

Description

The ZMOD4410 Gas Sensor Module is designed for detecting total volatile organic compounds (TVOC) and monitoring indoor air quality (IAQ) in different use cases. It is a 12-pin LGA assembly ($3.0 \times 3.0 \times 0.7$ mm) that consists of a gas sense element and a CMOS signal conditioning IC. The module's sense element consists of heater element on a Si-based MEMS structure and a metal oxide (MOx) chemiresistor. The signal conditioner controls the sensor temperature and measures the MOx conductivity, which is a function of the gas concentration.

The measurement results can be read via an I2C interface with the user's microprocessor, which processes the data to determine the TVOC concentration, IAQ rating, and estimated carbon dioxide (eCO₂) level. Alternatively, depending on the operation mode, the ZMOD4410 software can generate a control signal, which can trigger actions based on odor levels. With its low operating current consumption in Low-Power Operation Mode, the ZMOD4410 is an excellent choice for low-voltage and low-power battery applications. Built-in nonvolatile memory (NVM) stores the configuration and provides space for arbitrary user data.

Typical Applications

- Indoor air monitoring
- Monitor home, office, and personal environments for healthy conditions and comfort
- Detect hazardous materials and unhealthy conditions (e.g., fumes from construction materials)
- Automation based on indoor ambient air quality (HVAC, air purifiers, thermostats, etc.)

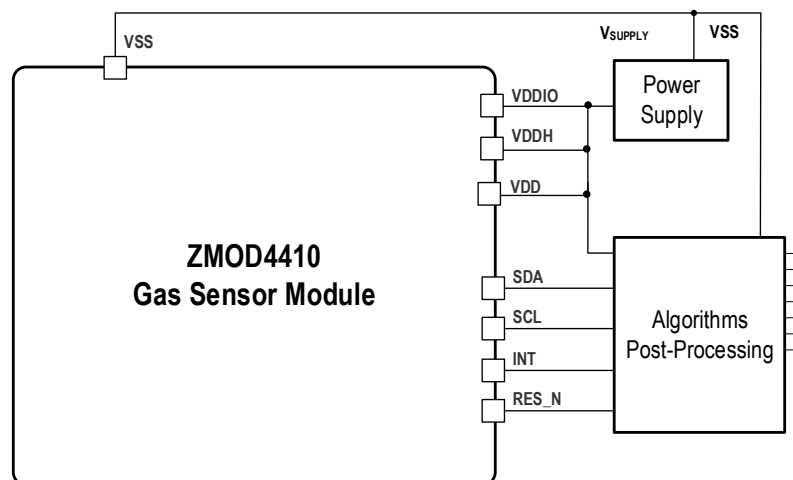
Available Support

- ZMOD4410 Evaluation Kit
- Manuals, application notes, blog, and white papers
- Instructional videos
- Programming libraries, example codes, and algorithm support to optimize performance
- Third-party certification for compliance with well-accepted international IAQ standards

Features

- Measurement of total organic compounds (TVOC) concentrations and indoor air quality (IAQ)
- Module algorithm estimates carbon dioxide level (eCO₂)
- Algorithm to set a control signal to trigger an external action based on IAQ and odor change
- Heater driver and regulation loop for constant heater voltage or constant heater resistance
- Internal auto-compensated temperature sensor; not stress sensitive
- I2C interface: up to 400kHz
- Configurable alarm/interrupt output with static and adaptive levels
- Adjustable ADC resolution for optimal speed versus resolution: 16-bit maximum
- Built-in nonvolatile memory (NVM) for user data
- Very low average power consumption down to 1mW
- Excellent for low-voltage and low-power battery applications
- No external trimming components required
- External reset pin (active-LOW)
- Customization for mobile and consumer applications
- Siloxane resistant
- Supply voltage: 1.7V to 3.6V
- Package: 12-LGA
- Assembly size: $3.0 \times 3.0 \times 0.7$ mm

ZMOD4410 Application Circuit



Contents

| | |
|--|----|
| 1. Pin Assignments..... | 4 |
| 2. Pin Descriptions..... | 4 |
| 3. Absolute Maximum Ratings..... | 5 |
| 4. Operating Conditions..... | 5 |
| 5. Electrical Characteristics..... | 6 |
| 6. Block Diagram..... | 7 |
| 7. Sensor Module Characteristics..... | 8 |
| 7.1 Gas Sensor Module..... | 8 |
| 7.2 Internal Temperature Sensor..... | 8 |
| 8. Gas Sensor Module Operation Modes and Characteristics..... | 9 |
| 8.1 Operation Mode 1: Standard – IAQ and eCO ₂ and Operation Mode 2: Low Power – IAQ and eCO ₂ | 9 |
| 8.1.1 Air Quality – UBA Levels..... | 9 |
| 8.1.2 Air Quality – Estimated Carbon Dioxide Correlation (eCO ₂)..... | 11 |
| 8.2 Operation Mode 3: Odor..... | 11 |
| 8.3 Conditioning and Stability..... | 12 |
| 8.4 Environmental Temperature and Humidity..... | 14 |
| 8.5 Accuracy..... | 14 |
| 9. Assembly Restrictions, Operation, Integration Notes and Storage..... | 15 |
| 10. Test and Calibration..... | 16 |
| 11. I2C Interface and Data Transmission Protocol..... | 16 |
| 12. Related Websites and Software..... | 18 |
| 13. Glossary..... | 18 |
| 14. Package Outline Drawings..... | 19 |
| 15. Ordering Information..... | 19 |
| 16. Revision History..... | 20 |

List of Figures

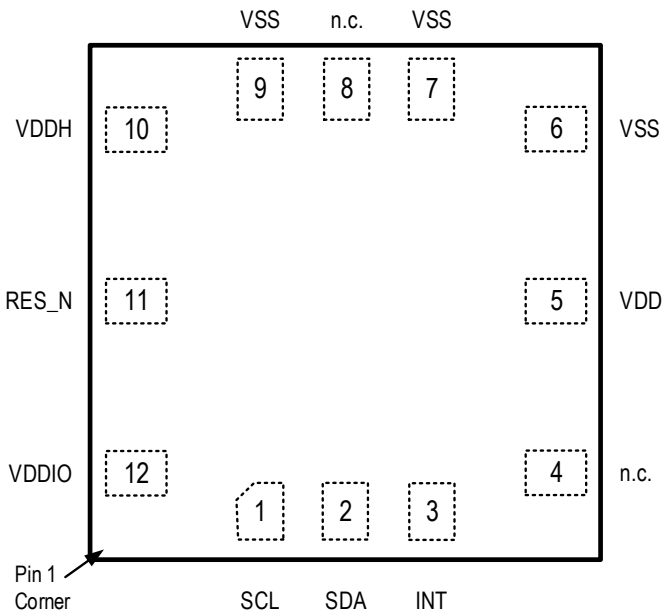
| | |
|---|----|
| Figure 1. ZMOD4410 Pin Assignments for 12-LGA Module – Top View..... | 4 |
| Figure 2. Block Diagram..... | 7 |
| Figure 3. Typical ZMOD4410 Response to Levels of TVOC Described by the UBA using an EPA Standard Mixture..... | 10 |
| Figure 4. Typical Graph of CO ₂ Correlation..... | 11 |
| Figure 5. ZMOD4410 Typical Response Time and Signal Stability for TVOC Exposure..... | 12 |
| Figure 6. Sensor Module Response to Exposures at Different TVOC Concentrations for 2 Hours Each..... | 13 |
| Figure 7. Humidity Influence at Three Different VOC Concentrations..... | 14 |
| Figure 8. Typical Solder Profile..... | 15 |
| Figure 9. I2C Data Transmission Protocol..... | 17 |
| Figure 10. Bus Timing..... | 17 |

List of Tables

| | | |
|-----------|---|----|
| Table 1. | ZMOD4410 Pin Descriptions | 4 |
| Table 2. | Absolute Maximum Ratings | 5 |
| Table 3. | Operating Conditions | 5 |
| Table 4. | ZMOD4410 Electrical Characteristics | 6 |
| Table 5. | Gas Sensor Module Specifications during Operation | 8 |
| Table 6. | Internal Temperature Sensor | 8 |
| Table 7. | Level of Air Quality Based on TVOC Levels Described by the UBA | 10 |
| Table 8. | Measurement of Estimated CO ₂ Levels (eCO ₂) | 11 |
| Table 9. | Control Parameters for Odor Operation | 11 |
| Table 10. | Typical ZMOD4410 Sensor Module Accuracy Achievable with Calibration | 14 |
| Table 11. | Final Test Parameters | 16 |
| Table 12. | Bus Timing Characteristic | 17 |

