

The easiest way to integrate the SGPC3 sensor into a device is Sensirion’s SGPC3 driver. This document explains how to implement the hardware abstraction layer of the SGP driver and describes the provided API.

COPY FILES TO YOUR PROJECT

STEP 1

1.1. Copy all SGP driver files (.c and .h) into your software project folder.
1.2. Make sure all files are added to your IDE

IMPLEMENT sensirion_hw_i2c_implementation.c

STEP 2

To use your I²C hardware the file sensirion_hw_i2c_implementation.c and sensirion_arch_config.h need to be completed. All parts marked with “// IMPLEMENT” have to be replaced with code performing the necessary setup. Some reference implementations are provided in the embedded-common/hw_i2c/sample-implementations folder.

2.1. Implement the I²C initialization for your specific hardware.

```c
void sensirion_i2c_init()
{
    // IMPLEMENT
}
```

2.2. Implement sensirion_i2c_read(), which executes a read command on the I²C bus, reading the given number of bytes. The specified address is the address of the SGP sensor. Write the number of read bytes (count) into the given data buffer.

```c
int8_t sensirion_i2c_read(uint8_t address, uint8_t* data, uint16_t count)
{
    // IMPLEMENT
    return 0;
}
```

Return: 0 if read command is executed successfully, else an error code.
2.3. Implement `sensirion_i2c_write()`, which executes a write command on the I2C bus. The specified address is the address of the SGP sensor. Write the given number of bytes (count) from the buffer data to the I2C bus.

```c
int8_t sensirion_i2c_write(uint8_t address, const uint8_t *data, uint16_t count)
{
    // IMPLEMENT
    return 0;
}
```

**Note:** Some implementations of I2C write/read expect an 8 bit sensor address (instead of 7 bit). In this case use `(address<<1)` instead of `address` in your implementation.

**Return:** 0 if the write command is executed successfully, else an error code.

2.4. Implement `sensirion_sleep_usec()`, which delays the execution for (at least) the given time in microseconds. Despite the name, millisecond-range resolution is amply sufficient.

```c
void sensirion_sleep_usec(uint32_t useconds) {
    // IMPLEMENT
}
```

MEASURE IAQ (tVOC) AND SIGNAL VALUES

The SGP driver provides functions to probe the sensor, to get the serial ID, and to measure/read tVOC.

3.1. Call `sgp_probe()` to initialize the I2C bus and test if the sensor is available.

```c
int16_t sgp_probe(void);
```

**Return:** 0 if the sensor is detected, else an error code.

3.2. Call `sgp_get_serial_id()` to readout the serial id of the SGP sensor.

```c
int16_t sgp_get_serial_id(u64 *serial_id);
```

**Return:** 0 if the command is successful, else an error code.

3.3. Call `sgp_get_feature_set_version()` to readout the feature set version and product type of the SGP sensor. If the product type is 0 it is a SGP30 gas sensor, if it is 1 it is an SGPC3 gas sensor.

```c
int16_t sgp_get_feature_set_version (u16 *feature_set_version, u8 *product_type);
```

**Return:** 0 if the command is successful, else an error code.

3.4. Call `sgp_measure_iaq_blocking_read()` to start a tVOC measurement and to readout the value.

```c
int16_t sgp_measure_iaq_blocking_read(uint16_t *tvoc_ppb);
```

**Note:** This function blocks the processor while the measurement is in progress.

**Return:** 0 if the command is successful, else an error code.
3.5. For non-blocking measurement and readout of tVOC use the two functions `sgp_measure_iaq()` and `sgp_read_iaq()`.

```c
int16_t sgp_measure_iaq(void);
```

*Return:* 0 if the command is successful, else an error code.

Be sure to wait until the SGP sensor finishes the measurement. Read the measurement result using `sgp_read_iaq()`.

```c
int16_t sgp_read_iaq(uint16_t *tvoc_ppb);
```

*Note:* If the measurement is still in progress, this function returns an error code.

*Return:* 0 if the command is successful, else an error code.

3.6. For best performance and faster startup times, the current baseline needs to be persistently stored on the device before shutting it down and set again accordingly after boot up.

Use `sgp_get_iaq_baseline()` to get the baseline.

```c
int16_t sgp_get_iaq_baseline (uint16_t *baseline);
```

*Return:* 0 if the command is successful, else an error code.

*Note:* If the call is not successful, the baseline value must be discarded. Approximately in the first 15 seconds of operation after `sgp_probe` or `sgp_iaq_init` the call will fail unless a previous baseline was restored.

