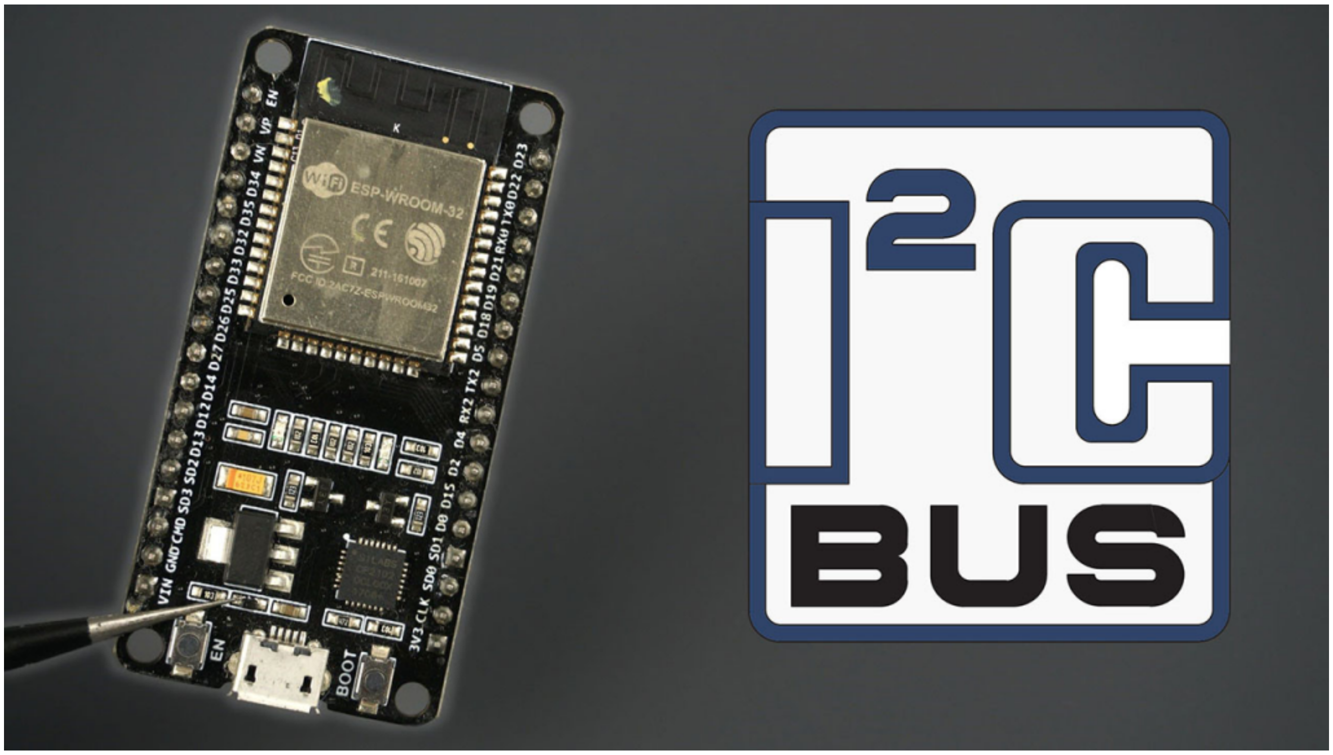
ESP32 I2C Communication: Set Pins, Multiple Bus Interfaces and Peripherals (Arduino IDE)

The ESP32 has two I2C bus interfaces that can serve as I2C master or slave. In this tutorial we'll take a look at the I2C communication protocol with the ESP32 using Arduino IDE: how to choose I2C pins, connect multiple I2C devices to the same bus and how to use the two I2C bus interfaces.



In this tutorial, we'll cover the following concepts:

- Connecting I2C Devices with ESP32
- Scan I2C Address with ESP32
- Use Different I2C Pins with ESP32 (change default I2C pins)
- ESP32 with Multiple I2C Devices
  - same bus, different addresses
  - same address
- ESP32 Using Two I2C Bus Interfaces

We'll program the ESP32 using Arduino IDE, so before proceeding with this tutorial you should have the ESP32 add-on installed in your Arduino IDE. Follow the next tutorial to install the ESP32 on the Arduino IDE, if you haven't already.

