GPIO Zero Documentation

Release 1.6.0

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Contents

CHAPTER 1

Installing GPIO Zero

GPIO Zero is installed by default in the Raspberry Pi OS[1] desktop image, and the Raspberry Pi Desktop[2] image for PC/Mac, both available from raspberrypi.org[3]. Follow these guides to installing on Raspberry Pi OS Lite and other operating systems, including for PCs using the *remote GPIO* (page 49) feature.

1.1 Raspberry Pi

GPIO Zero is packaged in the apt repositories of Raspberry Pi OS, Debian[4] and Ubuntu[5]. It is also available on PyPI[6].

1.1.1 apt

First, update your repositories list:

```
pi@raspberrypi:~$ sudo apt update
```

Then install the package for Python 3:

```
pi@raspberrypi:~$ sudo apt install python3-gpiozero
```

or Python 2:

```
pi@raspberrypi:~$ sudo apt install python-gpiozero
```

1.1.2 pip

If you're using another operating system on your Raspberry Pi, you may need to use pip to install GPIO Zero instead. Install pip using get-pip[7] and then type:

[1] https://www.raspberrypi.org/software/operating-systems/
[2] https://www.raspberrypi.org/software/raspberry-pi-desktop/
[3] https://www.raspberrypi.org/software/
[4] https://packages.debian.org/buster/python3-gpiozero
[5] https://packages.ubuntu.com/hirsute/python3-gpiozero
[6] https://pypi.org/project/gpiozero/
[7] https://pip.pypa.io/en/stable/installing/

```
pi@raspberrypi:~$ sudo pip3 install gpiozero
```

or for Python 2:

```
pi@raspberrypi:~$ sudo pip install gpiozero
```

To install GPIO Zero in a virtual environment, see the *Development* (page 99) page.

1.2 PC/Mac

In order to use GPIO Zero's remote GPIO feature from a PC or Mac, you'll need to install GPIO Zero on that computer using pip. See the *Configuring Remote GPIO* (page 49) page for more information.

1.3 Documentation

This documentation is also available for offline installation like so:

```
pi@raspberrypi:~$ sudo apt install python-gpiozero-doc
```

This will install the HTML version of the documentation under the `/usr/share/doc/python-gpiozero-doc/html` path. To view the offline documentation you have several options:

You can open the documentation directly by visiting file:///usr/share/doc/python-gpiozero-doc/html/index.html in your browser. However, be aware that using `file://` URLs sometimes breaks certain elements. To avoid this, you can view the docs from an `http://` style URL by starting a trivial HTTP server with Python, like so:

```
$ python3 -m http.server -d /usr/share/doc/python-gpiozero-doc/html
```

Then visit http://localhost:8000/ in your browser.

Alternatively, the package also integrates into Debian's doc-base[8] system, so you can install one of the doc-base clients (dochelp, dwww, dhelp, doc-central, etc.) and use its interface to locate this document.

If you want to view the documentation offline on a different device, such as an eReader, there are Epub and PDF versions of the documentation available for download from the ReadTheDocs site[9]. Simply click on the "Read the Docs" box at the bottom-left corner of the page (under the table of contents) and select "PDF" or "Epub" from the "Downloads" section.

[8] https://wiki.debian.org/doc-base
[9] https://gpiozero.readthedocs.io/

CHAPTER 2

Basic Recipes

The following recipes demonstrate some of the capabilities of the GPIO Zero library. Please note that all recipes are written assuming Python 3. Recipes *may* work under Python 2, but no guarantees!

2.1 Importing GPIO Zero

In Python, libraries and functions used in a script must be imported by name at the top of the file, with the exception of the functions built into Python by default.

For example, to use the *Button* (page 103) interface from GPIO Zero, it should be explicitly imported:

```
from gpiozero import Button
```

Now *Button* (page 103) is available directly in your script:

```
button = Button(2)
```

Alternatively, the whole GPIO Zero library can be imported:

```
import gpiozero
```

In this case, all references to items within GPIO Zero must be prefixed:

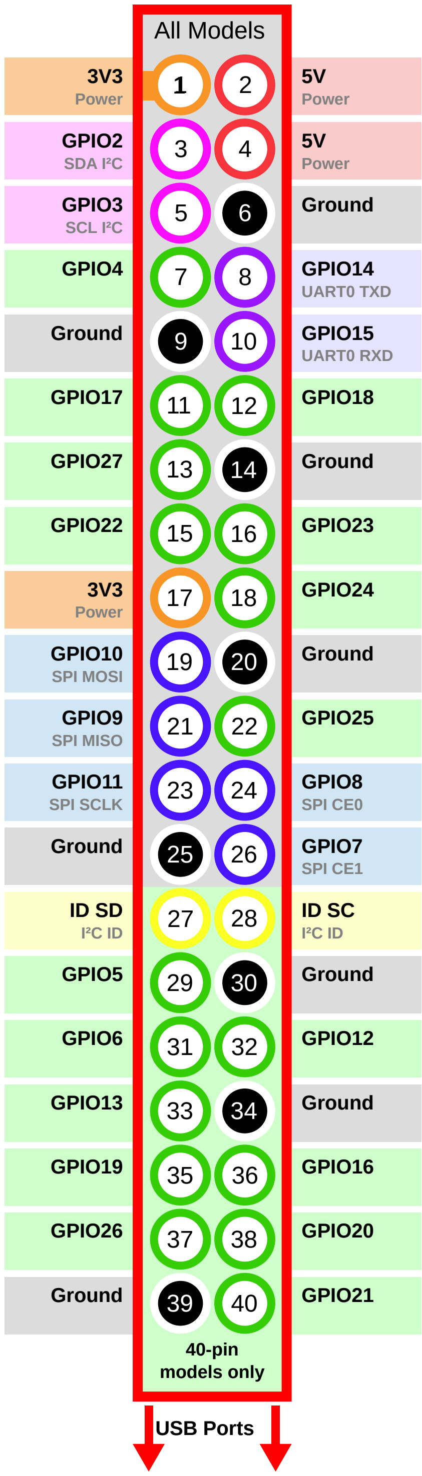
```
button = gpiozero.Button(2)
```

2.2 Pin Numbering

This library uses Broadcom (BCM) pin numbering for the GPIO pins, as opposed to physical (BOARD) numbering. Unlike in the RPi.GPIO[10] library, this is not configurable. However, translation from other schemes can be used by providing prefixes to pin numbers (see below).

Any pin marked "GPIO" in the diagram below can be used as a pin number. For example, if an LED was attached to "GPIO17" you would specify the pin number as 17 rather than 11:

[10] https://pypi.python.org/pypi/RPi.GPIO



If you wish to use physical (BOARD) numbering you can specify the pin number as "BOARD11". If you are familiar with the wiringPi[11] pin numbers (another physical layout) you could use "WPI0" instead. Finally, you can specify pins as "header:number", e.g. "J8:11" meaning physical pin 11 on header J8 (the GPIO header on modern Pis). Hence, the following lines are all equivalent:

```
>>> led = LED(17)
>>> led = LED("GPIO17")
>>> led = LED("BCM17")
>>> led = LED("BOARD11")
```

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[11] https://projects.drogon.net/raspberry-pi/wiringpi/pins/

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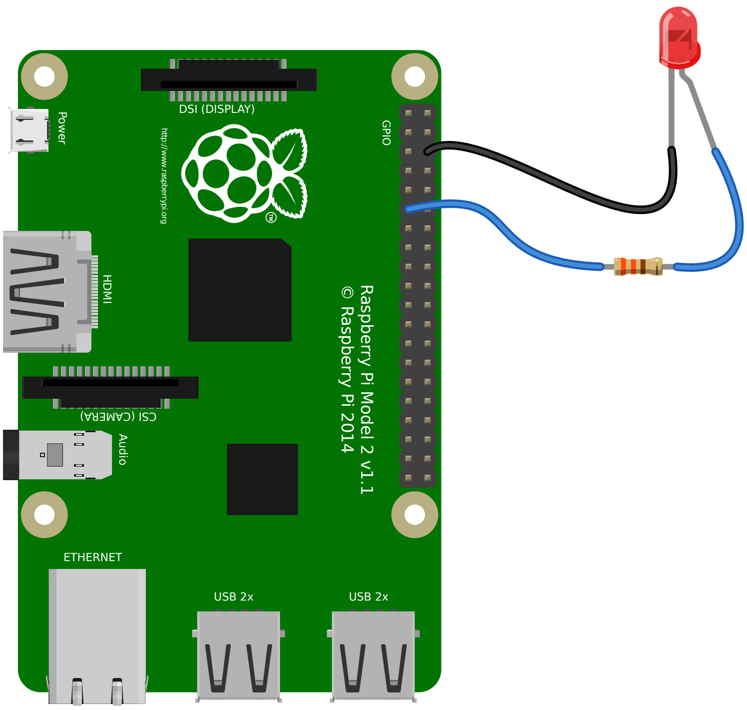
```
>>> led = LED("WPIO")
>>> led = LED("J8:11")
```

Note that these alternate schemes are merely translations. If you request the state of a device on the command line, the associated pin number will *always* be reported in the Broadcom (BCM) scheme:

```
>>> led = LED("BOARD11")
>>> led
<gpiozero.LED object on pin GPIO17, active_high=True, is_active=False>
```

Throughout this manual we will use the default integer pin numbers, in the Broadcom (BCM) layout shown above.

2.3 LED



Turn an *LED* (page 123) on and off repeatedly:

```
from gpiozero import LED
from time import sleep

red = LED(17)

while True:
    red.on()
    sleep(1)
    red.off()
    sleep(1)
```

Alternatively:

```
from gpiozero import LED
from signal import pause
```

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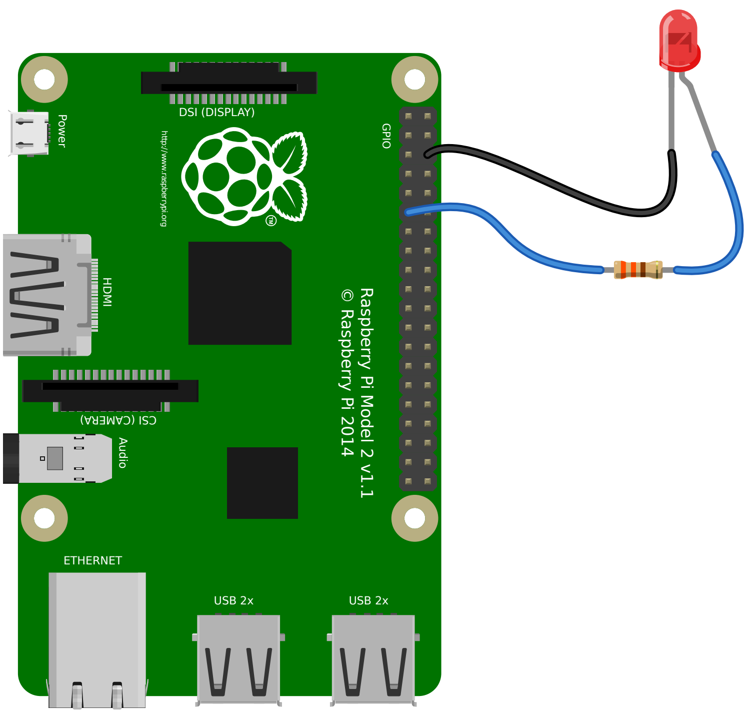
```
red = LED(17)

red.blink()

pause()
```

Note: Reaching the end of a Python script will terminate the process and GPIOs may be reset. Keep your script alive with `signal.pause()`[12]. See *How do I keep my script running?* (page 81) for more information.

2.4 LED with variable brightness



Any regular LED can have its brightness value set using PWM (pulse-width-modulation). In GPIO Zero, this can be achieved using *PWMLED* (page 125) using values between 0 and 1:

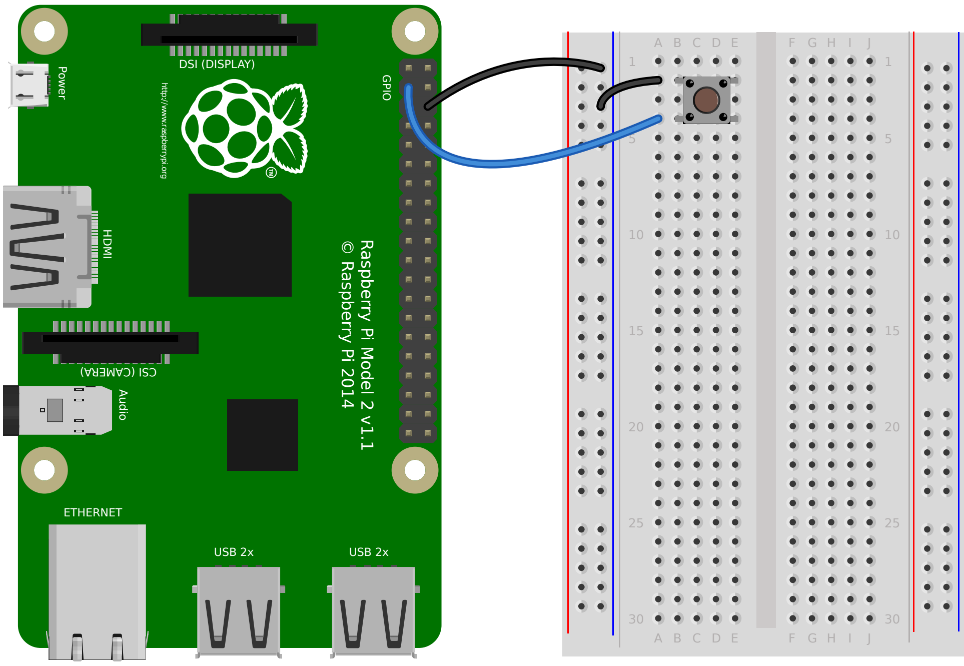
```
from gpiozero import PWMLED
from time import sleep

led = PWMLED(17)

while True:
    led.value = 0  # off
    sleep(1)
    led.value = 0.5  # half brightness
    sleep(1)
    led.value = 1  # full brightness
    sleep(1)
```

[12] https://docs.python.org/3.7/library/signal.html#signal.pause

Similarly to blinking on and off continuously, a PWMLED can pulse (fade in and out continuously):

```
from gpiozero import PWMLED
from signal import pause

led = PWMLED(17)

led.pulse()

pause()
```

2.5 Button



Check if a *Button* (page 103) is pressed:

```
from gpiozero import Button

button = Button(2)

while True:
    if button.is_pressed:
        print("Button is pressed")
    else:
        print("Button is not pressed")
```

Wait for a button to be pressed before continuing:

```
from gpiozero import Button

button = Button(2)

button.wait_for_press()
print("Button was pressed")
```

Run a function every time the button is pressed:

```
from gpiozero import Button
from signal import pause

def say_hello():
    print("Hello!")

button = Button(2)

button.when_pressed = say_hello

pause()
```

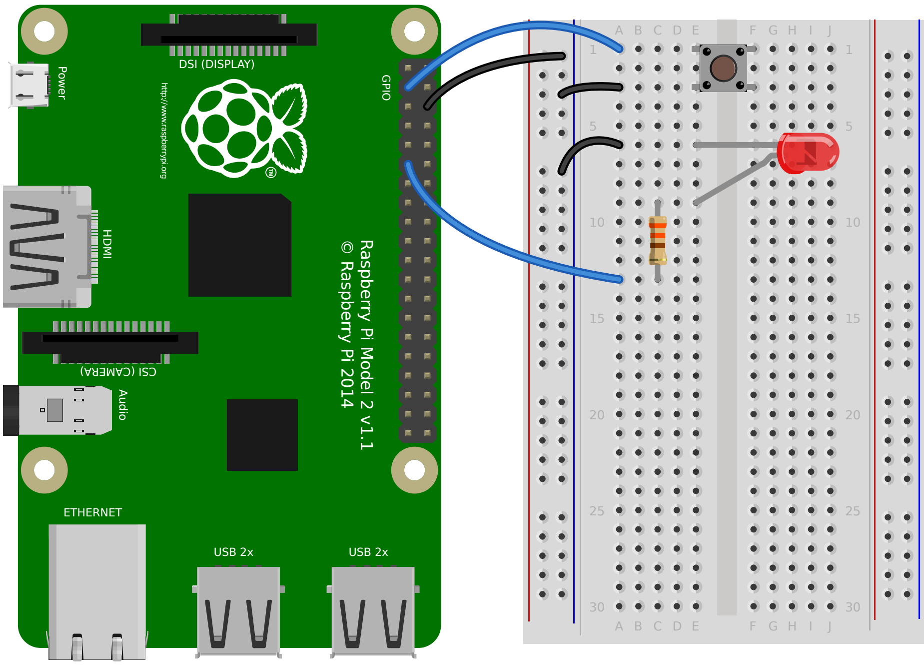
Note: Note that the line `button.when_pressed = say_hello` does not run the function `say_hello`, rather it creates a reference to the function to be called when the button is pressed. Accidental use of `button.when_pressed = say_hello()` would set the `when_pressed` action to `None`[13] (the return value of this function) which would mean nothing happens when the button is pressed.