1. Pin Assignments

Figure 1. ZMOD4410 Pin Assignments for 12-LGA Module – Top View



2. Pin Descriptions

Table 1. ZMOD4410 Pin Descriptions

| Pin Number | Name | Type | Description |
|------------|-------|--------------|---|
| 1 | SCL | Input | Serial clock for the I2C interface. |
| 2 | SDA | Input/Output | Serial data for the I2C interface. Default 7-bit slave address: 32 _{HEX} . |
| 3 | INT | Output | Interrupt signal (push-pull): <ul style="list-style-type: none"> ▪ HIGH when a measurement is running ▪ LOW when a measurement has finished |
| 4 | n.c. | – | Do not connect. |
| 5 | VDD | Supply | Voltage supply for the ZMOD4410. |
| 6 | VSS | Ground | Ground reference for the ZMOD4410. |
| 7 | VSS | Ground | Ground reference for the ZMOD4410. |
| 8 | n.c. | – | Do not connect. |
| 9 | VSS | Ground | Ground reference for the ZMOD4410. |
| 10 | VDDH | Supply | Voltage supply for the integrated heater in the ZMOD4410. |
| 11 | RES_N | Input | ZMOD4410 reset; active low. |
| 12 | VDDIO | Supply | Voltage supply for I/O-interface in ZMOD4410. |

3. Absolute Maximum Ratings

Note: The absolute maximum ratings are stress ratings only. The ZMOD4410 might not function or be operable below and above the recommended operating conditions given in Table 2. Stresses exceeding the absolute maximum ratings will change the sensor accuracy; lead to imprecision, and eventually cause irreversible damage to the device. In addition, extended exposure to stresses above the recommended operating conditions might affect device reliability. IDT does not recommend designing to the “Absolute Maximum Ratings.”

Table 2. Absolute Maximum Ratings

| Symbol | Parameter | Conditions | Minimum | Maximum | Units |
|-----------------------------|---|------------|---------|------------------|-------|
| $V_{DD}, V_{DDH}, V_{DDIO}$ | Maximum Analog and I/O Supply Voltage | | -0.4 | 3.63 | V |
| V_{A_IO}, V_{D_IO} | Maximum Voltage at all Analog and Digital I/O Pins | | -0.5 | $V_{DDIO} + 0.5$ | V |
| | Maximum Difference in Voltage between VDD and VDDH Pins | | – | 0.4 | V |
| I_{IN} | Input Current into any Pin Except Supply Pins (Latch-Up Immunity) | | -100 | 100 | mA |
| V_{HBM1} | Electrostatic Discharge Tolerance – Human Body Model (HBM) | | 2000 | – | V |
| V_{CDM} | Electrostatic Discharge Tolerance – Charged Device Model (CDM) on Packaged Module | | 750 | – | V |
| $T_{OPERATION}$ | Operation Temperature of MOx [a] | | 300 | 300 | °C |
| T_{STOR} | Storage Temperature | | -50 | 125 | °C |

[a] Does not apply for the 10 minute cleaning mode.

4. Operating Conditions

Note: The reference for all voltages is V_{SS} .

Table 3. Operating Conditions

| Symbol | Parameter | Min | Typ | Max | Unit |
|-----------|--|-----|-----|-----|------|
| V_{DD} | Supply Voltage | 1.7 | – | 3.6 | V |
| T_{AMB} | Ambient Temperature Range for Sensor Operation | -40 | – | 65 | °C |

5. Electrical Characteristics

Values below are valid at operating conditions unless noted otherwise.

Table 4. ZMOD4410 Electrical Characteristics

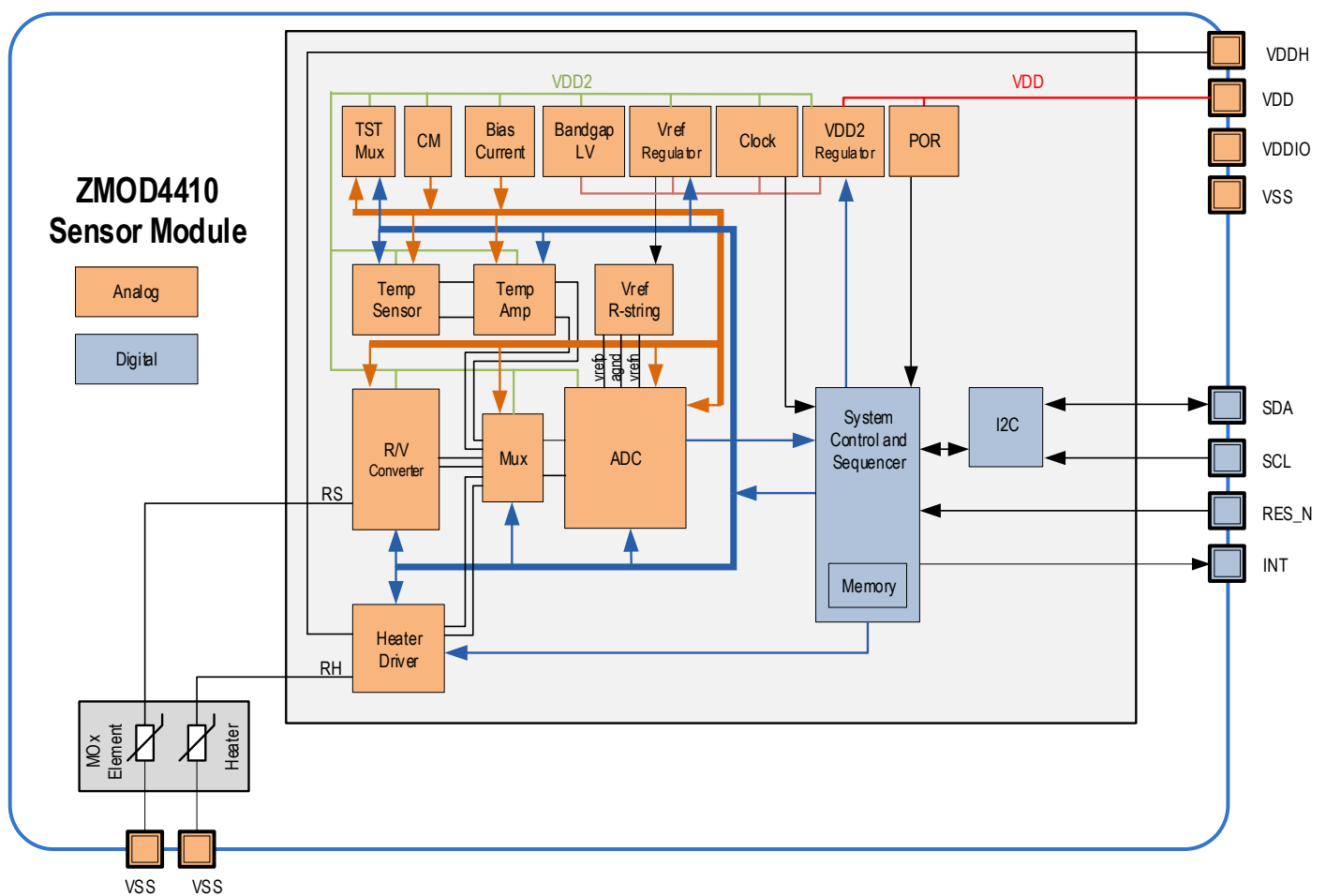
| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|--------------------------|---|--|---------|---------|---------|-------|
| | Average Power ZMOD4410 | Standard and Odor Operation Mode | – | 23 | – | mW |
| | | Low Power Operation Mode | – | 1 | – | mW |
| I _{ACTIVE} | Supply Current, Active Mode including Heater Current during Standard and Odor Operation Modes | At V _{DD} = 1.8 V | | 13 | | mA |
| | | At V _{DD} = 3.3V | | 7 | | mA |
| I _{SLEEP_Timer} | Supply Current, Sleep Mode ASIC with Wake-up Timer Active | Does not include heater current. | – | – | 500 | μA |
| I _{SLEEP} | Supply Current, Sleep Mode ASIC, No Wake-up Timer Active | Does not include sensor heater current. | – | 450 | – | nA |
| PSRR | Power Supply Rejection Ratio | V _{DD} ≥ 2.0V | – | 30 | – | dB |
| | Timing Accuracy (Valid for Measurements Only) (Sleep Timer is ±20%) | At room temperature; for timings derived from the internal clock. | -2 | – | 2 | % |
| | | Over-temperature range; for timings derived from the internal clock. | -0.1 | – | 0.1 | %/K |
| r _{ADC} | ADC Resolution | | 10 | – | 16 | Bit |
| t _{meas} | ADC Conversion Time | 10-bit, no auto-zero. | – | 0.238 | – | ms |
| | | 10-bit, auto-zero. | – | 0.476 | – | ms |
| | | 16-bit, auto-zero. | – | 3.36 | – | ms |
| V _{ref} | Reference Voltage | | – | 1.5 | – | V |
| I _{HTR_meas} | Heater Resistance Measurement Current | HTR_range=0 | – | 0.4 | – | mA |
| | | HTR_range=1 | – | 0.6 | – | mA |
| | | HTR_range=2 | – | 1.0 | – | mA |
| t _{STA1} | Start-up Time: V _{DD} Ramp up to Interface Communication | | – | – | 1 | ms |
| t _{STA2} | Start-up Time: V _{DD} Ramp up to Analog Operation | | – | – | 2.5 | ms |
| t _{WUP1} | Wake-up Time for Sleep to Active Mode: Interface Communication | | – | – | 0.5 | ms |
| t _{WUP2} | Wake-up Time for Sleep to Active Mode: Analog Operation | | – | – | 2 | ms |
| f _{c,I2C} | I2C Clock Frequency | | – | – | 400 | kHz |
| t _{VPP} | NVM Programming Time | | – | 6 | 16 | ms |
| t _{RET_FTP} | Data Retention | 85°C junction temperature | 10 | – | – | years |

| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|--------|-------------------------------------|---------------------------|---------|-------------------|---------|--------|
| | NVM Programming Cycles | | 1000 | – | – | cycles |
| | Default Communication Address | 7-bit slave address | – | 32 _{HEX} | – | – |
| | Blocking Capacitor for Power Supply | Recommended, ceramic type | 100 | – | – | nF |

6. Block Diagram

Note: See section 12 for definitions of abbreviations.

Figure 2. Block Diagram



7. Sensor Module Characteristics

7.1 Gas Sensor Module

The ZMOD4410 Gas Sensor Module is designed to detect typical TVOC contaminations based on studies and international standards for indoor air quality. Characteristic module parameters are shown in Table 5. The response time for a gas stimulation is always within a few seconds, depending on the TVOC and its concentration. An active or direct airflow onto the sensor module is not necessary since diffusion of ambient gas does not limit the sensor response time.

Important: The ZMOD4410 is also able to detect safety-relevant gases for indoor air, such as carbon monoxide (CO); however, the sensor is not designed to detect these interferants reliably and therefore it is not approved for use in any safety-critical or life-protecting applications. It must not be used in such applications, and IDT disclaims all liability for any such use.

Table 5. Gas Sensor Module Specifications during Operation

| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Unit [a] |
|--------|----------------------------------|---|---------|----------|---------|-----------------|
| | Measurement Range | Ethanol in air | 0 | | 1000 | ppm |
| | | | 0 | | 1000000 | ppb |
| | IAQ Specified Measurement Range* | Ethanol in air | 160 | | 30000 | ppb |
| | Humidity Range | Non-condensing | 0 | | 90 | % RH |
| S | Sensitivity over Lifetime | Resistance in air / resistance at 10ppm ethanol | | 15 | | Ω/Ω |
| | Repeatability | Variation in sensor signal | | ± 10 | | % |
| T-90 | Sensor Response Time [b] | Time to change to 90% of end value | | 5 | | s |

[a] The abbreviation ppm stands for “parts per million,” and ppb is an abbreviation for “parts per billion.” For example, 1 ppm equals 1000 ppb.

[b] Response times depend on TVOC gas and concentration.

7.2 Internal Temperature Sensor

Table 6. Internal Temperature Sensor

| Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|------------------------|-----------------------|---------|---------|---------|--------|
| Temperature Resolution | Range: -40°C to +65°C | – | 0.0165 | – | °C/LSB |
| Tolerance | Without calibration | -5 | – | 5 | K |

* Umweltbundesamt, *Beurteilung von Innenraumluftkontaminationen mittels Referenz- und Richtwerten*, (Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 2007).

8. Gas Sensor Module Operation Modes and Characteristics

This section covers information on the different operation modes of the ZMOD4410. At present, three operation modes are released.

Family of IAQ software releases:

- Operation Mode 1: Standard – measurement of UBA levels for IAQ and eCO₂
- Operation Mode 2: Low Power – measurement of UBA levels for IAQ and eCO₂
- Operation Mode 3: Odor – control signal based on IAQ changes

Further, details for sensitivity, reliability, sample rates, and sensor influences are explained in detail in the following sections. All graphs and information show the typical responses that are to be expected from the sensor module upon exposure to a variety of test conditions. More technical detailed information on sensitivity, selectivity, and stability for all operation modes is given in IDT's *ZMOD4410 Application Note – TVOC Sensing*. For additional information, including application notes, white papers, blog, and manuals, visit www.idt.com/ZMOD4410.

8.1 Operation Mode 1: Standard – IAQ and eCO₂ and Operation Mode 2: Low Power – IAQ and eCO₂

These operation modes are used for absolute measurements of indoor air quality according to UBA with eCO₂.

Note: Modes 1 and 2 have the same output signal and the same sensor performance.

The only differences are the power consumption and sample rate:

- Standard Operation Mode (1) will provide continuous data depending on the customer application and MCU polling.
- Low-Power Operation Mode (2) has a fixed sampling interval of 6 seconds.

The following sections cover information on TVOC gases, concentrations, and thresholds given by the German Federal Environmental Agency (UBA)* and the US Environmental Protection Agency (EPA). These standards provide reliable information on indoor air quality and recommendations for air improvements if necessary.

8.1.1 Air Quality – UBA Levels

The algorithm provided by IDT for the user's microprocessor uses the output from the ZMOD4410 to determine the relative level of TVOC gases present (see IDT's *ZMOD4410 Programming Manual – Read Me*; see section 12). The algorithm features an automated baseline correction function, ensuring that the module can learn from its environment and distinguish elevated levels of TVOC under all conditions. The proprietary metal oxide (MOx) used in the sensor ensures the ability of the sensor module to respond effectively to changing TVOC levels during long-term operation.

IDT has adopted the definition of TVOCs and their impact on user health and comfort proposed by the UBA; see Table 7. In Standard and Low-Power Operation Mode, the ZMOD4410 Gas Sensor Module is able to detect the presence of elevated TVOC levels as described in the UBA study.*

There are many sources of poor indoor air quality that can elevate TVOC levels in the typical home or office environments, and the types of TVOC that might be present can vary widely. Additional information on this topic is available in IDT's *ZMOD4410 White Paper – Overview of TVOC and Indoor Air Quality*.

The ZMOD4410 is able to respond reliably to all of the types of organic compounds that are typically found in indoor environments. To assess the response of the gas sensor module to the levels described in the UBA study, the module has been tested using several TO-15/17 multi-component TVOC standard defined by the EPA. The ZMOD4410 response to the EPA standard with the TVOC levels from UBA is shown in Figure 3. A third-party report and certification from an independent research lab is available on the IDT website confirming the very good conformity for IAQ measurements with respect to the UBA study and EPA standard.

* Umweltbundesamt, *Beurteilung von Innenraumluftkontaminationen mittels Referenz- und Richtwerten*, (Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz, 2007).