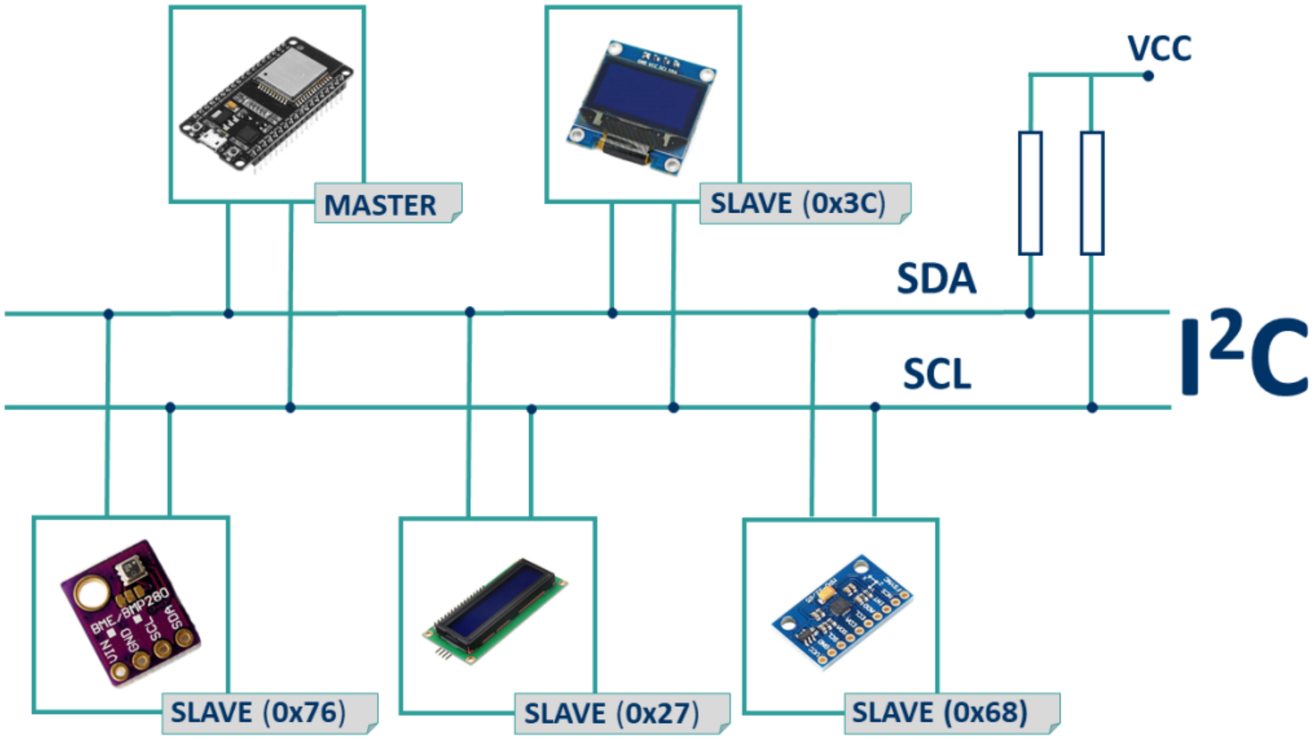
- Installing the ESP32 Board in Arduino IDE (Windows, Mac OS X, and Linux instructions)

Introducing ESP32 I2C Communication Protocol

I²C means **I**nter **I**ntegrated **C**ircuit (it's pronounced I-squared-C), and it is a synchronous, multi-master, multi-slave communication protocol. You can connect :

- **multiple slaves to one master:** for example, your ESP32 reads from a BME280 sensor using I2C and writes the sensor readings in an I2C OLED display.
- **multiple masters controlling the same slave:** for example, two ESP32 boards writing data to the same I2C OLED display.

We use this protocol many times with the ESP32 to communicate with external devices like sensors and displays. In these cases, the ESP32 is the master chip and the external devices are the slaves.



We have several tutorials with the ESP32 interfacing with I2C devices:

- 0.96 inch I2C OLED display with ESP32
- ESP32 Built-in OLED Board
- I2C LCD Display with ESP32
- BMP180 with ESP32
- BME280 with ESP32

ESP32 I2C Bus Interfaces

The ESP32 supports I2C communication through its two I2C bus interfaces that can serve as I2C master or slave, depending on the user's configuration. Accordingly to the ESP32 datasheet, the I2C interfaces of the ESP32 supports:

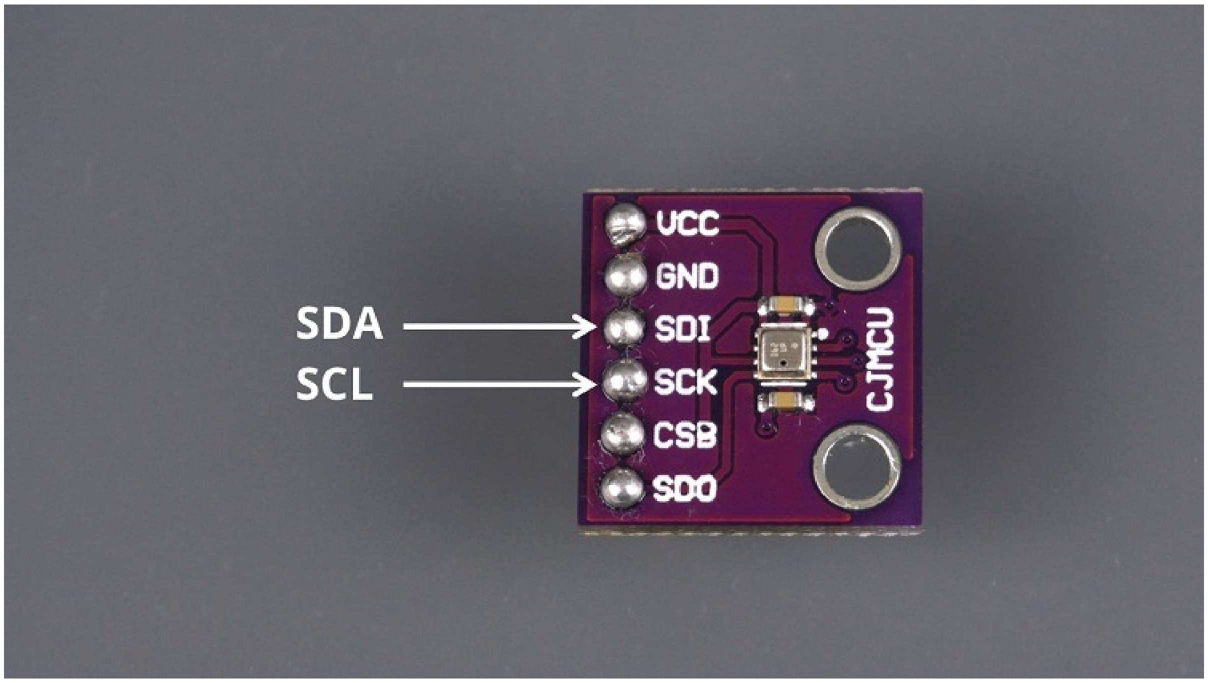
- Standard mode (100 Kbit/s)
- Fast mode (400 Kbit/s)
- Up to 5 MHz, yet constrained by SDA pull-up strength

- Dual addressing mode. Users can program command registers to control I²C interfaces, so that they have more flexibility

Connecting I2C Devices with ESP32

I2C communication protocol uses two wires to share information. One is used for the clock signal (**SCL**) and the other is used to send and receive data (**SDA**).

