Chapter 1 LCD1602

In this chapter, we will learn about the LCD1602 Display Screen.

Project 1.1 I2C LCD1602

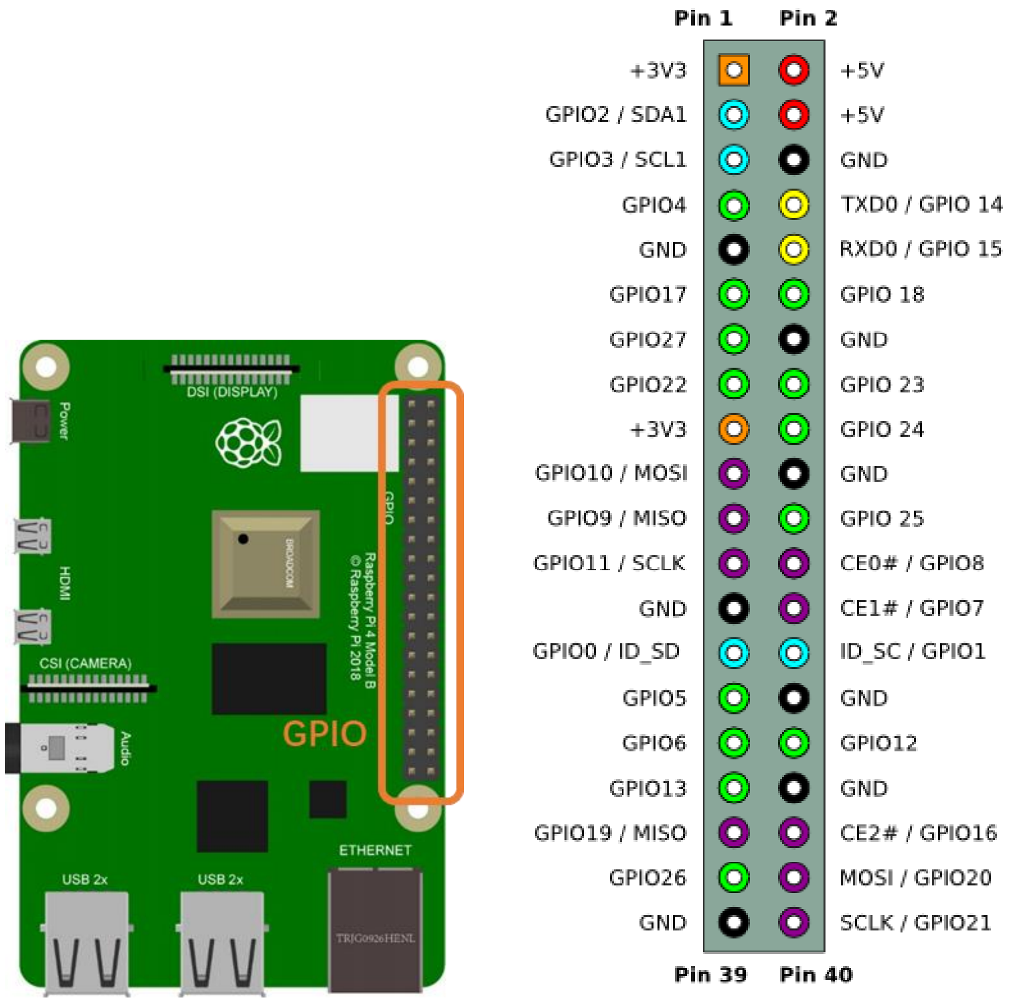
In this section we learn how to use lcd1602 to display something.

GPIO

GPIO: General Purpose Input/Output. Here we will introduce the specific function of the pins on the Raspberry Pi and how you can utilize them in all sorts of ways in your projects. Most RPi Module pins can be used as either an input or output, depending on your program and its functions.
When programming GPIO pins there are 3 different ways to reference them: GPIO Numbering, Physical Numbering and WiringPi GPIO Numbering.

BCM GPIO Numbering

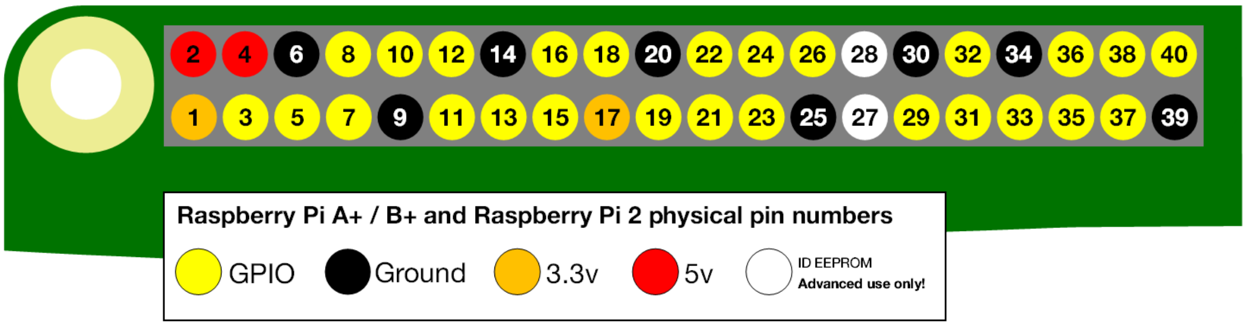
The Raspberry Pi CPU uses Broadcom (BCM) processing chips BCM2835, BCM2836 or BCM2837. GPIO pin numbers are assigned by the processing chip manufacturer and are how the computer recognizes each pin. The pin numbers themselves do not make sense or have meaning as they are only a form of identification. Since their numeric values and physical locations have no specific order, there is no way to remember them so you will need to have a printed reference or a reference board that fits over the pins.
Each pin's functional assignment is defined in the image below:



For more details about pin definition of GPIO, please refer to http://pinout.xyz/

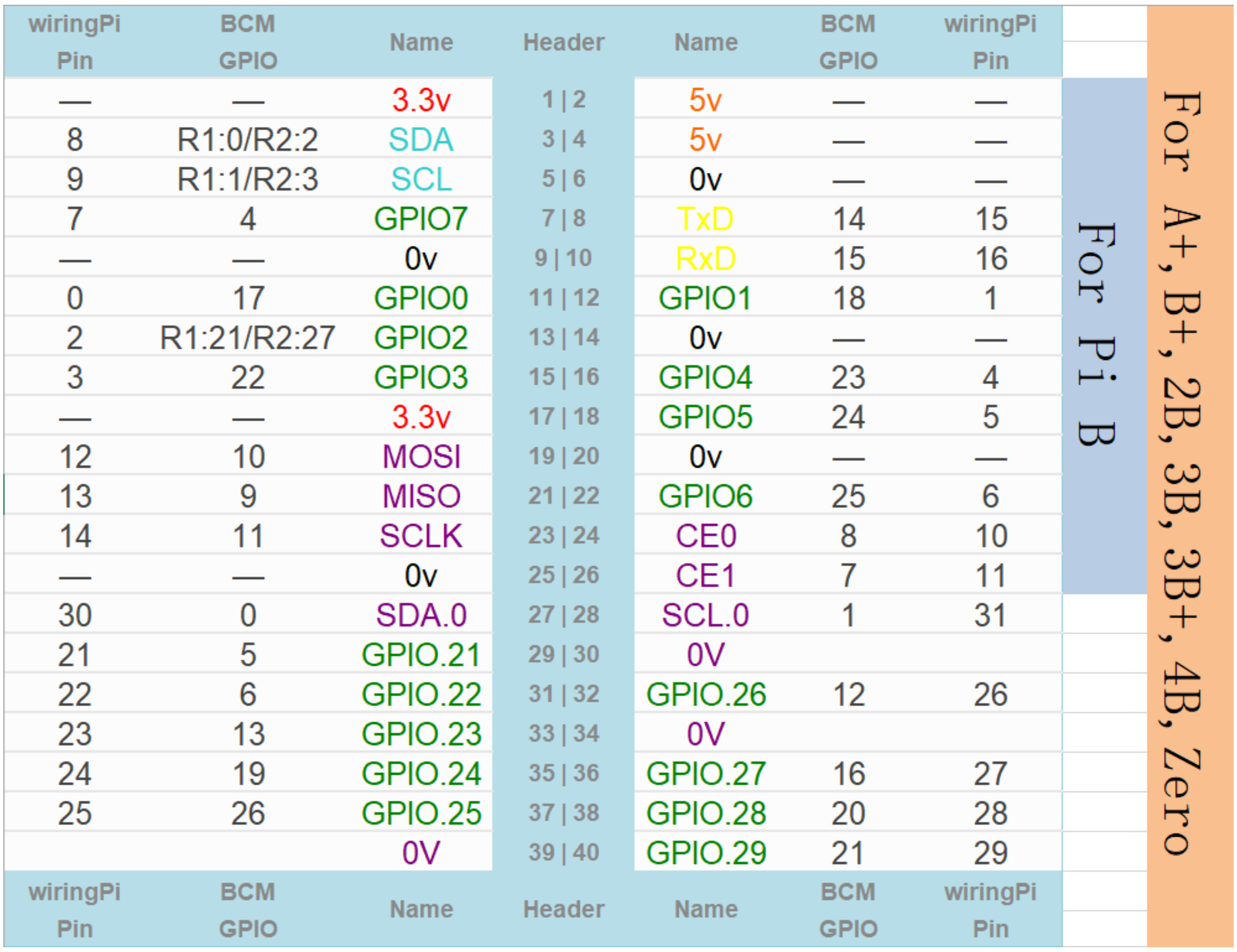
PHYSICAL Numbering

Another way to refer to the pins is by simply counting across and down from pin 1 at the top left (nearest to the SD card). This is 'Physical Numbering', as shown below:



WiringPi GPIO Numbering

Different from the previous two types of GPIO serial numbers, RPi GPIO serial number of the WiringPi are numbered according to the BCM chip use in RPi.



wiringPi Pin	BCM GPIO	Name	Header	Name	BCM GPIO	wiringPi Pin
—	—	3.3v	1 | 2	5v	—	—
8	R1:0/R2:2	SDA	3 | 4	5v	—	—
9	R1:1/R2:3	SCL	5 | 6	0v	—	—
7	4	GPIO7	7 | 8	TxD	14	15
—	—	0v	9 | 10	RxD	15	16
0	17	GPIO0	11 | 12	GPIO1	18	1
2	R1:21/R2:27	GPIO2	13 | 14	0v	—	—
3	22	GPIO3	15 | 16	GPIO4	23	4
—	—	3.3v	17 | 18	GPIO5	24	5
12	10	MOSI	19 | 20	0v	—	—
13	9	MISO	21 | 22	GPIO6	25	6
14	11	SCLK	23 | 24	CE0	8	10
—	—	0v	25 | 26	CE1	7	11
30	0	SDA.0	27 | 28	SCL.0	1	31
21	5	GPIO.21	29 | 30	0V		
22	6	GPIO.22	31 | 32	GPIO.26	12	26
23	13	GPIO.23	33 | 34	0V		
24	19	GPIO.24	35 | 36	GPIO.27	16	27
25	26	GPIO.25	37 | 38	GPIO.28	20	28
		0V	39 | 40	GPIO.29	21	29
wiringPi Pin	BCM GPIO	Name	Header	Name	BCM GPIO	wiringPi Pin

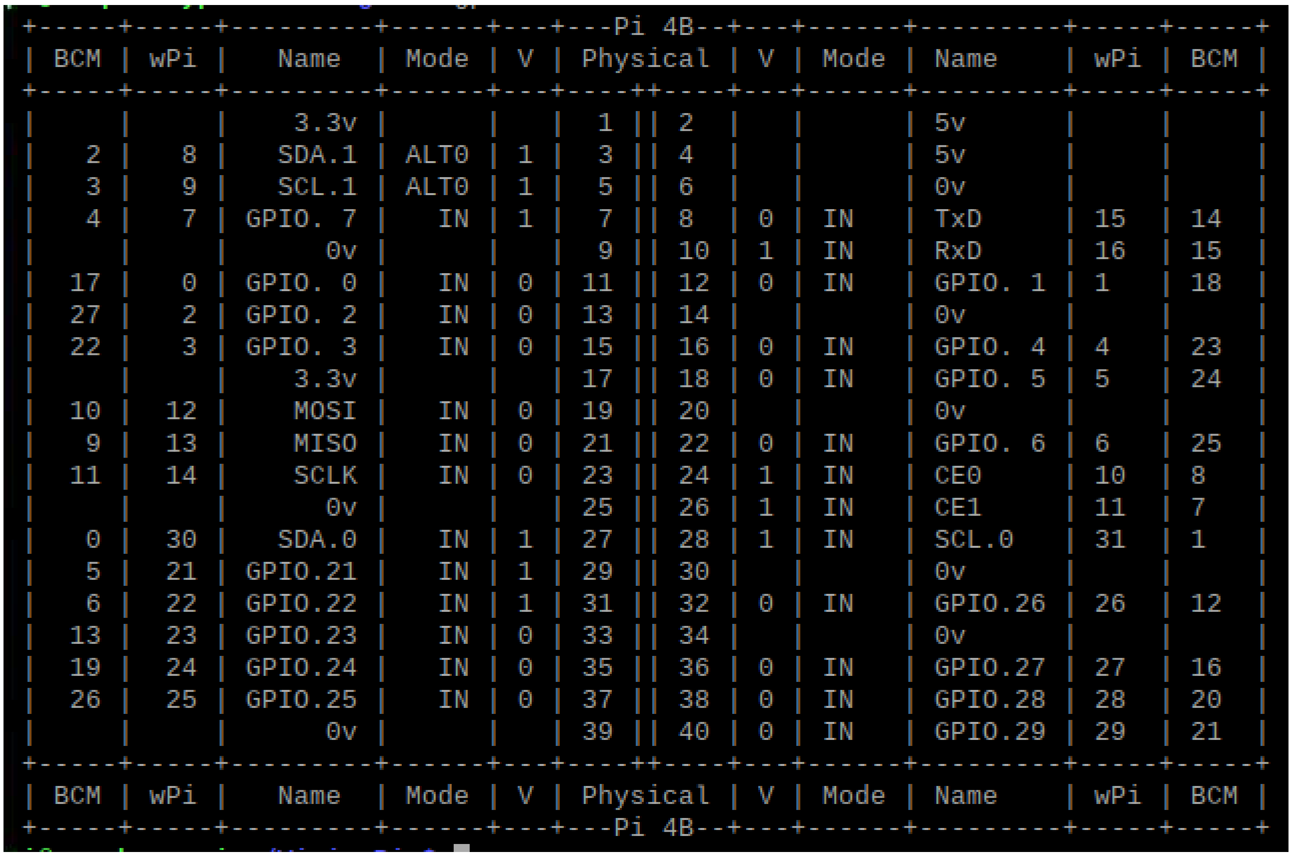
For Pi B

For A+, B+, 2B, 3B, 3B+, 4B, Zero

(For more details, please refer to https://projects.drogon.net/raspberry-pi/wiringpi/pins/)

You can also use the following command to view their correlation.

```
gpio readall
```

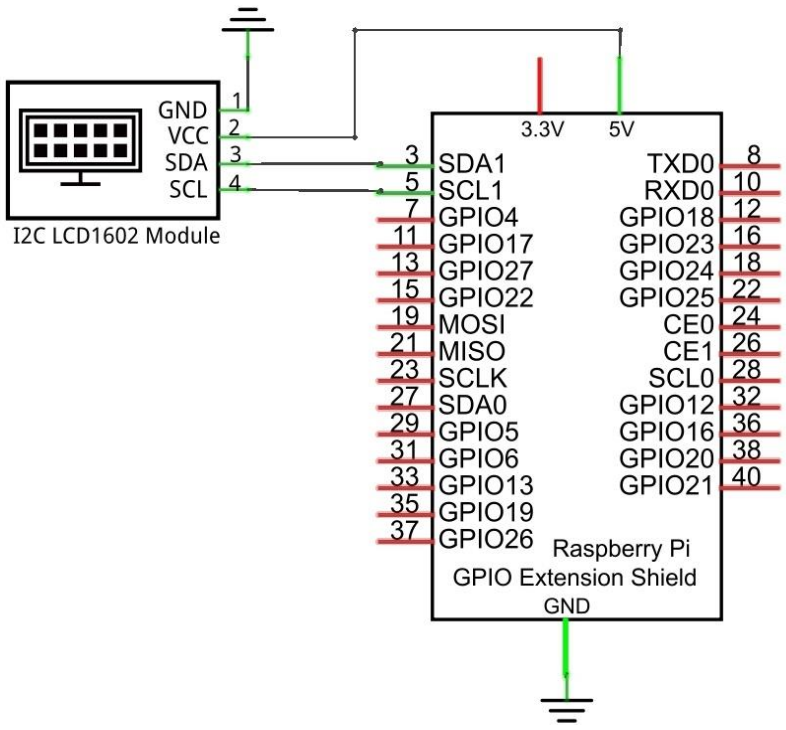


```
 +-----+-----+---------+------+---+---Pi 4B--+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 |     |     |    3.3v |      |   |  1 || 2  |   |      | 5v      |     |     |
 |   2 |   8 |   SDA.1 | ALT0 | 1 |  3 || 4  |   |      | 5v      |     |     |
 |   3 |   9 |   SCL.1 | ALT0 | 1 |  5 || 6  |   |      | 0v      |     |     |
 |   4 |   7 | GPIO. 7 |   IN | 1 |  7 || 8  | 0 | IN   | TxD     | 15  | 14  |
 |     |     |      0v |      |   |  9 || 10 | 1 | IN   | RxD     | 16  | 15  |
 |  17 |   0 | GPIO. 0 |   IN | 0 | 11 || 12 | 0 | IN   | GPIO. 1 | 1   | 18  |
 |  27 |   2 | GPIO. 2 |   IN | 0 | 13 || 14 |   |      | 0v      |     |     |
 |  22 |   3 | GPIO. 3 |   IN | 0 | 15 || 16 | 0 | IN   | GPIO. 4 | 4   | 23  |
 |     |     |    3.3v |      |   | 17 || 18 | 0 | IN   | GPIO. 5 | 5   | 24  |
 |  10 |  12 |    MOSI |   IN | 0 | 19 || 20 |   |      | 0v      |     |     |
 |   9 |  13 |    MISO |   IN | 0 | 21 || 22 | 0 | IN   | GPIO. 6 | 6   | 25  |
 |  11 |  14 |    SCLK |   IN | 0 | 23 || 24 | 1 | IN   | CE0     | 10  | 8   |
 |     |     |      0v |      |   | 25 || 26 | 1 | IN   | CE1     | 11  | 7   |
 |   0 |  30 |   SDA.0 |   IN | 1 | 27 || 28 | 1 | IN   | SCL.0   | 31  | 1   |
 |   5 |  21 | GPIO.21 |   IN | 1 | 29 || 30 |   |      | 0v      |     |     |
 |   6 |  22 | GPIO.22 |   IN | 1 | 31 || 32 | 0 | IN   | GPIO.26 | 26  | 12  |
 |  13 |  23 | GPIO.23 |   IN | 0 | 33 || 34 |   |      | 0v      |     |     |
 |  19 |  24 | GPIO.24 |   IN | 0 | 35 || 36 | 0 | IN   | GPIO.27 | 27  | 16  |
 |  26 |  25 | GPIO.25 |   IN | 0 | 37 || 38 | 0 | IN   | GPIO.28 | 28  | 20  |
 |     |     |      0v |      |   | 39 || 40 | 0 | IN   | GPIO.29 | 29  | 21  |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+---Pi 4B--+---+------+---------+-----+-----+
```