Similarly, functions can be attached to button releases:

```
from gpiozero import Button
from signal import pause

def say_hello():
    print("Hello!")

def say_goodbye():
    print("Goodbye!")

button = Button(2)

button.when_pressed = say_hello
button.when_released = say_goodbye

pause()
```

[13] https://docs.python.org/3.7/library/constants.html#None

2.6 Button controlled LED



Turn on an *LED* (page 123) when a *Button* (page 103) is pressed:

```
from gpiozero import LED, Button
from signal import pause

led = LED(17)
button = Button(2)

button.when_pressed = led.on
button.when_released = led.off

pause()
```

Alternatively:

```
from gpiozero import LED, Button
from signal import pause

led = LED(17)
button = Button(2)

led.source = button

pause()
```

2.7 Button controlled camera

Using the button press to trigger `PiCamera` to take a picture using `button.when_pressed = camera.capture` would not work because the `capture()` method requires an `output` parameter. However, this can be achieved using a custom function which requires no parameters:

```
from gpiozero import Button
from picamera import PiCamera
from datetime import datetime
from signal import pause

button = Button(2)
camera = PiCamera()

def capture():
    timestamp = datetime.now().isoformat()
    camera.capture('/home/pi/%s.jpg' % timestamp)

button.when_pressed = capture

pause()
```

Another example could use one button to start and stop the camera preview, and another to capture:

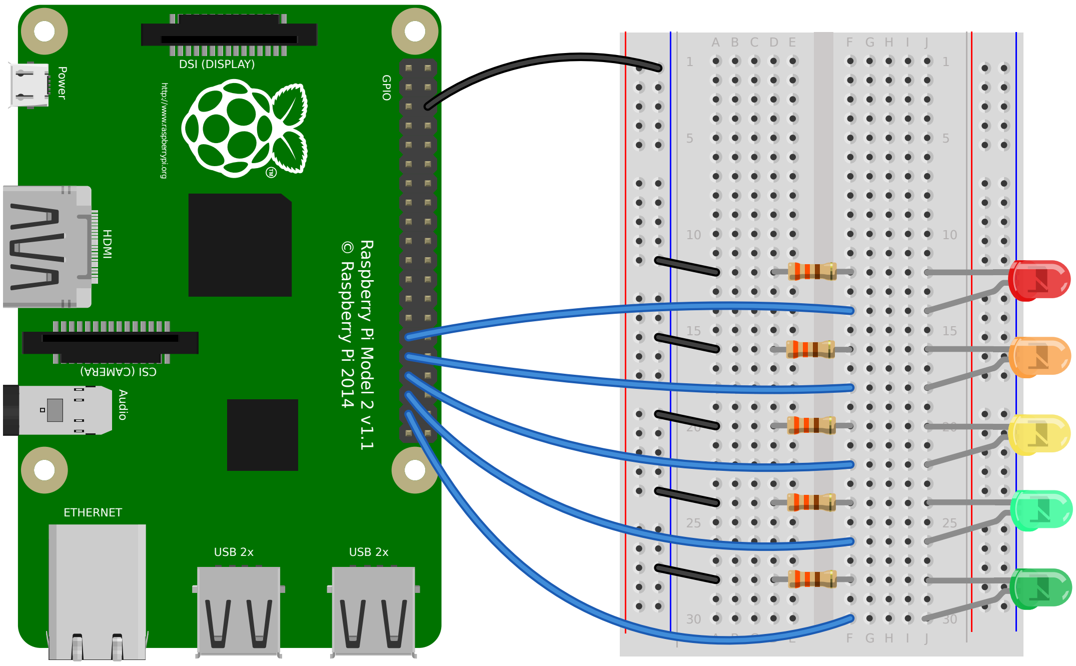
```
from gpiozero import Button
from picamera import PiCamera
from datetime import datetime
from signal import pause

left_button = Button(2)
right_button = Button(3)
camera = PiCamera()

def capture():
    timestamp = datetime.now().isoformat()
    camera.capture('/home/pi/%s.jpg' % timestamp)

left_button.when_pressed = camera.start_preview
left_button.when_released = camera.stop_preview
right_button.when_pressed = capture

pause()
```

2.8 Shutdown button

The *Button* (page 103) class also provides the ability to run a function when the button has been held for a given length of time. This example will shut down the Raspberry Pi when the button is held for 2 seconds:

```
from gpiozero import Button
from subprocess import check_call
from signal import pause

def shutdown():
    check_call(['sudo', 'poweroff'])

shutdown_btn = Button(17, hold_time=2)
shutdown_btn.when_held = shutdown

pause()
```

2.9 LEDBoard



A collection of LEDs can be accessed using *LEDBoard* (page 155):

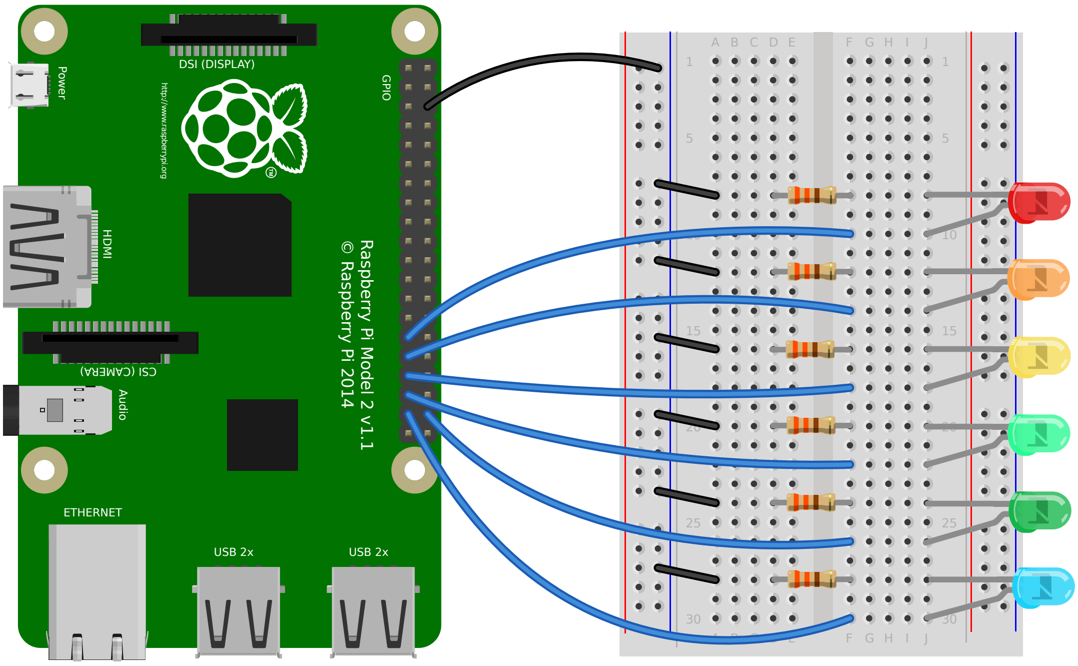
```
from gpiozero import LEDBoard
from time import sleep
from signal import pause

leds = LEDBoard(5, 6, 13, 19, 26)

leds.on()
sleep(1)
leds.off()
sleep(1)
leds.value = (1, 0, 1, 0, 1)
sleep(1)
leds.blink()

pause()
```

Using *LEDBoard* (page 155) with `pwm=True` allows each LED's brightness to be controlled:

```
from gpiozero import LEDBoard
from signal import pause

leds = LEDBoard(5, 6, 13, 19, 26, pwm=True)

leds.value = (0.2, 0.4, 0.6, 0.8, 1.0)

pause()
```

See more *LEDBoard* (page 155) examples in the *advanced LEDBoard recipes* (page 39).

2.10 LEDBarGraph



A collection of LEDs can be treated like a bar graph using *LEDBarGraph* (page 158):

```
from gpiozero import LEDBarGraph
from time import sleep
from __future__ import division  # required for python 2

graph = LEDBarGraph(5, 6, 13, 19, 26, 20)

graph.value = 1  # (1, 1, 1, 1, 1, 1)
sleep(1)
graph.value = 1/2  # (1, 1, 1, 0, 0, 0)
sleep(1)
graph.value = -1/2  # (0, 0, 0, 1, 1, 1)
sleep(1)
graph.value = 1/4  # (1, 0, 0, 0, 0, 0)
sleep(1)
graph.value = -1  # (1, 1, 1, 1, 1, 1)
sleep(1)
```

Note values are essentially rounded to account for the fact LEDs can only be on or off when `pwm=False` (the default).

However, using *LEDBarGraph* (page 158) with `pwm=True` allows more precise values using LED brightness:

```
from gpiozero import LEDBarGraph
from time import sleep
from __future__ import division  # required for python 2

graph = LEDBarGraph(5, 6, 13, 19, 26, pwm=True)

graph.value = 1/10  # (0.5, 0, 0, 0, 0)
sleep(1)
graph.value = 3/10  # (1, 0.5, 0, 0, 0)
sleep(1)
```

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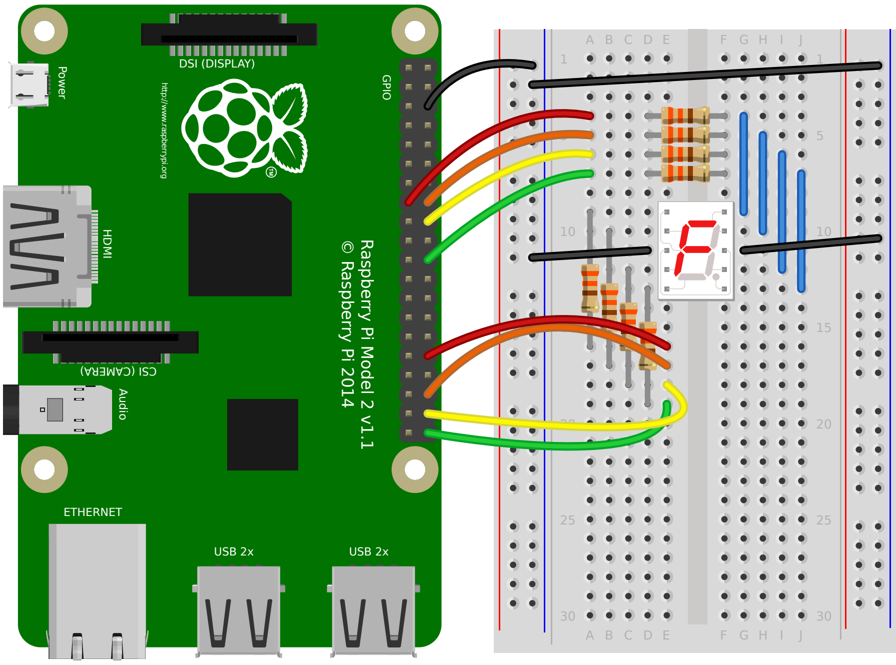
```
graph.value = -3/10  # (0, 0, 0, 0.5, 1)
sleep(1)
graph.value = 9/10  # (1, 1, 1, 1, 0.5)
sleep(1)
graph.value = 95/100  # (1, 1, 1, 1, 0.75)
sleep(1)
```

2.11 LEDCharDisplay



A common 7-segment display[14] can be used to represent a variety of characters using *LEDCharDisplay* (page 160) (which actually supports an arbitrary number of segments):

```
from gpiozero import LEDCharDisplay
from time import sleep

display = LEDCharDisplay(21, 20, 16, 22, 23, 24, 12, dp=25)

for char in '321GO':
    display.value = char
    sleep(1)

display.off()
```

Alternatively:

```
from gpiozero import LEDCharDisplay
from signal import pause

display = LEDCharDisplay(21, 20, 16, 22, 23, 24, 12, dp=25)
display.source_delay = 1
display.source = '321GO '
```

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[14] https://en.wikipedia.org/wiki/Seven-segment_display

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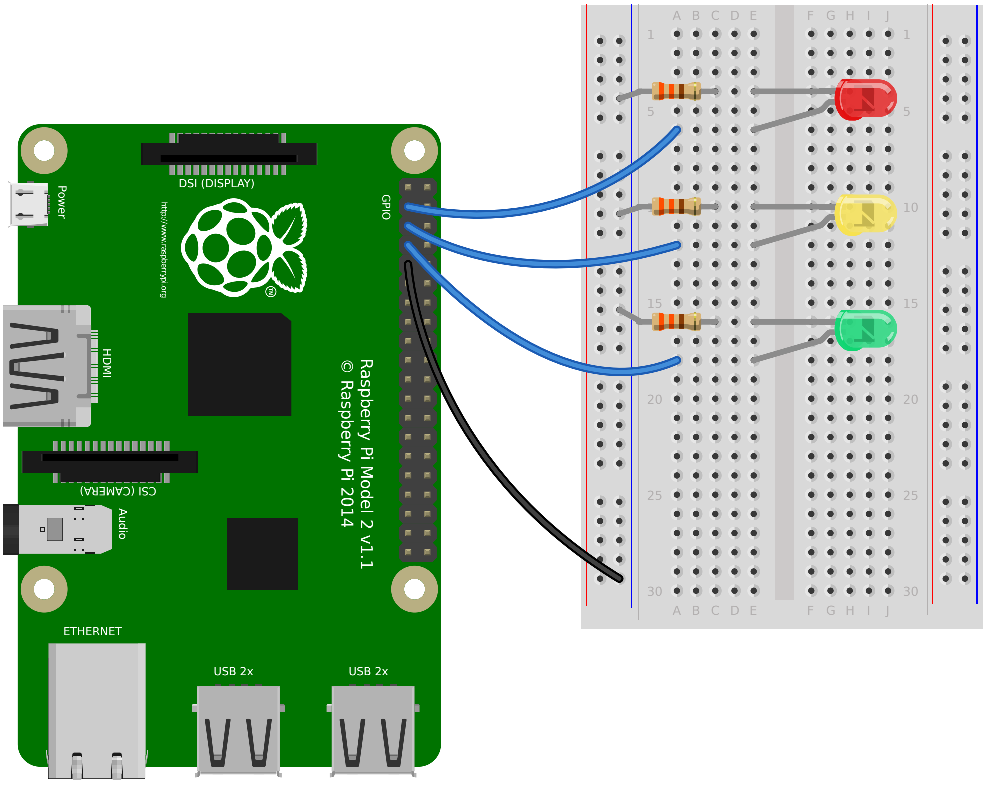
```
pause()
```

See a multi-character example in the *advanced recipes* (page 41) chapter.

2.12 Traffic Lights



A full traffic lights system.

