02.Knowledge contribution (2023-2024-S019-S020-S021)

3D Printing and Slicing

02.KNOWLEDGE CONTRIBUTION (2023-2024-S019)

CO2 Sensors

CCS811 Sensor Datasheet

- The CCS811 is an ultra-low power digital gas sensor solution which integrates a metal oxide (MOX) gas sensor to detect a wide range of Volatile Organic Compounds (VOCs) for indoor air quality monitoring with a microcontroller unit (MCU), which includes an Analog-to-Digital converter (ADC), and an I²C interface.
- CCS811 supports intelligent algorithms to process raw sensor measurements to output a TVOC value or equivalent CO2 (eCO2) levels, where the main cause of VOCs is from humans.
- The equivalent CO2 (eCO2) output range for CCS811 is from 400ppm to 8192ppm. Values outside this range are clipped.
- The CCS811 has 5 modes of operation as follows
  - Mode 0: Idle, low current mode
  - Mode 1: Constant power mode, IAQ measurement every second
  - Mode 2: Pulse heating mode IAQ measurement every 10 seconds
  - Mode 3: Low power pulse heating mode IAQ measurement every 60 seconds
  - Mode 4: Constant power mode, sensor measurement every 250ms
- In Modes 1, 2, 3, the equivalent CO2 concentration (ppm) and TVOC concentration (ppb) are calculated for every sample. Mode 1 reacts fastest to gas presence, but has a higher operating current while Mode 3 reacts more slowly to gas presence but has the lowest average operating current.
- Register overview:

Address	Register	R/W	Size	Description
0x00	STATUS	R	1 byte	Status register
0x01	MEAS_MODE	R/W	1 byte	Measurement mode and conditions register
0x02	ALG_RESULT_DATA	R	up to 8 bytes	Algorithm result. The most significant 2 bytes contain a ppm estimate of the equivalent CO_2 (eCO_2) level, and the next two bytes contain a ppb estimate of the total VOC level.
0x03	RAW_DATA	R	2 bytes	Raw ADC data values for resistance and current source used.
0x05	ENV_DATA	W	4 bytes	Temperature and Humidity data can be written to enable compensation
0x06	NTC	R	4 bytes	Provides the voltage across the reference resistor and the voltage across the NTC resistor – from which the ambient temperature can be determined.
0x10	THRESHOLDS	W	5 bytes	Thresholds for operation when interrupts are only generated when eCO2 ppm crosses a threshold
0x11	BASELINE	R/W	2 bytes	The encoded current baseline value can be read. A previously saved encoded baseline can be written.
0x20	HW_ID	R	1 byte	Hardware ID. The value is 0x81
0x21	HW Version	R	1 byte	Hardware Version. The value is 0x1X
0x23	FW_Boot_Version	R	2 bytes	Firmware Boot Version. The first 2 bytes contain the firmware version number for the boot code.
0x24	FW_App_Version	R	2 bytes	Firmware Application Version. The first 2 bytes contain the firmware version number for the application code
0xE0	ERROR_ID	R	1 byte	Error ID. When the status register reports an error its source is located in this register
0xFF	SW_RESET	W	4 bytes	If the correct 4 bytes (0x11 0xE5 0x72 0x8A) are written to this register in a single sequence the device will reset and return to BOOT mode.

- CO2 data:

ALG_RESULT_DATA (Algorithm Results Data) Register (0x02)

This multi-byte read only register contains the calculated eCO_2 (ppm) and TVOC (ppb) values followed by the STATUS register, ERROR_ID register and the RAW_DATA register.

- If only eCO_2 is required, only the first 2 bytes need to be read.
- If TVOC is required, 4 bytes need to be read.
- In a system where interrupts are not implemented and the host needs to poll the STATUS register to determine whether there is new data, an efficient alternative is to read 5 bytes in a single transaction since that returns eCO_2, TVOC and the status register.
- Optionally, all 8 bytes could be read in a single transaction, so that even the error status and the raw data is available.

Figure 14:
Algorithm Results Register Byte Order

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6 & 7
eCO_2 High Byte	eCO_2 Low Byte	TVOC High Byte	TVOC Low Byte	STATUS	ERROR_ID	See RAW_DATA

CO2 Sensor with MicroBit

CCS811 indoor air quality sensor on a micro:bit | Blog My Wiki!