Circuit

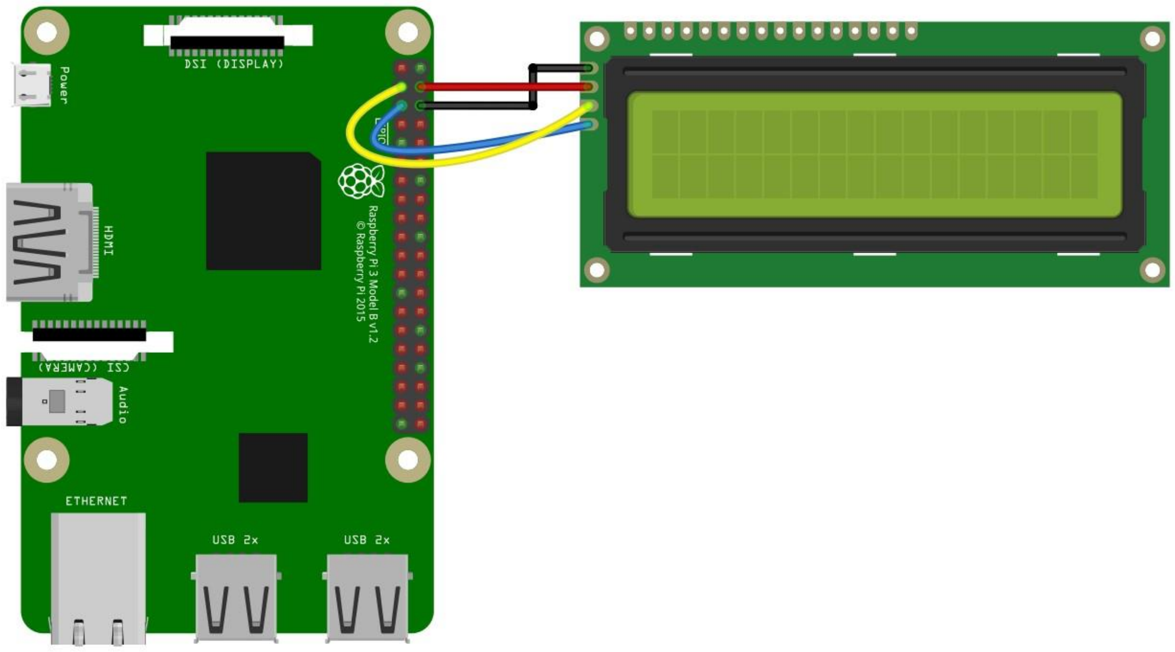
Note that the power supply for I2C LCD1602 in this circuit is 5V.

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: support@freenove.com

NOTE: It is necessary to configure 12C and install Smbus first.



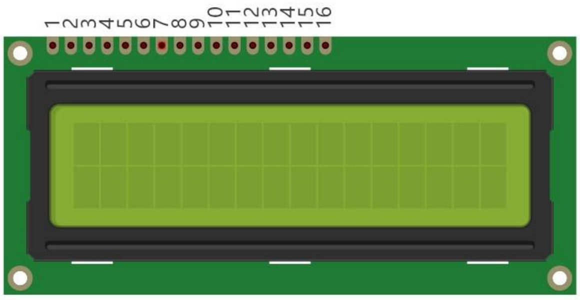
Component knowledge

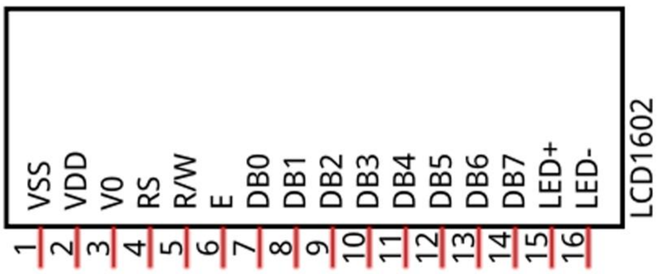
I2C communication

I2C (Inter-Integrated Circuit) has a two-wire serial communication mode, which can be used to connect a micro-controller and its peripheral equipment. Devices using I2C communications must be connected to the serial data line (SDA), and serial clock line (SCL) (called I2C bus). Each device has a unique address which can be used as a transmitter or receiver to communicate with devices connected via the bus.

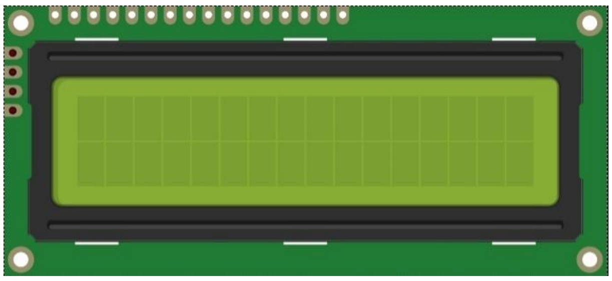
LCD1602 communication

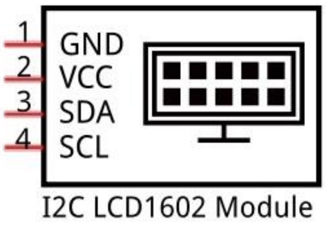
There are LCD1602 display screen and the I2C LCD. We will introduce both of them in this chapter. But what we use in this project is an I2C LCD1602 display screen. The LCD1602 Display Screen can display 2 lines of characters in 16 columns. It is capable of displaying numbers, letters, symbols, ASCII code and so on. As shown below is a monochrome LCD1602 Display Screen along with its circuit pin diagram





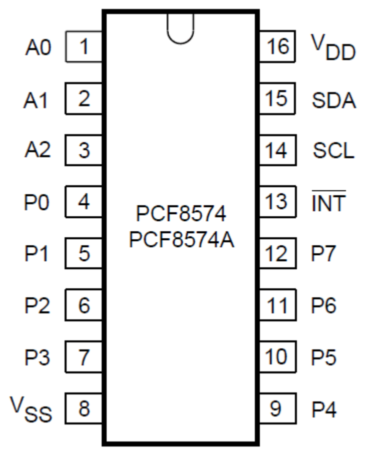
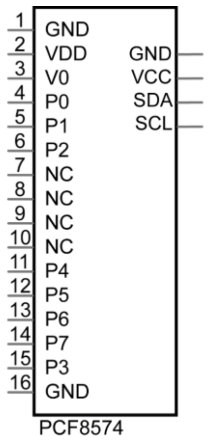
I2C LCD1602 Display Screen integrates a I2C interface, which connects the serial-input & parallel-output module to the LCD1602 Display Screen. This allows us to only use 4 lines to operate the LCD1602.