Using a *TrafficLights* (page 165) kit like Pi-Stop:

```
from gpiozero import TrafficLights
from time import sleep

lights = TrafficLights(2, 3, 4)

lights.green.on()

while True:
    sleep(10)
    lights.green.off()
    lights.amber.on()
    sleep(1)
    lights.amber.off()
    lights.red.on()
    sleep(10)
    lights.amber.on()
    sleep(1)
    lights.green.on()
```

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```
    lights.amber.off()
    lights.red.off()
```

Alternatively:

```
from gpiozero import TrafficLights
from time import sleep
from signal import pause

lights = TrafficLights(2, 3, 4)

def traffic_light_sequence():
    while True:
        yield (0, 0, 1) # green
        sleep(10)
        yield (0, 1, 0) # amber
        sleep(1)
        yield (1, 0, 0) # red
        sleep(10)
        yield (1, 1, 0) # red+amber
        sleep(1)

lights.source = traffic_light_sequence()

pause()
```

Using *LED* (page 123) components:

```
from gpiozero import LED
from time import sleep

red = LED(2)
amber = LED(3)
green = LED(4)

green.on()
amber.off()
red.off()

while True:
    sleep(10)
    green.off()
    amber.on()
    sleep(1)
    amber.off()
    red.on()
    sleep(10)
    amber.on()
    sleep(1)
    green.on()
    amber.off()
    red.off()
```

2.13 Push button stop motion

Capture a picture with the camera module every time a button is pressed:

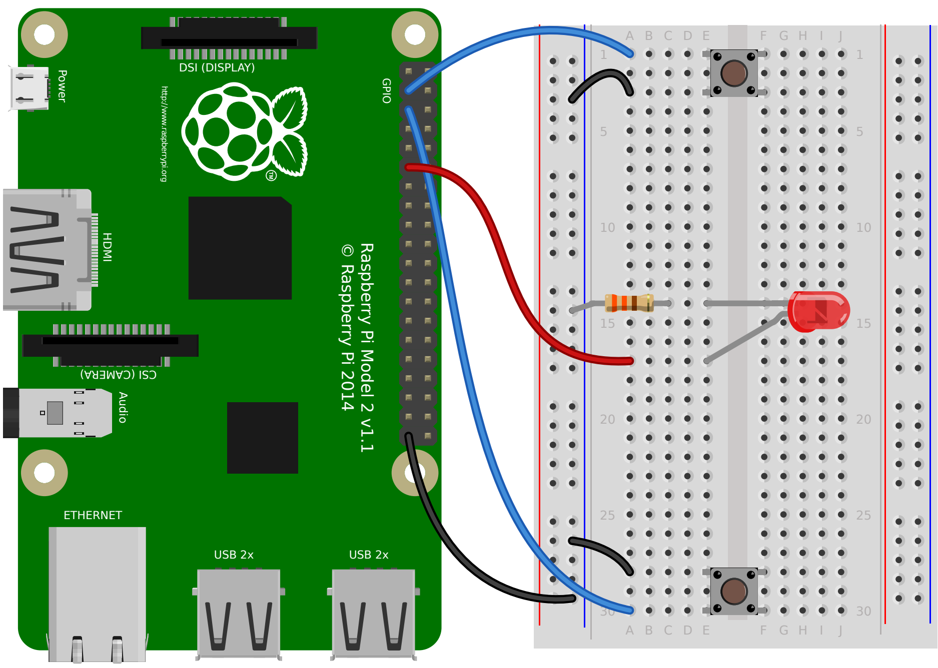
```
from gpiozero import Button
from picamera import PiCamera

button = Button(2)
camera = PiCamera()

camera.start_preview()
frame = 1
while True:
    button.wait_for_press()
    camera.capture('/home/pi/frame%03d.jpg' % frame)
    frame += 1
```

See Push Button Stop Motion[15] for a full resource.

2.14 Reaction Game



When you see the light come on, the first person to press their button wins!

```
from gpiozero import Button, LED
from time import sleep
import random

led = LED(17)

player_1 = Button(2)
player_2 = Button(3)
```

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[15] https://projects.raspberrypi.org/en/projects/push-button-stop-motion

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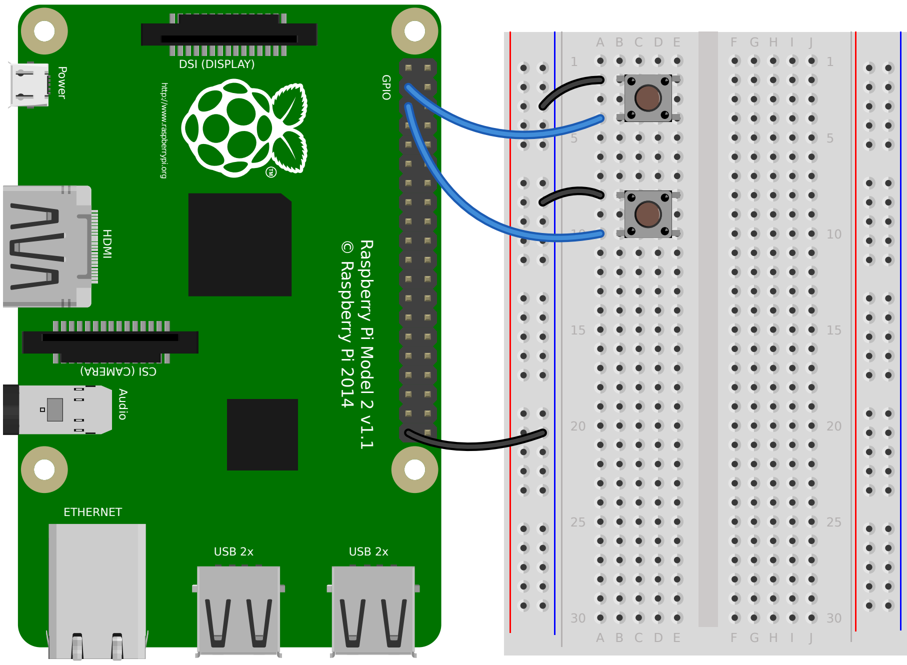
```
time = random.uniform(5, 10)
sleep(time)
led.on()

while True:
    if player_1.is_pressed:
        print("Player 1 wins!")
        break
    if player_2.is_pressed:
        print("Player 2 wins!")
        break

led.off()
```

See Quick Reaction Game[16] for a full resource.

2.15 GPIO Music Box



Each button plays a different sound!

```
from gpiozero import Button
import pygame.mixer
from pygame.mixer import Sound
from signal import pause

pygame.mixer.init()

button_sounds = {
    Button(2): Sound("samples/drum_tom_mid_hard.wav"),
    Button(3): Sound("samples/drum_cymbal_open.wav"),
}
```

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[16] https://projects.raspberrypi.org/en/projects/python-quick-reaction-game

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```
for button, sound in button_sounds.items():
    button.when_pressed = sound.play

pause()
```

See GPIO Music Box[17] for a full resource.

2.16 All on when pressed

While the button is pressed down, the buzzer and all the lights come on.

FishDish (page 171):

```
from gpiozero import FishDish
from signal import pause

fish = FishDish()

fish.button.when_pressed = fish.on
fish.button.when_released = fish.off

pause()
```

Ryanteck *TrafficHat* (page 172):

```
from gpiozero import TrafficHat
from signal import pause

th = TrafficHat()

th.button.when_pressed = th.on
th.button.when_released = th.off

pause()
```

Using *LED* (page 123), *Buzzer* (page 130), and *Button* (page 103) components:

```
from gpiozero import LED, Buzzer, Button
from signal import pause

button = Button(2)
buzzer = Buzzer(3)
red = LED(4)
amber = LED(5)
green = LED(6)

things = [red, amber, green, buzzer]

def things_on():
    for thing in things:
        thing.on()

def things_off():
```

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[17] https://projects.raspberrypi.org/en/projects/gpio-music-box

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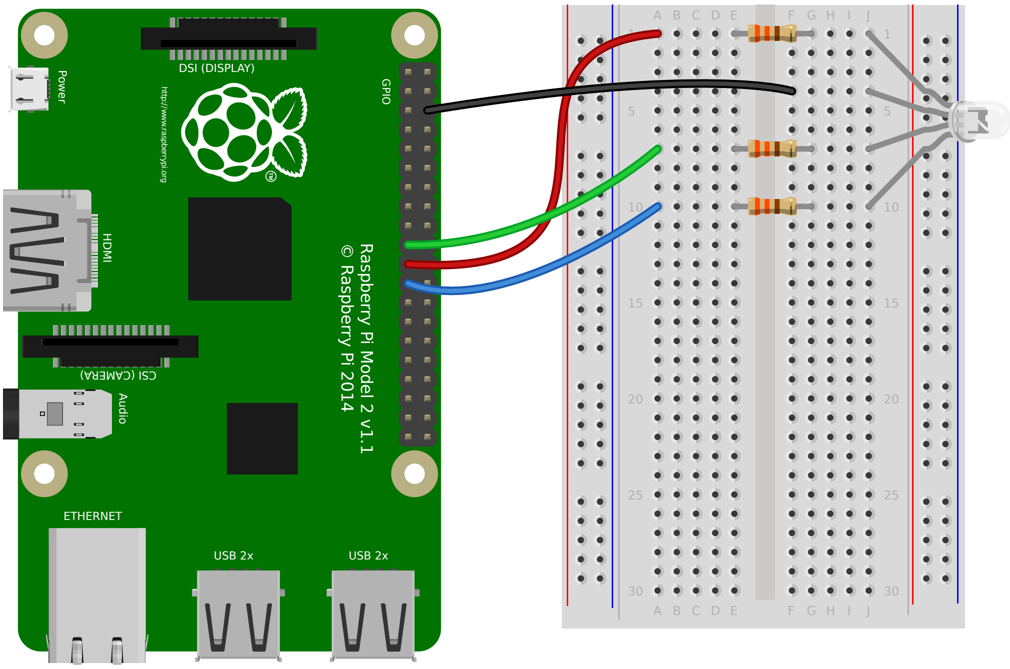
```
    for thing in things:
        thing.off()

button.when_pressed = things_on
button.when_released = things_off

pause()
```

2.17 Full color LED



Making colours with an *RGBLED* (page 127):

```
from gpiozero import RGBLED
from time import sleep
from __future__ import division  # required for python 2

led = RGBLED(red=9, green=10, blue=11)

led.red = 1  # full red
sleep(1)
led.red = 0.5  # half red
sleep(1)

led.color = (0, 1, 0)  # full green
sleep(1)
led.color = (1, 0, 1)  # magenta
sleep(1)
led.color = (1, 1, 0)  # yellow
sleep(1)
led.color = (0, 1, 1)  # cyan
sleep(1)
led.color = (1, 1, 1)  # white
```

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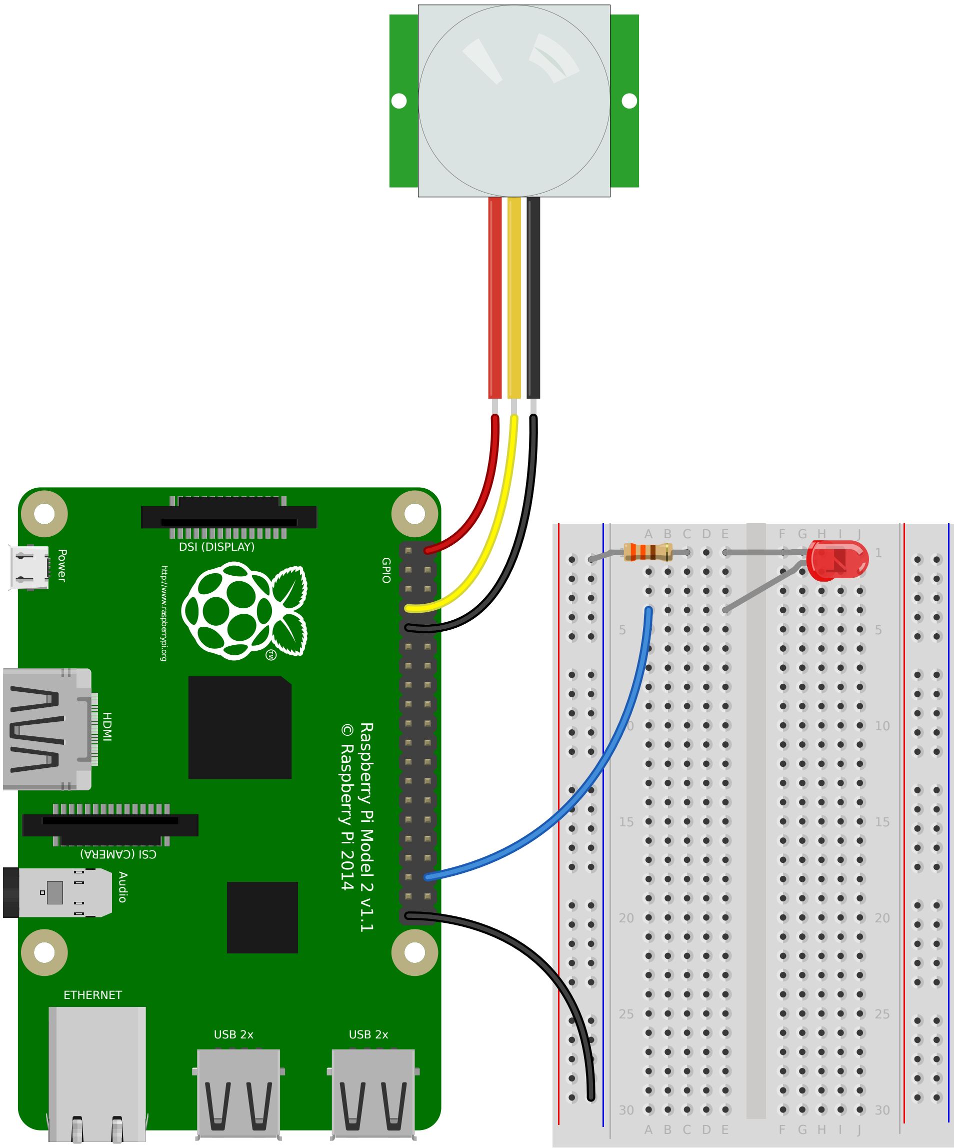
```
sleep(1)

led.color = (0, 0, 0)  # off
sleep(1)

# slowly increase intensity of blue
for n in range(100):
    led.blue = n/100
    sleep(0.1)
```

2.18 Motion sensor



Light an *LED* (page 123) when a *MotionSensor* (page 108) detects motion:

```
from gpiozero import MotionSensor, LED
from signal import pause

```

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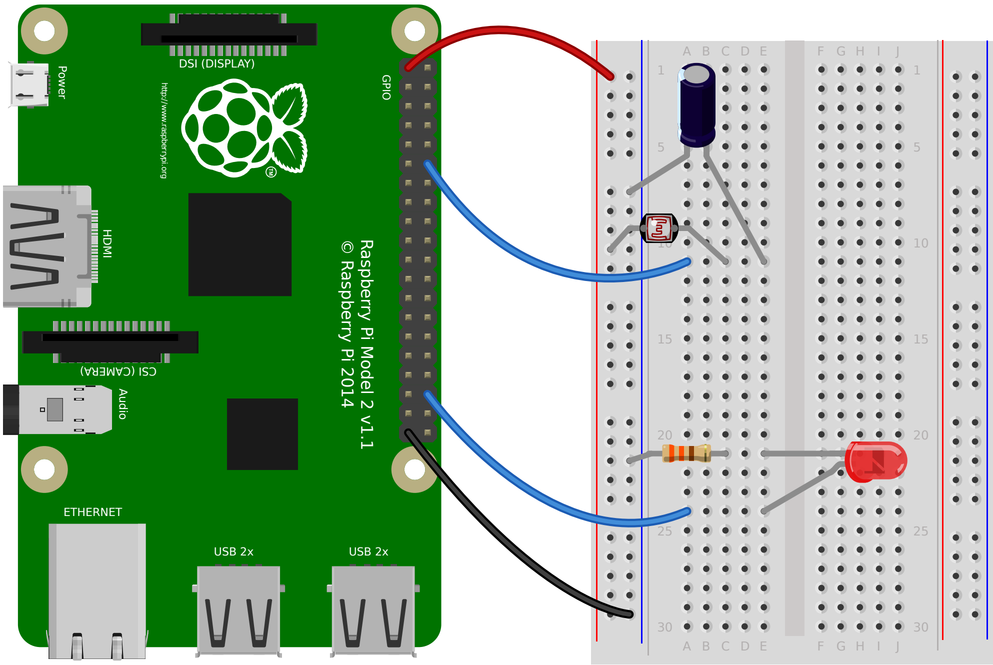
```
pir = MotionSensor(4)
led = LED(16)

pir.when_motion = led.on
pir.when_no_motion = led.off

pause()
```

