

EE351

None

Qijun Han

None

Table of contents

1. EE351	3
1.1	3
2.	4
2.1	4
2.2	6
2.3	8
2.4 PCF8691	10
2.5	12
2.6 Lab 6	14
2.7	16
2.8 PS2	18
2.9	20
2.10	22

1. EE351

EE351“ ”24Fall
4B RaspberryPi OS-64-bit-desktop
- 4B - PCF8591 - - LED - PS2 -
- RPi.GPIO Python - wiringPi C/C++ - python-smbus I2C

1.1

-
-
-
- PCF8691
-
-
-
- PS2
-
-
-

2. `sudo raspi-config`
3. “Network Options” Wi-Fi SSID
4. `/etc/wpa_supplicant/wpa_supplicant.conf` Wi-Fi
- 5.
6. `ping google.com`
- 7.

4

- 1.
2. `ls`
3. `cd`
4. `mkdir`
5. `rm`
6. `cp`
7. `mv`
- 8.
9. `nano` `nano example.txt`
10. `Ctrl+O` `Ctrl+X`
- 11.
12. `--help` `ls --help`

5

- 1.
2. `sudo apt-get update`
- 3.
4. `sudo apt-get upgrade`
- 5.
6. Python bash
`sudo apt-get install python3-pip`
`pip3 install --upgrade pip setuptools wheel`
7. Git bash
`sudo apt-get install git`

Raspberry Pi

“Raspberry Pi ”

Mu Geany IDE Python C/C++

```
import RPi.GPIO as GPIO
import time

# Define GPIO pins for the LED (BCM numbering)
RED_PIN = 19 # Red part of the dual-color LED
GREEN_PIN = 20 # Green part of the dual-color LED

# Setup GPIO mode and pin directions
GPIO.setmode(GPIO.BCM)
GPIO.setup(RED_PIN, GPIO.OUT)
GPIO.setup(GREEN_PIN, GPIO.OUT)

try:
```

```
while True:
    # Turn on red LED
    GPIO.output(RED_PIN, GPIO.HIGH)
    GPIO.output(GREEN_PIN, GPIO.LOW)
    print("Red LED is ON")
    time.sleep(1) # Wait for 1 second

    # Turn on green LED
    GPIO.output(RED_PIN, GPIO.LOW)
    GPIO.output(GREEN_PIN, GPIO.HIGH)
    print("Green LED is ON")
    time.sleep(1) # Wait for 1 second

except KeyboardInterrupt:
    print("Program stopped by user")

finally:
    # Clean up GPIO settings before exiting
    GPIO.cleanup()
```

LED - - - 1

2.3

Lab3

8 Raspberry Pi LED LED GPIO Python

1. Raspberry Pi GPIO

2. Raspberry Pi General Purpose Input Output, GPIO

3. BCM GPIO LED /

4. LED

5. LED LED

6. LED LED LED GPIO LED

7.

8. Python `time.sleep()` LED

9.

10. for while LED

1.

2. Raspberry Pi T 8 LED VCC GND SIG

3. LED GPIO GPIO17, GPIO27, GPIO22 LED GND

4. LED

5.

6. Python RPi.GPIO GPIO

7. LED GPIO

8. GPIO LED

9.

```
import RPi.GPIO as GPIO
import time

# Define GPIO pins for the LEDs (BCM numbering)
led_pins = [17, 27, 22, 5, 6, 13, 19, 26] # Adjust these based on your setup

# Setup GPIO mode and pin directions
GPIO.setmode(GPIO.BCM)
for pin in led_pins:
    GPIO.setup(pin, GPIO.OUT)

def set_leds(state):
    """Set all LEDs to the given state (True=ON, False=OFF)."""
    for pin in led_pins:
        GPIO.output(pin, state)

try:
    print("Running LED chaser...")

    while True:
        # Turn on each LED one by one
        for i in range(len(led_pins)):
            set_leds(False) # Turn off all LEDs
            GPIO.output(led_pins[i], True) # Turn on current LED
            print(f"LED {i+1} is ON")
            time.sleep(0.2) # Wait for a short period

except KeyboardInterrupt:
    print("\nProgram stopped by user")
```



```
finally:  
    set_leds(False) # Ensure all LEDs are turned off before exiting  
    GPIO.cleanup() # Clean up GPIO settings
```

LED LED 0.2 Ctrl+C

- 1.
2. Python LED
3. `time.sleep()`
- 4.
- 5.
- 6.