Note: in many breakout boards, the SDA line may also be labeled as SDI and the SCL line as SCK.



The SDA and SCL lines are active low, so they should be pulled up with resistors. Typical values are 4.7k Ohm for 5V devices and 2.4k Ohm for 3.3V devices.

Most sensors we use in our projects are breakout boards that already have the resistors built-in. So, usually, when you're dealing with this type of electronics components you don't need to worry about this.

Connecting an I2C device to an ESP32 is normally as simple as connecting GND to GND, SDA to SDA, SCL to SCL and a positive power supply to a peripheral, usually 3.3V (but it depends on the module you're using).

I2C Device	ESP32
SDA	SDA (default is GPIO 21)
SCL	SCL (default is GPIO 22)
GND	GND
VCC	usually 3.3V or 5V

When using the ESP32 with Arduino IDE, the default I2C pins are GPIO 22 (SCL) and GPIO 21 (SDA) but you can configure your code to use any other pins.

Recommended reading: ESP32 GPIO Reference Guide

Scan I2C Address with ESP32

With I2C communication, each slave on the bus has its own address, a hexadecimal number that allows the ESP32 to communicate with each device.

The I2C address can be usually found on the component's datasheet. However, if it is difficult to find out, you may need to run an I2C scanner sketch to find out the I2C address.

You can use the following sketch to find your devices' I2C address.

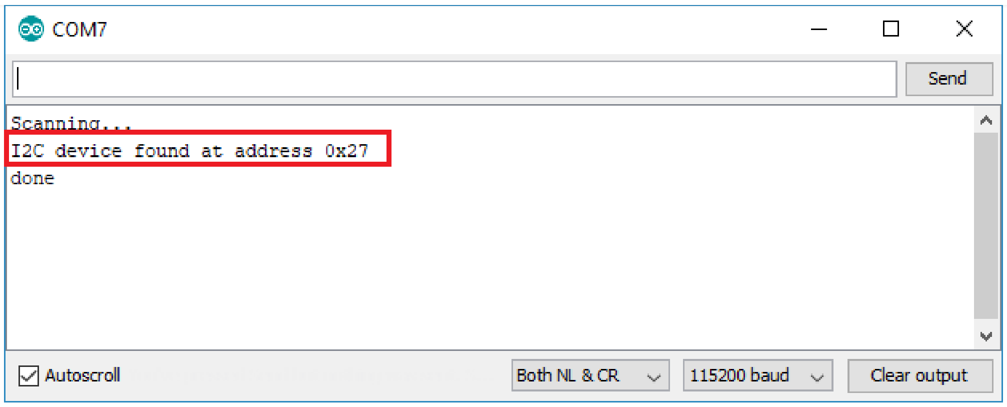
```
/*********
  Rui Santos
  Complete project details at https://randomnerdtutorials.com
*********/

#include <Wire.h>

void setup() {
  Wire.begin();
  Serial.begin(115200);
  Serial.println("\nI2C Scanner");
}

void loop() {
  byte error, address;
  int nDevices;
  Serial.println("Scanning...");
  nDevices = 0;
  for(address = 1; address < 127; address++ ) {
    Wire.beginTransmission(address);
    error = Wire.endTransmission();
    if (error == 0) {
      Serial.print("I2C device found at address 0x");
      if (address<16) {
        Serial.print("0");
      }
      Serial.println(address,HEX);
```

View raw code



```
Scanning...
I2C device found at address 0x27
done
```

Use Different I2C Pins with ESP32 (change default I2C pins)

With the ESP32 you can set almost any pin to have I2C capabilities, you just need to set that in your code.

When using the ESP32 with the Arduino IDE, use the `Wire.h` library to communicate with devices using I2C. With this library, you initialize the I2C as follows:

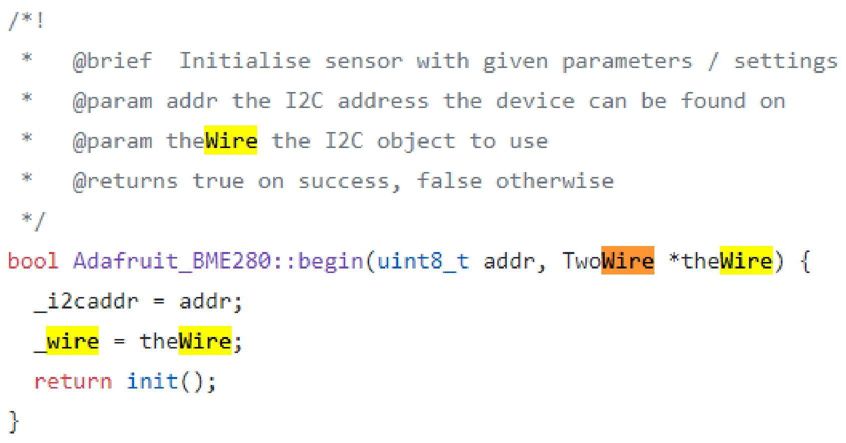
```
Wire.begin(I2C_SDA, I2C_SCL);
```

So, you just need to set your desired SDA and SCL GPIOs on the `I2C_SDA` and `I2C_SCL` variables.

