Internship

Sensor comparison

Stage IT Factory

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INTRODUCTION

For the execution of our project, we need a way to capture temperature data. We have three different sensors that can do that. Every sensor has its own features. We will select one sensor for this project. This document will describe every sensor to ease the selection process.

1 Overview

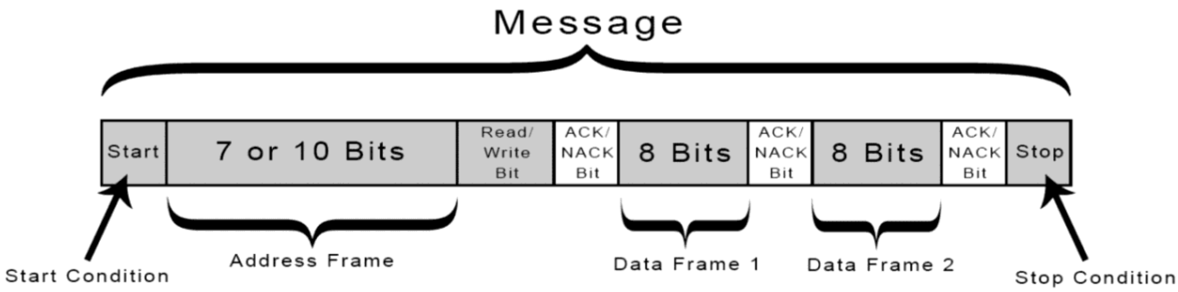
Model	BMP280	BME280	BME680
			
price	€ 9,95	€ 18,00	€ 22,95
interface	I^2C	I^2C/SPI	I^2C
voltage	2-6V	3,3-5V	2-6V
Adress	76 or 77	76 or 77	76 or 77
temperature	✓	✓	✓
pressure	✓	✓	✓
humidity	×	✓	✓
Air quality	×	×	✓

2 INTERFACE

2.1 I2C

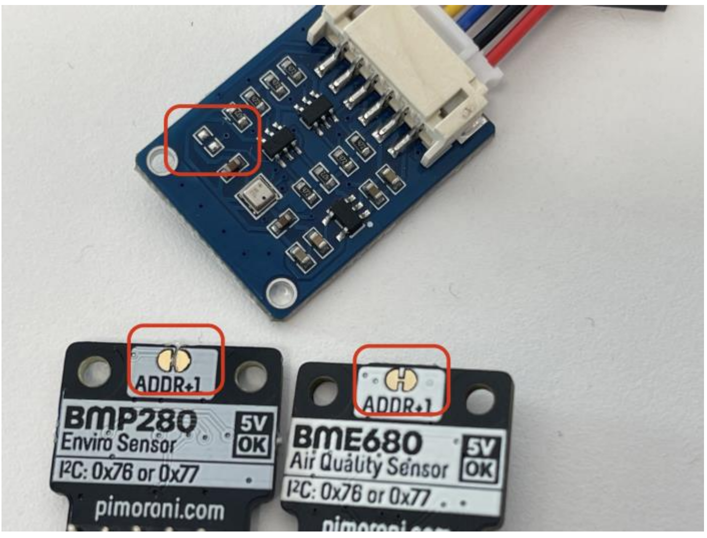
I²C or IIC (Inter Integrated Circuit) is a two-way serial protocol invented by Philips. The Serial bus uses two lines SCL (Serial Clock Line) and SDA (Serial Data Line). These lines need pull-up resistors to work. I²C is mostly used for low-speed communication over short distances which is perfect for our application. Adding more devices can be easily done without the need of extra bus lines. These sensors all support the High-speed I²C specification with a maximum speed of 3.4Mbit/s.

The communication is controlled by a master module. The master will decide which module is allowed to send data over the bus. The master will send out start bit with an address and read/write bit. After the slave module sends out an acknowledgment we can send or receive data. After every byte we expect an acknowledgment. We stop the communication by sending a stop bit. We only use one line for data transitions, so the communication isn't full duplex. This explains the lower speed.



2.2 Address

Every slave device needs its own address. This address is defined by the manufacturer of the device. In most cases it is possible to change the address by one. All three sensor we have use the address 76, we can change this to 77 by cutting a small copper trace or by soldering a bridge. Using two modules with the same address is not possible.