2.4 PCF8691

Lab5 PCF8591

PCF8591 Analog-to-Digital Converter, ADC Raspberry Pi PCF8591 8
ADC I2C PCF8591 LED

1. PCF8591

2. PCF8591 CMOS 8 A/D 8 D/A

3. I2C 0x48 A0, A1, A2 8 I2C

4. I2C

5. I2C SDA SCL Raspberry Pi PCF8591

6.

7. AIN0 AOUT LED LED

8. NTC

1.

2. Raspberry Pi T PCF8591 SDA SCL VCC GND

3. LED PCF8591 AOUT GND LED GND GPIO GPIO17

4. I2C

5. Raspberry Pi Preferences -> Raspberry Pi Configuration

6. Interfaces I2C OK

7.

8. Python smbus I2C

9. SMBus PCF8591 AIN0 AOUT LED

10.

```
import smbus
import time

# Define the I2C address of the PCF8591 and control bits
address = 0x48 # Default address for PCF8591
control_bit = 0x40 # Command to start conversion on channel 0 (AIN0)

# Initialize the SMBus library
bus = smbus.SMBus(1) # Use I2C bus 1

try:
    while True:
        # Write the control byte to initiate an A/D conversion on channel 0
        bus.write_byte(address, control_bit)

        # Read back the converted value from the PCF8591
        analog_value = bus.read_byte(address)

        # Print out the raw analog value
        print("Analog Value:", analog_value)

        # Map the analog value to a range suitable for controlling LED brightness
        led_brightness = int((analog_value / 255.0) * 100)

        # Here you would add code to set the LED brightness using PWM or similar method.
        # For demonstration purposes, we'll just print the calculated brightness.
        print("LED Brightness (%):", led_brightness)

        time.sleep(0.1) # Small delay between readings
```

```
except KeyboardInterrupt:  
    pass # Allow the program to exit cleanly with Ctrl+C
```

- 1.
2. Python LED
- 3.
- 4.
- 5.

2.5

Lab5

NTC

Raspberry Pi

PCF8591

Raspberry Pi

/

1. **NTC**

2. NTC

3. Steinhart-Hart -

4.

5. NTC 10kΩ

6. PCF8591 AIN0

7.

8. PCF8591 A/D 5V ADC 8 0~255 0~5V

9. Steinhart-Hart T

10. **Steinhart-Hart**

11. Steinhart-Hart $\left(\frac{1}{T}\right) = A + B \ln(R) + C(\ln(R))^3$ (T) (R) (A), (B), (C)
 (R_0) 10kΩ B 3950K

1.

2. Raspberry Pi T PCF8591 SDA SCL VCC GND

3. AO PCF8591 AIN0 DO VCC 5V GND

4. **I2C**

5. Raspberry Pi Preferences -> Raspberry Pi Configuration

6. Interfaces I2C OK

7.

8. Python smbus I2C

9. SMBus PCF8591 AIN0

10.

```
import smbus
import math
import time

# Define the I2C address of the PCF8591 and control bits
address = 0x48 # Default address for PCF8591
control_bit = 0x40 # Command to start conversion on channel 0 (AIN0)

# Constants for the thermistor calculation
R0 = 10000 # Resistance at 25°C in ohms
B = 3950 # Thermistor constant in Kelvin
T0 = 298.15 # Standard temperature in Kelvin (25°C)
Vcc = 5.0 # Supply voltage in volts

# Initialize the SMBus library
bus = smbus.SMBus(1) # Use I2C bus 1

def read_temperature():
    try:
        # Write the control byte to initiate an A/D conversion on channel 0
        bus.write_byte(address, control_bit)

        # Read back the converted value from the PCF8591
```

```

    analog_value = bus.read_byte(address)

    # Calculate the analog voltage
    Vr = (analog_value / 255.0) * Vcc

    # Calculate the resistance of the thermistor
    Rt = R0 * Vr / (Vcc - Vr)

    # Apply the Steinhart-Hart equation to calculate temperature
    temp_kelvin = 1 / (math.log(Rt / R0) / B + 1 / T0)
    temp_celsius = temp_kelvin - 273.15

    return round(temp_celsius, 2)

except Exception as e:
    print("Error reading temperature:", str(e))
    return None

try:
    while True:
        temperature = read_temperature()
        if temperature is not None:
            print(f"Temperature: {temperature}°C")
        else:
            print("Failed to read temperature.")

        time.sleep(1) # Small delay between readings

except KeyboardInterrupt:
    pass # Allow the program to exit cleanly with Ctrl+C

```

- 1.
2. Python
- 3.
- 4.
- 5.

