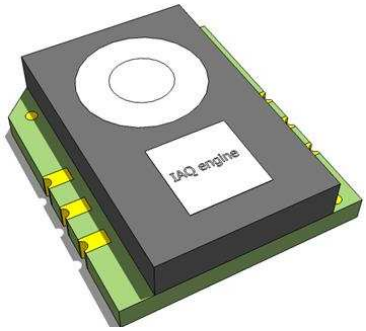
# Manual iAQ-engine

Indoor Air Quality sensor module

- I²C interface
- Analog ouput
- SMD type package




**Product summary**

The iAQ-engine is used to measure VOC levels as CO2 equivalent predictions. The data is available via I²C bus or as an analog output signal. The 0-5V analog output of the iAQ-engine can be used to directly control external devices.

The sensor itself is protected by a plastic cap and a filter membrane. The sensor module can be soldered directly to a host circuit board with selective soldering via the edge connectors. The sensor is protected by a membrane, which should not be removed.

*Note: Please read the I²C addressing instructions carefully. An undefined use of the I²C interface could harm the iAQ-engine module and cause a loss of functionality.*

**Dimensions**

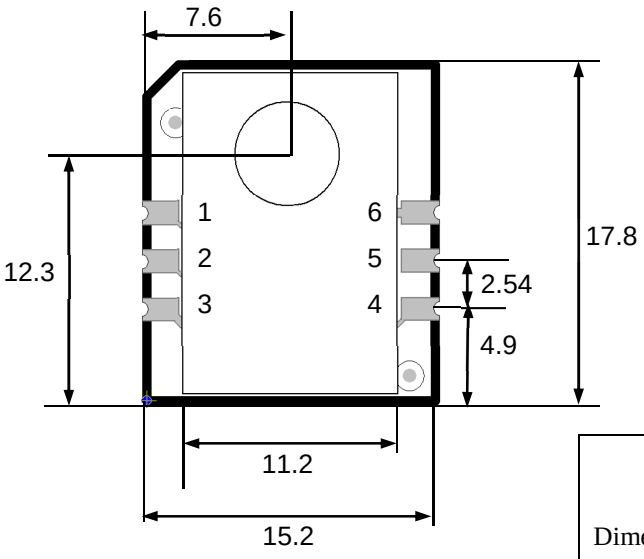



**Figure 1**: iAQ-engine sensor (dimensions in mm, Top View)

| Pin | Name | Comment |
|---|---|---|
| 1 | DAC | 0-5V analog output |
| 2 | SCL | I²C serial clock |
| 3 | GND | Ground |
| 4 | SDA | I²C serial data |
| 5 | NC | Not connected |
| 6 | VCC | +5V |

| | |
|---|---|
| Dimensions (approximate values) | PCB 15.24 x 17.78 mm |
| | HEIGHT PCB 1.7 mm |
| | HOOD 11.2 x 17.78 mm |
| | TOTAL HEIGHT 4.3 mm |
| Sensor position (approximate values) | 7.6 x 12.3 mm<br>Radius 3.5 mm |
| Weight | Approximately 1g |
| IP-Class | 50 (at proper installation) |
| Connector | Card edge (cut via) |

# Contents

# 1 Electrical specifications

## 1.1 Power supply

| | |
|---|---|
| Voltage | 5.0 ± 0.25V, max. 20mV ripple |
| Power consumption | 225mW @ 5.0VDC |

**Note**: decoupling capacitor included in design.

## 1.2 Communication

| | |
|---|---|
| Output signal options | $I^2C$ |
| | DAC (0-5)V linear |
| First functional reading after start up | 15 minutes |

➔ For more communication details see chapter 4

# 2 Environmental specifications

| | |
|---|---|
| Temperature range operation | 0 to 50°C |
| Temperature range storage | -25 to 50°C |
| Humidity range | 5 to 95 %r.h., non-condensing |

# 3 Sensor Features

| | |
|---|---|
| Sensing technology | MEMS metal oxide sensor |
| Sensing range | I²C: 450 – 2000 ppm $CO_2$ equivalents (relative) |
| | DAC: 450 – 2000 ppm $CO_2$ equivalents (relative) |
| Module | Automatic baseline correction |

# 4 I²C Interface

## 4.1 Interface description

### 4.1.1 Physical interface

The physical interface is two-wire open drain SCL (clock) and SDA (data).