2.19 Light sensor



Have a *LightSensor* (page 109) detect light and dark:

```
from gpiozero import LightSensor

sensor = LightSensor(18)

while True:
    sensor.wait_for_light()
    print("It's light! :)")
    sensor.wait_for_dark()
    print("It's dark :(")
```

Run a function when the light changes:

```
from gpiozero import LightSensor, LED
from signal import pause

sensor = LightSensor(18)
led = LED(16)

sensor.when_dark = led.on
sensor.when_light = led.off
```

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```
pause()
```

Or make a *PWMLED* (page 125) change brightness according to the detected light level:

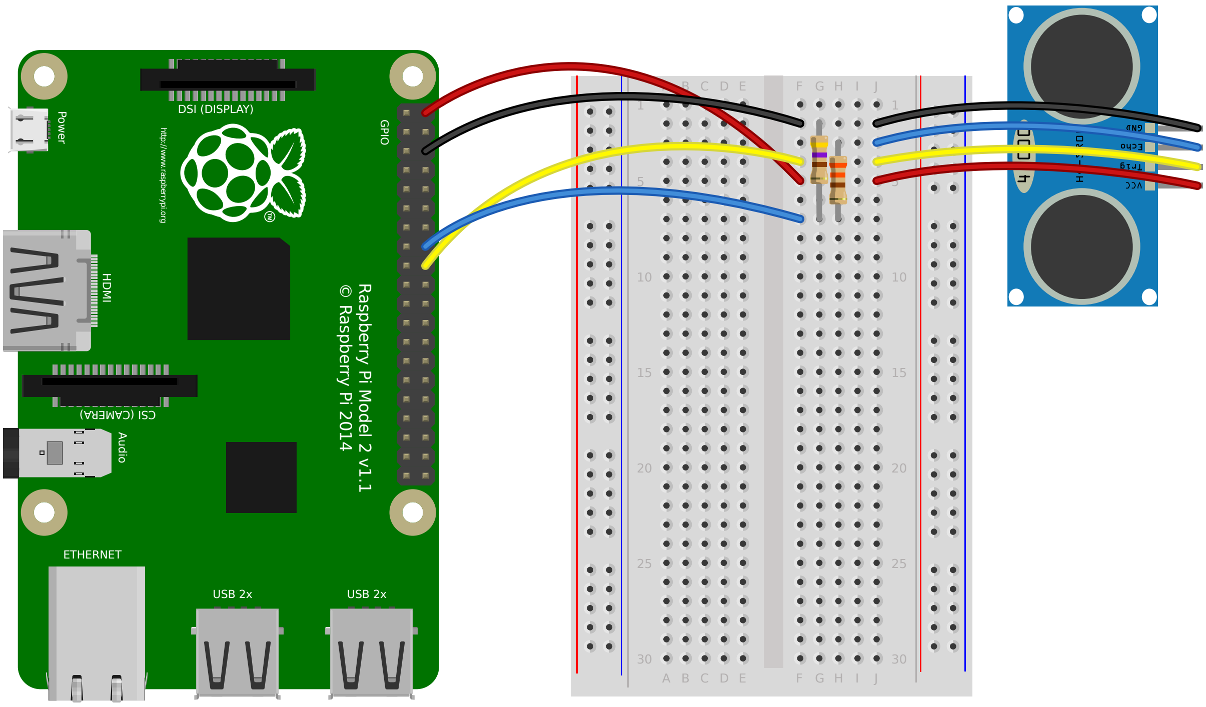
```
from gpiozero import LightSensor, PWMLED
from signal import pause

sensor = LightSensor(18)
led = PWMLED(16)

led.source = sensor

pause()
```

2.20 Distance sensor



Note: In the diagram above, the wires leading from the sensor to the breadboard can be omitted; simply plug the sensor directly into the breadboard facing the edge (unfortunately this is difficult to illustrate in the diagram without the sensor's diagram obscuring most of the breadboard!)

Have a *DistanceSensor* (page 111) detect the distance to the nearest object:

```
from gpiozero import DistanceSensor
from time import sleep

sensor = DistanceSensor(23, 24)

while True:
```

(continues on next page)

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```
    print('Distance to nearest object is', sensor.distance, 'm')
    sleep(1)
```

Run a function when something gets near the sensor:

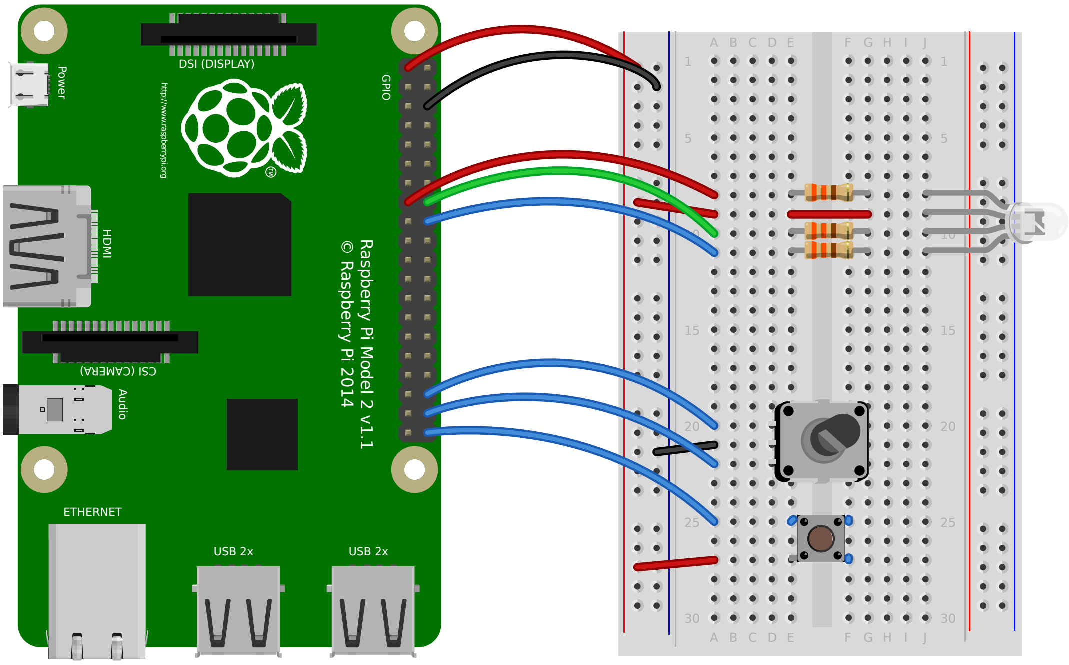
```
from gpiozero import DistanceSensor, LED
from signal import pause

sensor = DistanceSensor(23, 24, max_distance=1, threshold_distance=0.2)
led = LED(16)

sensor.when_in_range = led.on
sensor.when_out_of_range = led.off

pause()
```

2.21 Rotary encoder



Note: In this recipe, I've used a common *anode* RGB LED. Often, Pi projects use common *cathode* RGB LEDs because they're slightly easier to think about electrically. However, in this case all three components can be found in an illuminated rotary encoder which incorporates a common anode RGB LED, and a momentary push button. This is also the reason for the button being wired active-low, contrary to most other examples in this documentation.

For the sake of clarity, the diagram shows the three separate components, but this same circuit will work equally well with this commonly available illuminated rotary encoder[18] instead.

Have a rotary encoder, an RGB LED, and button act as a color picker.

[18] https://shop.pimoroni.com/products/rotary-encoder-illuminated-rgb

```
from threading import Event
from colorzero import Color
from gpiozero import RotaryEncoder, RGBLED, Button

rotor = RotaryEncoder(16, 20, wrap=True, max_steps=180)
rotor.steps = -180
led = RGBLED(22, 23, 24, active_high=False)
btn = Button(21, pull_up=False)
led.color = Color('#f00')
done = Event()

def change_hue():
    # Scale the rotor steps (-180..180) to 0..1
    hue = (rotor.steps + 180) / 360
    led.color = Color(h=hue, s=1, v=1)

def show_color():
    print('Hue {led.color.hue.deg:.1f}° = {led.color.html}'.format(led=led))

def stop_script():
    print('Exiting')
    done.set()

print('Select a color by turning the knob')
rotor.when_rotated = change_hue
print('Push the button to see the HTML code for the color')
btn.when_released = show_color
print('Hold the button to exit')
btn.when_held = stop_script
done.wait()
```

2.22 Servo

Control a servo between its minimum, mid-point and maximum positions in sequence:

```
from gpiozero import Servo
from time import sleep

servo = Servo(17)

while True:
    servo.min()
    sleep(2)
    servo.mid()
    sleep(2)
    servo.max()
    sleep(2)
```

Use a button to control the servo between its minimum and maximum positions:

```
from gpiozero import Servo, Button

servo = Servo(17)
btn = Button(14)

```

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```
while True:
    servo.min()
    btn.wait_for_press()
    servo.max()
    btn.wait_for_press()
```

Automate the servo to continuously slowly sweep:

```
from gpiozero import Servo
from gpiozero.tools import sin_values
from signal import pause

servo = Servo(17)

servo.source = sin_values()
servo.source_delay = 0.1

pause()
```

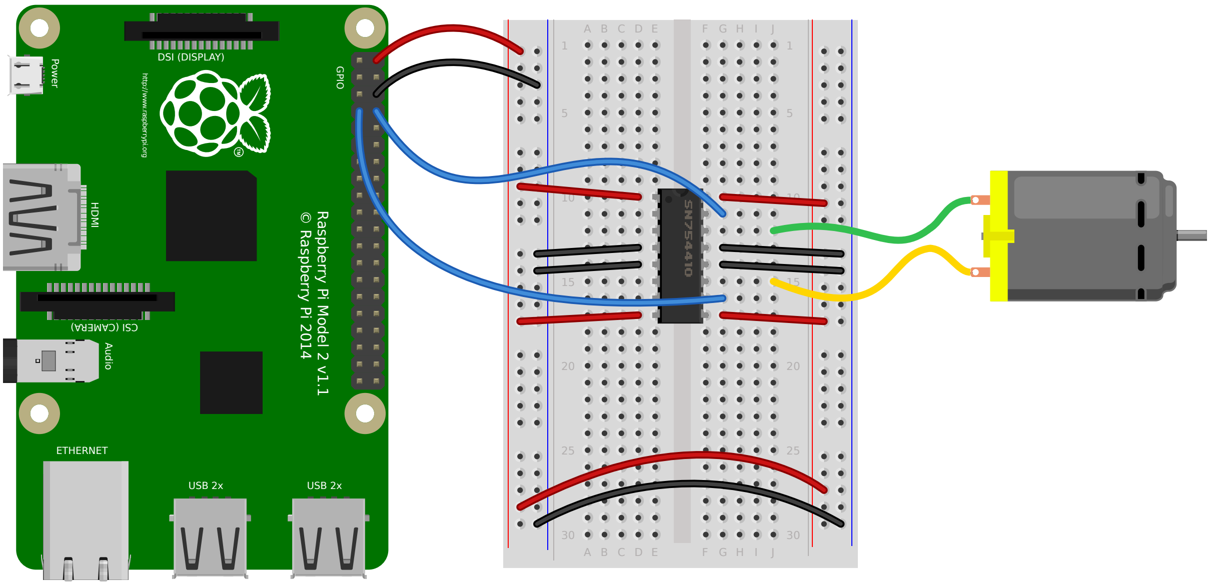
Use *AngularServo* (page 137) so you can specify an angle:

```
from gpiozero import AngularServo
from time import sleep

servo = AngularServo(17, min_angle=-90, max_angle=90)

while True:
    servo.angle = -90
    sleep(2)
    servo.angle = -45
    sleep(2)
    servo.angle = 0
    sleep(2)
    servo.angle = 45
    sleep(2)
    servo.angle = 90
    sleep(2)
```

2.23 Motors



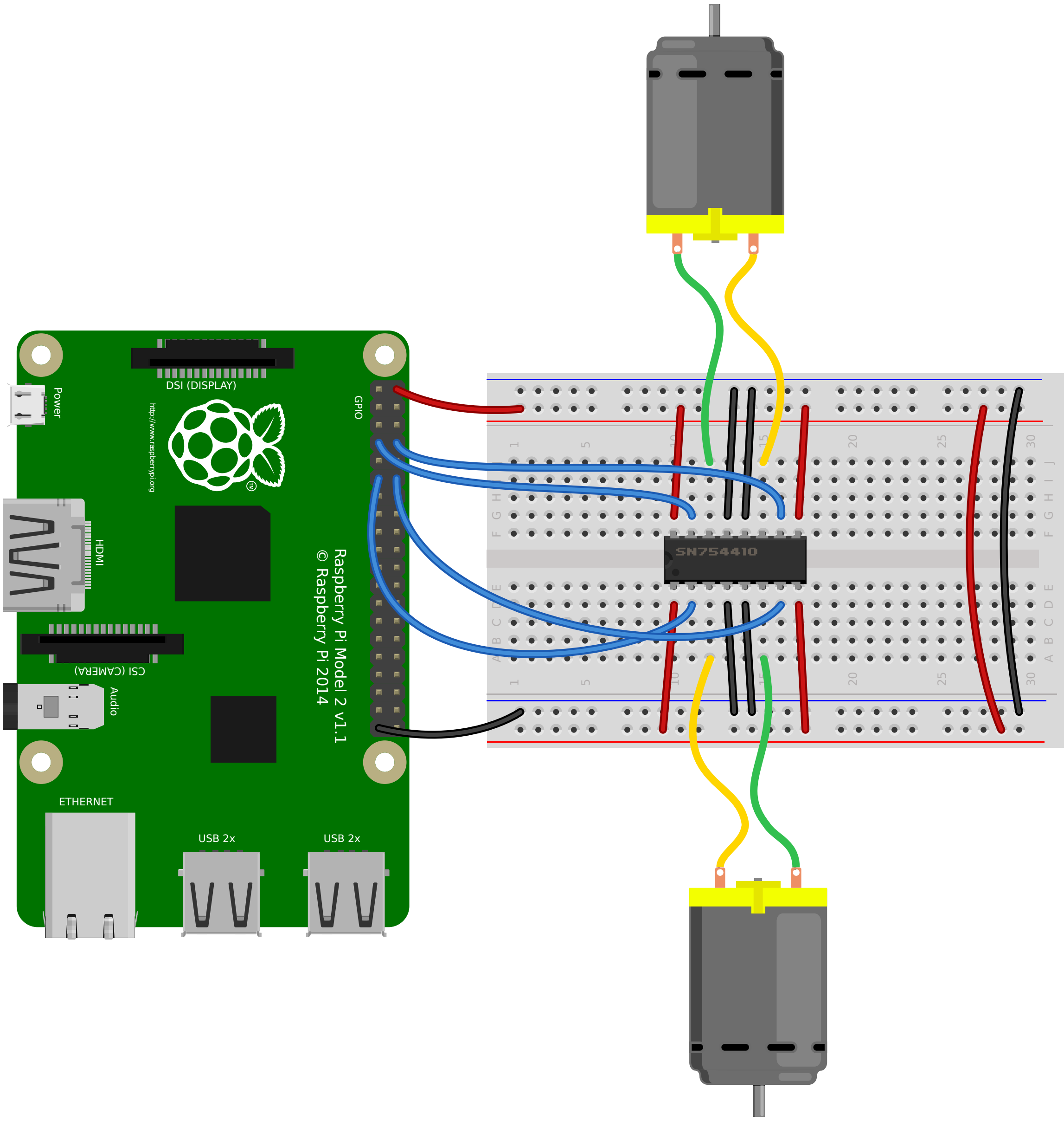
Spin a *Motor* (page 132) around forwards and backwards:

```
from gpiozero import Motor
from time import sleep

motor = Motor(forward=4, backward=14)

while True:
    motor.forward()
    sleep(5)
    motor.backward()
    sleep(5)
```

2.24 Robot



Make a *Robot* (page 175) drive around in (roughly) a square:

```
from gpiozero import Robot
from time import sleep

robot = Robot(left=(4, 14), right=(17, 18))

for i in range(4):
    robot.forward()
    sleep(10)
    robot.right()
    sleep(1)
```

Make a robot with a distance sensor that runs away when things get within 20cm of it:

```
from gpiozero import Robot, DistanceSensor
from signal import pause
```

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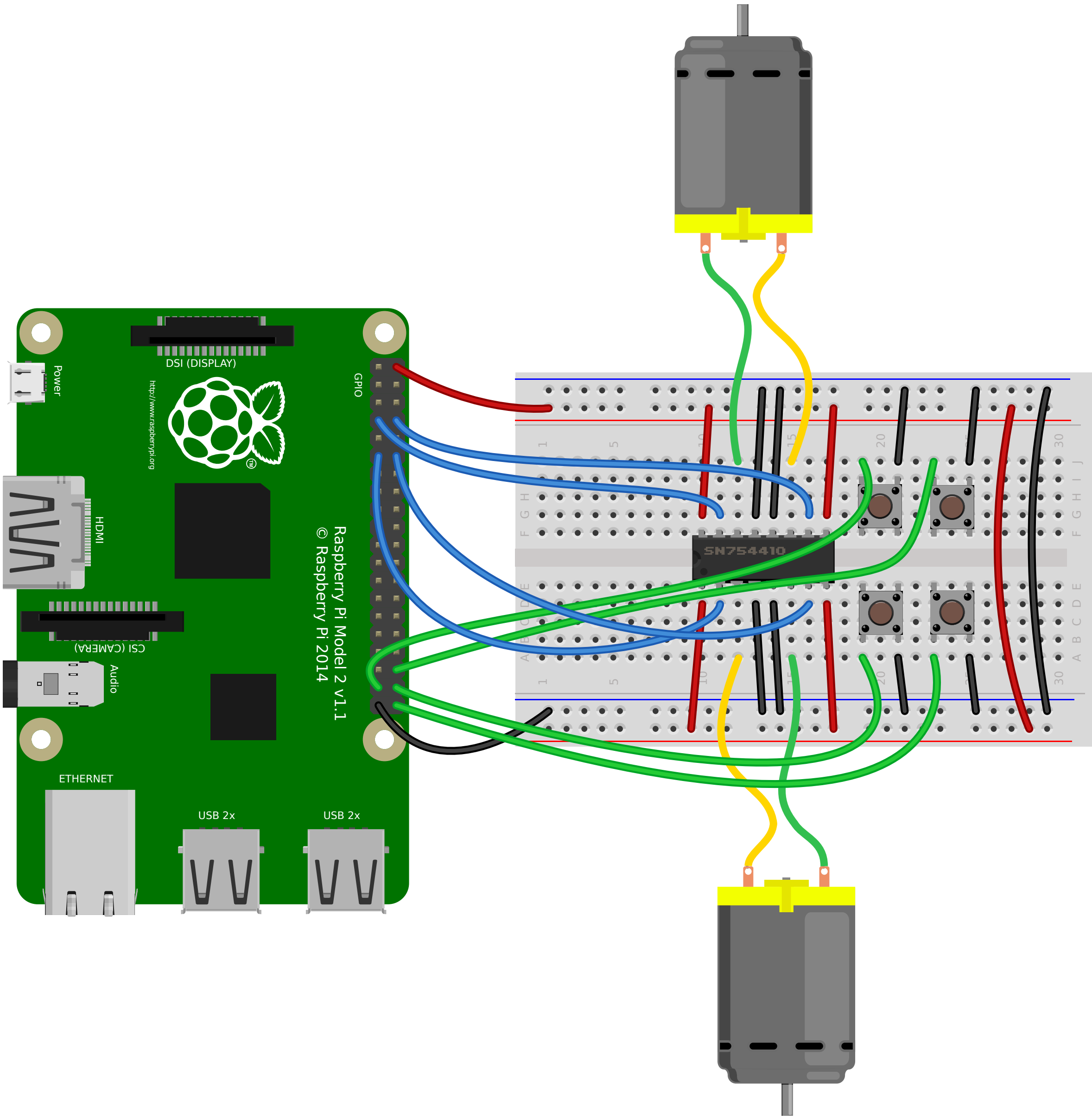
```
sensor = DistanceSensor(23, 24, max_distance=1, threshold_distance=0.2)
robot = Robot(left=(4, 14), right=(17, 18))

sensor.when_in_range = robot.backward
sensor.when_out_of_range = robot.stop
pause()
```

2.25 Button controlled robot



Use four GPIO buttons as forward/back/left/right controls for a robot:

```
from gpiozero import Robot, Button
from signal import pause
```

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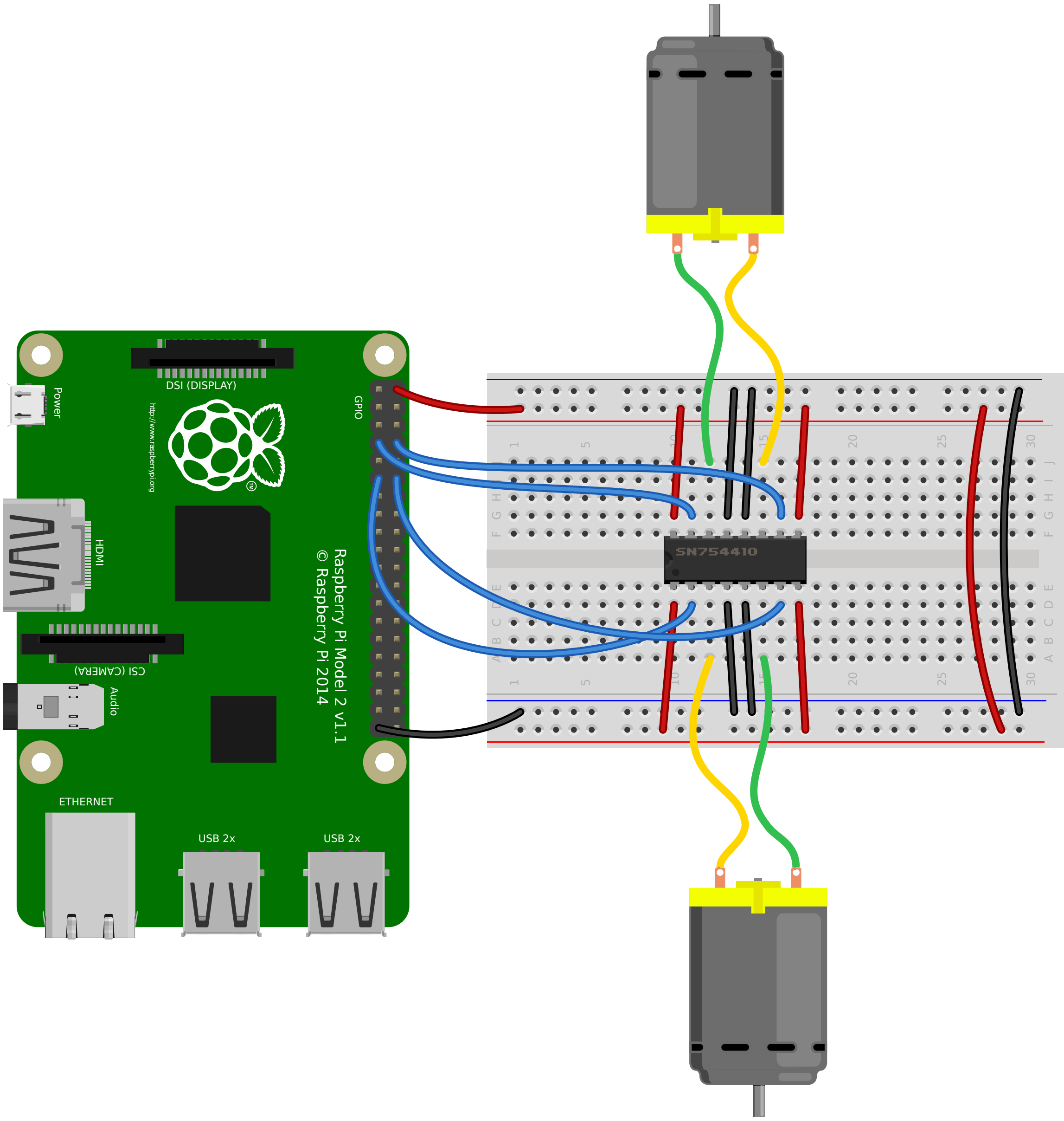
```
robot = Robot(left=(4, 14), right=(17, 18))

left = Button(26)
right = Button(16)
fw = Button(21)
bw = Button(20)

fw.when_pressed = robot.forward
fw.when_released = robot.stop

left.when_pressed = robot.left
left.when_released = robot.stop

right.when_pressed = robot.right
right.when_released = robot.stop

bw.when_pressed = robot.backward
bw.when_released = robot.stop

pause()
```

2.26 Keyboard controlled robot



Use up/down/left/right keys to control a robot:

```
import curses
from gpiozero import Robot

robot = Robot(left=(4, 14), right=(17, 18))

actions = {
    curses.KEY_UP:    robot.forward,
    curses.KEY_DOWN:  robot.backward,
    curses.KEY_LEFT:  robot.left,
    curses.KEY_RIGHT: robot.right,
}

def main(window):
    next_key = None
```

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```
    while True:
        curses.halfdelay(1)
        if next_key is None:
            key = window.getch()
        else:
            key = next_key
            next_key = None
        if key != -1:
            # KEY PRESSED
            curses.halfdelay(3)
            action = actions.get(key)
            if action is not None:
                action()
            next_key = key
            while next_key == key:
                next_key = window.getch()
            # KEY RELEASED
            robot.stop()

curses.wrapper(main)
```

Note: This recipe uses the standard `curses`[19] module. This module requires that Python is running in a terminal in order to work correctly, hence this recipe will *not* work in environments like IDLE.

If you prefer a version that works under IDLE, the following recipe should suffice:

```
from gpiozero import Robot
from evdev import InputDevice, list_devices, ecodes

robot = Robot(left=(4, 14), right=(17, 18))

# Get the list of available input devices
devices = [InputDevice(device) for device in list_devices()]
# Filter out everything that's not a keyboard. Keyboards are defined as any
# device which has keys, and which specifically has keys 1..31 (roughly Esc,
# the numeric keys, the first row of QWERTY plus a few more) and which does
# *not* have key 0 (reserved)
must_have = {i for i in range(1, 32)}
must_not_have = {0}
devices = [
    dev
    for dev in devices
    for keys in (set(dev.capabilities().get(ecodes.EV_KEY, [])),)
    if must_have.issubset(keys)
    and must_not_have.isdisjoint(keys)
]
# Pick the first keyboard
keyboard = devices[0]

keypress_actions = {
    ecodes.KEY_UP: robot.forward,
    ecodes.KEY_DOWN: robot.backward,
    ecodes.KEY_LEFT: robot.left,
```

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[19] https://docs.python.org/3.7/library/curses.html#module-curses

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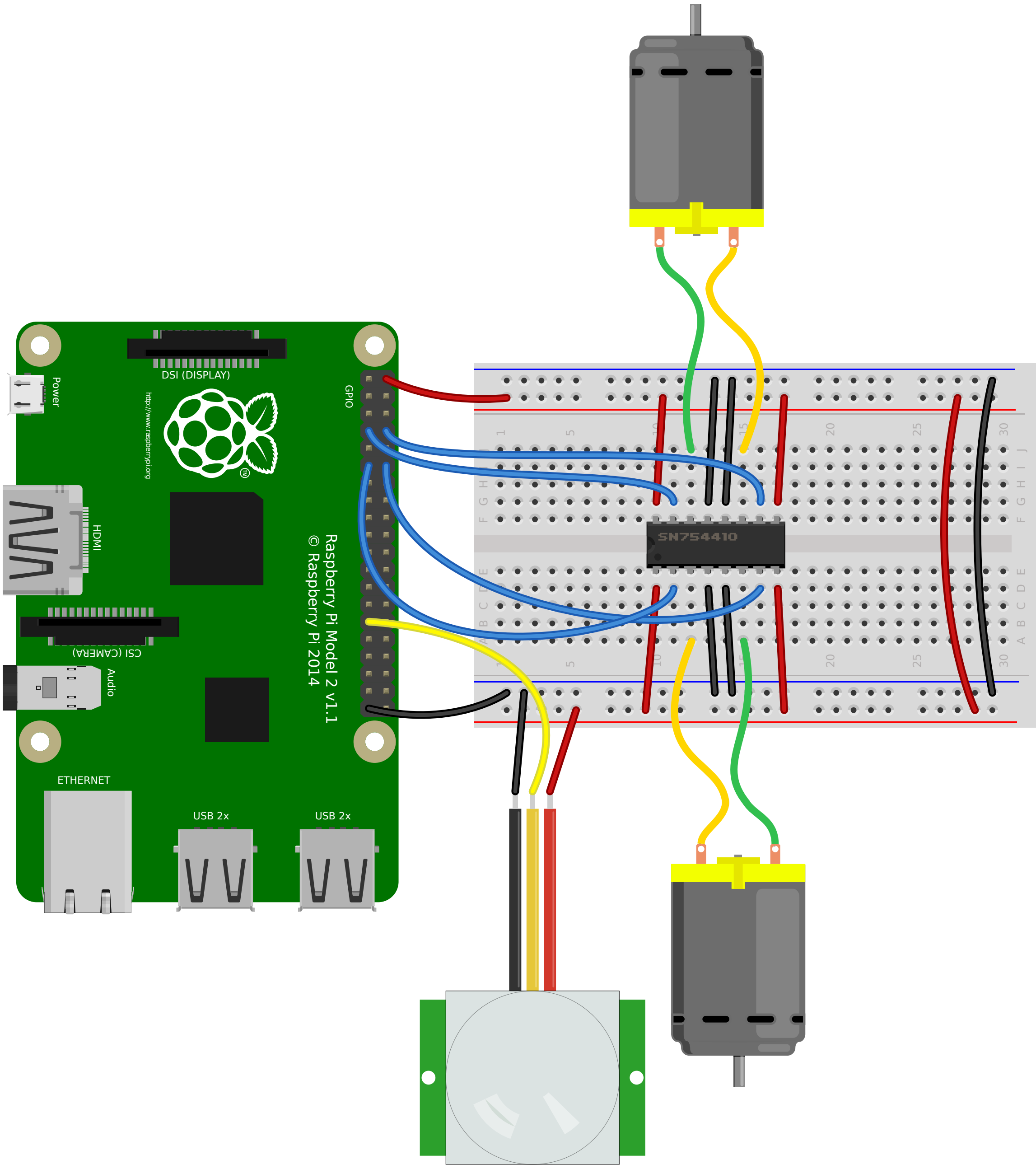
```
    ecodes.KEY_RIGHT: robot.right,
}

for event in keyboard.read_loop():
    if event.type == ecodes.EV_KEY and event.code in keypress_actions:
        if event.value == 1:  # key pressed
            keypress_actions[event.code]()
        if event.value == 0:  # key released
            robot.stop()
```

Note: This recipe uses the third-party `evdev` module. Install this library with `sudo pip3 install evdev` first. Be aware that `evdev` will only work with local input devices; this recipe will *not* work over SSH.