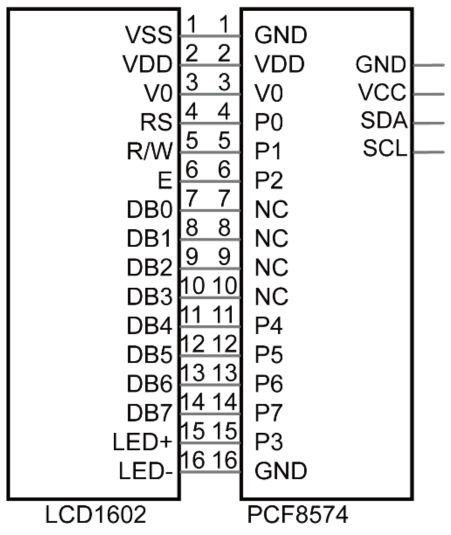


The serial-to-parallel IC chip used in this module is PCF8574T (PCF8574AT), and its default I2C address is 0x27(0x3F). You can also view the RPI bus on your I2C device address through command "i2cdetect -y 1" (refer to the "configuration I2C" section below).

Below is the PCF8574 chip pin diagram and its module pin diagram:

PCF8574 chip pin diagram:	PCF8574 module pin diagram
	

PCF8574 module pins and LCD1602 pins correspond to each other and connected to each other:



Because of this, as stated earlier, we only need 4 pins to control the16 pins of the LCD1602 Display Screen through the I2C interface.

In this project, we will use the I2C LCD1602 to display some static characters and dynamic variables.

Configure I2C and Install Smbus

If you have already configured I2C and installed Smbus, skip this section. If you have not, proceed with the following configuration.

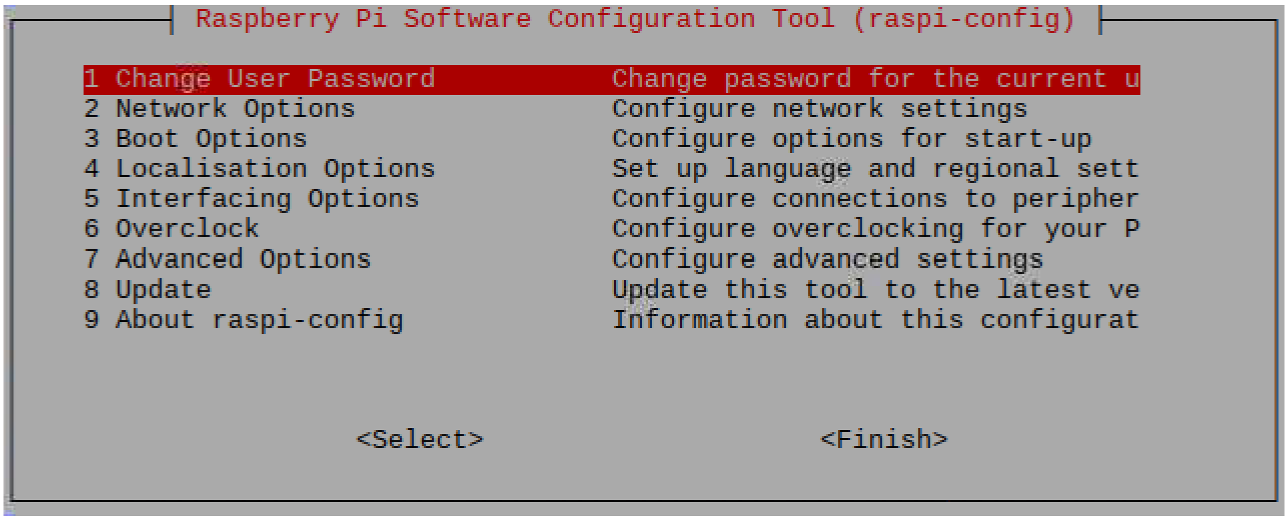
Enable I2C

The I2C interface in Raspberry Pi is disabled by default. You will need to open it manually and enable the I2C interface as follows:

Type command in the Terminal:

```
sudo raspi-config
```

Then open the following dialog box:



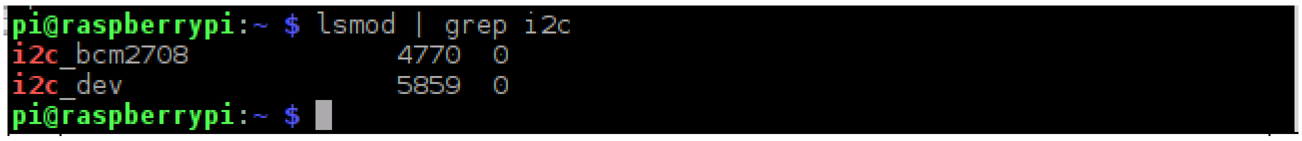
```
Raspberry Pi Software Configuration Tool (raspi-config)

1 Change User Password         Change password for the current u
2 Network Options              Configure network settings
3 Boot Options                 Configure options for start-up
4 Localisation Options         Set up language and regional sett
5 Interfacing Options          Configure connections to peripher
6 Overclock                    Configure overclocking for your P
7 Advanced Options             Configure advanced settings
8 Update                       Update this tool to the latest ve
9 About raspi-config           Information about this configurat
```

Choose "5 Interfacing Options" then "P5 I2C" then "Yes" and then "Finish" in this order and restart your RPi. The I2C module will then be started.

Type a command to check whether the I2C module is started:

```
lsmod | grep i2c
```

If the I2C module has been started, the following content will be shown. "bcm2708" refers to the CPU model. Different models of Raspberry Pi display different contents depending on the CPU installed:



```
pi@raspberrypi:~ $ lsmod | grep i2c
i2c_bcm2708            4770  0
i2c_dev                5859  0
pi@raspberrypi:~ $
```

Install I2C-Tools

Next, type the command to install I2C-Tools. It is available with the Raspberry Pi OS by default.

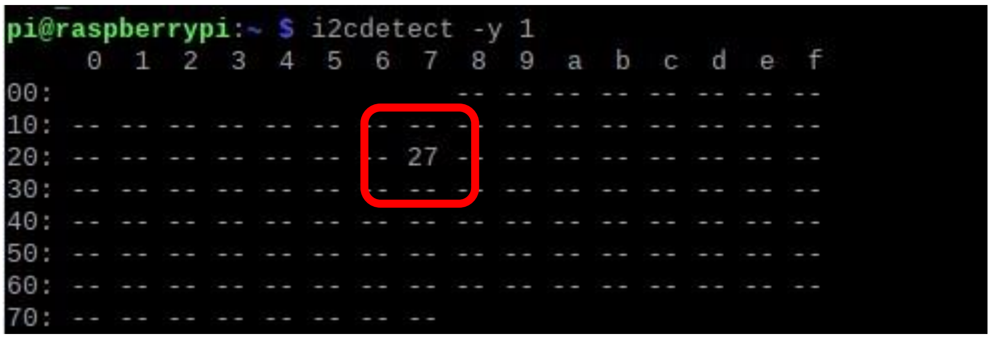
```
sudo apt-get install i2c-tools
```

I2C device address detection:

```
i2cdetect -y 1
```

When you use the serial-parallel IC chip PCF8574T, its I2C default address is 0x27. When the serial-parallel IC chip you use is PCF8574AT, its I2C default address is 0x3F.

When you use the serial-parallel IC chip PCF8574T, the result should look like this:



```
pi@raspberrypi:~ $ i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                          -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- 27 -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

Here, 27 (HEX) is the I2C address of LCD2004 Module (PCF8574T).

When you are using PCF8574AT, and its default I2C address is 0x3F.

Install Smbus Module