3.7. Use `sgp_set_iaq_baseline()` to set the baseline.

```c
int16_t sgp_set_iaq_baseline (uint16_t baseline);
```

*Return:* 0 if the command is successful, else an error code.

*Note:* The baseline value must be exactly as returned by `sgp_get_iaq_baseline()` and should only be set if it’s less than one week old.

3.8. SGP baseline states

Call `sgp_iaq_init_continuous()` to reset all SGP baselines. After the accelerated warm-up phase (see 3.9. for durations), the initialization takes 20 seconds, during which the IAQ output will not change.

If no stored baseline is available after initializing the baseline algorithm, the sensor has to run for 12 hours until the baseline can be stored. This will ensure an optimal behavior for subsequent startups. Reading out the baseline prior should be avoided unless a valid baseline is restored first. Once the baseline is properly initialized or restored, the current baseline value should be stored approximately once per hour. While the sensor is off, baseline values are valid for a maximum of seven days.

```c
int16_t sgp_measure_iaq(void);
```
3.9. Call the initialization function sgp_iaq_init_continuous() to initialize or re-initialize the indoor air quality algorithm.

<table>
<thead>
<tr>
<th>Sensor down-time</th>
<th>Recommended initialization</th>
<th>Accelerated warm-up time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 min – 30 min</td>
<td>sgp_iaq_init_continuous(); sgp_set_iaq_baseline(); sgp_measure_tvoc_blocking_read();</td>
<td></td>
</tr>
<tr>
<td>30 min – 6 h</td>
<td>sgp_iaq_init_continuous(); sgp_set_iaq_baseline(); sleep(16); sgp_measure_tvoc_blocking_read();</td>
<td>16 s</td>
</tr>
<tr>
<td>6 h – 1 week</td>
<td>sgp_iaq_init_continuous(); sgp_set_iaq_baseline(); sleep(184); sgp_measure_tvoc_blocking_read();</td>
<td>184 s</td>
</tr>
<tr>
<td>more than 1 week / initial switch-on</td>
<td>sgp_iaq_init_continuous(); sleep(184); sgp_measure_tvoc_blocking_read()</td>
<td>184 s</td>
</tr>
</tbody>
</table>

The above initialization logic ensures fast switch-on behavior for typical IAQ applications. It can be modified and optimized according to the specific limitations and requirements of individual devices.

```c
int16_t sgp_iaq_init_continuous(void);
```

**Return:** 0 if the command is successful, else an error code.

**Note:** sgp_iaq_init_continuous() is already called as part of sgp_probe().

**Note:** The accelerated warm-up phase is interrupted by the first IAQ measurement. The caller must thus sleep for the desired amount of accelerated warm-up time before measuring IAQ with sgp_measure_tvoc() or sgp_measure_tvoc_blocking_read().

3.10. Call sgp_measure_tvoc_blocking_read() to start a tVOC measurement and to readout the value in ppb.

```c
int16_t sgp_measure_tvoc_blocking_read(uint16_t *tvoc_ppb);
```

**Note:** This function blocks the processor while the measurement is in progress.

**Return:** 0 if the command is successful, else an error code.

3.11. For non-blocking measurement and readout of tVOC use the two functions sgp_measure_tvoc() and sgp_read_tvoc()

```c
int16_t sgp_measure_tvoc(void);
```

**Return:** 0 if the command is successful, else an error code.

Be sure to wait until the SGP sensor finishes the measurement. Read the measurement result using sgp_read_tvoc().

```c
int16_t sgp_read_tvoc(uint16_t *tvoc_ppb);
```

**Note:** If the measurement is still in progress, this function returns an error code.

**Return:** 0 if the command is successful, else an error code.
3.12. Call `sgp_measure_signals_blocking_read()` to start signal measurements and to readout the values.

```c
int16_t sgp_measure_signals_blocking_read(uint16_t *ethanol_signal);
```

**Return:** 0 if the command is successful, else an error code.

**Note:** This function blocks the processor while the measurement is in progress.

```c
uint16_t ret;
uint16_t ethanol_signal;

// run signals measurement
ret = sgp_measure_signals_blocking_read(&ethanol_signal);
```

3.13. For non-blocking measurement and readout of signals values use the two functions `sgp_measure_signals()` and `sgp_read_signals()`.

```c
int16_t sgp_measure_signals(void);
```

**Return:** 0 if the command is successful, else an error code.

```c
uint16_t ret;
uint16_t ethanol_signal;

// run signals measurement
ret = sgp_measure_signals();
usleep(200000);
sgp_read_signals(&ethanol_signal);
```