| | |
|---|---|
| Pull-up resistors | External pull-up resistor required |
| Clock speed | 100kHz |
| Clock stretching | Bus master clock stretching support is required |

### 4.1.2 Clock stretching

Clock stretching pauses a transaction by holding the clock line low. The transaction cannot continue until the line is released to high again. Although the module could send the bytes of data at a fast rate, it could happen that the module is busy at the request time. It can then hold the clock line low after reception and acknowledgement of a byte to force the master into a wait state until the iAQ-engine module is ready for the next byte transfer in a type of handshake procedure. (See official I²C specification and user manual UM10204, http://www.nxp.com/documents/user_manual/UM10204.pdf)

### 4.1.3 Address

Standard 7 bit I²C address for iAQ-engine is **decimal 90** or **hexadecimal 0x5A**. The addressing byte includes the read/write bit at the lowest significant bit. The communication with the iAQ-engine starts with **0xB5** for reading data.
Please note: avoid addressing the iAQ-engine with write bit. This could cause a loss of communication relevant information on modules side and the iAQ-engine is no longer contactable.

| | Address | | | | | | | R/ W |
|---|---|---|---|---|---|---|---|---|
| **Bit** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| **data** | **1** | **0** | **1** | **1** | **0** | **1** | **0** | **1** |

**Table 1**: Addressing byte for the iAQ-engine

## 4.2 Interface protocol

The standard I²C specification is used for the iAQ-engine interface protocol. The I²C bus master should request 7 bytes. These seven bytes include information about the indoor air quality value, the iAQ-engine status and the resistance of the sensor. If only the indoor air quality value and the status byte is required, the master should request three bytes from the iAQ-engine. All bytes are reported back as shown in the following table. A graphical description for a standard I²C communication with the iAQ-engine module is shown in figure 2 – figure 5.

| Byte | Name | Data type | Typical/example value | Explanation / notes |
|---|---|---|---|---|
| **0-1** | pred | uint16 | 450 | Prediction [ppm] |
| **2** | status | uint8 | 0 | 0x00: OK (data valid)<br>0x01: BUSY (re-read multi byte data!)<br>0x80: ERROR (if constant:replace sensor) |
| **3-6** | resistance | int32 | 256431 | Sensor resistance [Ohm] |

**Table 3**: Read data from the iAQ-engine

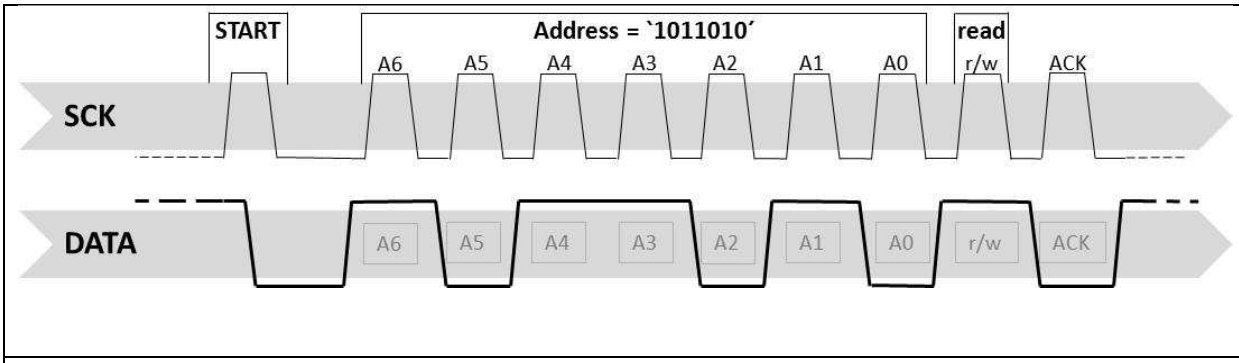



**Figure 2:** The first byte is send by the master, containing address (0x5A) and read/write bit. The slave sends an acknowledgement (ACK) by pulling the data line to low.