```
sudo apt-get install python-smbus
sudo apt-get install python3-smbus
```

Code

This code will have your RPi's CPU temperature and System Time Displayed on the LCD1602.

Python Code 1.1 I2CLCD1602

If you did not configure I2C and install Smbus, please complete the configuration and installation. If you did, please continue.

First, observe the project result, and then learn about the code in detail.

If you have any concerns, please contact us via: support@freenove.com

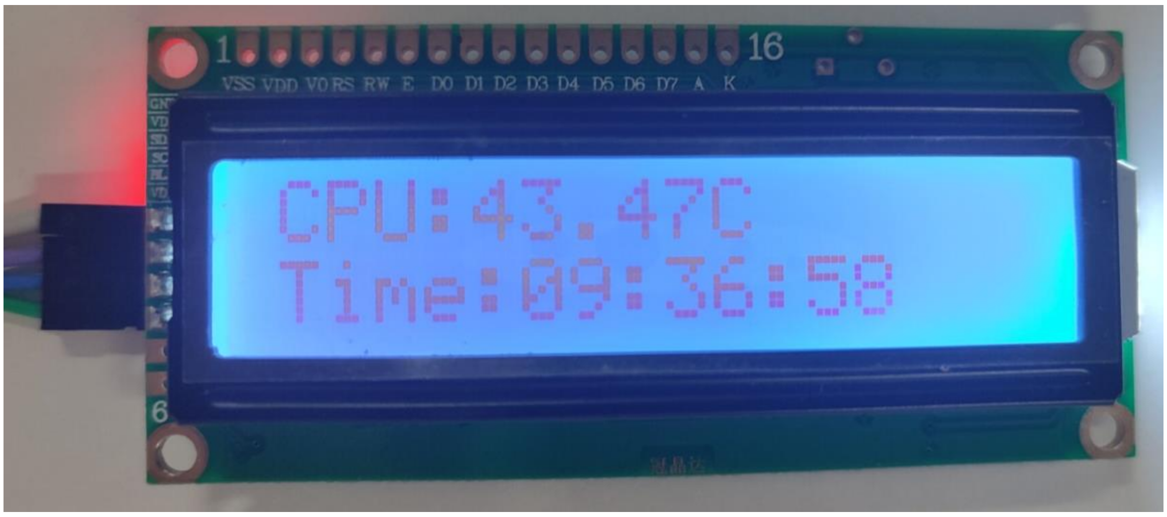
1. Use cd command to enter 1.1_ I2CLCD1602 directory of Python code.

```
cd
~/Freenove_LCD_Module/Freenove_LCD_Module_for_Raspberry_Pi/Python/Python_Code/1.1_I2CLCD1602
```

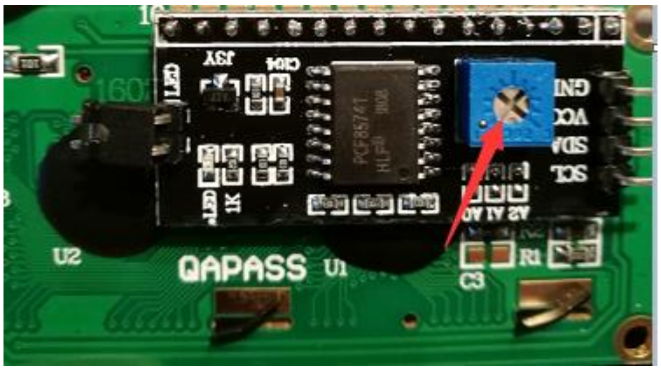
2. Use Python command to execute Python code "I2CLCD1602.py".

```
python I2CLCD1602.py
```

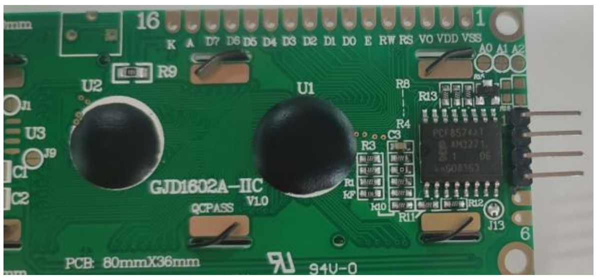
After the program is executed, the LCD1602 Screen will display your RPi's CPU Temperature and System Time.



NOTE: After the program is executed, if you cannot see anything on the display or the display is not clear, try rotating the white knob on back of LCD1602 slowly, which adjusts the contrast, until the screen can display the Time and Temperature clearly.



In addition, if the back of your LCD module looks like the picture below, there is no need to adjust the contrast, this circuit has adjusted the contrast to a suitable value.



The following is the program code:

```
from PCF8574 import PCF8574_GPIO
from Adafruit_LCD1602 import Adafruit_CharLCD

from time import sleep, strftime
from datetime import datetime

def get_cpu_temp():     # get CPU temperature and store it into file
"/sys/class/thermal/thermal_zone0/temp"
    tmp = open('/sys/class/thermal/thermal_zone0/temp')
    cpu = tmp.read()
    tmp.close()
    return '{:.2f}'.format( float(cpu)/1000 ) + ' C'

def get_time_now():     # get system time
    return datetime.now().strftime('    %H:%M:%S')

def loop():
    mcp.output(3,1)     # turn on LCD backlight
    lcd.begin(16,2)     # set number of LCD lines and columns
    while(True):
        #lcd.clear()
        lcd.setCursor(0,0)  # set cursor position
        lcd.message( 'CPU: ' + get_cpu_temp()+'\n' )# display CPU temperature
        lcd.message( get_time_now() )   # display the time
        sleep(1)

def destroy():
    lcd.clear()

PCF8574_address = 0x27  # I2C address of the PCF8574 chip.
PCF8574A_address = 0x3F  # I2C address of the PCF8574A chip.
# Create PCF8574 GPIO adapter.
try:
    mcp = PCF8574_GPIO(PCF8574_address)
except:
    try:
        mcp = PCF8574_GPIO(PCF8574A_address)
    except:
        print ('I2C Address Error !')
        exit(1)
# Create LCD, passing in MCP GPIO adapter.
lcd = Adafruit_CharLCD(pin_rs=0, pin_e=2, pins_db=[4,5,6,7], GPIO=mcp)

if __name__ == '__main__':
    print ('Program is starting ... ')
    try:
        loop()
    except KeyboardInterrupt:
        destroy()

```

Two modules are used in the code, PCF8574.py and Adafruit_LCD1602.py. These two documents and the code files are stored in the same directory, and neither of them is dispensable. Please DO NOT DELETE THEM! PCF8574.py is used to provide I2C communication mode and operation method of some of the ports for the RPi and PCF8574 IC Chip. Adafruit module Adafruit_LCD1602.py is used to provide some functional operation method for the LCD1602 Display.
In the code, first get the object used to operate the PCF8574's port, then get the object used to operate the LCD1602.

```
address = 0x27  # I2C address of the PCF8574 chip.
# Create PCF8574 GPIO adapter.
mcp = PCF8574_GPIO(address)
# Create LCD, passing in MCP GPIO adapter.
lcd = Adafruit_CharLCD(pin_rs=0, pin_e=2, pins_db=[4,5,6,7], GPIO=mcp)
```

According to the circuit connection, port 3 of PCF8574 is connected to the positive pole of the LCD1602 Display's backlight. Then in the loop () function, use of mcp.output (3,1) to turn the LCD1602 Display's backlight ON and then set the number of LCD lines and columns.

```
def loop():
    mcp.output(3,1)     # turn on the LCD backlight
    lcd.begin(16,2)     # set number of LCD lines and columns
```

In the next while loop, set the cursor position, and display the CPU temperature and time.

```
    while(True):
        #lcd.clear()
        lcd.setCursor(0,0)  # set cursor position
        lcd.message( 'CPU: ' + get_cpu_temp()+'\n' )# display CPU temperature
        lcd.message( get_time_now() )   # display the time
        sleep(1)
```

CPU temperature is stored in file “/sys/class/thermal/thermal_zone0/temp”. Open the file and read content of the file, and then convert it to Celsius degrees and return. Subfunction used to get CPU temperature is shown below:

```
def get_cpu_temp():     # get CPU temperature and store it into file
  “/sys/class/thermal/thermal_zone0/temp”
    tmp = open('/sys/class/thermal/thermal_zone0/temp')
    cpu = tmp.read()
    tmp.close()
    return '{:.2f}'.format( float(cpu)/1000 ) + ' C'
```

Subfunction used to get time:

```
def get_time_now():     # get the time
    return datetime.now().strftime('    %H:%M:%S')
```

Details about PCF8574.py and Adafruit_LCD1602.py:

Module PCF8574

This module provides two classes **PCF8574_I2C** and **PCF8574_GPIO**.

Class **PCF8574_I2C**: provides reading and writing method for PCF8574.

Class **PCF8574_GPIO**: provides a standardized set of GPIO functions.

More information can be viewed through opening PCF8574.py.

Adafruit_LCD1602 Module

Module Adafruit_LCD1602

This module provides the basic operation method of LCD1602, including class Adafruit_CharLCD. Some member functions are described as follows:

def begin(self, cols, lines): set the number of lines and columns of the screen.

def clear(self): clear the screen

def setCursor(self, col, row): set the cursor position

def message(self, text): display contents

More information can be viewed through opening Adafruit_CharLCD.py.

Chapter 2 LCD2004

In the previous chapter, we studied the LCD1602 display. In order to display more content,In this chapter, we will learn about the LCD2004 Display Screen.

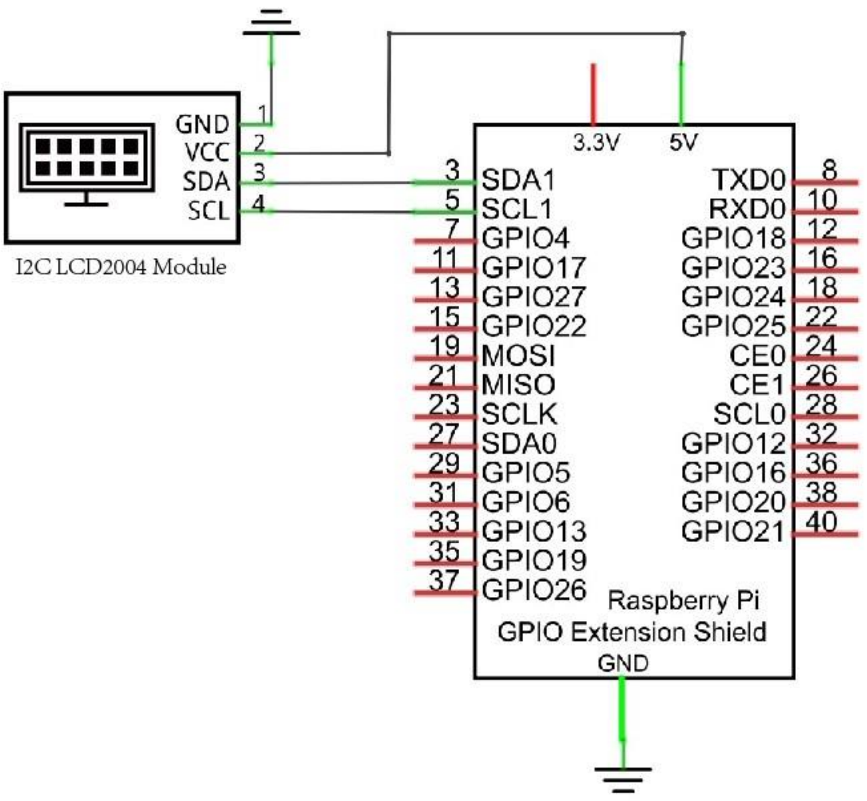
Project 2.1 I2C LCD2004

In this section we learn how to use LCD2004 to display something.

Circuit

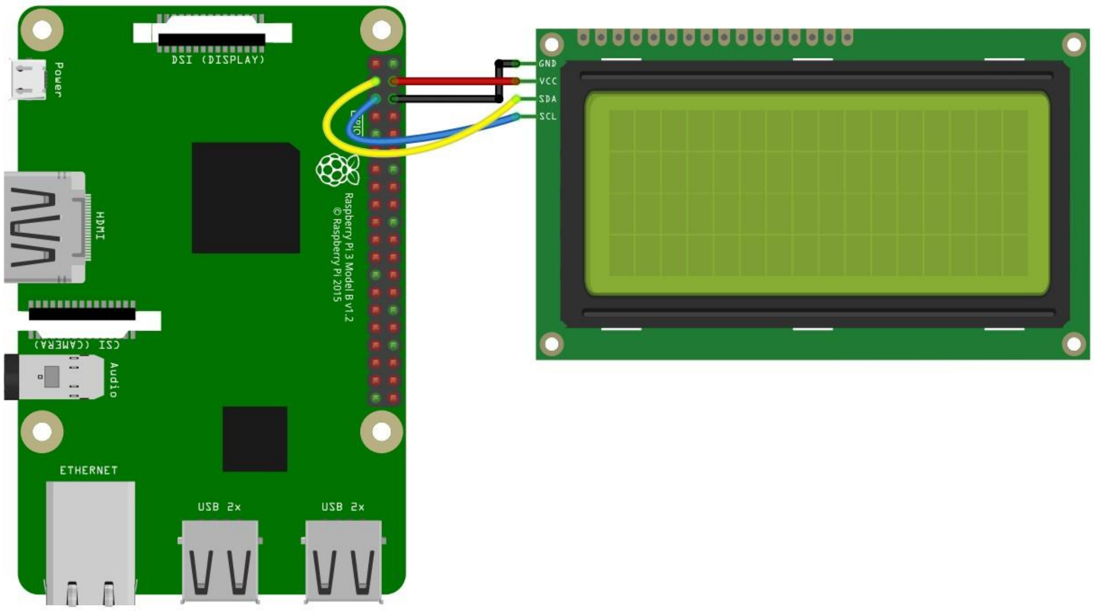
Note that the power supply for I2C LCD2004 in this circuit is 5V.

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: support@freenove.com

NOTE: It is necessary to configure 12C and install Smbus first.



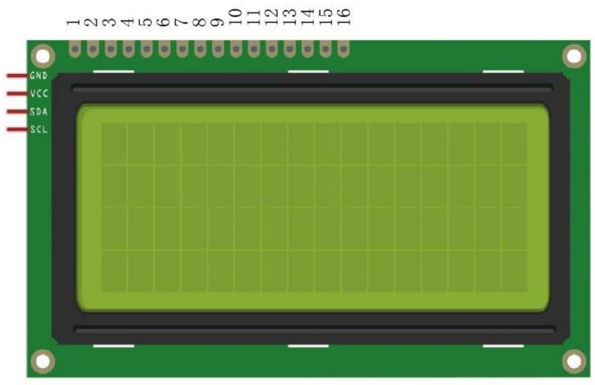
Component knowledge

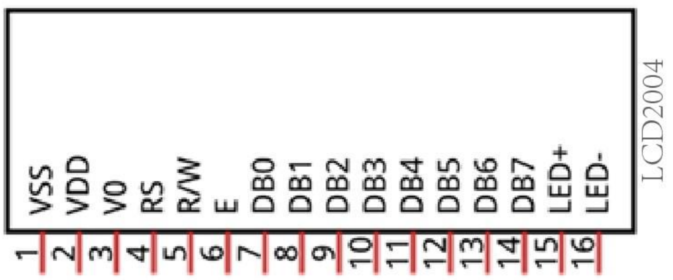
I2C communication

I2C (Inter-Integrated Circuit) has a two-wire serial communication mode, which can be used to connect a micro-controller and its peripheral equipment. Devices using I2C communications must be connected to the serial data line (SDA), and serial clock line (SCL) (called I2C bus). Each device has a unique address which can be used as a transmitter or receiver to communicate with devices connected via the bus.

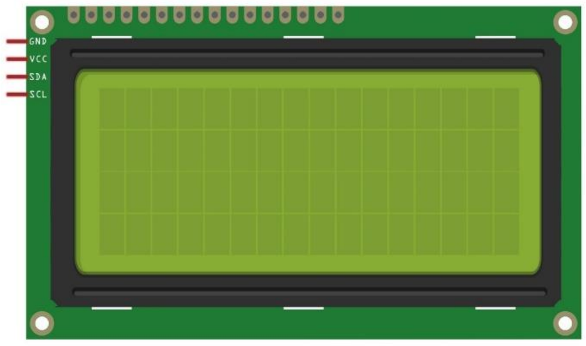
LCD2004 communication

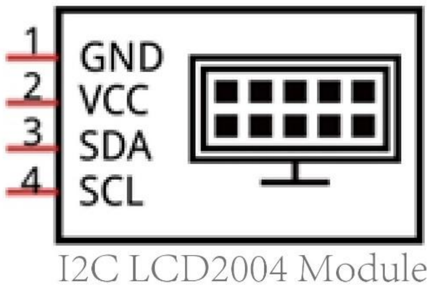
There are LCD2004 display screen and the I2C LCD. We will introduce both of them in this chapter. But what we use in this project is an I2C LCD2004 display screen. The LCD2004 Display Screen can display 4 lines of characters in 20 columns. It is capable of displaying numbers, letters, symbols, ASCII code and so on. As shown below is a monochrome LCD2004 Display Screen along with its circuit pin diagram.





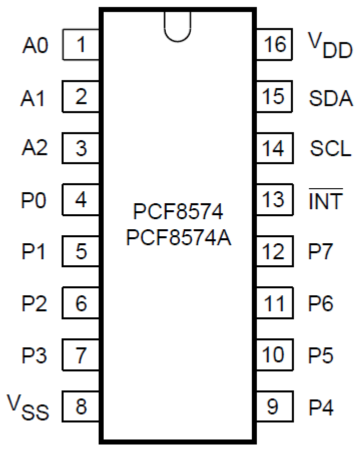
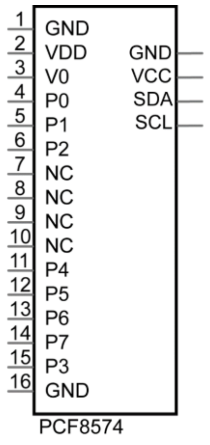
I2C LCD2004 display screen integrates a I2C interface, which connects the serial-input & parallel-output module to the LCD2004 display screen. This allows us to only use 4 lines to the operate the LCD2004.



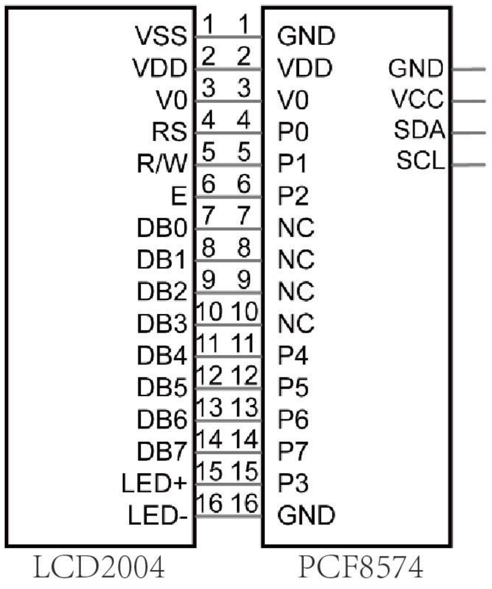


The serial-to-parallel IC chip used in this module is PCF8574T (PCF8574AT), and its default I2C address is 0x27(0x3F). You can also view the RPI bus on your I2C device address through command "i2cdetect -y 1".

Below is the PCF8574 chip pin diagram and its module pin diagram:

PCF8574 chip pin diagram:	PCF8574 module pin diagram
 A0 1 A1 2 A2 3 P0 4 P1 5 P2 6 P3 7 VSS 8 16 VDD 15 SDA 14 SCL 13 INT 12 P7 11 P6 10 P5 9 P4 PCF8574 PCF8574A	 1 GND 2 VDD 3 V0 4 P0 5 P1 6 P2 7 NC 8 NC 9 NC 10 NC 11 P4 12 P5 13 P6 14 P7 15 P3 16 GND GND VCC SDA SCL PCF8574

PCF8574 module pins and LCD1602 pins correspond to each other and connected to each other:



Because of this, as stated earlier, we only need 4 pins to control the16 pins of the LCD2004 Display Screen through the I2C interface.

In this project, we will use the I2C LCD2004 to display some static characters and dynamic variables.

Configure I2C and Install Smbus

If you did not configure I2C and install Smbus, please complete the configuration and installation. If you have, skip this section.

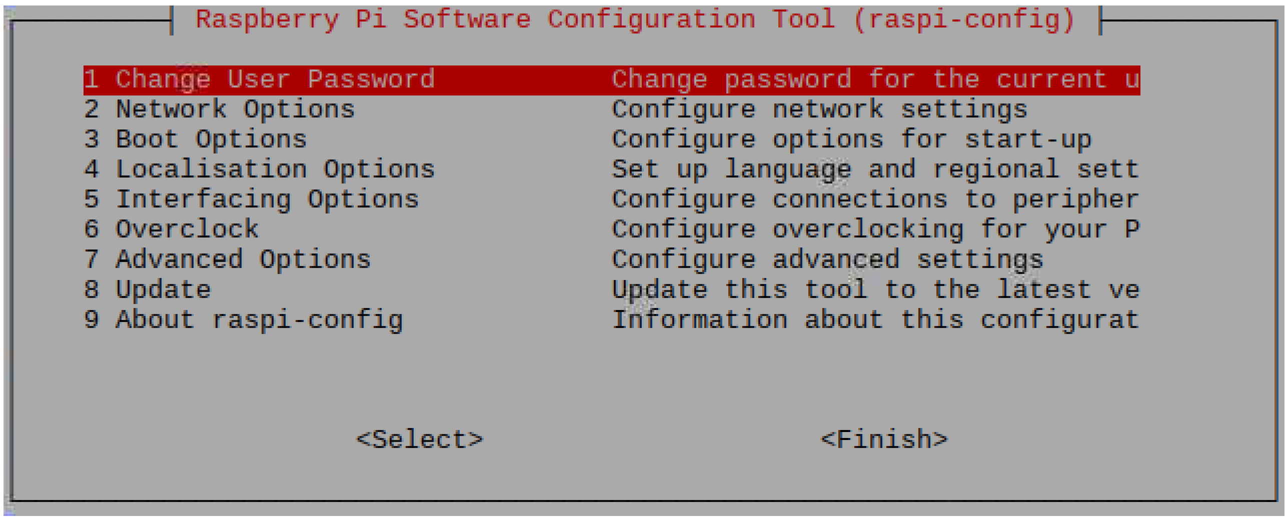
Enable I2C

The I2C interface in Raspberry Pi is disabled by default. You will need to open it manually and enable the I2C interface as follows:

Type command in the Terminal:

```
sudo raspi-config
```

Then open the following dialog box:



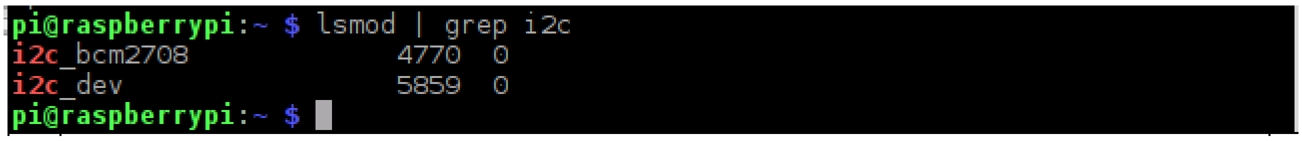
```
              Raspberry Pi Software Configuration Tool (raspi-config)

    1 Change User Password           Change password for the current u
    2 Network Options                Configure network settings
    3 Boot Options                   Configure options for start-up
    4 Localisation Options           Set up language and regional sett
    5 Interfacing Options            Configure connections to peripher
    6 Overclock                      Configure overclocking for your P
    7 Advanced Options               Configure advanced settings
    8 Update                         Update this tool to the latest ve
    9 About raspi-config             Information about this configurat

                   <Select>                     <Finish>
```

Choose "5 Interfacing Options" then "P5 I2C" then "Yes" and then "Finish" in this order and restart your RPi. The I2C module will then be started.

Type a command to check whether the I2C module is started:

```
lsmod | grep i2c
```

If the I2C module has been started, the following content will be shown. "bcm2708" refers to the CPU model. Different models of Raspberry Pi display different contents depending on the CPU installed:



```
pi@raspberrypi:~ $ lsmod | grep i2c
i2c_bcm2708            4770  0
i2c_dev                5859  0
pi@raspberrypi:~ $
```

Install I2C-Tools

Next, type the command to install I2C-Tools. It is available with the Raspberry Pi OS by default.

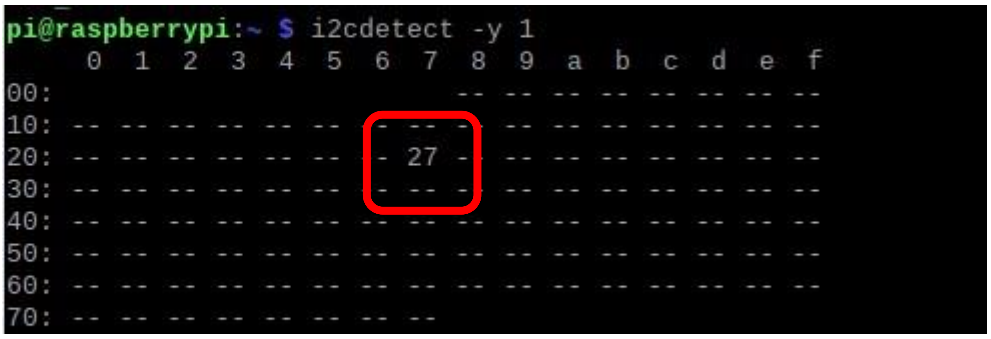
```
sudo apt-get install i2c-tools
```

I2C device address detection:

```
i2cdetect -y 1
```

When you use the serial-parallel IC chip PCF8574T, its I2C default address is 0x27. When the serial-parallel IC chip you use is PCF8574AT, its I2C default address is 0x3F.

When you use the serial-parallel IC chip PCF8574T, the result should look like this:



```
pi@raspberrypi:~ $ i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                         -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- 27 -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

Here, 27 (HEX) is the I2C address of LCD2004 Module (PCF8574T).

When you are using PCF8574AT, and its default I2C address is 0x3F.

Install Smbus Module

```
sudo apt-get install python-smbus
sudo apt-get install python3-smbus
```

Code

This code will have your RPi's CPU temperature and System Time Displayed on the LCD2004.