However, if you're using libraries to communicate with those sensors, this might not work and it might be a bit tricky to select other pins. That happens because those libraries might overwrite your pins if you don't pass your own `Wire` instance when initializing the library.

In those cases, you need to take a closer look at the *.cpp* library files and see how to pass your own `TwoWire` parameters.

For example, if you take a closer look at the Adafruit BME280 library, you'll find out that you can pass your own `TwoWire` to the `begin()` method.



```
/*!
 *   @brief  Initialise sensor with given parameters / settings
 *   @param addr the I2C address the device can be found on
 *   @param theWire the I2C object to use
 *   @returns true on success, false otherwise
 */
bool Adafruit_BME280::begin(uint8_t addr, TwoWire *theWire) {
  _i2caddr = addr;
  _wire = theWire;
  return init();
}
```

So, the example sketch to read from the BME280 using other pins, for example GPIO 33 as SDA and and GPIO 32 as SCL is as follows.

```
/*
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*/

#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>

#define I2C_SDA 33
#define I2C_SCL 32

#define SEALEVELPRESSURE_HPA (1013.25)

TwoWire I2CBME = TwoWire(0);
Adafruit_BME280 bme;

unsigned long delayTime;

void setup() {
  Serial.begin(115200);
```
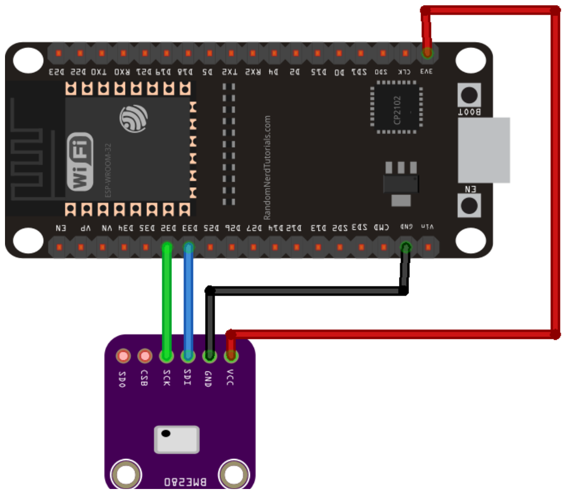

View raw code



Let's take a look at the relevant parts to use other I2C pins.

First, define your new I2C pins on the `I2C_SDA` and `I2C_SCL` variables. In this case, we're using GPIO 33 and GPIO 32.

```
#define I2C_SDA 33
#define I2C_SCL 32
```

Create a new `TwoWire` instance. In this case, it's called `I2CBME`. This simply creates an I2C bus.

```
TwoWire I2CBME = TwoWire(0);
```

In the `setup()`, initialize the I2C communication with the pins you've defined earlier. The third parameter is the clock frequency.

```
I2CBME.begin(I2C_SDA, I2C_SCL, 400000);
```

Finally, initialize a BME280 object with your sensor address and your `TwoWire` object.

```
status = bme.begin(0x76, &I2CBME);
```

After this, you can use use the usual methods on your `bme` object to request temperature, humidity and pressure.

Note: if the library you're using uses a statement like `wire.begin()` in its file, you may need to comment that line, so that you can use your own pins.

ESP32 with Multiple I2C Devices

As we've mentioned previously, each I2C device has its own address, so it is possible to have multiple I2C devices on the same bus.

Multiple I2C devices (same bus, different addresses)

When we have multiple devices with different addresses, it is trivial how to set them up:

- connect both peripherals to the ESP32 SCL and SDA lines;
- in the code, refer to each peripheral by its address;