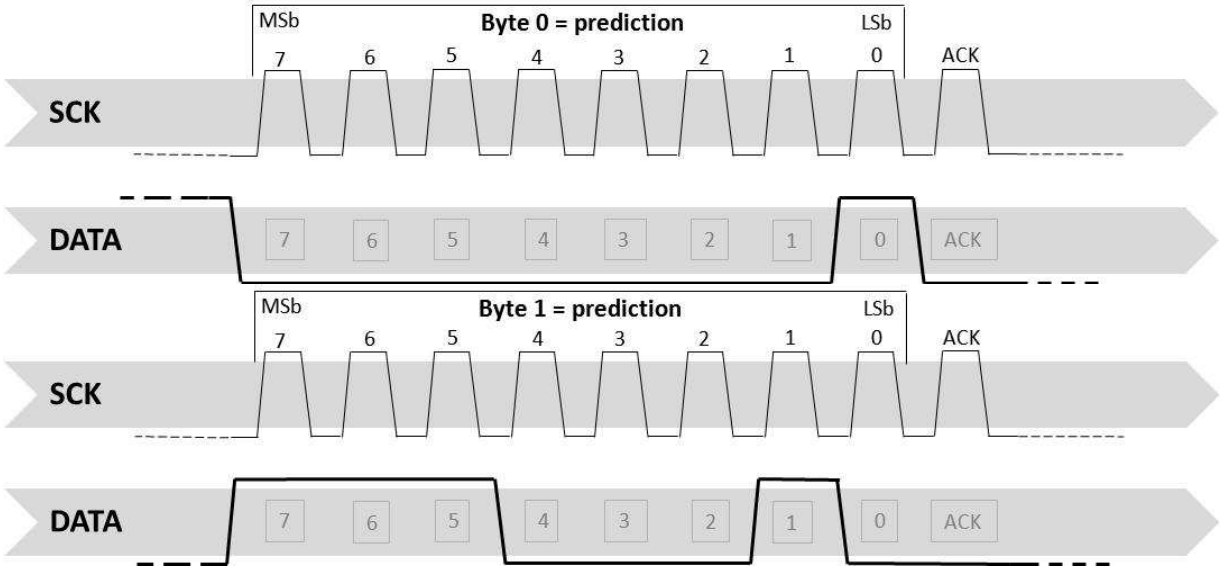



**Figure 3:** The slave will answer by sending bytes with MSB first. Byte0 and byte1 contain the prediction value. All bytes are Acknowledged by the master.

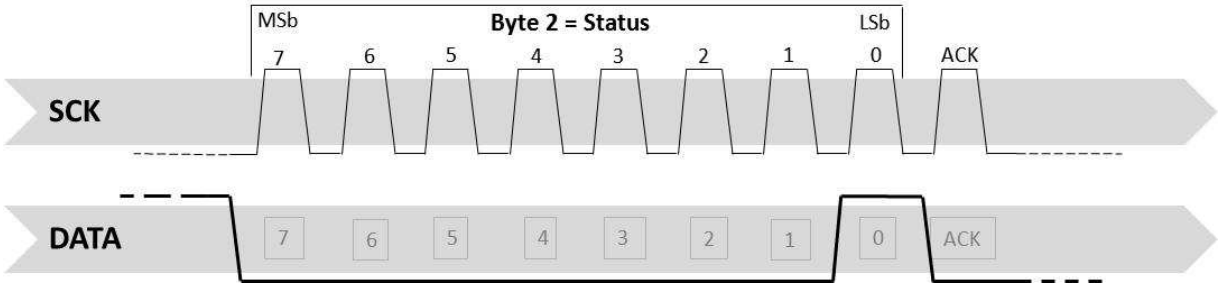



**Figure 4:** The third byte contains the information of the iAQ-engine module state, in this case status = 1. The master answeres with an Acknowledge.