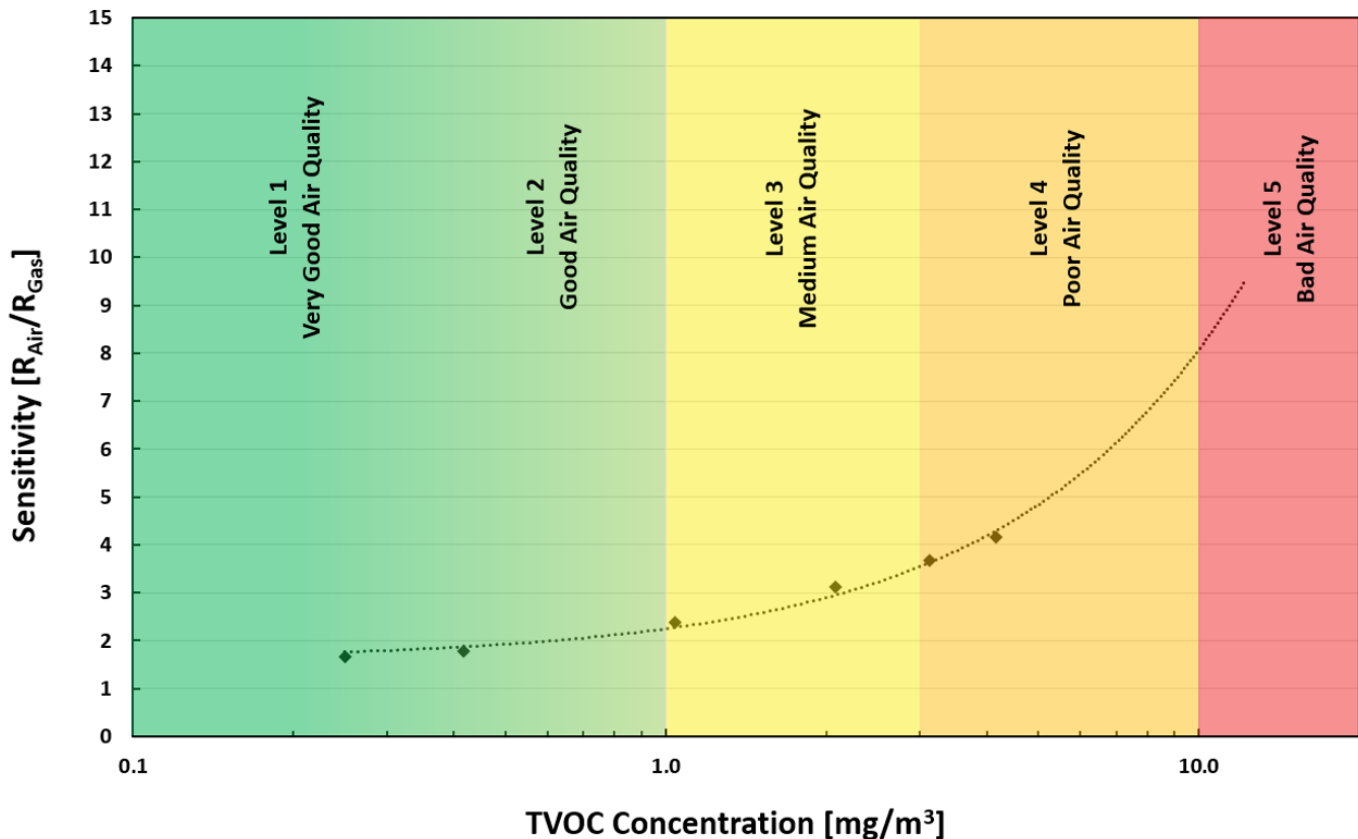
Table 7. Level of Air Quality Based on TVOC Levels Described by the UBA

| IDT IAQ Rating | Reference Level* | Air Information | TVOC (mg/m ³) [a] | Air Quality |
|----------------|------------------|---|-------------------------------|-------------|
| ≤ 1.99 | Level 1 | Clean Hygienic Air (target value) | < 0.3 | Very Good |
| 2.00 to 2.99 | Level 2 | Good Air Quality (if no threshold value is exceeded) | 0.3 to 1.0 | Good |
| 3.00 to 3.99 | Level 3 | Noticeable Comfort Concerns (not recommended for exposure > 12 months) | 1.0 to 3.0 | Medium |
| 4.00 to 4.99 | Level 4 | Significant Comfort Issues (not recommended for exposure > 1 month) | 3.0 to 10.0 | Poor |
| ≥ 5.00 | Level 5 | Unacceptable Conditions (not recommended) | > 10.0 | Bad |

[a] Conversion from mg/m³ to ppm for most common TVOC is by the factor approximately 0.5; for example, 10mg/m³ equals approximately 5ppm. Conversion from ppm to ppb is by the factor 1000; for example, 0.1ppm equals 100ppb.

Figure 3. Typical ZMOD4410 Response to Levels of TVOC Described by the UBA using an EPA Standard Mixture

Note: TVOC is a subset comprising 25 of the EPA's TO-15/17 certified mixtures.



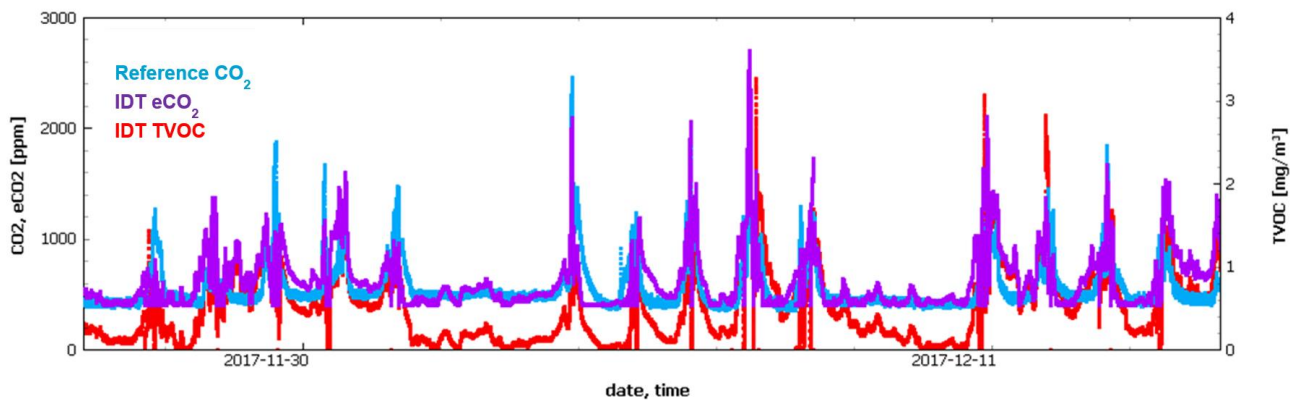
8.1.2 Air Quality – Estimated Carbon Dioxide Correlation (eCO₂)

A very reliable correlation can be made based on TVOC levels for situations where an elevated carbon dioxide (CO₂) concentration is caused by human occupancy, although the sensor module is not directly responsive to CO₂. IDT has developed a robust, patent pending, correlation between elevated VOCs and CO₂ attributable to human occupancy in a wide variety of living spaces, including homes and offices. The correlation is able to predict the CO₂ level as shown in Figure 3. Additional details for IDT's CO₂ correlation are available in IDT's *ZMOD4410 Application Note – Estimating Carbon Dioxide*.

Table 8. Measurement of Estimated CO₂ Levels (eCO₂)

| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|------------------|------------------------------------|---|---------|---------|---------|------|
| eCO ₂ | Estimated CO ₂ Range | Human occupied space (home, office, etc.) | 400 | | 5000 | ppm |
| | Estimated CO ₂ Accuracy | Versus reference nondispersive Infrared (NDIR) reference instrument | | ±25 | | % |

Figure 4. Typical Graph of CO₂ Correlation



8.2 Operation Mode 3: Odor

Operation Mode 3 can be used to control an external device, such as a fan or ventilation system, based on the IAQ changes.

IDT provides firmware and algorithms, which allow the ZMOD4410 to learn its environment. The gas sensor module will only respond to changes in the ambient conditions by detecting changes in the relative ambient TVOC concentration. When a user-defined threshold is exceeded, an I/O control signal (trigger) based on the algorithm output may control an external device. Recommendation: Activate the external device for at least a few minutes (stop delay time) to ensure air quality improvement and avoid an on-off activation at the threshold limit.