Take a look at the following example that gets sensor readings from a BME280 sensor (via I2C) and displays the results

```
/*
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*/

#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);

Adafruit_BME280 bme;

void setup() {
  Serial.begin(115200);
```
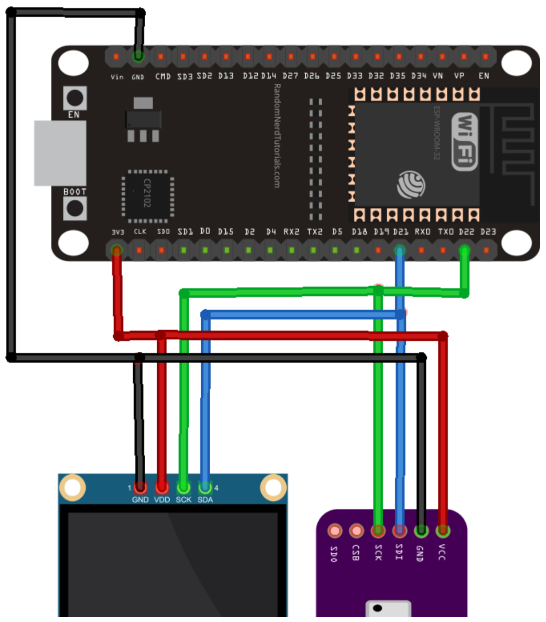
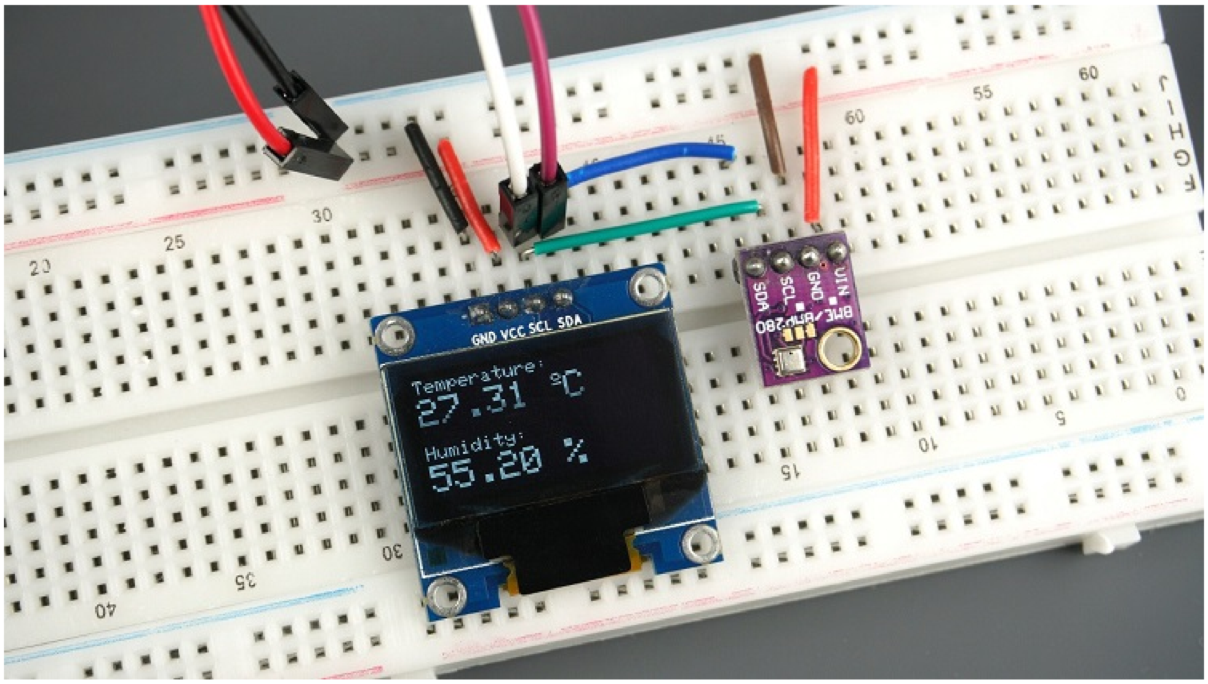

View raw code


Vin GND CMD SD3 SD2 D13 D12 D14 D27 D26 D25 D33 D32 D35 D34 VN VP EN
EN
BOOT
3V3 CLK SDO SD1 D0 D15 D2 D4 RX2 TX2 D5 D18 D19 D21 RXD TXD D22 D23
GND VDD SCK SDA
SDO CSB SCK SDI GND VCC

Click image to enlarge

Because the OLED and the BME280 have different addresses, we can use the same SDA and SCL lines without any problem. The OLED display address is `0x3C` and the BME280 address is `0x76`.

```
if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
  Serial.println(F("SSD1306 allocation failed"));
  for(;;);
}

bool status = bme.begin(0x76);
if (!status) {
  Serial.println("Could not find a valid BME280 sensor, check wiring!");
  while (1);
}
```



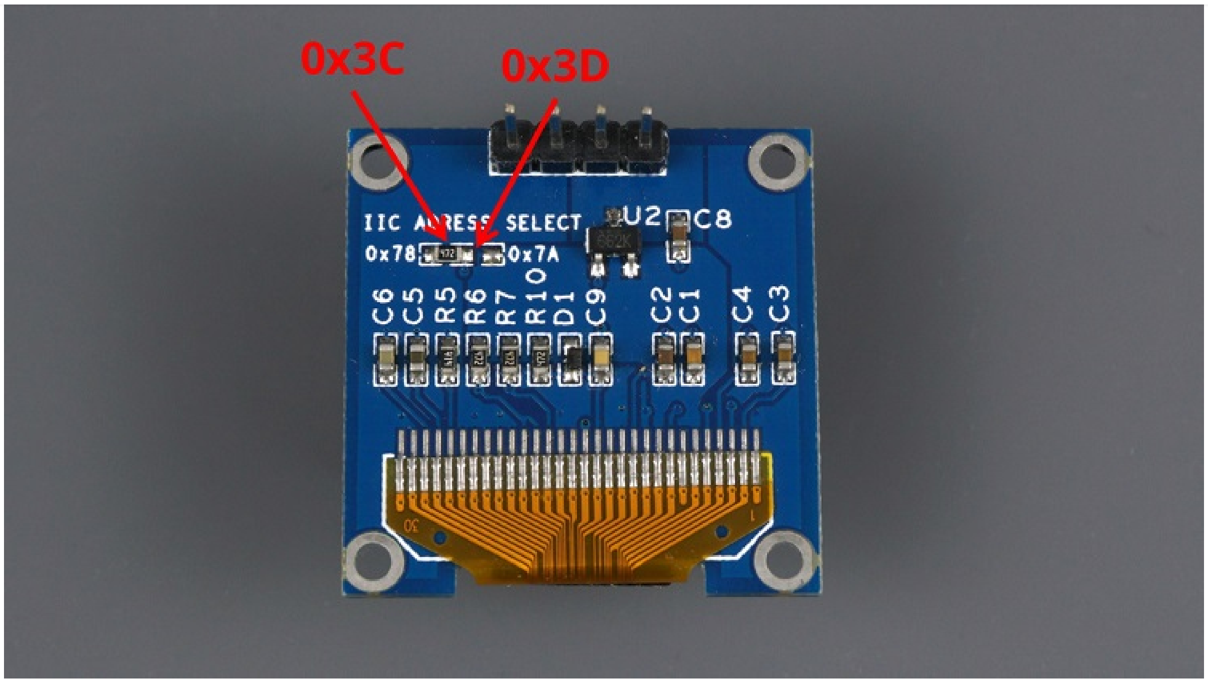
Recommended reading: ESP32 OLED Display with Arduino IDE