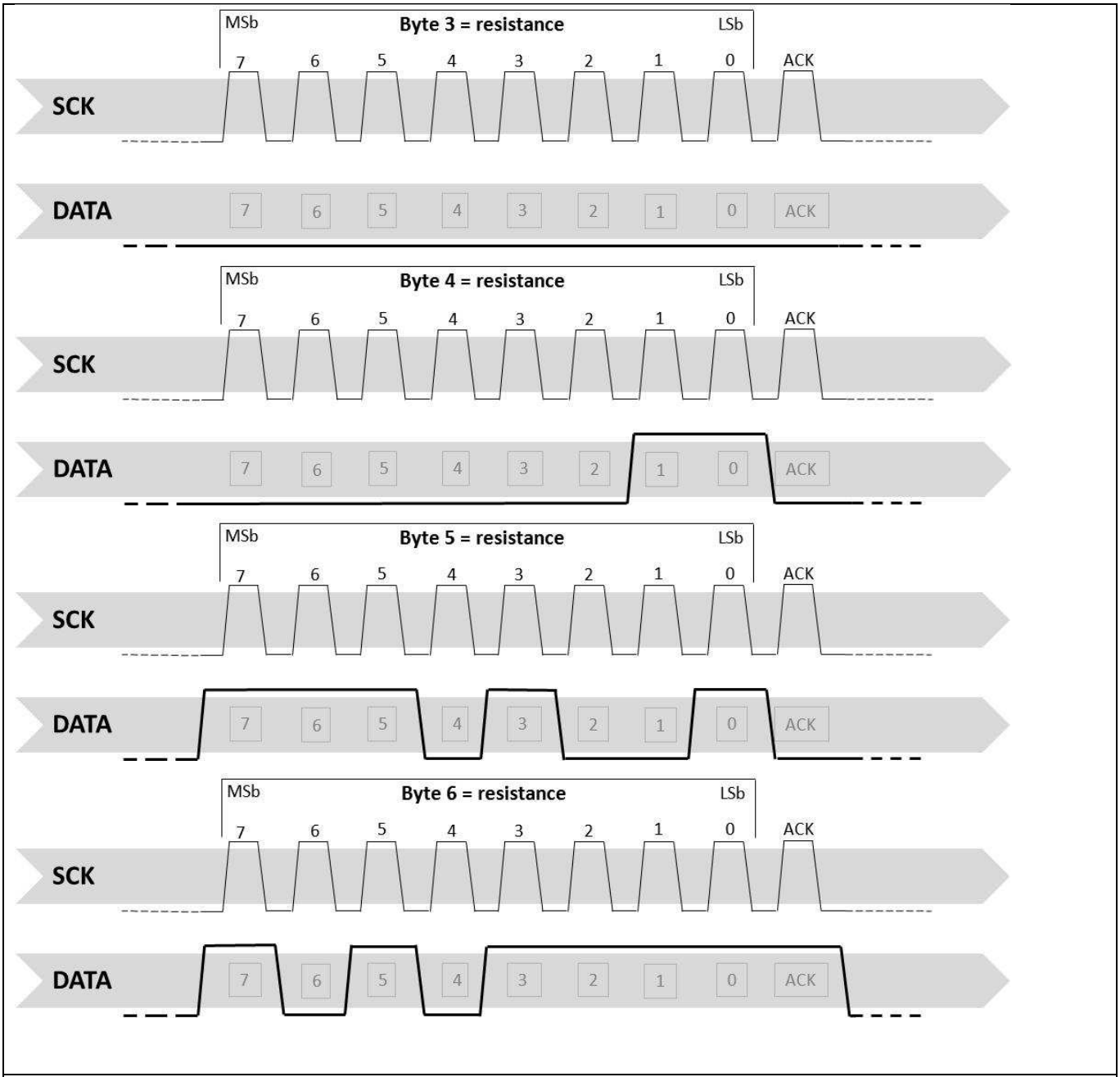



**Figure 5:** The last four bytes contain the resistance value. For the calculation of the resistance only byte4, byte5 and byte 6 are relevant, because byte3 is zero. After the last requested byte, the master sends a Not Acknowledge.

### 4.2.1 Prediction

| Byte0 | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 |
|---|---|---|---|---|---|---|

The first two bytes contain the prediction value, which gives the information about the indoor air quality. The value is a $CO_2$ equivalent and the calculation is shown in the following example.

**Equation 1 :**

$$\boldsymbol{Prediction = byte0 * 2^8 + byte1}$$

### 4.2.2 Status Flag

| Byte0 | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 |
|---|---|---|---|---|---|---|

The third byte indicates status of the module.

- 0x00: OK
- 0x01: BUSY
- 0x80: ERROR

If status is OK the data is valid. If the status is BUSY, the data integrity is not guaranteed for variables of size > 8 bits, because the module may be updating a part of the variable.
If the status is ERROR constantly (or very frequently) this indicates that the module is reading non-realistic values, and the sensor element is probably defective.

### 4.2.3 Resistance

| Byte0 | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 |
|---|---|---|---|---|---|---|

The next four bytes contain the sensor resistance in Ohm. Byte3 is always 0.