2.27 Motion sensor robot



Make a robot drive forward when it detects motion:

```
from gpiozero import Robot, MotionSensor
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))
pir = MotionSensor(5)

pir.when_motion = robot.forward
pir.when_no_motion = robot.stop

pause()
```

Alternatively:

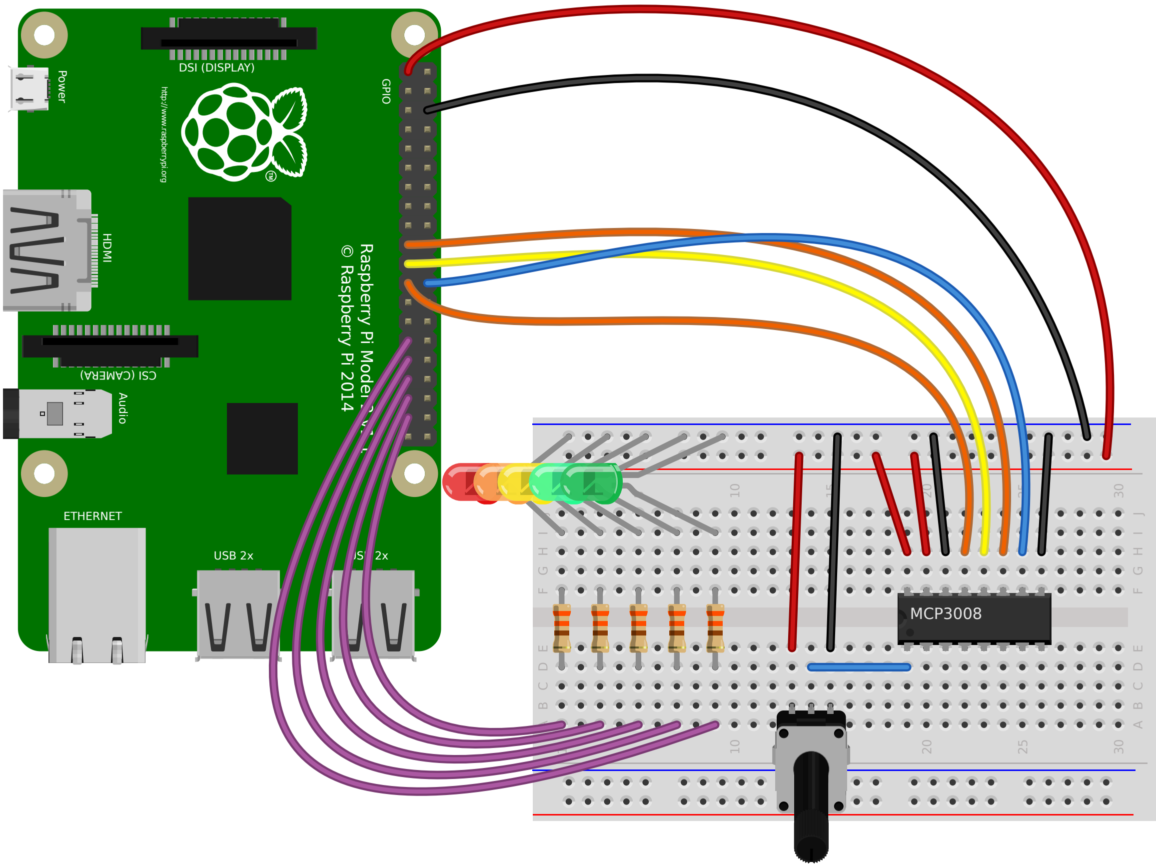
```
from gpiozero import Robot, MotionSensor
from gpiozero.tools import zip_values
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))
pir = MotionSensor(5)

robot.source = zip_values(pir, pir)

pause()
```

2.28 Potentiometer



Continually print the value of a potentiometer (values between 0 and 1) connected to a *MCP3008* (page 147) analog to digital converter:

```
from gpiozero import MCP3008

pot = MCP3008(channel=0)

while True:
    print(pot.value)
```

Present the value of a potentiometer on an LED bar graph using PWM to represent states that won't "fill" an LED:

```
from gpiozero import LEDBarGraph, MCP3008
from signal import pause

graph = LEDBarGraph(5, 6, 13, 19, 26, pwm=True)
pot = MCP3008(channel=0)

graph.source = pot

pause()
```

2.29 Measure temperature with an ADC

Wire a TMP36 temperature sensor to the first channel of an *MCP3008* (page 147) analog to digital converter:

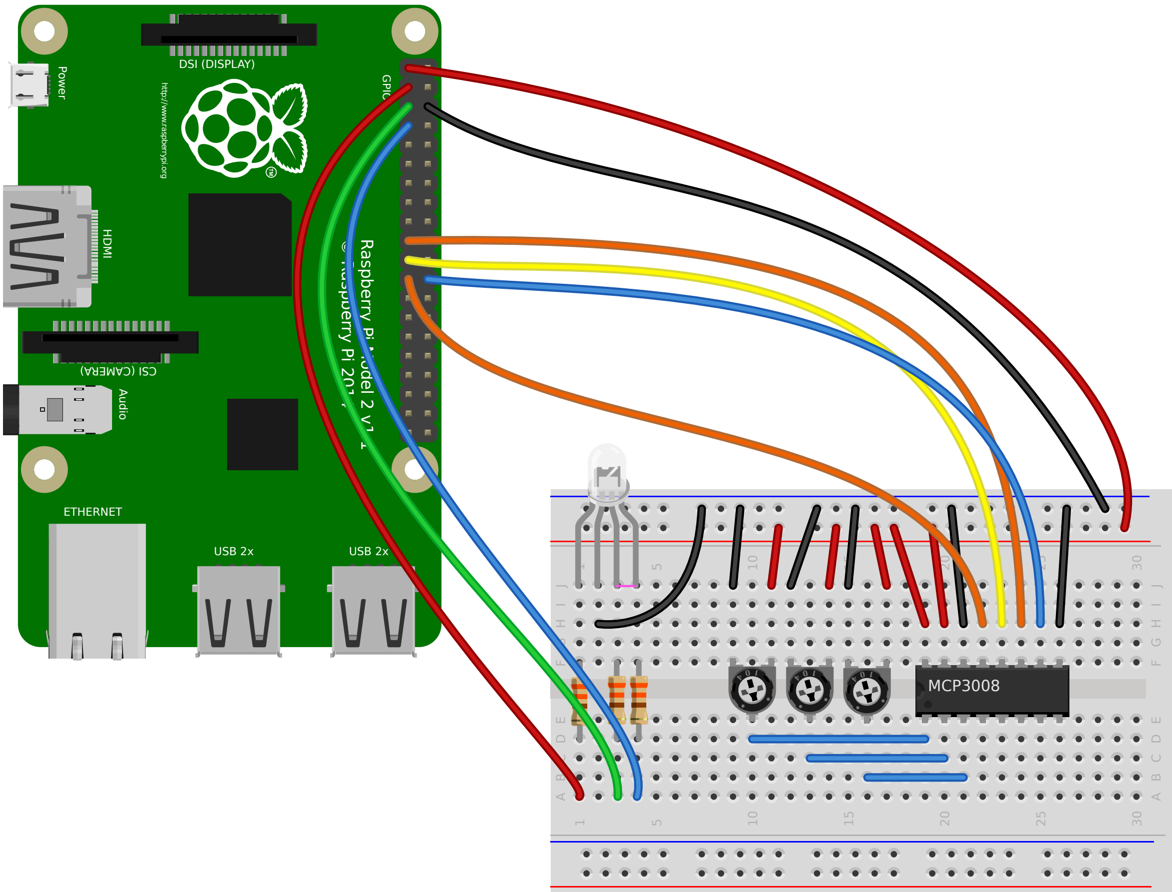
```
from gpiozero import MCP3008
from time import sleep

def convert_temp(gen):
    for value in gen:
        yield (value * 3.3 - 0.5) * 100

adc = MCP3008(channel=0)

for temp in convert_temp(adc.values):
    print('The temperature is', temp, 'C')
    sleep(1)
```

2.30 Full color LED controlled by 3 potentiometers



Wire up three potentiometers (for red, green and blue) and use each of their values to make up the colour of the LED:

```
from gpiozero import RGBLED, MCP3008

led = RGBLED(red=2, green=3, blue=4)
red_pot = MCP3008(channel=0)
green_pot = MCP3008(channel=1)
blue_pot = MCP3008(channel=2)

while True:
    led.red = red_pot.value
    led.green = green_pot.value
    led.blue = blue_pot.value
```

Alternatively, the following example is identical, but uses the *source* (page 202) property rather than a `while`[20] loop:

```
from gpiozero import RGBLED, MCP3008
from gpiozero.tools import zip_values
from signal import pause

led = RGBLED(2, 3, 4)
red_pot = MCP3008(0)
green_pot = MCP3008(1)
```

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[20] https://docs.python.org/3.7/reference/compound_stmts.html#while

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```
blue_pot = MCP3008(2)

led.source = zip_values(red_pot, green_pot, blue_pot)

pause()
```

2.31 Timed heat lamp

If you have a pet (e.g. a tortoise) which requires a heat lamp to be switched on for a certain amount of time each day, you can use an Energenie Pi-mote[21] to remotely control the lamp, and the *TimeOfDay* (page 190) class to control the timing:

```
from gpiozero import Energenie, TimeOfDay
from datetime import time
from signal import pause

lamp = Energenie(1)
daytime = TimeOfDay(time(8), time(20))

daytime.when_activated = lamp.on
daytime.when_deactivated = lamp.off

pause()
```

2.32 Internet connection status indicator

You can use a pair of green and red LEDs to indicate whether or not your internet connection is working. Simply use the *PingServer* (page 191) class to identify whether a ping to *google.com* is successful. If successful, the green LED is lit, and if not, the red LED is lit:

```
from gpiozero import LED, PingServer
from gpiozero.tools import negated
from signal import pause

green = LED(17)
red = LED(18)

google = PingServer('google.com')

google.when_activated = green.on
google.when_deactivated = green.off
red.source = negated(green)

pause()
```

2.33 CPU Temperature Bar Graph

You can read the Raspberry Pi's own CPU temperature using the built-in *CPUTemperature* (page 192) class, and display this on a "bar graph" of LEDs:

[21] https://energenie4u.co.uk/catalogue/product/ENER002-2PI

```
from gpiozero import LEDBarGraph, CPUTemperature
from signal import pause

cpu = CPUTemperature(min_temp=50, max_temp=90)
leds = LEDBarGraph(2, 3, 4, 5, 6, 7, 8, pwm=True)

leds.source = cpu

pause()
```

2.34 More recipes

Continue to:

- *Advanced Recipes* (page 39)
- *Remote GPIO Recipes* (page 57)

CHAPTER 3

Advanced Recipes

The following recipes demonstrate some of the capabilities of the GPIO Zero library. Please note that all recipes are written assuming Python 3. Recipes *may* work under Python 2, but no guarantees!

3.1 LEDBoard

You can iterate over the LEDs in a *LEDBoard* (page 155) object one-by-one:

```
from gpiozero import LEDBoard
from time import sleep

leds = LEDBoard(5, 6, 13, 19, 26)

for led in leds:
    led.on()
    sleep(1)
    led.off()
```

LEDBoard (page 155) also supports indexing. This means you can access the individual *LED* (page 123) objects using `leds[i]` where `i` is an integer from 0 up to (not including) the number of LEDs:

```
from gpiozero import LEDBoard
from time import sleep

leds = LEDBoard(2, 3, 4, 5, 6, 7, 8, 9)

leds[0].on()  # first led on
sleep(1)
leds[7].on()  # last led on
sleep(1)
leds[-1].off()  # last led off
sleep(1)
```

This also means you can use slicing to access a subset of the LEDs:

```
from gpiozero import LEDBoard
from time import sleep

leds = LEDBoard(2, 3, 4, 5, 6, 7, 8, 9)

for led in leds[3:]:  # leds 3 and onward
    led.on()
sleep(1)
leds.off()

for led in leds[:2]:  # leds 0 and 1
    led.on()
sleep(1)
leds.off()

for led in leds[::2]:  # even leds (0, 2, 4...)
    led.on()
sleep(1)
leds.off()

for led in leds[1::2]:  # odd leds (1, 3, 5...)
    led.on()
sleep(1)
leds.off()
```

LEDBoard (page 155) objects can have their *LED* objects named upon construction. This means the individual LEDs can be accessed by their name:

```
from gpiozero import LEDBoard
from time import sleep

leds = LEDBoard(red=2, green=3, blue=4)

leds.red.on()
sleep(1)
leds.green.on()
sleep(1)
leds.blue.on()
sleep(1)
```

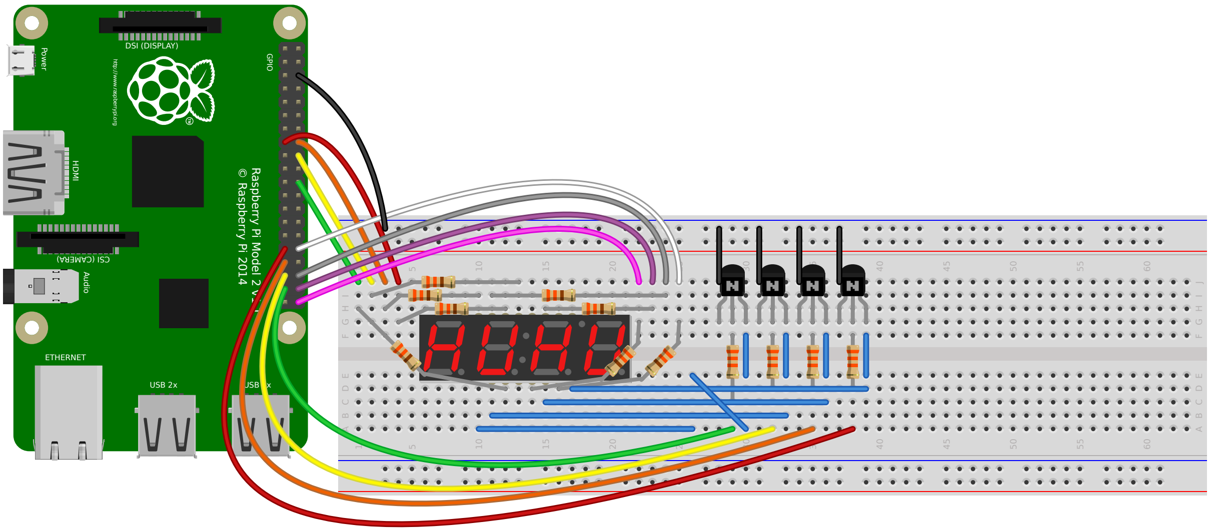
LEDBoard (page 155) objects can also be nested within other *LEDBoard* (page 155) objects:

```
from gpiozero import LEDBoard
from time import sleep

leds = LEDBoard(red=LEDBoard(top=2, bottom=3), green=LEDBoard(top=4, bottom=5))

leds.red.on() ## both reds on
sleep(1)
leds.green.on()  # both greens on
sleep(1)
leds.off()  # all off
sleep(1)
leds.red.top.on()  # top red on
sleep(1)
leds.green.bottom.on()  # bottom green on
sleep(1)
```

3.2 Multi-character 7-segment display

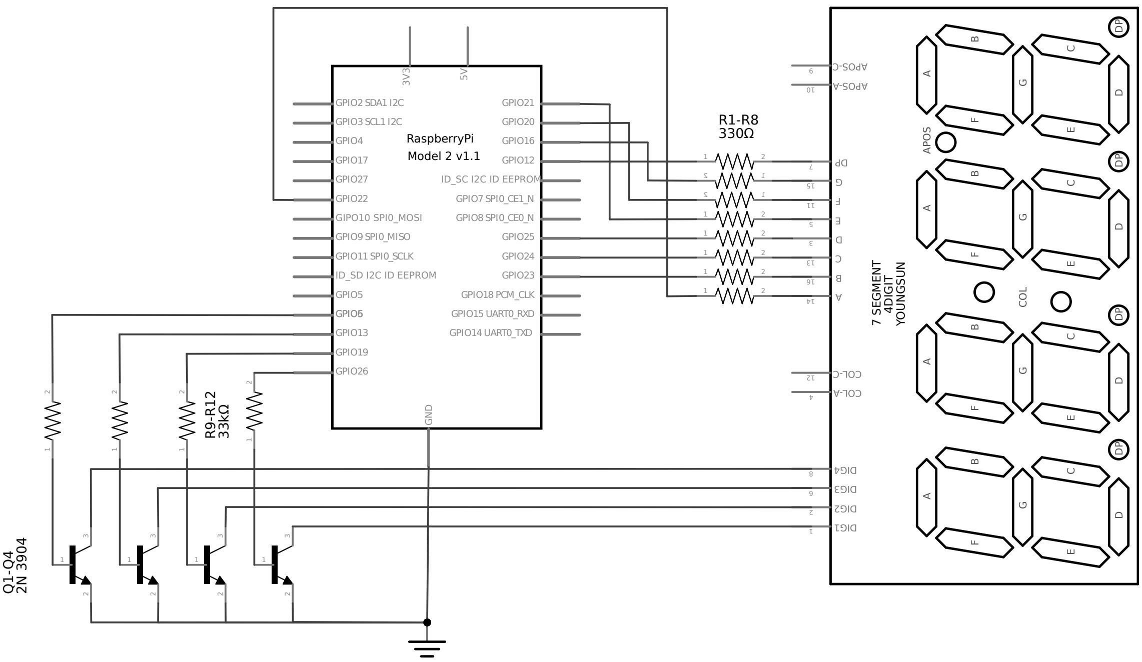
The 7-segment display demonstrated in the previous chapter is often available in multi-character variants (typically 4 characters long). Such displays are multiplexed meaning that the LED pins are typically the same as for the single character display but are shared across all characters. Each character in turn then has its own common line which can be tied to ground (in the case of a common cathode display) to enable that particular character. By activating each character in turn very quickly, the eye can be fooled into thinking four different characters are being displayed simultaneously.

In such circuits you should not attempt to sink all the current from a single character (which may have up to 8 LEDs, in the case of a decimal-point, active) into a single GPIO. Rather, use some appropriate transistor (or similar component, e.g. an opto-coupler) to tie the digit's cathode to ground, and control that component from a GPIO.



This circuit demonstrates a 4-character 7-segment (actually 8-segment, with decimal-point) display, controlled by the Pi's GPIOs with 4 2N-3904 NPN transistors to control the digits.

> **Warning:** You are strongly advised to check the data-sheet for your particular multi-character 7-segment display. The pin-outs of these displays vary significantly and are very likely to be different to that shown on the breadboard above. For this reason, the schematic for this circuit is provided below; adapt it to your particular display.



The following code can be used to scroll a message across the display:

```
from itertools import cycle
from collections import deque
from gpiozero import LEDMultiCharDisplay
from signal import pause

display = LEDMultiCharDisplay(
    LEDCharDisplay(22, 23, 24, 25, 21, 20, 16, dp=12), 26, 19, 13, 6)

def scroller(message, chars=4):
    d = deque(maxlen=chars)
    for c in cycle(message):
        d.append(c)
        if len(d) == chars:
            yield ''.join(d)

display.source_delay = 0.2
display.source = scroller('GPIO 2ER0    ')
pause()
```

3.3 Who's home indicator

Using a number of green-red LED pairs, you can show the status of who's home, according to which IP addresses you can ping successfully. Note that this assumes each person's mobile phone has a reserved IP address on the home router.