Multiple I2C devices (same address)

But, what if you have multiple peripherals with the same address? For example, multiple OLED displays or multiple BME280 sensors? There are several solutions.

- change the device I2C address;
- use an I2C multiplexer.

Changing the I2C address

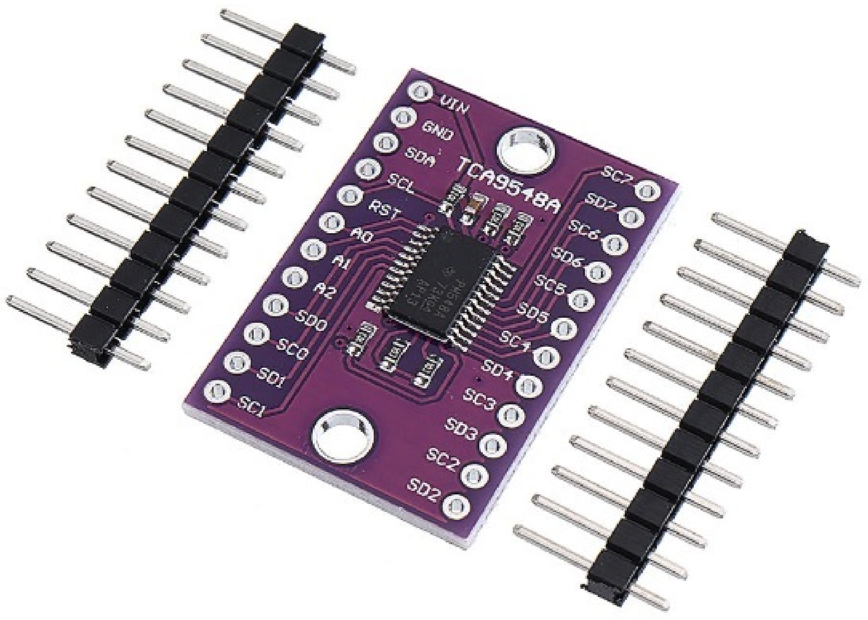


By placing the resistor on one side or the other, you can select different I2C addresses. This also happens with other components.

Using an I2C Multiplexer

However, in this previous example, this only allows you to have two I2C displays on the same bus: one with 0x3C address and another with 0x3D address.

Additionally, sometimes it is not trivial changing the I2C address. So, in order to have multiple devices with the same address in the same I2C bus, you can use an I2C multiplexer like the TCA9548A that allows you to communicate with up to 8 devices with the same address.



We have a detailed tutorial explaining how to use an I2C multiplexer to connect multiple devices with the same address to the ESP32: Guide for TCA9548A I2C Multiplexer: ESP32, ESP8266, Arduino.

ESP32 Using Two I2C Bus Interfaces

To use the two I2C bus interfaces of the ESP32, you need to create two `TwoWire` instances.

```
TwoWire I2Cone = TwoWire(0);
TwoWire I2Ctwo = TwoWire(1)
```

Then, initialize I2C communication on your desired pins with a defined frequency.

```
void setup() {
  I2Cone.begin(SDA_1, SCL_1, freq1);
  I2Ctwo.begin(SDA_2, SCL_2, freq2);
}
```

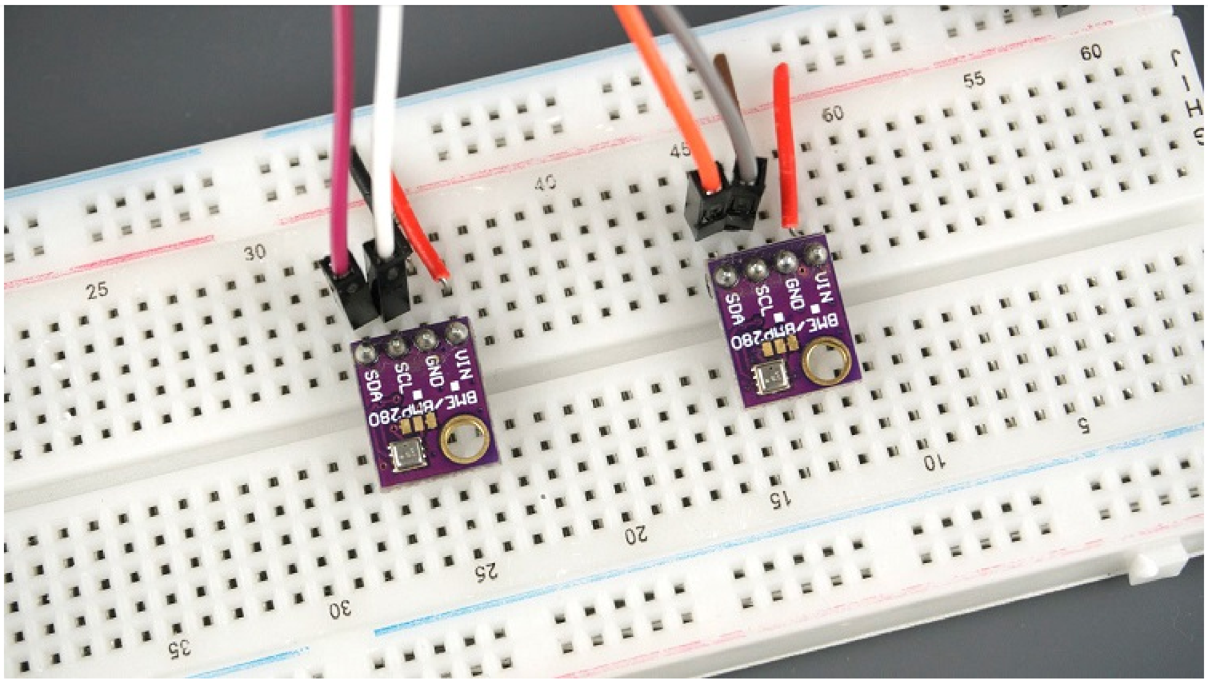
Then, you can use the methods from the `Wire.h` library to interact with the I2C bus interfaces.