Table 9. Control Parameters for Odor Operation

| Parameter | Conditions | Typical Value | Unit |
|---------------------------|---|---------------|------|
| Learning Time Environment | Typical value valid for sample rate of 10 seconds | 60 | min |
| Sensor Response Time | Sample rate dependent, typically 1 sample | 10 | s |
| Threshold Trigger | Change of raw sensor signal; recommended difference: 30% | 1.3 | – |
| Stop Delay | Stop delay for external device; defines minimum activation time | 2 | min |

When using the ZMOD4410 Evaluation Kit, the AD5 pin (GPIO) on connector K3 on the ZMOD4410 HiCom Communication Board is the trigger control signal output that is set to HIGH/LOW for Operation Mode 3. For more details, refer to the *ZMOD4410 Evaluation Kit User Manual*.

8.3 Conditioning and Stability

The ZMOD4410 will respond to TVOC immediate upon start-up; however, a conditioning period of 48 hours in an ambient environment is recommended to improve stability and get maximum performance. Best results are achieved with continuous operation, as the module algorithm is able to learn about the environment over time.

Figure 5 shows the ZMOD4410 sensor module's raw data response during standard operation (Mode 1) to clean air with 30%RH and its response to 5ppm, 10ppm, and 20ppm ethanol mixed in clean air. The result is a very stable, fast changing, and repeatable sensor signal with a high sensitivity. Signal stability even at high TVOC indoor air quality contaminations is shown in Figure 6.

Figure 5. ZMOD4410 Typical Response Time and Signal Stability for TVOC Exposure

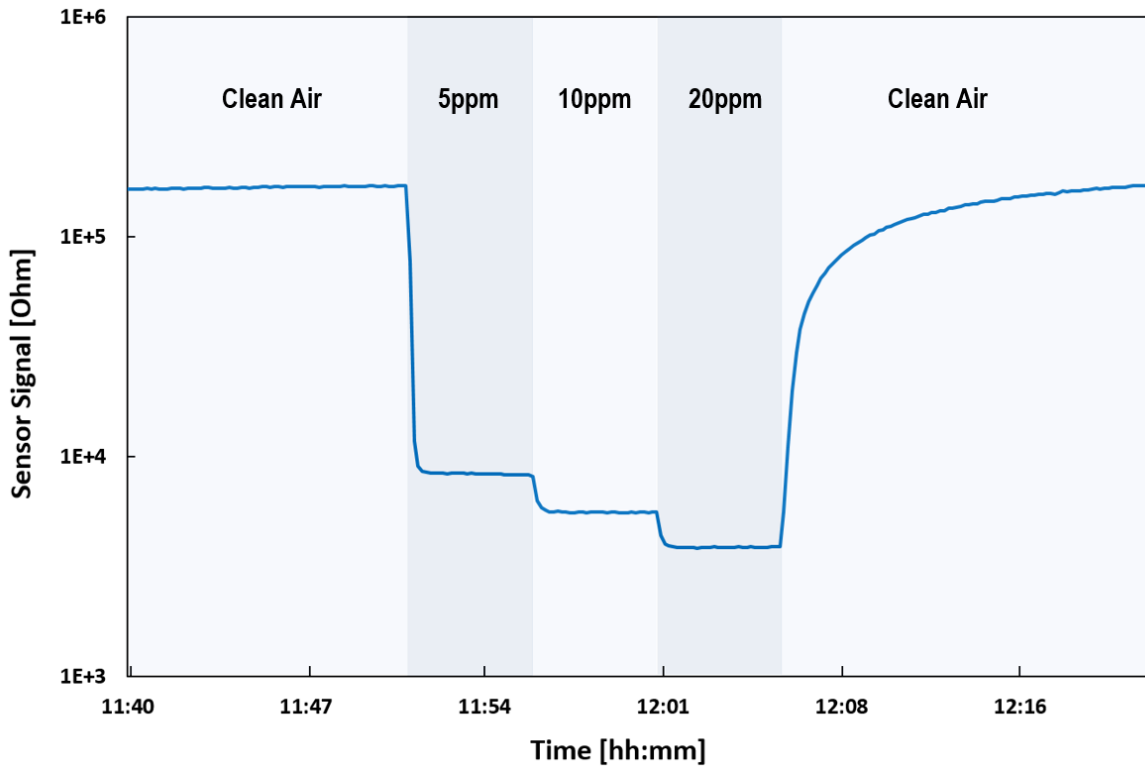
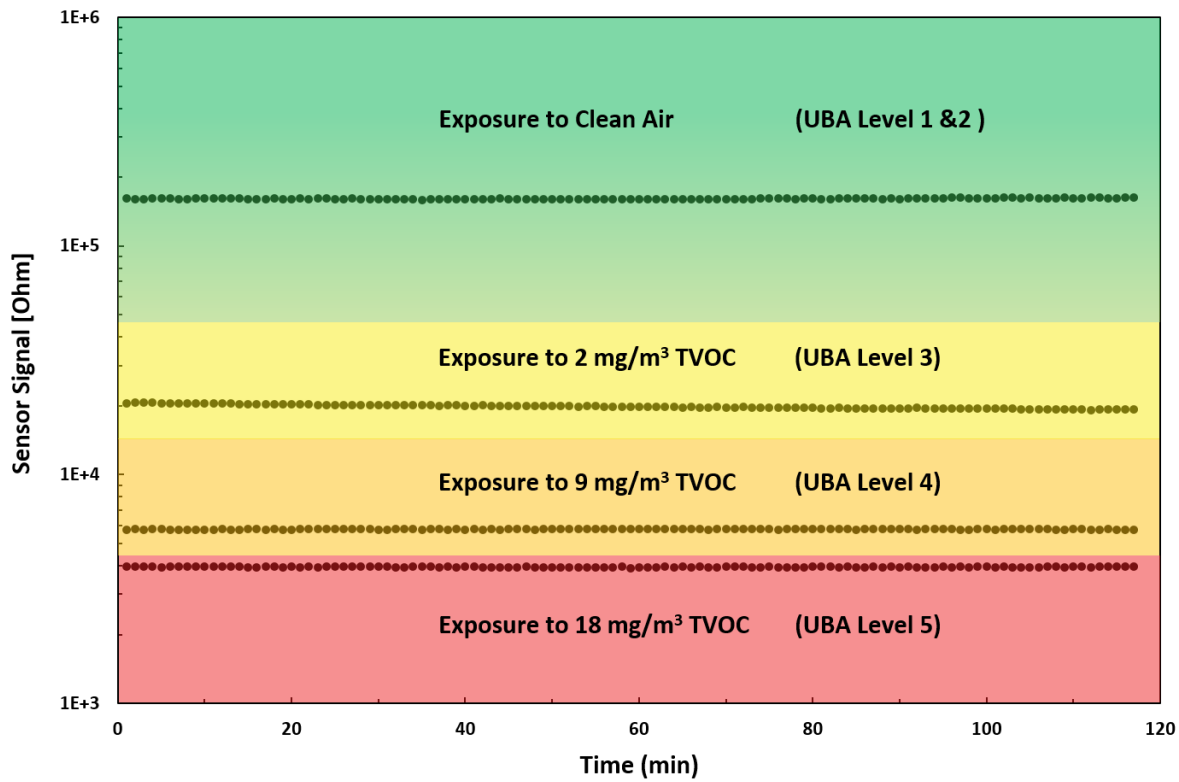
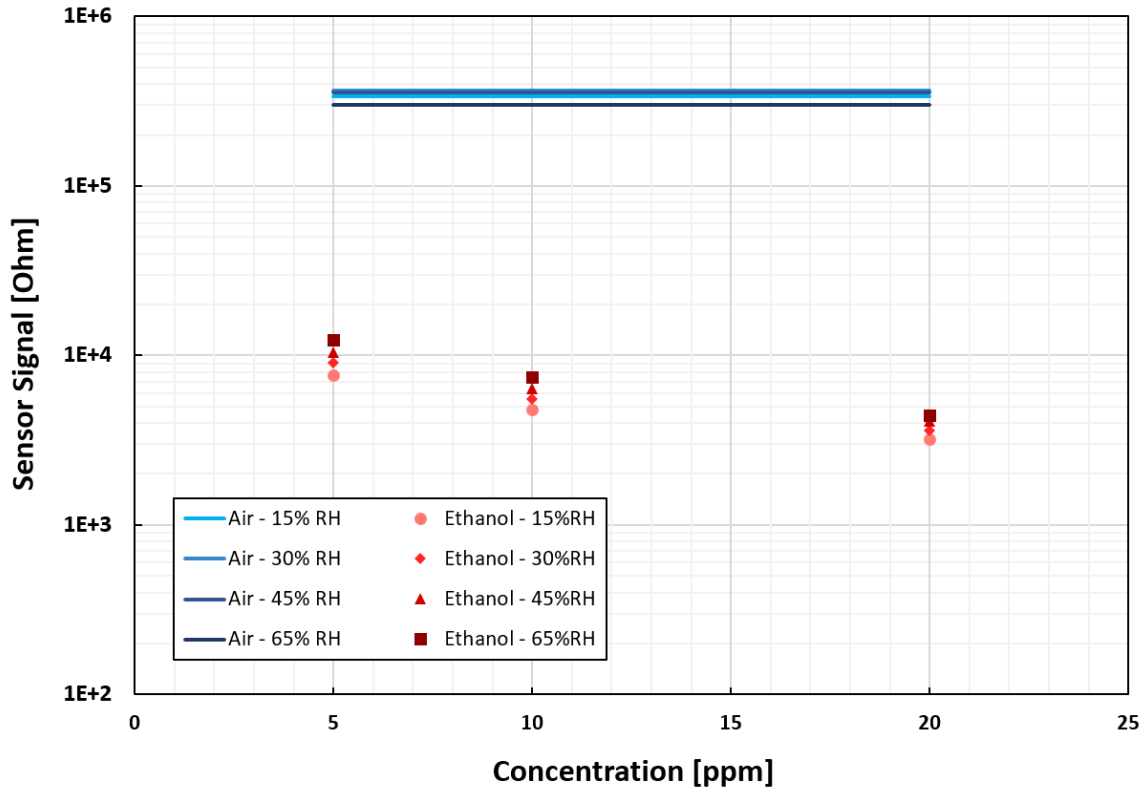