2.6 Lab 6

2.6.1

2.6.2

2.6.3

Lab6

HC-SR04 Raspberry Pi HC-SR04
Python

- 1.
- 2. Trig 10 8 40kHz
- 3. Echo Echo
- 4. 343 / 20 Echo

- 5.
- 6. **VCC 5V**
- 7. **Trig**
- 8. **Echo**
- 9. **GND**

- 10.
- 11. GPIO 3.3V Echo 5V Echo

- 1.
- 2. Raspberry Pi T VCC Trig Echo GND
- 3. Trig Raspberry Pi GPIO17 BCM Echo GPIO18 BCM VCC 5V GND
- 4.
- 5. Python RPi.GPIO GPIO
- 6. get_distance() Trig 10 Echo Echo

- 7.

```
import RPi.GPIO as GPIO
import time

# Define GPIO pins for the ultrasonic sensor
TRIG = 17 # BCM numbering
ECHO = 18 # BCM numbering

# Setup GPIO mode and pin directions
GPIO.setmode(GPIO.BCM)
GPIO.setup(TRIG, GPIO.OUT)
GPIO.setup(ECHO, GPIO.IN)

def get_distance():
    # Ensure TRIG is low initially
    GPIO.output(TRIG, False)
    time.sleep(0.2)

    # Send a 10us pulse to TRIG
    GPIO.output(TRIG, True)
    time.sleep(0.00001)
```

```

GPIO.output(TRIG, False)

# Wait for ECHO to go high
while GPIO.input(ECHO) == 0:
    pulse_start = time.time()

# Wait for ECHO to go low again
while GPIO.input(ECHO) == 1:
    pulse_end = time.time()

# Calculate the duration of the pulse
pulse_duration = pulse_end - pulse_start

# Convert pulse duration to distance in centimeters
distance = pulse_duration * 17150 # Speed of sound in cm/s divided by 2 (round trip)
distance = round(distance, 2)

return distance

try:
    print("Measuring distance...")
    while True:
        dist = get_distance()
        print(f"Distance: {dist} cm")
        time.sleep(1)

except KeyboardInterrupt:
    print("Measurement stopped by user")

finally:
    GPIO.cleanup() # Clean up GPIO settings before exiting

```

- 1.
2. Python
- 3.
- 4.
- 5.

2.7

Lab7

Raspberry Pi

- 1.
- 2.
3. GPIO
- 4.
- 5.
6. PFM Pulse-Frequency Modulation /
7. PWM Pulse-Width Modulation
- 8.
9. GPIO
10. PWM

1

- 1.
2. Raspberry Pi T I/O VCC GND
3. 3.3V
- 4.
5. Python RPi.GPIO GPIO
6. play_tone() GPIO
- 7.

```
import RPi.GPIO as GPIO
import time

# Define GPIO pin for the buzzer (BCM numbering)
BUZZER_PIN = 17 # BCM 17, physical pin 11

# Setup GPIO mode and pin direction
GPIO.setmode(GPIO.BCM)
GPIO.setup(BUZZER_PIN, GPIO.OUT)

def play_tone(duration=0.5):
    """Play a tone using the active buzzer."""
    try:
        # Turn on the buzzer (low level trigger)
        GPIO.output(BUZZER_PIN, GPIO.LOW)
        time.sleep(duration)

        # Turn off the buzzer
        GPIO.output(BUZZER_PIN, GPIO.HIGH)
        time.sleep(0.1) # Short pause between tones

    except KeyboardInterrupt:
        print("Stopped by user")

finally:
    GPIO.cleanup() # Clean up GPIO settings before exiting

if __name__ == "__main__":
    print("Playing tone...")
    while True:
        play_tone()
```


2

1.

2. Raspberry Pi T I/O VCC GND

3. PWM GPIO GPIO18 BCM

4.