A simpler alternative is using the predefined `Wire()` and `Wire1()` objects. `Wire().begin()` creates an I2C communication on the first I2C bus using the default pins and default frequency. For the `Wire1.begin()` you should pass your desired SDA and SCL pins as well as the frequency.

```
setup(){
  Wire.begin(); //uses default SDA and SCL and 100000HZ freq
  Wire1.begin(SDA_2, SCL_2, freq);
}
```

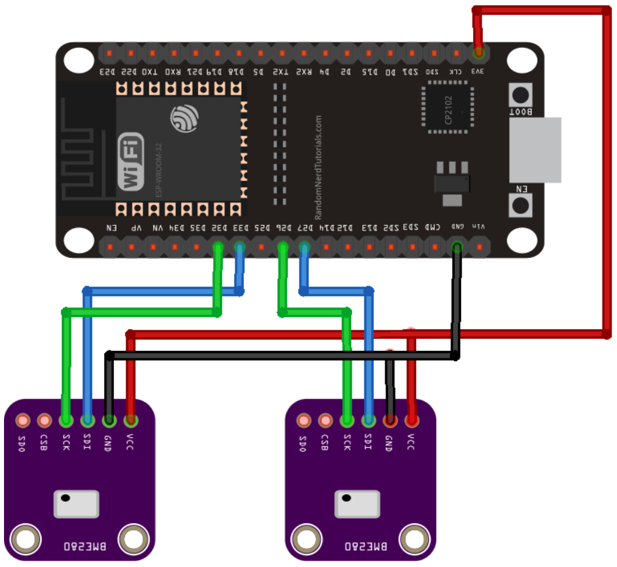
This method allows you to use two I2C buses, one of them uses the default parameters.

To better understand how this works, we’ll take a look at a simple example that reads temperature, humidity and pressure from two BME280 sensors.



Each sensor is connected to a different I2C bus.

- I2C Bus 1: uses GPIO 27 (SDA) and GPIO 26 (SCL);
- I2C Bus 2: uses GPIO 33 (SDA) and GPIO 32 (SCL);



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```
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```

```
*/

#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>

#define SDA_1 27
#define SCL_1 26

#define SDA_2 33
#define SCL_2 32

TwoWire I2Cone = TwoWire(0);
TwoWire I2Ctwo = TwoWire(1);

Adafruit_BME280 bme1;
Adafruit_BME280 bme2;
```

View raw code

Let's take a look at the relevant parts to use the two I2C bus interfaces.

Define the SDA and SCL pins you want to use:

```
#define SDA_1 27
#define SCL_1 26

#define SDA_2 33
#define SCL_2 32
```

Create two `TwoWire` objects (two I2C bus interfaces):

```
TwoWire I2Cone = TwoWire(0);
TwoWire I2Ctwo = TwoWire(1);
```

Create two instances of the `Adafruit_BME280` library to interact with your sensors: `bme1` and `bme2`.

```
Adafruit_BME280 bme1;
Adafruit_BME280 bme2;
```

Initialize an I2C communication on the defined pins and frequency:

```
I2Cone.begin(SDA_1, SCL_1, 100000);
I2Ctwo.begin(SDA_2, SCL_2, 100000);
```

Then, you should initialize the `bme1` and `bme2` objects with the right address and I2C bus. `bme1` uses `I2Cone`:

```
bool status = bme1.begin(0x76, &I2Cone);
```

And `bme2` uses `I2Ctwo`:

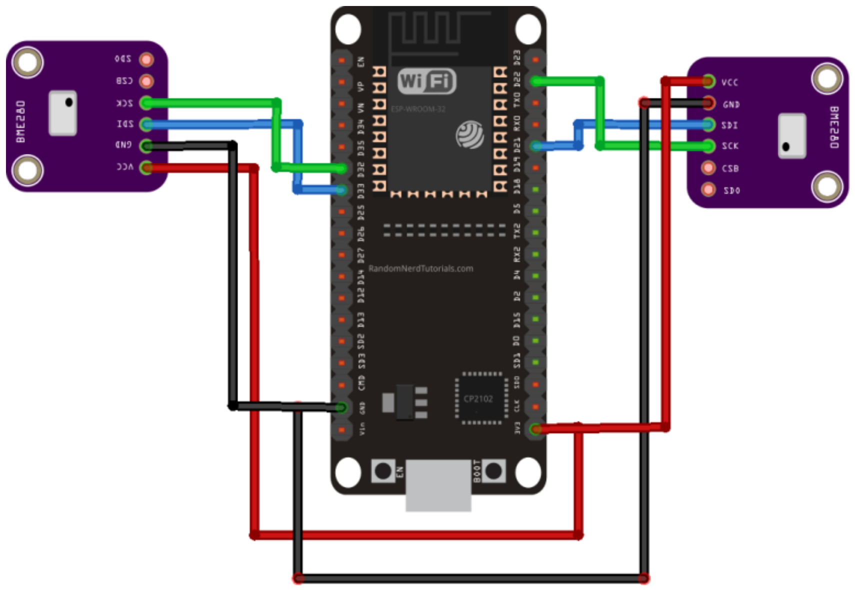
```
bool status1 = bme2.begin(0x76, &I2Ctwo);
```

Now, you can use the methods from the `Adafruit_BME280` library on your `bme1` and `bme2` objects to read temperature, humidity and pressure.

Another alternative

For simplicity, you can use the predefined `Wire()` and `Wire1()` objects:

- `Wire()`: creates an I2C bus on the default pins GPIO 21 (SDA) and GPIO 22 (SCL)
- `Wire1(SDA_2, SCL_2, freq)`: creates an I2C bus on the defined `SDA_2` and `SCL_2` pins with the desired frequency.



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Here's the same example but using this method. Now, one of your sensors uses the default pins, and the other uses GPIO 32 and GPIO 33.

```
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*/

#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>

#define SDA_2 33
#define SCL_2 32

Adafruit_BME280 bme1;
Adafruit_BME280 bme2;

void setup() {
  Serial.begin(115200);
  Serial.println(F("BME280 test"));

  Wire.begin();
```
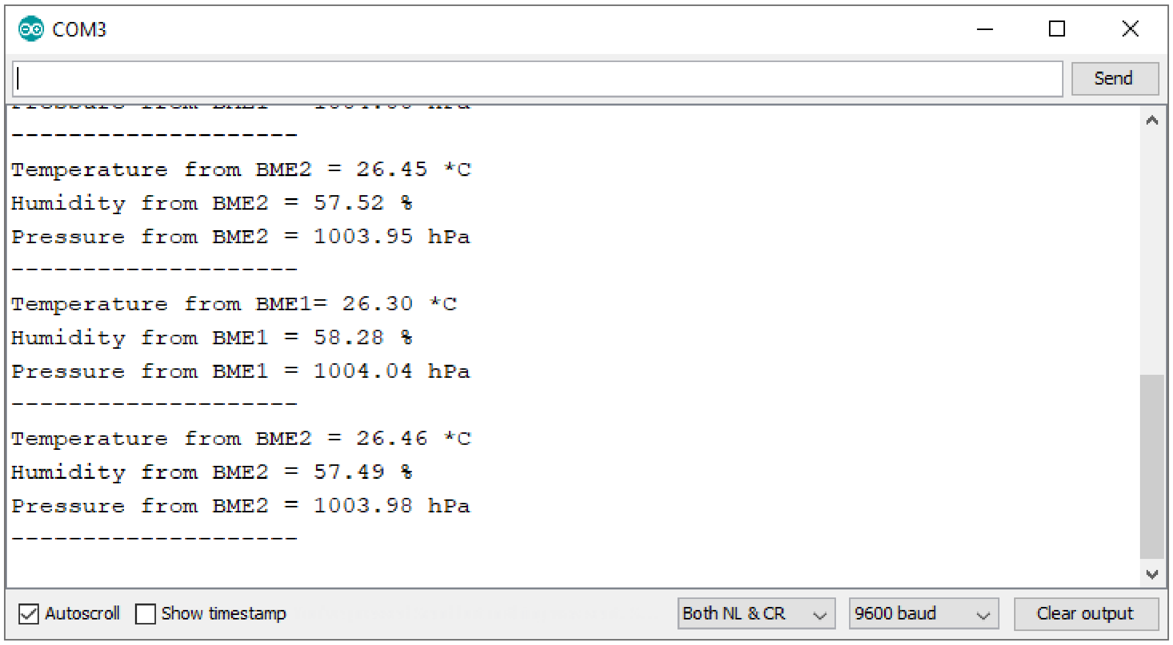

View raw code

You should get both sensor readings on your Serial Monitor.



```
---------------------
Temperature from BME2 = 26.45 *C
Humidity from BME2 = 57.52 %
Pressure from BME2 = 1003.95 hPa
---------------------
Temperature from BME1= 26.30 *C
Humidity from BME1 = 58.28 %
Pressure from BME1 = 1004.04 hPa
---------------------
Temperature from BME2 = 26.46 *C
Humidity from BME2 = 57.49 %
Pressure from BME2 = 1003.98 hPa
---------------------
```

In this tutorial you learned more about I2C communication protocol with the ESP32. We hope you've found the information in this article useful.

To learn more about the ESP32 GPIOs, read our reference guide: ESP32 Pinout Reference: Which GPIO pins should you use?

Learn more about the ESP32 with our resources:

- **Learn ESP32 with Arduino IDE (Video course + eBook)**
- MicroPython Programming with ESP32 and ESP8266 (eBook)
- More ESP32 tutorials…

Thanks for reading.

Recommended Resources