Figure 6. Sensor Module Response to Exposures at Different TVOC Concentrations for 2 Hours Each

8.4 Environmental Temperature and Humidity

Although the sensor module is tested, qualified, and functional in the range of -40°C to +65°C, the best performance according to its calibration is achieved in the temperature range of 0°C to +40°C. Figure 7 shows the module’s response during standard operation (Mode 1) to variations in the range from 15% to 65% relative humidity for ethanol concentrations mentioned in section 8.3.

Figure 7. Humidity Influence at Three Different VOC Concentrations



8.5 Accuracy

All IDT gas sensor modules come with electrical and chemical factory calibration with data stored in the module’s nonvolatile memory (NVM). Using the software provided by IDT and the calibration coefficients in the NVM will lead to stable measurement of the UBA level discussed in section 8.1.1 with a maximum deviation of 1 category over the module’s lifetime.

Users who require an absolute measurement with the maximum achievable accuracy are advised to re-calibrate the sensor with a known organic compound. This enables an absolute accuracy of ±15% in standard operation (Mode 1); see Table 10. For some environments, an interference response to siloxanes is of concern; however, IDT’s ZMOD4410 has proven to be resistant against siloxanes. A maximum potential life-time exposure has been simulated in all ZMOD4410 operation modes by applying the chemicals D4 (octamethylcyclotetrasiloxane) and D5 (decamethylcyclopentasiloxane) in high concentration for several hundred hours. For more information on test conditions and results, refer to IDT’s *ZMOD4410 Application Note – TVOC Sensing*.

Table 10. Typical ZMOD4410 Sensor Module Accuracy Achievable with Calibration

| Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|-------------------------|-----------------------------|---------|---------|---------|------|
| Accuracy | With additional calibration | | ±15 | | % |
| Durability to Siloxanes | Change in sensitivity | | ±5 | | % |

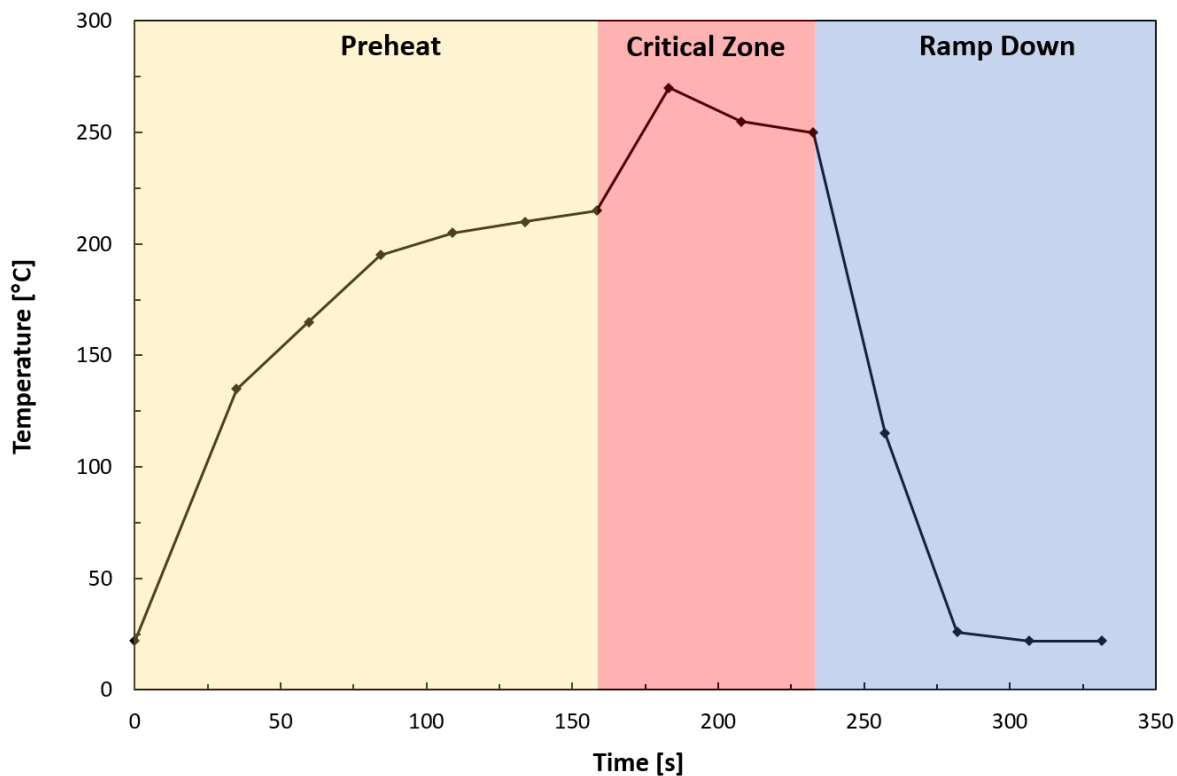
9. Assembly Restrictions, Operation, Integration Notes and Storage

When implementing the ZMOD4410 in electrical circuit boards, it should be understood that a gas sensor module might react to chemicals during the assembly process and to outgassing components, such as resins from the printed circuit board (PCB) assembly. A standard soldering profile can be used to assemble the ZMOD4410 on the user's PCB and should fulfill the IPC/JEDEC J-STD-020C Standard ("Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices"). A typical lead-free reflow solder profile is shown in Figure 8. After assembly, an outgassing of the PCB and electronic components must be considered, especially when operating the sensor module at elevated temperatures. This will ultimately influence the sensor signal and may dominate the air quality reading. A PCB heat treatment before assembling the ZMOD4410 is recommended. After the gas sensor module assembly, no coating, cleaning, or ultrasonic bath should be applied to the PCB. Also, after assembly, IDT recommends cleaning the sensor module by operating it at 450°C for 10 min to remove any contamination of solder vapor.

