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

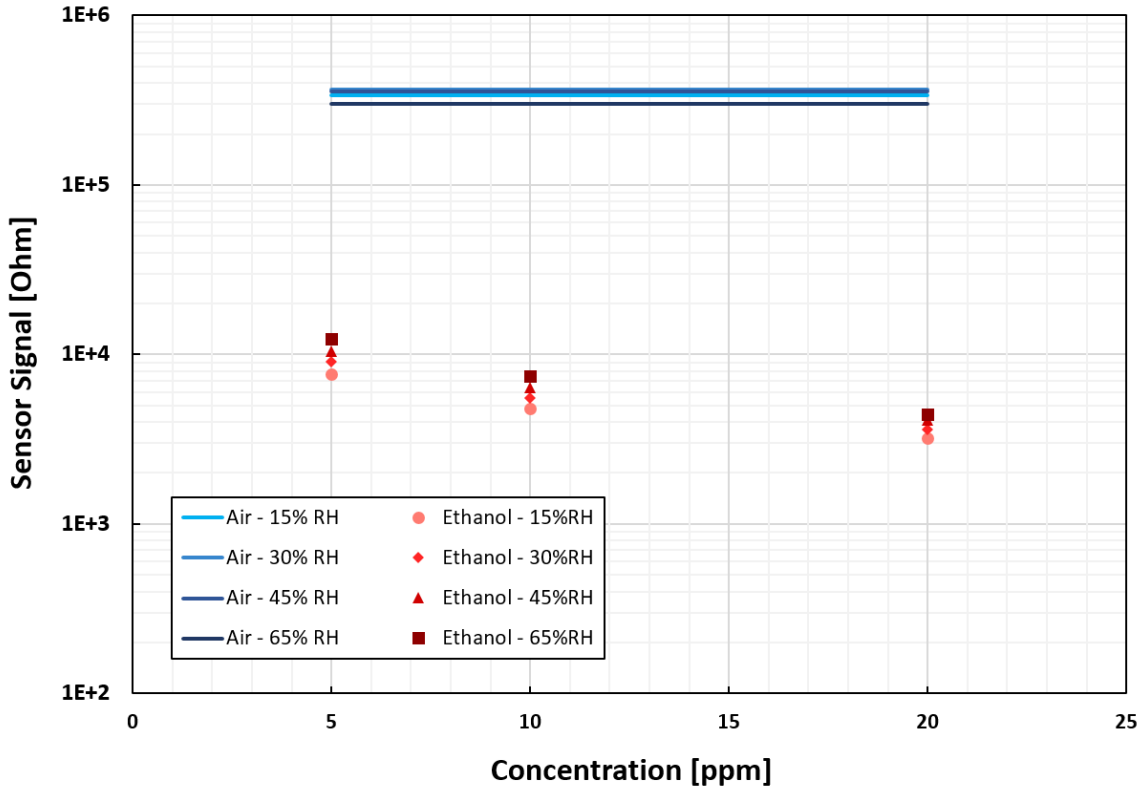
Parameter	Conditions	Minimum	Typical	Maximum	Unit
Temperature Resolution	Range: -40°C to +65°C	–	0.0165	–	°C/LSB
Tolerance	Without calibration	-5	–	5	K

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

8.4 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		%

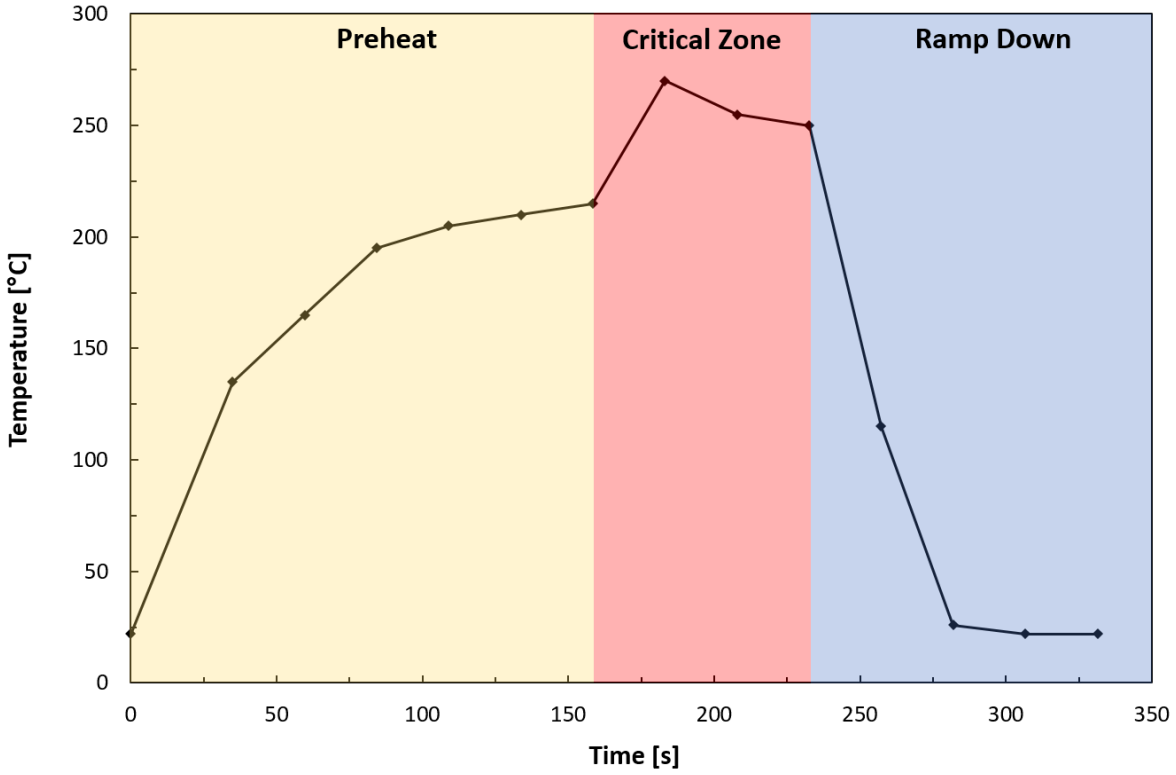
9. Assembly Restrictions, Operation, Integration Notes and Storage