**Equation 2:**

$$\boldsymbol{Resistance = byte4 * 2^{16} + byte5 * 2^8 + byte6}$$

# 5 Analog Interface

The analog interface is represented by a 6-bit DAC, which offers the possibility for controlling a system without additional electronic driver. The DAC gives back values linear to the I²C interface in the range 450 ppm to 2000 ppm. For technical reason the output of the 5V DAC is limited and gives not the first and the last step. The minimum resistive load is 100kΩ. To calculate the matching air quality level use the following equation.

**Equation 3:**

$$\boldsymbol{Prediction = 310 * U + 450}$$

# 6 Application Information

## 6.1 Handling Instructions

The iAQ-engine module should be handled carefully, shear stress should be avoided. The sensor is protected by a membrane. This membrane should not be removed or touched.

## 6.2 Soldering Instructions

The iAQ-engine module can be mounted with selective soldering at the edge connectors. For the fact, that the package temperature should not be higher than 80°C, reflow soldering is not applicable.

## 6.3 Typical Application

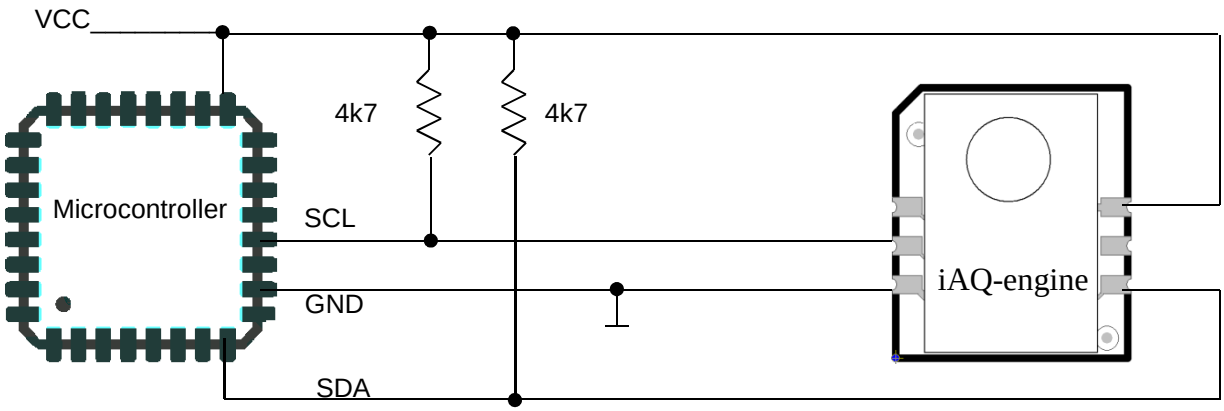



**Figure 6:** Simple microcontroller application

## 6.4 Recommended footprint

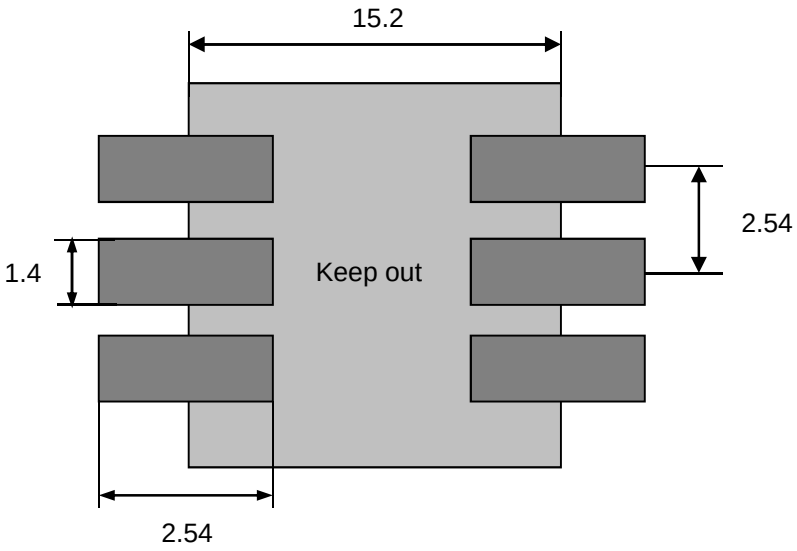



**Figure 7:** Recommended footprint (standard)

## 6.5 Ordering information

| Order code | Comment |
|---|---|
| 60-0100 | iAQ-engine |

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