Store the sensor in an antistatic metallic bag with a low VOC background after the sensor module is removed from its original packaging or the assembled PCB is populated. The optimal storage conditions are <1 ppm TVOC, 10°C to 50°C, and humidity levels within 20% to 80%RH. If the sensor is stored outside of these conditions for extended periods of time, the sensor readings can exhibit a temporary offset. The sensor can be reconditioned and brought back to its calibration state by operation for 24 hours to 48 hours in clean air.

To operate the ZMOD4410, the software and libraries provided by IDT can be used. For implementing the sensor module in a customer-specific application, detailed information on the programming is available. The *ZMOD4410 Programming Manual - Read Me* explains documentation, libraries for supported controllers and compilers, code examples in C, and the minimum requirements for the host MCU for an easy integration (see section 12).

Figure 8. Typical Solder Profile



10. Test and Calibration

As a unique feature, all sampled gas sensor modules are fully tested during IDT's final test. The final test parameters in Table 11 are applied for each ZMOD4410. All sensor modules are pre-stabilized in the final test although the user might see a small change in the module's raw signal during an initial warm-up phase during the first operation. The gas sensor module qualification is based on JEDEC (JESD47) and its subsequent standard (JESD22, JESD78 etc.); it has been tested for a lifetime of 5 years. IDT has proven an MOx lifetime of over 15 years in actual continuous operation in conditions without exposures to stressful environments.

Table 11. Final Test Parameters

| Test | Test Object | Parameters | Test Results Saved in NVM? |
|------------|-------------|---|----------------------------|
| Electrical | ASIC | Voltages, current consumption, frequencies, scan pattern | No |
| Electrical | Module | Calibration conditions, tracking ID, resistances | Yes |
| Gas | Module | Sensitivity parameters (slope and intercept) at stimulation with different gas concentrations | Yes |
| Gas | Module | Pre-stabilization | No |

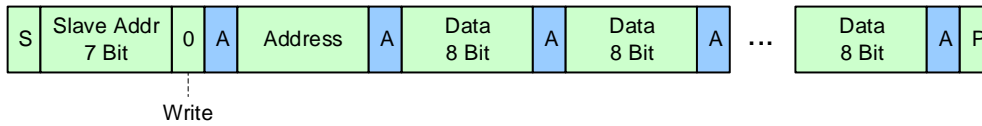
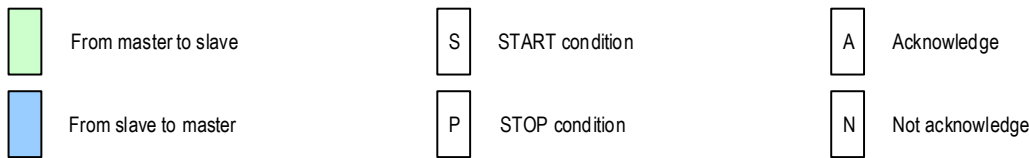
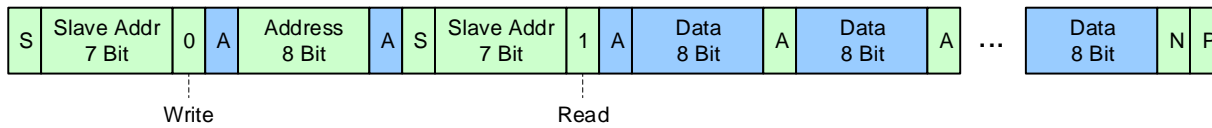
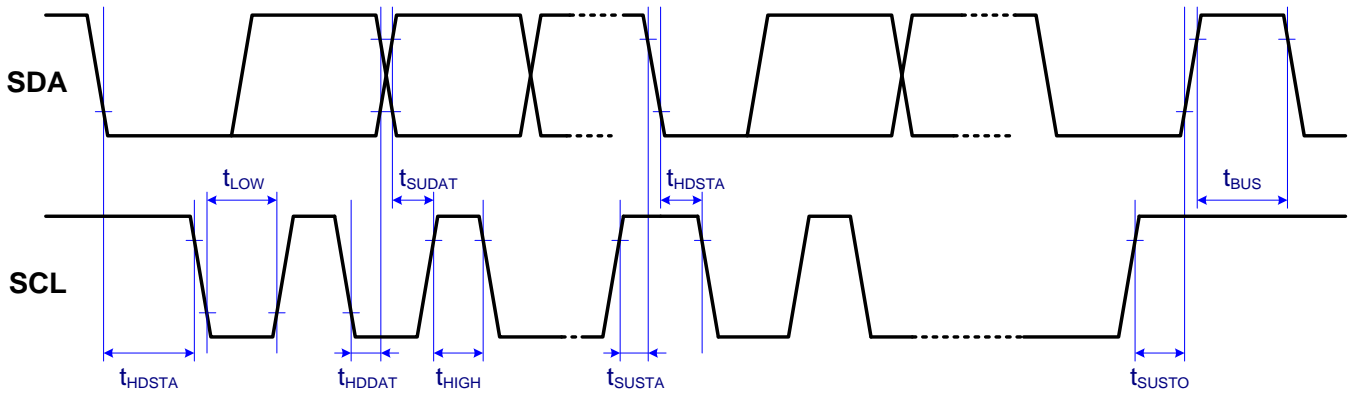
11. I2C Interface and Data Transmission Protocol

The I2C slave device interface supports various bus speeds: Standard Mode ($\leq 100\text{kHz}$) and Fast Mode ($\leq 400\text{kHz}$).

By default, the 7-bit slave address for the serial I2C data interface is set to 32_{HEX} . The implemented data transmission protocol is similar to the one used for conventional EEPROM devices. The register to read/write is selected by a register address pointer. This address pointer must be set during an I2C write operation. After transmission of a register, the address pointer is automatically incremented. An increment from the address FF_{HEX} rolls over to 00_{HEX} .

For more information on I2C, see Figure 9 for an illustration of the data transmission protocol and Figure 10 for information on bus timing. See Table 12 for I2C bus characteristics.

To validate the read/write access it is possible to write random values to registers $0x88$ to $0x8B$ and read them afterwards. After register testing reset the device by disconnecting the power support; otherwise the device may not operate properly.

Figure 9. I2C Data Transmission Protocol
WRITE Access RAM

READ Access NVM and RAM

Figure 10. Bus Timing

Table 12. Bus Timing Characteristic

| Parameter | Symbol | Standard Mode | Fast Mode | Units |
|--|-------------|---------------|-----------|---------|
| Maximum SCL clock frequency | f_{SCL} | 100 | 400 | kHz |
| Minimum START condition hold time relative to SCL edge | t_{HDSTA} | 4 | | μs |
| Minimum SCL clock low width | t_{LOW} | 4.7 | | μs |
| Minimum SCL clock high width | t_{HIGH} | 4 | | μs |
| Minimum START condition setup time relative to SCL edge | t_{SUSTA} | 4.7 | | μs |
| Minimum data hold time on SDA relative to SCL edge | t_{HDDAT} | 0 | | μs |
| Minimum data setup time on SDA relative to SCL edge | t_{SUDAT} | 0.1 | 0.1 | μs |
| Minimum STOP condition setup time on SCL | t_{SUSTO} | 4 | | μs |
| Minimum bus free time between stop condition and start condition | t_{BUS} | 4.7 | | μs |

12. Related Websites and Software

Visit the ZMOD4410 and ZMOD4410 Evaluation Kit (ZMOD4410-EVK) product pages on IDT's website to download software and the latest version of related documents, such as application notes, white papers, product briefs, and third party reports.

Note that some documents require logging in with a free customer account, which can be set up under the "LOG IN" button on www.IDT.com. Some downloads require an additional step to complete a request form that appears when the link is clicked.

| Product | Web Page |
|--------------|--|
| ZMOD4410 | www.IDT.com/ZMOD4410 |
| ZMOD4410-EVK | www.IDT.com/ZMOD4410-EVK |

If further support is needed for downloading, contact IDT via the contact information on the last page.