5. Python RPi.GPIO pigpio PWM

6. play_music()

7.

```

import RPi.GPIO as GPIO
import pigpio
import time

# Define GPIO pin for the passive buzzer (BCM numbering)
BUZZER_PIN = 18 # BCM 18, physical pin 12

# Initialize pigpio library
pi = pigpio.pi()

# Notes and their frequencies in Hz
NOTES = {
    'C4': 262, 'D4': 294, 'E4': 330, 'F4': 349, 'G4': 392, 'A4': 440, 'B4': 494,
    'C5': 523, 'D5': 587, 'E5': 659, 'F5': 698, 'G5': 784, 'A5': 880, 'B5': 988,
}

# A simple melody to play
MELODY = ['C4', 'D4', 'E4', 'C4', 'E4', 'D4', 'C4']

# Function to set frequency of the passive buzzer
def set_frequency(freq):
    pi.hardware_PWM(BUZZER_PIN, freq, 500000) # Frequency, Duty cycle (50%)

def play_music(melody):
    try:
        for note in melody:
            if note in NOTES:
                set_frequency(NOTES[note])
                time.sleep(0.5) # Duration of each note
                set_frequency(0) # Stop sound between notes
                time.sleep(0.1) # Short pause between notes
    except KeyboardInterrupt:
        print("Music stopped by user")

finally:
    pi.stop() # Clean up pigpio resources
    GPIO.cleanup() # Clean up GPIO settings before exiting

if __name__ == "__main__":
    print("Playing music...")
    play_music(MELODY)

```

1.

2. Python

3.

4.

5.

2.8 PS2

Lab8 PS2

PS2 Raspberry Pi LED PS2 X Y Z
PCF8591 LED

1. PS2

2. PS2 X Y 0V 5V 2.5V

3. SW 0V

4.

5. PS2 X VRX Y VRY PCF8591 AIN0 AIN1 SW GPIO

6. PCF8591 Raspberry Pi

7.

8. PCF8591 X Y

9. PCF8591 AOUT LED LED LED

1.

2. Raspberry Pi T PCF8591 PS2 SDA SCL VCC GND VRX VRY SW

3. PS2 VRX PCF8591 AIN0 VRY AIN1 SW GPIO VCC 5V GND

4. I2C

5. Raspberry Pi Preferences -> Raspberry Pi Configuration

6. Interfaces I2C OK

7.

8. Python smbus I2C

9. SMBus PCF8591 AIN0 AIN1 LED

10.

```
import smbus
import time

# Define the I2C address of the PCF8591 and control bits
address = 0x48 # Default address for PCF8591
control_bit_x = 0x40 # Command to start conversion on channel 0 (AIN0, X-axis)
control_bit_y = 0x41 # Command to start conversion on channel 1 (AIN1, Y-axis)

# Initialize the SMBus library
bus = smbus.SMBus(1) # Use I2C bus 1

def read_joystick(axis='x'):
    """Read joystick position from specified axis."""
    if axis.lower() == 'x':
        control_bit = control_bit_x
    elif axis.lower() == 'y':
        control_bit = control_bit_y
    else:
        raise ValueError("Invalid axis. Choose 'x' or 'y'.")

    try:
        # Write the control byte to initiate an A/D conversion on selected channel
        bus.write_byte(address, control_bit)

        # Read back the converted value from the PCF8591
        analog_value = bus.read_byte(address)

        return analog_value
```

```

except Exception as e:
    print(f"Error reading {axis}-axis:", str(e))
    return None

def map_to_brightness(value, in_min=0, in_max=255, out_min=0, out_max=100):
    """Map joystick value to LED brightness percentage."""
    return int((value - in_min) * (out_max - out_min) / (in_max - in_min) + out_min)

try:
    while True:
        x_value = read_joystick('x')
        y_value = read_joystick('y')

        if x_value is not None and y_value is not None:
            print(f"X-axis: {x_value}, Y-axis: {y_value}")

            # Calculate LED brightness based on joystick position
            led_brightness_x = map_to_brightness(x_value)
            led_brightness_y = map_to_brightness(y_value)

            # Here you would add code to set the LED brightness using PWM or similar method.
            # For demonstration purposes, we'll just print the calculated brightness.
            print(f"LED Brightness X (%): {led_brightness_x}, Y (%): {led_brightness_y}")

            time.sleep(0.1) # Small delay between readings

except KeyboardInterrupt:
    pass # Allow the program to exit cleanly with Ctrl+C

```

- 1.
2. Python LED
- 3.
- 4.
- 5.