Be sure to wait until the SGP sensor finishes the measurement. Read the measurement results using `sgp_read_signals()`.

```c
int16_t sgp_read_signals(uint16_t * ethanol_signal);
```

**Note:** If the measurement is still in progress, this function returns an error code.

**Return:** 0 if the command is successful, else an error code.

3.14. From feature set 6 on, the SGPC3 features an ultra-low power mode. Run `sgp_set_power_mode()` to change the power mode. Valid power modes are 0 (ultra-low power mode with 30s measurement interval) and 1 (low power mode with 2s measurement interval). 1 (low power mode) is the sensor’s startup or reset default.

```c
int16_t sgp_set_power_mode(uint16_t power_mode);
```

**Return:** 0 if the command is successful, else an error code.

**Note:** IAQ must be reinitialized after changing the power mode. Also, the IAQ baseline is tied to the power mode. Only set a baseline that was acquired in the same power mode.

**Note:** In ultra-low power mode IAQ must be initialized with `sgp_iaq_init_continuous()`.

```c
uint16_t ret;
uint16_t tvoc_ppb;

// Set the Ultra-Low power mode
ret = sgp_set_power_mode(0);

// reinitialize IAQ
ret = sgp_iaq_init_continuous();
// sleep for the desired accelerated warmup time, e.g. 64s (See 3.9)
sleep(64);

// enter measurement loop
while (1) {
    sgp_measure_tvoc_blocking_read(tvoc_ppb);
    sleep(30); // Measurement interval is 30s in ultra-low power mode, 2s in low power mode
}

3.15. Call `sgp_set_absolute_humidity()` to a value greater than 0 and smaller than 256000 mg/m^3 to enable the humidity compensation feature, or write 0 to disable it.

The absolute humidity in g/m^3 can be retrieved by measuring the relative humidity and temperature using a Sensirion SHT sensor and converting the value to absolute humidity with the formula

\[
AH = 216.7 \cdot \frac{RH}{100.0} \cdot 6.112 \cdot \exp \frac{17.62 \cdot t}{243.12 + t} \cdot \frac{273.15 + t}{273.15}
\]

With \(AH\) in g/m^3, \(RH\) in 0-100%, and \(t\) in °C

**Note:** the value in g/m^3 has to be multiplied by 1000 to convert to mg/m^3 and any remaining decimal places have to be rounded and removed since the interface does not support floating point numbers.

```c
int16_t sgp_set_absolute_humidity(uint32_t absolute_humidity);
```

**Return:** 0 if the command is successful, else an error code.

**Note:** The humidity compensation is disabled by setting the value to 0.

**Example:** To set the absolute humidity to 13.000 g/m^3:

```c
uint32_t ah = 13000;
sgp_set_absolute_humidity(ah);
```

3.16. Call `sgp_measure_test()` to run the on-chip self-test. This command can be used during production to ensure the SGP30 is not damaged. A success is indicated by a return code of 0, in which case the value of `test_result` is 0xd400.

```c
// Run the on-chip self-test
uint16_t test_result;
int16_t ret = sgp_measure_test(&test_result);
if (ret != STATUS_OK) {
    // The sensor is likely damaged
}
```

3.17. Call `sgp_get_driver_version()` to retrieve the driver version.

```c
const char *sgp_get_driver_version(void);
```

**Return:** The driver version string is returned in the form "major.minor.patchset" e.g. "2.2.1"
3.18. **Call** `sgp_get_tvoc_inceptive_baseline()` **to retrieve the on-chip inceptive baseline and call**
`sgp_set_iaq_baseline()` **to set it.**

The inceptive baseline may only be used on the very first startup of the sensor. It ensures that measured concentrations are consistent with the air quality even before the first clean air event.

The command chain to use the inceptive baseline is thus:

```c
s16 ret;
uint16 tvoc_inceptive_baseline;
ret = sgp_get_tvoc_inceptive_baseline(&tvoc_inceptive_baseline);
if (ret == STATUS_OK) {
    ret = sgp_set_iaq_baseline(tvoc_inceptive_baseline);
    if (ret != STATUS_OK) { /* error */ }
}
```

**Note:** The inceptive baseline may only be used on the very first startup of the sensor.
The inceptive baseline is available on SGP30 with feature set >= 1.1 (0x0021) and SGPC3 with feature set >= 0.5 (0x1005). An error is reported when trying to read the inceptive baseline from a sensor that does not support it.
REVISION HISTORY

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<td>Initial release</td>
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<tr>
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<td>Add CO2-eq output to the driver</td>
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<td>January 2017</td>
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