13. Glossary

| Term | Description |
|------|---|
| ADC | Analog-to-Digital Converter |
| CDM | Charged Device Model |
| CM | Common Mode Generator |
| HBM | Human Body Model |
| LGA | Land Grid Array |
| LV | Low Voltage |
| MOx | Metal Oxide |
| MSL | Moisture Sensitivity Level |
| Mux | Multiplexer |
| n.a. | Not Applicable |
| NVM | Nonvolatile Memory |
| POR | Power-On Reset |
| SDA | Serial Data |
| SCL | Serial Clock |
| SSC | Sensor Signal Conditioner |
| TST | Test |
| TVOC | Total Volatile Organic Compounds |
| UBA | Umweltbundesamt (German Federal Environmental Agency) |

14. Package Outline Drawings

The package outline drawings are appended at the end of this document and are accessible from the link below. The package information is the most current data available.

<https://www.idt.com/document/psc/12-lga-package-outline-drawing-30-x-30-x-07-mm-body-05-x-10-mm-pitch-lgg12d1>

15. Ordering Information

| Orderable Part Number | Description and Package | MSL Rating | Carrier Type | Temperature |
|-----------------------|---|------------|--------------|----------------|
| ZMOD4410AI1V | ZMOD4410 Sensor Module, 3.0 × 3.0 × 0.7 mm 12-LGA | 3 | Tray | -40°C to +65°C |
| ZMOD4410AI1R | ZMOD4410 Sensor Module, 3.0 × 3.0 × 0.7 mm 12-LGA | 3 | Reel | -40°C to +65°C |
| ZMOD4410-EVK-HC | ZMOD4410 Evaluation Kit including the ZMOD4410 Sensor Board, ZMOD4410 HiCom Communication Board (USB Interface), and Micro-USB Cable. (The ZMOD4410 Evaluation Software is available for download free of charge on www.IDT.com/ZMOD4410-EVK .) | | | |

16. Revision History

| Revision Date | Description of Change |
|--------------------|--|
| July 30, 2019 | <ul style="list-style-type: none"> MSL rating corrected in the Ordering table. |
| May 9, 2019 | <ul style="list-style-type: none"> Addition of storage conditions. Improved programming description for customer-specific applications. Improved pin description for INT. Addition of lifetime for qualification. Addition of the "Related Website and Software" section. |
| March 12, 2019 | <ul style="list-style-type: none"> Update to add I2C specification. Update figure for humidity influence. Update to add disclaimer for safety-related applications in section 7.1. Minor edits. |
| November 2, 2018 | <ul style="list-style-type: none"> Update with Low Power Operation Method. |
| September 24, 2018 | <ul style="list-style-type: none"> Update for operation methods for trigger/control signal option. Update for power consumption and minor update in electrical characteristics. Update references. |
| September 1, 2018 | Initial release. |



Corporate Headquarters

6024 Silver Creek Valley Road
San Jose, CA 95138
www.IDT.com

Sales

1-800-345-7015 or 408-284-8200
Fax: 408-284-2775
www.IDT.com/go/sales

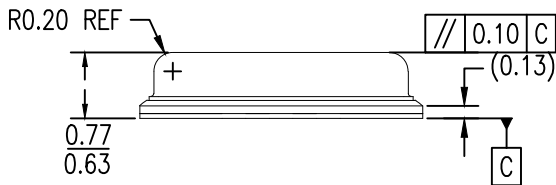
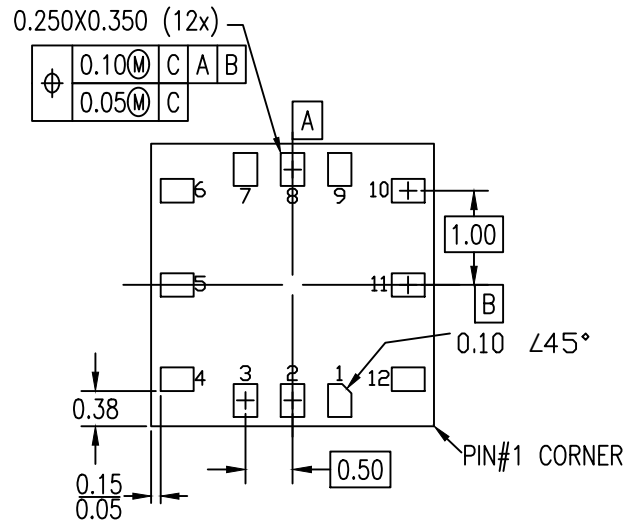
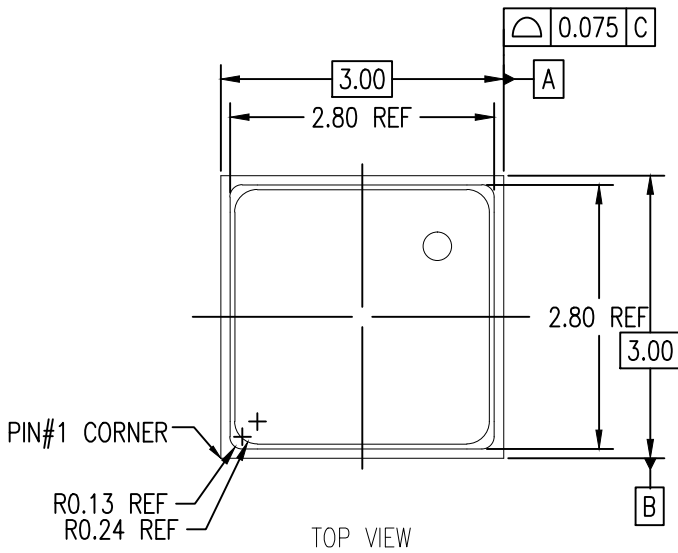
Tech Support

www.IDT.com/go/support

DISCLAIMER Integrated Device Technology, Inc. (IDT) and its affiliated companies (herein referred to as "IDT") reserve the right to modify the products and/or specifications described herein at any time, without notice, at IDT's sole discretion. Performance specifications and operating parameters of the described products are determined in an independent state and are not guaranteed to perform the same way when installed in customer products. The information contained herein is provided without representation or warranty of any kind, whether express or implied, including, but not limited to, the suitability of IDT's products for any particular purpose, an implied warranty of merchantability, or non-infringement of the intellectual property rights of others. This document is presented only as a guide and does not convey any license under intellectual property rights of IDT or any third parties.

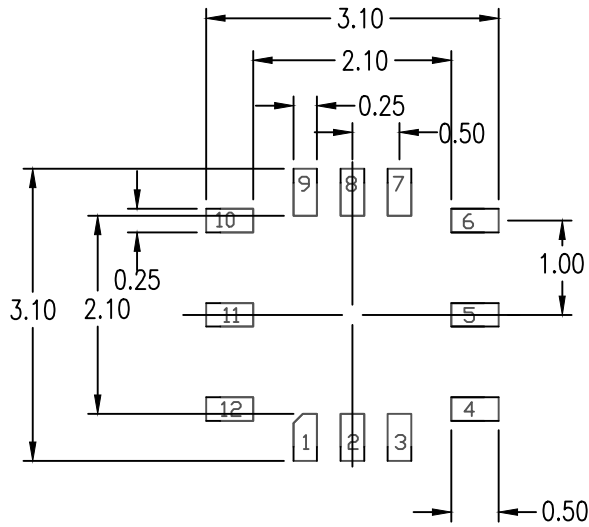
IDT's products are not intended for use in applications involving extreme environmental conditions or in life support systems or similar devices where the failure or malfunction of an IDT product can be reasonably expected to significantly affect the health or safety of users. Anyone using an IDT product in such a manner does so at their own risk, absent an express, written agreement by IDT.

Integrated Device Technology, IDT and the IDT logo are trademarks or registered trademarks of IDT and its subsidiaries in the United States and other countries. Other trademarks used herein are the property of IDT or their respective third party owners. For datasheet type definitions and a glossary of common terms, visit www.idt.com/go/glossary. All contents of this document are copyright of Integrated Device Technology, Inc. All rights reserved.



NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5M-1982
2. ALL DIMENSION ARE IN MILLIMETERS.



RECOMMENDED LAND PATTERN DIMENSION

NOTES:

1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
2. TOP DOWN VIEW. AS VIEWED ON PCB.
3. LAND PATTERN RECOMMENDATION PER IPC-7351B GENERIC REQUIREMENT FOR SURFACE MOUNT DESIGN AND LAND PATTERN.

| Package Revision History | | |
|--------------------------|---------|-----------------|
| Date Created | Rev No. | Description |
| Sept 19, 2017 | Rev 00 | Initial Release |