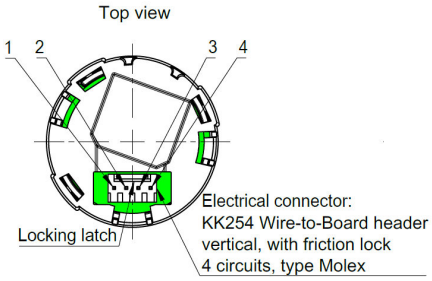
Application Note:

NO - Industrial Sensor / Type I-29D

.: ELECTRICAL INTERFACE :.

Pin 1: 0 V
Pin 2: SDA
Pin 3: SCL
Pin 4: Between +3.3V to +5.0V



.: General Information :.

I2C_Start, I2C_Stop, I2C_Sendbyte and I2C_Readbyte are functions defined by the programming language. For more information see datasheet of I2C-device and programming library of your I2C-Master device.

.: READ OUT SENSOR DATA :.

Address (write to device): **0xD8**
Address (read from device): **0xD9**
ADC type (see datasheet): **MCP3427**

No.	Step	Description	Example (pseudo code)	Result
#1	Configure	Send configuration byte (0x98) after *bus connection* of sensor or *power on reset*	I2C_Start() I2C_Sendbyte(0xD8) I2C_Sendbyte(0x98) I2C_Stop()	ADC is configured
#2	Read Out	Read sensor signal as 3 Byte repetition	I2C_Start() I2C_Sendbyte(0xD9) I2C_Readbyte(ACK) I2C_Readbyte(ACK) I2C_Readbyte(NACK) I2C_Stop()	3 Byte repetition until NACK send by master: Upper Data Byte (8 Bit); Lower Data Byte (8 Bit); Configuration Byte (8 Bit)
#3	Control Option	Compare (Bit 0-6) of configuration byte from read out (#2) to configuration byte 0x98 (#1)	-	Read out is performed correct

Important note: The read out value (#3, Upper Data Byte and Lower Data Byte) is an INT(16) number and may not be treated as INT(32). Calculation example for INT(16): FF1A = -230.

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.: READ OUT TEMPERATURE :.

Address (write to device): **0x38**
Address (read from device): **0x39**
Temperature sensor type (see datasheet): **MCP9808**

No.	Step	Description	Example (pseudo code)	Result
#1	Select and Read Out	Read out 2 Bytes from temperature device [Bit 4 – 7 (Upper Data Byte) = flag bits]	I2C_Start() I2C_Sendbyte(0x38) I2C_Sendbyte(0x05) I2C_Start() I2C_Sendbyte(0x39) I2C_Readbyte(ACK) I2C_Readbyte(NACK) I2C_Stop()	Temperature device is activated and 2 Bytes received from temperature register **Bit 7 (Upper Data Byte):** Critical temperature (not used) **Bit 6 (Upper Data Byte):** Upper limit (not used) **Bit 5 (Upper Data Byte):** Lower limit (not used) **Bit 4 (Upper Data Byte):** Algebraic sign **Bit 0 - 3 (Upper Data byte) +** **Bit 0 - 7 (Lower Data Byte):** ambient temperature bits **Clear flag bits:** Upper Data Byte = Upper Data Byte & 0x1F **Temperature $T_A \geq 0$ °C [Bit 4 (Upper Data Byte) = 0]** T_A = (Upper Data Byte x 2^4 + Lower Data Byte x 2^{-4}) **Temperature $T_A < 0$ °C [Bit 4 (Upper Data Byte) = 1]** T_A = 256 - (Upper Data Byte x 2^4 + Lower Data Byte x 2^{-4})

.: READ OUT EEPROM DATA :.

Address (write to device): **0xA8**
Address (read from device): **0xA9**
EEPROM type (see datasheet): **24LC32A**

Example for read out the first two Bytes (address: 0x00)

No.	Step	Description	Example (pseudo code)	Result
#1	Select and Read Out	Send selected EEPROM register address as High Byte and Low Byte to EEPROM device and read out EEPROM content until NACK send by master	I2C_Start() I2C_Sendbyte(0xA8) I2C_Sendbyte(0x00) I2C_Sendbyte(0x00) I2C_Start() I2C_Sendbyte(0xA9) I2C_Readbyte(ACK) I2C_Readbyte(NACK) I2C_Stop()	EEPROM register address is selected and get back EEPROM content (Bytes) until NACK send by master

The EEPROM content (e. g. serial number, manufacturing data, sensitivity, ambient measurement conditions, temperature and humidity coefficients and **data types**) depends on individual agreements with customer (see EEPROM document).

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.: READ OUT BATTERY VOLTAGE :.

Address (write to device): **0xD8**
Address (read from device): **0xD9**
ADC type (see datasheet): **MCP3427**

No.	Step	Description	Example (pseudo code)	Result
#1	Configure	Send configuration byte (0xA8) after *bus connection* of sensor or *power on reset*	I2C_Start() I2C_Sendbyte(0xD8) I2C_Sendbyte(0xA8) I2C_Stop()	ADC is configured
#2	Read Out	Read sensor signal as 3 Byte repetition until (Byte 3) bitwise AND 0x80 == 0	I2C_Start() I2C_Sendbyte(0xD9) I2C_Readbyte(ACK) I2C_Readbyte(ACK) I2C_Readbyte(NACK) I2C_Stop()	3 Byte repetition until NACK send by master: Upper Data Byte (8 Bit); Lower Data Byte (8 Bit); Configuration Byte (8 Bit) verify (Configuration Byte) bitwise AND 0x80 == 0
#3	Calculate	Use Upper Data Byte (HByte) and Lower Data Byte (LByte) to calculate battery voltage	-	Battery voltage [µV]

.: CALIBRATION AND MEASUREMENT :.

1. Supply sensor with zero gas (contains no NO, e.g. N_2 or scrubbed air) and record sensor signal as baseline (temperature, humidity, pressure and flow constant). Convert Upper Data Byte and Lower Data Byte of senor signal to decimal number (0 to 32768).
2. Supply sensor with calibration gas (e. g. 500ppm NO bal. N_2) and record sensor signal as calibration signal (no change in temperature, humidity, pressure and flow). Convert Upper Data Byte and Lower Data Byte of senor signal to decimal number (0 to 32768).
3. Calibration signal minus baseline (=span) as decimal number equals calibration gas concentration (e. g. 500ppm NO bal. N_2) The sensitivity of the sensor can be calculated.
4. Measure other test gases and Read Out sensor output. Change of decimal number is linear to change of ppb NO over full scale if measurement and calibration conditions are the same (repeat calibration if measurement conditions differ from calibration conditions).

Example:

1-3. Calibration	Baseline (100 Vol.%N_2):	Sensor output: 10 Digits	
	Calibration gas (500ppm NO bal. N_2):	Sensor output: 2500 Digits	
	Span and sensitivity (500ppm NO):	Span = 2500 -10 Digits = 2490 Digits	Sensitivity = 2490 Digits / 500ppm
4. Measurement	Test gas (250ppm NO bal. N_2):	Span: 1245 Digits	2490 Digits /500ppm * 250ppm = 1245 Digits
Measurement	Test gas (750ppm NO bal. N_2):	Span: 3735 Digits	2490 Digits /500ppm * 750ppm = 3735 Digits

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