Python Code 2.1 I2CLCD2004

If you did not configure I2C and install Smbus, please complete the configuration and installation. If you did, please continue.
First, observe the project result, and then learn about the code in detail.
If you have any concerns, please contact us via: support@freenove.com

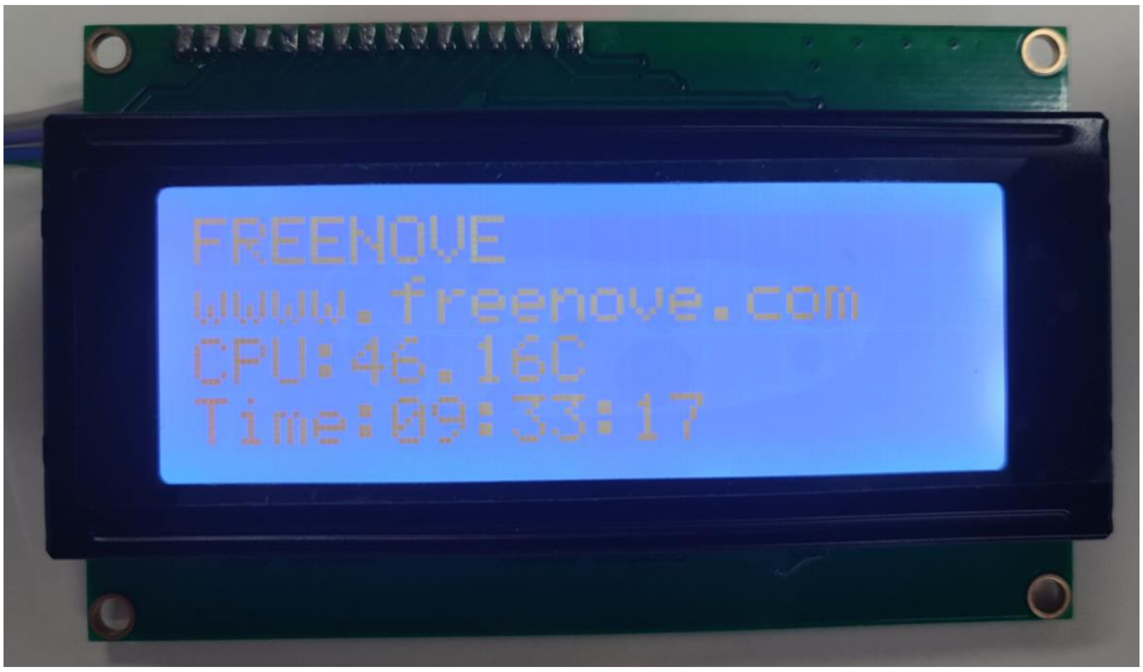
3. Use cd command to enter 2.1_I2CLCD2004 directory of Python code.

```
cd
~/Freenove_LCD_Module/Freenove_LCD_Module_for_Raspberry_Pi/Python/Python_Code/2.1_I2CLCD2004
```

4. Use Python command to execute Python code "I2CLCD2004.py".

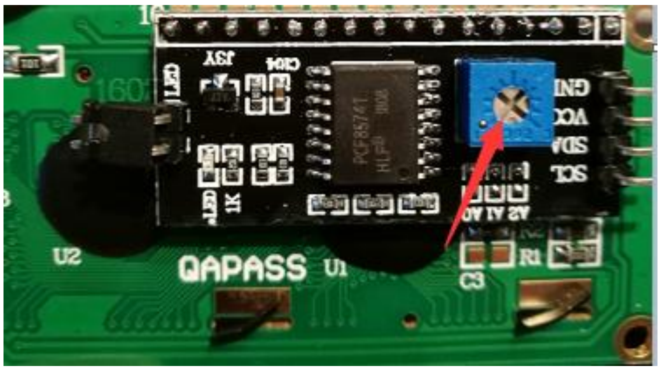
```
python I2CLCD2004.py
```

After the program is executed, the LCD2004 Screen will display your RPi's CPU Temperature and System Time.



```
FREENOVE
www.freenove.com
CPU:46.16C
Time:09:33:17
```

NOTE: After the program is executed, if you cannot see anything on the display or the display is not clear, try rotating the white knob on back of LCD2004 slowly, which adjusts the contrast, until the screen can display the Time and Temperature clearly.



The following is the program code:

```
from PCF8574 import PCF8574_GPIO
from Adafruit_LCD2004 import Adafruit_CharLCD

from time import sleep, strftime
from datetime import datetime

def get_cpu_temp():     # get CPU temperature and store it into file
"/sys/class/thermal/thermal_zone0/temp"
    tmp = open('/sys/class/thermal/thermal_zone0/temp')
    cpu = tmp.read()
    tmp.close()
    return '{:.2f}'.format( float(cpu)/1000 ) + ' C'

def get_time_now():     # get system time
    return datetime.now().strftime('    %H:%M:%S')

def loop():
    mcp.output(3,1)     # turn on LCD backlight
    lcd.begin(20,4)     # set number of LCD lines and columns
    lcd.setCursor(0,0)  # set cursor position
    lcd.message( 'FREENOVE')
    lcd.setCursor(0,1)  # set cursor position
    lcd.message( 'wwww.freenove.com')
    while(True):
        #lcd.clear()
        lcd.setCursor(0,2)  # set cursor position
        lcd.message( 'CPU: ' + get_cpu_temp()+'\n' )# display CPU temperature
        lcd.setCursor(0,3)  # set cursor position
        lcd.message( get_time_now() )   # display the time
        sleep(1)

def destroy():
    lcd.clear()

PCF8574_address = 0x27  # I2C address of the PCF8574 chip.
PCF8574A_address = 0x3F  # I2C address of the PCF8574A chip.
# Create PCF8574 GPIO adapter.
try:
    mcp = PCF8574_GPIO(PCF8574_address)
except:
    try:
        mcp = PCF8574_GPIO(PCF8574A_address)
    except:
        print ('I2C Address Error !')
        exit(1)
# Create LCD, passing in MCP GPIO adapter.
lcd = Adafruit_CharLCD(pin_rs=0, pin_e=2, pins_db=[4,5,6,7], GPIO=mcp)

if __name__ == '__main__':
    print ('Program is starting ... ')
    try:
        loop()
    except KeyboardInterrupt:
        destroy()
```

Two modules are used in the code, PCF8574.py and Adafruit_LCD2004.py. These two documents and the code files are stored in the same directory, and neither of them is dispensable. Please DO NOT DELETE THEM! PCF8574.py is used to provide I2C communication mode and operation method of some of the ports for the RPi and PCF8574 IC Chip. Adafruit module Adafruit_LCD2004.py is used to provide some functional operation method for the LCD2004 Display.

In the code, first get the object used to operate the PCF8574's port, then get the object used to operate the LCD2004.

```
address = 0x27  # I2C address of the PCF8574 chip.
# Create PCF8574 GPIO adapter.
mcp = PCF8574_GPIO(address)
# Create LCD, passing in MCP GPIO adapter.
lcd = Adafruit_CharLCD(pin_rs=0, pin_e=2, pins_db=[4,5,6,7], GPIO=mcp)
```

According to the circuit connection, port 3 of PCF8574 is connected to the positive pole of the LCD2004 Display's backlight. Then in the loop () function, use of mcp.output (3,1) to turn the LCD2004 Display's backlight ON and then set the number of LCD lines and columns.

```
def loop():
    mcp.output(3,1)     # turn on the LCD backlight
    lcd.begin(20,4)     # set number of LCD lines and columns
```

In the next while loop, set the cursor position, and display the CPU temperature and time.

```
    while(True):
        #lcd.clear()
        lcd.setCursor(0,2)  # set cursor position
        lcd.message( 'CPU: ' + get_cpu_temp()+'\n' )# display CPU temperature
        lcd.setCursor(0,3)  # set cursor position
        lcd.message( get_time_now() )   # display the time
        sleep(1)
```

CPU temperature is stored in file "/sys/class/thermal/thermal_zone0/temp". Open the file and read content of the file, and then convert it to Celsius degrees and return. Subfunction used to get CPU temperature is shown below:

```
def get_cpu_temp():     # get CPU temperature and store it into file
  "/sys/class/thermal/thermal_zone0/temp"
    tmp = open('/sys/class/thermal/thermal_zone0/temp')
    cpu = tmp.read()
    tmp.close()
    return '{:.2f}'.format( float(cpu)/1000 ) + ' C'
```

Subfunction used to get time:

```
def get_time_now():     # get the time
    return datetime.now().strftime('    %H:%M:%S')
```

Details about PCF8574.py and Adafruit_LCD2004.py:

Module PCF8574

This module provides two classes **PCF8574_I2C** and **PCF8574_GPIO**.

Class **PCF8574_I2C**: provides reading and writing method for PCF8574.

Class **PCF8574_GPIO**: provides a standardized set of GPIO functions.

More information can be viewed through opening PCF8574.py.

Adafruit_LCD2004 Module

Module Adafruit_LCD2004

This module provides the basic operation method of LCD2004, including class Adafruit_CharLCD. Some member functions are described as follows:

def begin(self, cols, lines): set the number of lines and columns of the screen.

def clear(self): clear the screen

def setCursor(self, col, row): set the cursor position

def message(self, text): display contents

More information can be viewed through opening Adafruit_CharLCD.py.