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 (≤100kHz) and Fast Mode (≤400kHz).

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

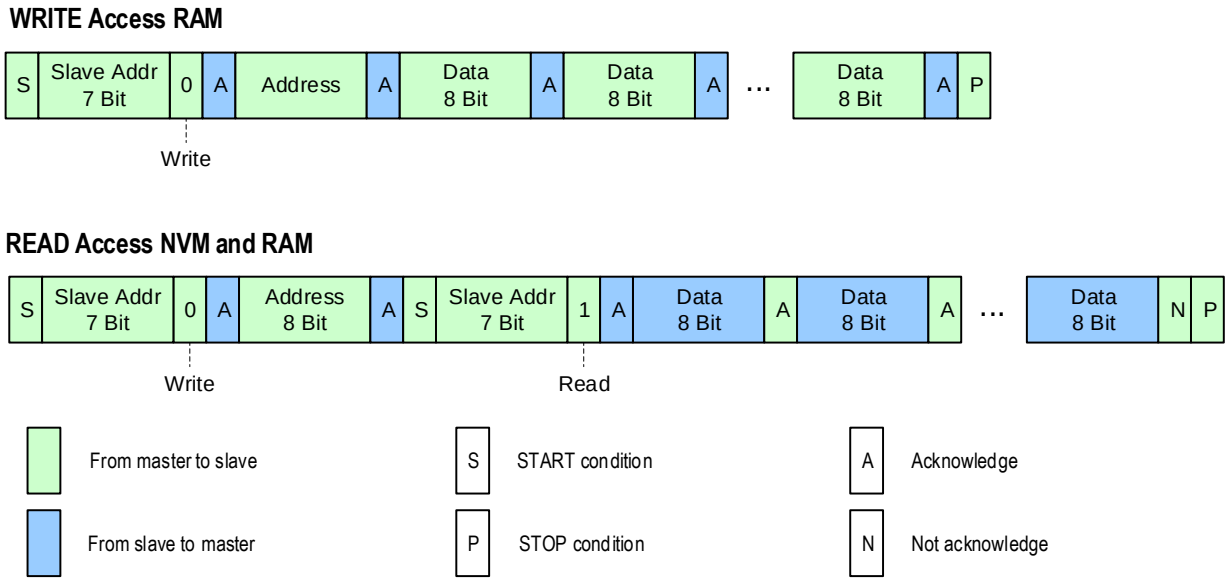


Figure 10. Bus Timing

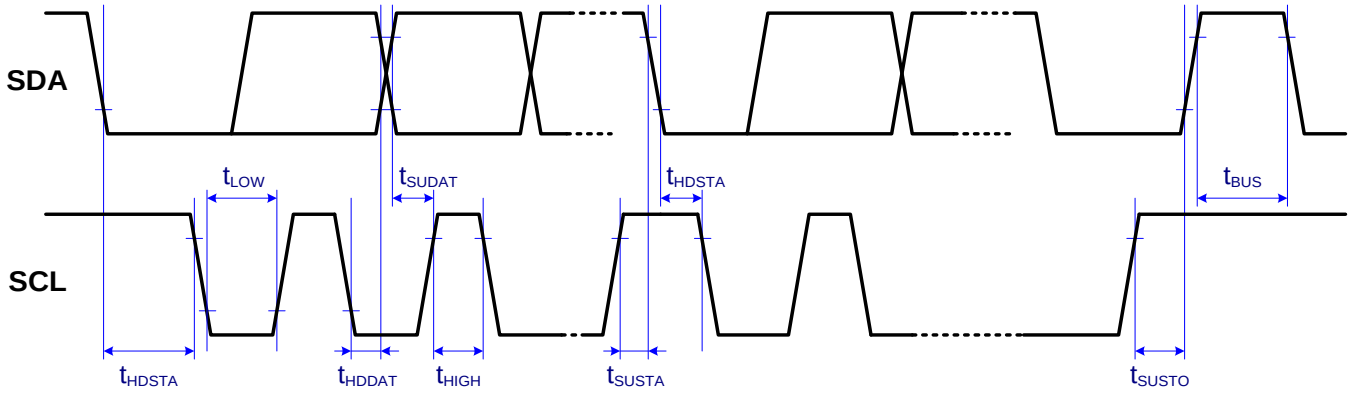


Table 12. Bus Timing Characteristic

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	▪ MSL rating corrected in the Ordering table.
May 9, 2019	▪ 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	▪ 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	▪ Update with Low Power Operation Method.
September 24, 2018	▪ 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.