- Here's what I used:
  - a CCS811 sensor with some pins soldered on
  - a BBC micro:bit (V1 or V2) and a micro USB lead to connect to a computer

    - a breakout board that exposes the I2C pins – I used a Monk Makes one, but you could also use ones by Adafruit, Kitronik or Pimoroni, just make sure they have the I2C pins broken out as not all do.
    - jumper leads to attach the sensor to the breakout board – I used 4 female to female jumpers
    - a way of attaching the sensor's WAK (wake) pin the GND on the micro:bit – I used a female to male jumper wire and a crocodile clip lead, but there will be far more elegant ways than this
    - A computer with the micro:bit Python editor in a Chrome or Edge browser window, like micro:bit Python Editor or Python Editor for micro:bit
- Pin connections:

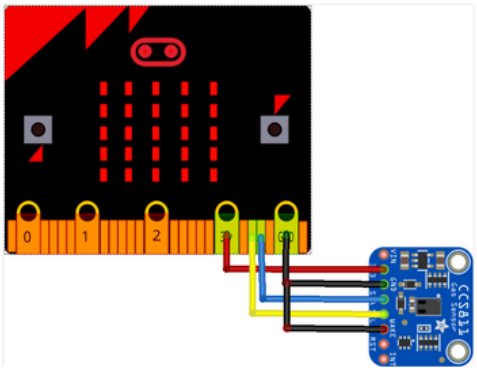
```
sensor  micro:bit
----------------
VCC     3v
GND     GND
SCL     SCL (pin 19)
SDA     SDA (pin 20)
WAK     GND
INT     not connected
RST     not connected
ADD     not connected
```

- Then flash this hex file on to your micro:bit (right-click and save link or save target). If you want to examine the contents, you can just drag the HEX file into an online micro:bit Python editor. You'll see two files, main.py and the module CCS811.py.
- Then you need to open a serial console. Make sure you're using Chrome or Edge. In the current regular Python editor, click on Connect and then Open Serial. In the Alpha editor, which has a serial console in the same screen as the code editor, click Connect and Show serial.

Connecting I2C Devices to the BBC micro:bit

- The BBC micro:bit supports the I²C bus protocol, for communicating with other devices.
- Commands to read and write to the device:
    - ```
      i2c.init(I2C.MASTER)
      i2c.writeto(0x42, '123')        # send 3 bytes to slave with address 0x42
      i2c.writeto(addr=0x42, b'456')  # keyword for address
      ```
- Commands to read and write to memory locations on the device:
    - ```
      i2c.scan()                          # scan for slaves on the bus, returning
                                          #   a list of valid addresses
      i2c.readfrom_mem(0x42, 2, 3)        # read 3 bytes from memory of slave 0x42,
                                          #   starting at address 2 in the slave
      i2c.writeto_mem(0x42, 2, 'abc')     # write 'abc' (3 bytes) to memory of slave 0x42
                                          # starting at address 2 in the slave, timeout after 1 second
      ```

CCS811 digital gas sensor and micro:bit example



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Air quality

Vetranie - meranie CO2 - Geotherm Slovakia s.r.o.

- Koncentráciu oxidu uhličitého meriame v jednotkách ppm (parts per milion). Pocit pohody je možný len pri dostatočnom prísune kyslíka.
- Vplyv koncentrácie oxidu uhličitého na človeka:
Koncentrácia oxidu uhličitého v ppm	Koncentrácia oxidu uhličitého v percentách	Vplyv koncentrácie CO_2 na človeka
300-450 ppm /v mestách aj viac/	0,035 – 0,045 %	koncentrácia CO_2 vo vonkajšom prostredí
do 1 000 ppm	> 0,1 %	zdravotne vhodná koncentrácia CO_2
600 -1 200 ppm	> 0,12 %	maximálna akceptovateľná úroveň CO_2 v interiéri
1 200 -1 500 ppm	0,12 – 0,15 %	pocit vydýchaného vzduchu, začínajú ťažkosti / únava/
1 500 -3 000 ppm	0,15 – 0,3 %	znížená koncentrácia, únava, ospalosť
3 000 -5 000 ppm	0,3 – 0,5 %	zvýšená srdcová frekvencia, bolesti hlavy
10 000-60 000 ppm	1 – 6 %	príznaky otravy a pocit dusenia
60 000-100 000 ppm	6 – 10 %	bezvedomie, smrť v priebehu niekoľko minút
- Koncentrácia CO2 v slabo vetraných priestoroch často presahuje 1700 ppm. V menších a uzavretých spálňach bez vetrania môže hodnota CO2 v nočných hodinách presiahnuť aj 2500 ppm. Niektoré zdroje uvádzajú až alarmujúcu hranicu 4000 ppm. Pri takýchto hodnotách si človek nemôže pri spánku odpočinúť a ráno vstať s pocitom sviežosti.
- Ak sa zhromaždí veľký počet ľudí v miestnosti, CO2 sa rýchlo zvýši a prispieva k zlej kvalite ovzdušia. Koncentrácie okolo 0,1% CO2 vo vzduchu sú napríklad v zaplnenej prednáškovej miestnosti s nedostatočným vetraním a spôsobujú ospalosť. Pri koncentrácii viac ako 2% sa môžu už vyskytnúť príznaky ako je ťažoba na hrudníku a začína sa prehlbovať dýchanie. Pri koncentrácii viac ako 5% je CO2 toxický priamo a nesúvisí s účinkami, ktoré nastávajú pri nedostatočnom zásobovaní kyslíkom, preto obsah kyslíka vo vzduchu nie je účinným indikátorom možnej intoxikácie.