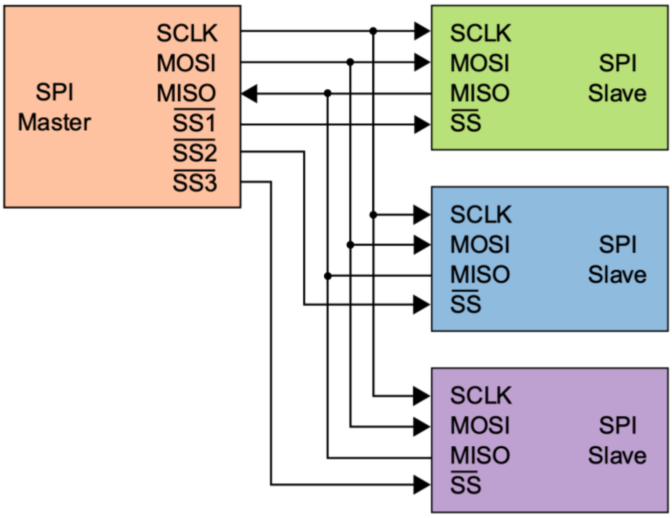


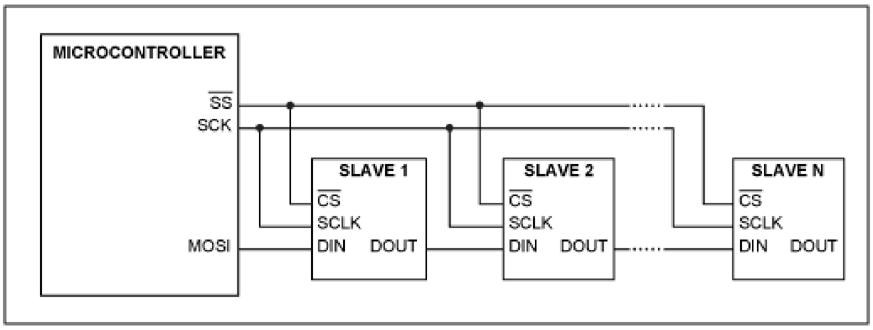
2.3 SPI

SPI (Serial Peripheral Interface) was designed by Motorola and is heavily used for flash storage and liquid crystal displays in embedded systems. A two-way SPI communication needs a minimum of four lines to operate.

- SCLK: Serial clock
- MOSI: Master out, slave in
- MISO: Master in, slave out
- CS: Chip select (sometimes defined as SS: slave select)

Each device added requires an additional chip select lane. Expansion is limited because of this. Daisy chaining is possible, but this must be supported by the hardware. SPI is capable of full duplex communication because we have two lines available.





To start the communication the chip-select line of the desired slave is pulled low. This activates the slave. Data can flow in both directions. To stop the communication the chip-select is set high.

2.4 Comparison

SPI

- Higher transfer rate
- No chance of address collisions
- Full duplex
- Simple software implementation
- No wait for start or stop
- Every slave needs separate chip select wire

I2C

- Easy expansion
- Multiple masters can be used
- Only two wires needed
- Acknowledgements provide some form of error handling
- Slow speeds (not recommended for displays or flash memory)

3 SENSORS

The available sensors are all made by Bosh. The sensors are mounted to breakout board for ease of use. The breakout modules also include voltage regulators so they can be used with 5v or 3.3V. Every sensor is factory calibrated and fairly accurate.

3.1 Temperature & pressure

All the sensors are capable of measuring the temperature with an accuracy of ±1.0°C and pressure with an accuracy of ±1 hPa. If we know the pressure at sea level, we can use this sensor to calculate our altitude. The temperature measurement is made with a diode that changes the voltage in relation to temperature. The pressure sensor is made of a resistive material that changes in relation to the pressure.

3.2 Humidity

The BME280 and the BME680 both use a capacitive humidity sensor with an accuracy of ±3%.

3.3 Air Quality

The BME680 adds the ability to measure VOC (Volatile organic compound). The sensor contains a small, heated MOX (Metal Oxide) layer. When particles come in contact with the heated plate, the resistance will change. A higher concentration will decrease the resistance. This can be used to measure ethanol, alcohol and carbon monoxide. The sensor will only measure the overall VOC, it cannot differentiate gasses. With this measurement we can calculate the approximate CO2 level*, this is defined as a CO2 equivalent measurement.

Because the MOX plate needs heat to operate, this can influence the temperature measurement. Other VOC sensors like the CCS811 suffer from this problem. A compensation algorithm is used to overcome this. The temperature sensor on these VOC modules is usually not used because of this problem. The Bosch datasheet mentions that "Its output is used for temperature compensation of the humidity, pressure and gas sensor and can also be used as well for estimation of ambient temperature.". I suggest using a different sensor for temperature measurements.

*This is just a calculation! Cannot replace an actual CO2 sensor.

3.4 Power consumption

Low power consumption is very important for IoT devices. The power consumption of the sensors also needs to be taken in account. All these sensors are classified as “low power”. It is possible to disable part of the sensors so we can get a lower power consumption. The BME680 uses a hot metal oxide layer, this means that the power consumption will be considerably higher. The gas sensor needs 30 minutes to heat up and normalize after power on. Periodically disabling this sensor can only be done when no measurements are necessary for longer period of time.

Power consumption in µA

	BMP280	BME280	BME680
Pressure and temperature	2.7	2.8	3.1
Pressure, temperature and humidity	X	3.6	3.7
Pressure, temperature, humidity and gas	X	X	90-120 (depending on operation)

3.5 Library support

All these sensors are heavily used by hobbyists. There are a lot of libraries written to ease the implementation of these sensors. Adafruit made their own breakout boards and libraries for these sensors. The libraries of Adafruit can be customized to your liking without much difficulty.

4 TEST

I used the ESP-32 to read the sensor values and send them to Home Assistant. In Home Assistant I used Grafana and Influx DB to visualize the collected data. The test ran over three days. The sensors follow the same trendline but there is a noticeable offset. This can be because of false calibration data. We can compensate for this in software if we have a calibrated reference.

The heating effect of the bme680 does not seem to influence the temperature reading, Bosch might have found a solution for this problem. The bme280 does move in a different direction on some occasions. It is difficult to select the best sensor without the use of a calibrated sensor we can compare to. We can conclude that all sensors can measure the temperature with relative accuracy for this use case.

5 CONCLUSION

5.1 Solution 1

Because we cannot thrust the BME680 for making accurate ambient temperature measurements, I recommend using the BMP280 in combination with the BME680. We can use the BMP280 for making temperature and pressure measurements while using the BME680 for air quality measurements.

5.2 Solution 2

The BME280 give us a good and accurate measurement of temperature, humidity and pressure. We can use this sensor in our proof of concept and later expand this with the air quality sensor if desired.

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