2.9

Lab9

Raspberry Pi LIRC Raspberry Pi

- 1.
2. LED PIN
- 3.
4. PIN
- 5.
6. **LIRC**
7. LIRC Linux Infrared Remote Control LIRC

1. **LIRC**
2. LIRC bash


```
sudo apt-get update
sudo apt-get install lirc
```
3. /boot/config.txt GPIO 22 23 text


```
dtoverlay=gpio-ir,gpio_pin=22
dtoverlay=gpio-ir-tx,gpio_pin=23
```
- 4.
5. /etc/lirc/lirc_options.conf LIRC bash


```
sudo nano /etc/lirc/lirc_options.conf text
driver = default
device = /dev/lirc0
```
- 6.
7. Raspberry Pi bash


```
sudo reboot
```
8. **IR**
9. irw bash


```
irw
```
- 10.
- 11.
12. Python LIRC
13. Python

```
import subprocess

def listen_to_remote():
    try:
        process = subprocess.Popen(['irw'], stdout=subprocess.PIPE)

        while True:
            line = process.stdout.readline().decode('utf-8').strip()
            if not line:
                break

            print("Received IR command:", line)
```

```
except KeyboardInterrupt:
    print("\nListening stopped.")

if __name__ == "__main__":
    print("Listening for IR commands...")
    listen_to_remote()
```

- 1.
2. Python
- 3.
- 4.
- 5.

2.10

Lab10

Raspberry Pi
LED

GPIO

- 1.
2. `GPIO.add_event_detect()` GPIO
 - `channel` GPIO
 - `edge` GPIO.RISING GPIO.FALLING GPIO.BOTH
 - `callback`
 - `bouncetime`
- 3.
4. `GPIO.wait_for_edge()` CPU
- 5.
6. " "
- 1.
2. Raspberry Pi T SIG(S) VCC GND
3. SIG(S) Raspberry Pi GPIO23 BCM VCC 5V GND
4. LED LED GPIO17 LED GPIO27
- 5.
6. Python RPi.GPIO GPIO
7. `setup_gpio()` GPIO
8. `button_pressed_callback()` LED
- 9.

```
import RPi.GPIO as GPIO
import time

# Define GPIO pins for the LED and button (BCM numbering)
RED_LED_PIN = 17 # BCM 17, physical pin 11
GREEN_LED_PIN = 27 # BCM 27, physical pin 13
BUTTON_PIN = 23 # BCM 23, physical pin 16

def setup_gpio():
    """Setup GPIO mode and pin directions."""
    GPIO.setmode(GPIO.BCM)

    # Setup LEDs as output
    GPIO.setup(RED_LED_PIN, GPIO.OUT)
    GPIO.setup(GREEN_LED_PIN, GPIO.OUT)

    # Setup button as input with pull-up resistor
    GPIO.setup(BUTTON_PIN, GPIO.IN, pull_up_down=GPIO.PUD_UP)

def button_pressed_callback(channel):
    """Callback function called when the button is pressed."""
    if channel == BUTTON_PIN:
        print("Button pressed!")

        # Toggle between red and green LED
        if GPIO.input(RED_LED_PIN):
            GPIO.output(RED_LED_PIN, GPIO.LOW)
            GPIO.output(GREEN_LED_PIN, GPIO.HIGH)
        else:
```

```
GPIO.output(RED_LED_PIN, GPIO.HIGH)
GPIO.output(GREEN_LED_PIN, GPIO.LOW)

try:
    setup_gpio()

    # Add event detection on the button pin with debouncing
    GPIO.add_event_detect(BUTTON_PIN, GPIO.FALLING, callback=button_pressed_callback, bouncetime=200)

    print("Waiting for button press...")
    while True:
        time.sleep(1) # Keep script running to allow callbacks to work

except KeyboardInterrupt:
    print("\nProgram stopped by user")

finally:
    GPIO.cleanup() # Clean up GPIO settings before exiting
```

1.

2. Python LED

3. bouncetime

4.

5. ...

6.

7.

8.