```
from gpiozero import PingServer, LEDBoard
from gpiozero.tools import negated
from signal import pause

status = LEDBoard(
    mum=LEDBoard(red=14, green=15),
    dad=LEDBoard(red=17, green=18),
```

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```
    alice=LEDBoard(red=21, green=22)
)

statuses = {
    PingServer('192.168.1.5'): status.mum,
    PingServer('192.168.1.6'): status.dad,
    PingServer('192.168.1.7'): status.alice,
}

for server, leds in statuses.items():
    leds.green.source = server
    leds.green.source_delay = 60
    leds.red.source = negated(leds.green)

pause()
```

Alternatively, using the STATUS Zero[22] board:

```
from gpiozero import PingServer, StatusZero
from gpiozero.tools import negated
from signal import pause

status = StatusZero('mum', 'dad', 'alice')

statuses = {
    PingServer('192.168.1.5'): status.mum,
    PingServer('192.168.1.6'): status.dad,
    PingServer('192.168.1.7'): status.alice,
}

for server, leds in statuses.items():
    leds.green.source = server
    leds.green.source_delay = 60
    leds.red.source = negated(leds.green)

pause()
```

3.4 Travis build LED indicator

Use LEDs to indicate the status of a Travis build. A green light means the tests are passing, a red light means the build is broken:

```
from travispy import TravisPy
from gpiozero import LED
from gpiozero.tools import negated
from time import sleep
from signal import pause

def build_passed(repo):
    t = TravisPy()
    r = t.repo(repo)
    while True:
        yield r.last_build_state == 'passed'
```

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[22] https://thepihut.com/status

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```
red = LED(12)
green = LED(16)

green.source = build_passed('gpiozero/gpiozero')
green.source_delay = 60 * 5  # check every 5 minutes
red.source = negated(green)

pause()
```

Note this recipe requires travispy[23]. Install with `sudo pip3 install travispy`.

3.5 Button controlled robot

Alternatively to the examples in the simple recipes, you can use four buttons to program the directions and add a fifth button to process them in turn, like a Bee-Bot or Turtle robot.

```
from gpiozero import Button, Robot
from time import sleep
from signal import pause

robot = Robot((17, 18), (22, 23))

left = Button(2)
right = Button(3)
forward = Button(4)
backward = Button(5)
go = Button(6)

instructions = []

def add_instruction(btn):
    instructions.append({
        left:     (-1, 1),
        right:    (1, -1),
        forward:  (1, 1),
        backward: (-1, -1),
    }[btn])

def do_instructions():
    instructions.append((0, 0))
    robot.source_delay = 0.5
    robot.source = instructions
    sleep(robot.source_delay * len(instructions))
    del instructions[:]

go.when_pressed = do_instructions
for button in (left, right, forward, backward):
    button.when_pressed = add_instruction

pause()
```

[23] https://travispy.readthedocs.io/

3.6 Robot controlled by 2 potentiometers

Use two potentiometers to control the left and right motor speed of a robot:

```
from gpiozero import Robot, MCP3008
from gpiozero.tools import zip_values
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))

left_pot = MCP3008(0)
right_pot = MCP3008(1)

robot.source = zip_values(left_pot, right_pot)

pause()
```

To include reverse direction, scale the potentiometer values from 0->1 to -1->1:

```
from gpiozero import Robot, MCP3008
from gpiozero.tools import scaled
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))

left_pot = MCP3008(0)
right_pot = MCP3008(1)

robot.source = zip(scaled(left_pot, -1, 1), scaled(right_pot, -1, 1))

pause()
```

Note: Please note the example above requires Python 3. In Python 2, `zip()`[24] doesn't support lazy evaluation so the script will simply hang.

3.7 BlueDot LED

BlueDot is a Python library an Android app which allows you to easily add Bluetooth control to your Raspberry Pi project. A simple example to control a LED using the BlueDot app:

```
from bluedot import BlueDot
from gpiozero import LED

bd = BlueDot()
led = LED(17)

while True:
    bd.wait_for_press()
    led.on()
    bd.wait_for_release()
    led.off()
```

[24] https://docs.python.org/3.7/library/functions.html#zip

Note this recipe requires **bluedot** and the associated Android app. See the BlueDot documentation[25] for installation instructions.

3.8 BlueDot robot

You can create a Bluetooth controlled robot which moves forward when the dot is pressed and stops when it is released:

```
from bluedot import BlueDot
from gpiozero import Robot
from signal import pause

bd = BlueDot()
robot = Robot(left=(4, 14), right=(17, 18))

def move(pos):
    if pos.top:
        robot.forward(pos.distance)
    elif pos.bottom:
        robot.backward(pos.distance)
    elif pos.left:
        robot.left(pos.distance)
    elif pos.right:
        robot.right(pos.distance)

bd.when_pressed = move
bd.when_moved = move
bd.when_released = robot.stop

pause()
```

Or a more advanced example including controlling the robot's speed and precise direction:

```
from gpiozero import Robot
from bluedot import BlueDot
from signal import pause

def pos_to_values(x, y):
    left = y if x > 0 else y + x
    right = y if x < 0 else y - x
    return (clamped(left), clamped(right))

def clamped(v):
    return max(-1, min(1, v))

def drive():
    while True:
        if bd.is_pressed:
            x, y = bd.position.x, bd.position.y
            yield pos_to_values(x, y)
        else:
            yield (0, 0)

robot = Robot(left=(4, 14), right=(17, 18))
```

(continues on next page)

[25] https://bluedot.readthedocs.io/en/latest/index.html

(continued from previous page)

```
bd = BlueDot()

robot.source = drive()

pause()
```

3.9 Controlling the Pi's own LEDs

On certain models of Pi (specifically the model A+, B+, and 2B) it's possible to control the power and activity LEDs. This can be useful for testing GPIO functionality without the need to wire up your own LEDs (also useful because the power and activity LEDs are "known good").

Firstly you need to disable the usual triggers for the built-in LEDs. This can be done from the terminal with the following commands:

```
$ echo none | sudo tee /sys/class/leds/led0/trigger
$ echo gpio | sudo tee /sys/class/leds/led1/trigger
```

Now you can control the LEDs with gpiozero like so:

```
from gpiozero import LED
from signal import pause

power = LED(35) # /sys/class/leds/led1
activity = LED(47) # /sys/class/leds/led0

activity.blink()
power.blink()
pause()
```

To revert the LEDs to their usual purpose you can either reboot your Pi or run the following commands:

```
$ echo mmc0 | sudo tee /sys/class/leds/led0/trigger
$ echo input | sudo tee /sys/class/leds/led1/trigger
```

Note: On the Pi Zero you can control the activity LED with this recipe, but there's no separate power LED to control (it's also worth noting the activity LED is active low, so set `active_high=False` when constructing your LED component).

On the original Pi 1 (model A or B), the activity LED can be controlled with GPIO16 (after disabling its trigger as above) but the power LED is hard-wired on.

On the Pi 3 the LEDs are controlled by a GPIO expander which is not accessible from gpiozero (yet).

CHAPTER 4

Configuring Remote GPIO

GPIO Zero supports a number of different pin implementations (low-level pin libraries which deal with the GPIO pins directly). By default, the RPi.GPIO[26] library is used (assuming it is installed on your system), but you can optionally specify one to use. For more information, see the *API - Pins* (page 225) documentation page.

One of the pin libraries supported, pigpio[27], provides the ability to control GPIO pins remotely over the network, which means you can use GPIO Zero to control devices connected to a Raspberry Pi on the network. You can do this from another Raspberry Pi, or even from a PC.

See the *Remote GPIO Recipes* (page 57) page for examples on how remote pins can be used.

4.1 Preparing the Raspberry Pi

If you're using Raspberry Pi OS (desktop - not Lite) then you have everything you need to use the remote GPIO feature. If you're using Raspberry Pi OS Lite, or another distribution, you'll need to install pigpio:

```
$ sudo apt install pigpio
```

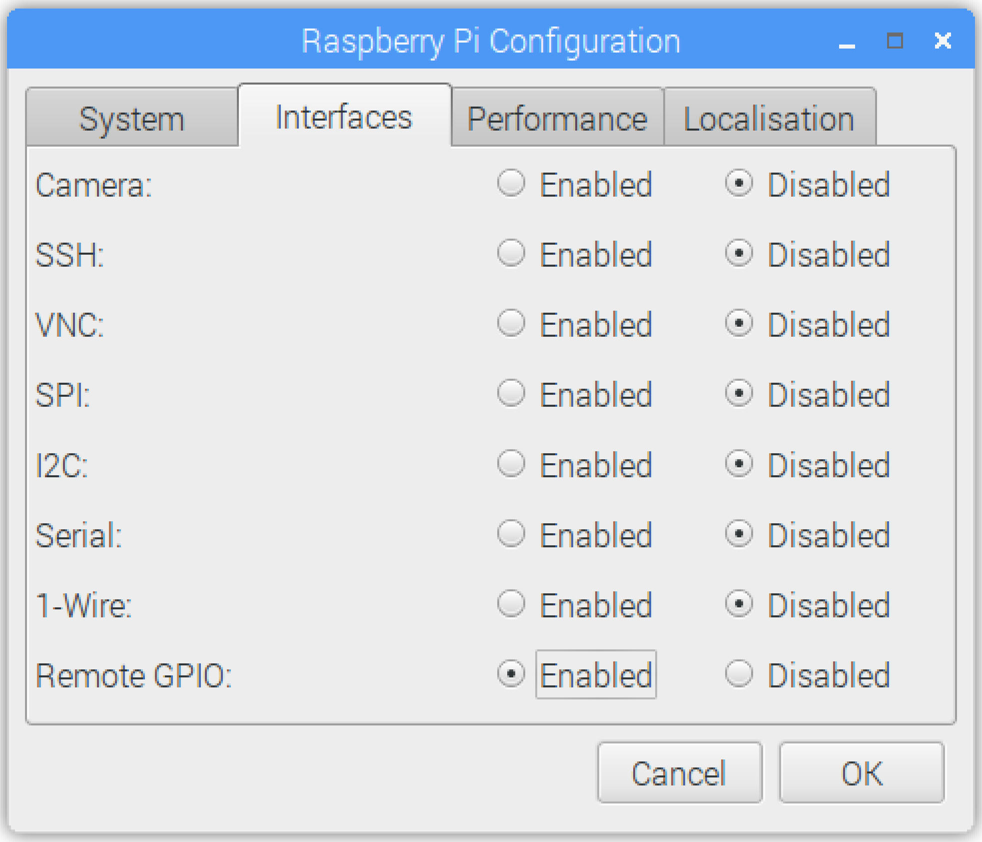
Alternatively, pigpio is available from abyz.me.uk[28].

You'll need to enable remote connections, and launch the pigpio daemon on the Raspberry Pi.

4.1.1 Enable remote connections

On the Raspberry Pi OS desktop image, you can enable *Remote GPIO* in the Raspberry Pi configuration tool:

[26] https://pypi.python.org/pypi/RPi.GPIO
[27] http://abyz.me.uk/rpi/pigpio/python.html
[28] http://abyz.me.uk/rpi/pigpio/download.html



Alternatively, enter **sudo raspi-config** on the command line, and enable Remote GPIO. This is functionally equivalent to the desktop method.

This will allow remote connections (until disabled) when the pigpio daemon is launched using **systemctl** (see below). It will also launch the pigpio daemon for the current session. Therefore, nothing further is required for the current session, but after a reboot, a **systemctl** command will be required.

4.1.2 Command-line: systemctl

To automate running the daemon at boot time, run:

```
$ sudo systemctl enable pigpiod
```

To run the daemon once using **systemctl**, run:

```
$ sudo systemctl start pigpiod
```

4.1.3 Command-line: pigpiod

Another option is to launch the pigpio daemon manually:

```
$ sudo pigpiod
```

This is for single-session-use and will not persist after a reboot. However, this method can be used to allow connections from a specific IP address, using the **-n** flag. For example:

```
$ sudo pigpiod -n localhost # allow localhost only
$ sudo pigpiod -n 192.168.1.65 # allow 192.168.1.65 only
$ sudo pigpiod -n localhost -n 192.168.1.65 # allow localhost and 192.168.1.65 only
```

Note: Note that running `sudo pigpiod` will not honour the Remote GPIO configuration setting (i.e. without the `-n` flag it will allow remote connections even if the remote setting is disabled), but `sudo systemctl enable pigpiod` or `sudo systemctl start pigpiod` will not allow remote connections unless configured accordingly.

4.2 Preparing the control computer

If the control computer (the computer you're running your Python code from) is a Raspberry Pi running Raspberry Pi OS (or a PC running Raspberry Pi Desktop x86[29]), then you have everything you need. If you're using another Linux distribution, Mac OS or Windows then you'll need to install the pigpio[30] Python library on the PC.

4.2.1 Raspberry Pi

First, update your repositories list:

```
$ sudo apt update
```

Then install GPIO Zero and the pigpio library for Python 3:

```
$ sudo apt install python3-gpiozero python3-pigpio
```

or Python 2:

```
$ sudo apt install python-gpiozero python-pigpio
```

Alternatively, install with pip:

```
$ sudo pip3 install gpiozero pigpio
```

or for Python 2:

```
$ sudo pip install gpiozero pigpio
```

4.2.2 Linux

First, update your distribution's repositories list. For example:

```
$ sudo apt update
```

Then install pip for Python 3:

```
$ sudo apt install python3-pip
```

or Python 2:

```
$ sudo apt install python-pip
```

(Alternatively, install pip with get-pip[31].)

Next, install GPIO Zero and pigpio for Python 3:

[29] https://www.raspberrypi.org/downloads/raspberry-pi-desktop/
[30] http://abyz.me.uk/rpi/pigpio/python.html
[31] https://pip.pypa.io/en/stable/installing/

```
$ sudo pip3 install gpiozero pigpio
```

or Python 2:

```
$ sudo pip install gpiozero pigpio
```

4.2.3 Mac OS

First, install pip. If you installed Python 3 using brew, you will already have pip. If not, install pip with get-pip[32].

Next, install GPIO Zero and pigpio with pip:

```
$ pip3 install gpiozero pigpio
```

Or for Python 2:

```
$ pip install gpiozero pigpio
```

4.2.4 Windows

Modern Python installers for Windows bundle pip with Python. If pip is not installed, you can follow this guide[33]. Next, install GPIO Zero and pigpio with pip:

```
C:\Users\user1> pip install gpiozero pigpio
```

4.3 Environment variables

The simplest way to use devices with remote pins is to set the *PIGPIO_ADDR* (page 80) environment variable to the IP address of the desired Raspberry Pi. You must run your Python script or launch your development environment with the environment variable set using the command line. For example, one of the following:

```
$ PIGPIO_ADDR=192.168.1.3 python3 hello.py
$ PIGPIO_ADDR=192.168.1.3 python3
$ PIGPIO_ADDR=192.168.1.3 ipython3
$ PIGPIO_ADDR=192.168.1.3 idle3 &
```

If you are running this from a PC (not a Raspberry Pi) with gpiozero and the pigpio[34] Python library installed, this will work with no further configuration. However, if you are running this from a Raspberry Pi, you will also need to ensure the default pin factory is set to *PiGPIOFactory* (page 241). If RPi.GPIO[35] is installed, this will be selected as the default pin factory, so either uninstall it, or use the *GPIOZERO_PIN_FACTORY* (page 80) environment variable to override it:

```
$ GPIOZERO_PIN_FACTORY=pigpio PIGPIO_ADDR=192.168.1.3 python3 hello.py
```

This usage will set the pin factory to *PiGPIOFactory* (page 241) with a default host of `192.168.1.3`. The pin factory can be changed inline in the code, as seen in the following sections.

With this usage, you can write gpiozero code like you would on a Raspberry Pi, with no modifications needed. For example:

[32] https://pip.pypa.io/en/stable/installing/
[33] https://projects.raspberrypi.org/en/projects/using-pip-on-windows
[34] http://abyz.me.uk/rpi/pigpio/python.html
[35] https://pypi.python.org/pypi/RPi.GPIO

```
from gpiozero import LED
from time import sleep

red = LED(17)

while True:
    red.on()
    sleep(1)
    red.off()
    sleep(1)
```

When run with:

```
$ PIGPIO_ADDR=192.168.1.3 python3 led.py
```

will flash the LED connected to pin 17 of the Raspberry Pi with the IP address `192.168.1.3`. And:

```
$ PIGPIO_ADDR=192.168.1.4 python3 led.py
```

will flash the LED connected to pin 17 of the Raspberry Pi with the IP address `192.168.1.4`, without any code changes, as long as the Raspberry Pi has the pigpio daemon running.

Note: When running code directly on a Raspberry Pi, any pin factory can be used (assuming the relevant library is installed), but when a device is used remotely, only *PiGPIOFactory* (page 241) can be used, as pigpio[36] is the only pin library which supports remote GPIO.

4.4 Pin factories

An alternative (or additional) method of configuring gpiozero objects to use remote pins is to create instances of *PiGPIOFactory* (page 241) objects, and use them when instantiating device objects. For example, with no environment variables set:

```
from gpiozero import LED
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep

factory = PiGPIOFactory(host='192.168.1.3')
led = LED(17, pin_factory=factory)

while True:
    led.on()
    sleep(1)
    led.off()
    sleep(1)
```

This allows devices on multiple Raspberry Pis to be used in the same script:

```
from gpiozero import LED
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep

factory3 = PiGPIOFactory(host='192.168.1.3')
factory4 = PiGPIOFactory(host='192.168.1.4')
```

(continues on next page)

[36] http://abyz.me.uk/rpi/pigpio/python.html

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```
led_1 = LED(17, pin_factory=factory3)
led_2 = LED(17, pin_factory=factory4)

while True:
    led_1.on()
    led_2.off()
    sleep(1)
    led_1.off()
    led_2.on()
    sleep(1)
```

You can, of course, continue to create gpiozero device objects as normal, and create others using remote pins. For example, if run on a Raspberry Pi, the following script will flash an LED on the controller Pi, and also on another Pi on the network:

```
from gpiozero import LED
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep

remote_factory = PiGPIOFactory(host='192.168.1.3')
led_1 = LED(17)  # local pin
led_2 = LED(17, pin_factory=remote_factory)  # remote pin

while True:
    led_1.on()
    led_2.off()
    sleep(1)
    led_1.off()
    led_2.on()
    sleep(1)
```

Alternatively, when run with the environment variables `GPIOZERO_PIN_FACTORY=pigpio PIGPIO_ADDR=192.168.1.3` set, the following script will behave exactly the same as the previous one:

```
from gpiozero import LED
from gpiozero.pins.rpigpio import RPiGPIOFactory
from time import sleep

local_factory = RPiGPIOFactory()
led_1 = LED(17, pin_factory=local_factory)  # local pin
led_2 = LED(17)  # remote pin

while True:
    led_1.on()
    led_2.off()
    sleep(1)
    led_1.off()
    led_2.on()
    sleep(1)
```

Of course, multiple IP addresses can be used:

```
from gpiozero import LED
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep
```

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```
factory3 = PiGPIOFactory(host='192.168.1.3')
factory4 = PiGPIOFactory(host='192.168.1.4')

led_1 = LED(17)  # local pin
led_2 = LED(17, pin_factory=factory3)  # remote pin on one pi
led_3 = LED(17, pin_factory=factory4)  # remote pin on another pi

while True:
    led_1.on()
    led_2.off()
    led_3.on()
    sleep(1)
    led_1.off()
    led_2.on()
    led_3.off()
    sleep(1)
```

Note that these examples use the *LED* (page 123) class, which takes a *pin* argument to initialise. Some classes, particularly those representing HATs and other add-on boards, do not require their pin numbers to be specified. However, it is still possible to use remote pins with these devices, either using environment variables, or the *pin_factory* keyword argument:

```
import gpiozero
from gpiozero import TrafficHat
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep

gpiozero.Device.pin_factory = PiGPIOFactory(host='192.168.1.3')
th = TrafficHat()  # traffic hat on 192.168.1.3 using remote pins
```

This also allows you to swap between two IP addresses and create instances of multiple HATs connected to different Pis:

```
import gpiozero
from gpiozero import TrafficHat
from gpiozero.pins.pigpio import PiGPIOFactory
from time import sleep

remote_factory = PiGPIOFactory(host='192.168.1.3')

th_1 = TrafficHat()  # traffic hat using local pins
th_2 = TrafficHat(pin_factory=remote_factory)  # traffic hat on 192.168.1.3 using␣
↪remote pins
```

You could even use a HAT which is not supported by GPIO Zero (such as the Sense HAT[37]) on one Pi, and use remote pins to control another over the network:

```
from gpiozero import MotionSensor
from gpiozero.pins.pigpio import PiGPIOFactory
from sense_hat import SenseHat

remote_factory = PiGPIOFactory(host='192.198.1.4')
pir = MotionSensor(4, pin_factory=remote_factory)  # remote motion sensor
sense = SenseHat()  # local sense hat

```

(continues on next page)

[37] https://www.raspberrypi.org/products/sense-hat/

(continued from previous page)

```
while True:
    pir.wait_for_motion()
    sense.show_message(sense.temperature)
```

Note that in this case, the Sense HAT code must be run locally, and the GPIO remotely.

4.5 Remote GPIO usage

Continue to:

- *Remote GPIO Recipes* (page 57)
- *Pi Zero USB OTG* (page 61)

CHAPTER 5

Remote GPIO Recipes

The following recipes demonstrate some of the capabilities of the remote GPIO feature of the GPIO Zero library. Before you start following these examples, please read up on preparing your Pi and your host PC to work with *Configuring Remote GPIO* (page 49).

Please note that all recipes are written assuming Python 3. Recipes *may* work under Python 2, but no guarantees!

5.1 LED + Button

Let a *Button* (page 103) on one Raspberry Pi control the *LED* (page 123) of another:

```
from gpiozero import Button, LED
from gpiozero.pins.pigpio import PiGPIOFactory
from signal import pause

factory = PiGPIOFactory(host='192.168.1.3')

button = Button(2)
led = LED(17, pin_factory=factory)

led.source = button

pause()
```

5.2 LED + 2 Buttons

The *LED* (page 123) will come on when both buttons are pressed:

```
from gpiozero import Button, LED
from gpiozero.pins.pigpio import PiGPIOFactory
from gpiozero.tools import all_values
from signal import pause
```

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```
factory3 = PiGPIOFactory(host='192.168.1.3')
factory4 = PiGPIOFactory(host='192.168.1.4')

led = LED(17)
button_1 = Button(17, pin_factory=factory3)
button_2 = Button(17, pin_factory=factory4)

led.source = all_values(button_1, button_2)

pause()
```

5.3 Multi-room motion alert

Install a Raspberry Pi with a *MotionSensor* (page 108) in each room of your house, and have an class:*LED* indicator showing when there's motion in each room:

```
from gpiozero import LEDBoard, MotionSensor
from gpiozero.pins.pigpio import PiGPIOFactory
from gpiozero.tools import zip_values
from signal import pause

ips = ['192.168.1.3', '192.168.1.4', '192.168.1.5', '192.168.1.6']
remotes = [PiGPIOFactory(host=ip) for ip in ips]

leds = LEDBoard(2, 3, 4, 5)  # leds on this pi
sensors = [MotionSensor(17, pin_factory=r) for r in remotes]  # remote sensors

leds.source = zip_values(*sensors)

pause()
```

5.4 Multi-room doorbell

Install a Raspberry Pi with a *Buzzer* (page 130) attached in each room you want to hear the doorbell, and use a push *Button* (page 103) as the doorbell:

```
from gpiozero import LEDBoard, MotionSensor
from gpiozero.pins.pigpio import PiGPIOFactory
from signal import pause

ips = ['192.168.1.3', '192.168.1.4', '192.168.1.5', '192.168.1.6']
remotes = [PiGPIOFactory(host=ip) for ip in ips]

button = Button(17)  # button on this pi
buzzers = [Buzzer(pin, pin_factory=r) for r in remotes]  # buzzers on remote pins

for buzzer in buzzers:
    buzzer.source = button

pause()
```

This could also be used as an internal doorbell (tell people it's time for dinner from the kitchen).

5.5 Remote button robot

Similarly to the simple recipe for the button controlled *Robot* (page 175), this example uses four buttons to control the direction of a robot. However, using remote pins for the robot means the control buttons can be separate from the robot:

```
from gpiozero import Button, Robot
from gpiozero.pins.pigpio import PiGPIOFactory
from signal import pause

factory = PiGPIOFactory(host='192.168.1.17')
robot = Robot(left=(4, 14), right=(17, 18), pin_factory=factory)  # remote pins

# local buttons
left = Button(26)
right = Button(16)
fw = Button(21)
bw = Button(20)

fw.when_pressed = robot.forward
fw.when_released = robot.stop

left.when_pressed = robot.left
left.when_released = robot.stop

right.when_pressed = robot.right
right.when_released = robot.stop

bw.when_pressed = robot.backward
bw.when_released = robot.stop

pause()
```

5.6 Light sensor + Sense HAT

The Sense HAT[38] (not supported by GPIO Zero) includes temperature, humidity and pressure sensors, but no light sensor. Remote GPIO allows an external *LightSensor* (page 109) to be used as well. The Sense HAT LED display can be used to show different colours according to the light levels:

```
from gpiozero import LightSensor
from gpiozero.pins.pigpio import PiGPIOFactory
from sense_hat import SenseHat

remote_factory = PiGPIOFactory(host='192.168.1.4')
light = LightSensor(4, pin_factory=remote_factory)  # remote motion sensor
sense = SenseHat()  # local sense hat

blue = (0, 0, 255)
yellow = (255, 255, 0)

while True:
    if light.value > 0.5:
        sense.clear(yellow)
```

(continues on next page)

[38] https://www.raspberrypi.org/products/sense-hat/

(continued from previous page)

```
    else:
        sense.clear(blue)
```

Note that in this case, the Sense HAT code must be run locally, and the GPIO remotely.

CHAPTER 6

Pi Zero USB OTG

The Raspberry Pi Zero[39] and Pi Zero W[40] feature a USB OTG port, allowing users to configure the device as (amongst other things) an Ethernet device. In this mode, it is possible to control the Pi Zero's GPIO pins over USB from another computer using the *remote GPIO* (page 49) feature.

6.1 GPIO expander method - no SD card required

The GPIO expander method allows you to boot the Pi Zero over USB from the PC, without an SD card. Your PC sends the required boot firmware to the Pi over the USB cable, launching a mini version of Raspberry Pi OS and booting it in RAM. The OS then starts the pigpio daemon, allowing "remote" access over the USB cable.

At the time of writing, this is only possible using either the Raspberry Pi Desktop x86 OS, or Ubuntu (or a derivative), or from another Raspberry Pi. Usage from Windows and Mac OS is not supported at present.

6.1.1 Raspberry Pi Desktop x86 setup

1. Download an ISO of the Raspberry Pi Desktop OS[41] from raspberrypi.org
2. Write the image to a USB stick or burn to a DVD.
3. Live boot your PC or Mac into the OS (select "Run with persistence" and your computer will be back to normal afterwards).

6.1.2 Raspberry Pi setup (using Raspberry Pi OS)

1. Update your package list and install the `usbbootgui` package:

```
$ sudo apt update
$ sudo apt install usbbootgui
```

[39] https://www.raspberrypi.org/products/raspberry-pi-zero/
[40] https://www.raspberrypi.org/products/raspberry-pi-zero-w/
[41] https://www.raspberrypi.org/downloads/raspberry-pi-desktop/

6.1.3 Ubuntu setup

1. Add the Raspberry Pi PPA to your system:

```
$ sudo add-apt-repository ppa:rpi-distro/ppa
```

2. If you have previously installed `gpiozero` or `pigpio` with pip, uninstall these first:

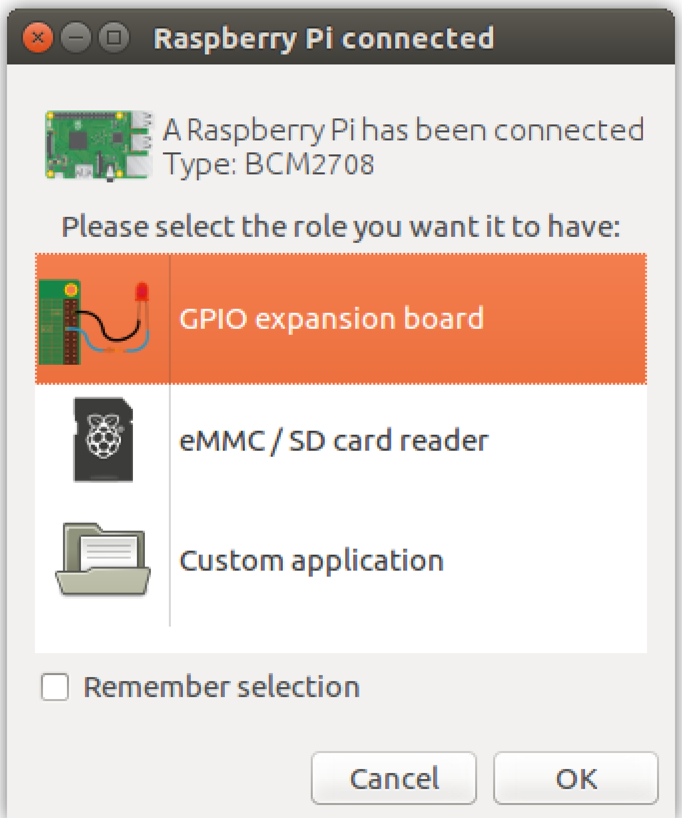
```
$ sudo pip3 uninstall gpiozero pigpio
```

3. Install the required packages from the PPA:

```
$ sudo apt install usbbootgui pigpio python3-gpiozero python3-pigpio
```

6.1.4 Access the GPIOs

Once your PC or Pi has the USB Boot GUI tool installed, connecting a Pi Zero will automatically launch a prompt to select a role for the device. Select "GPIO expansion board" and continue:



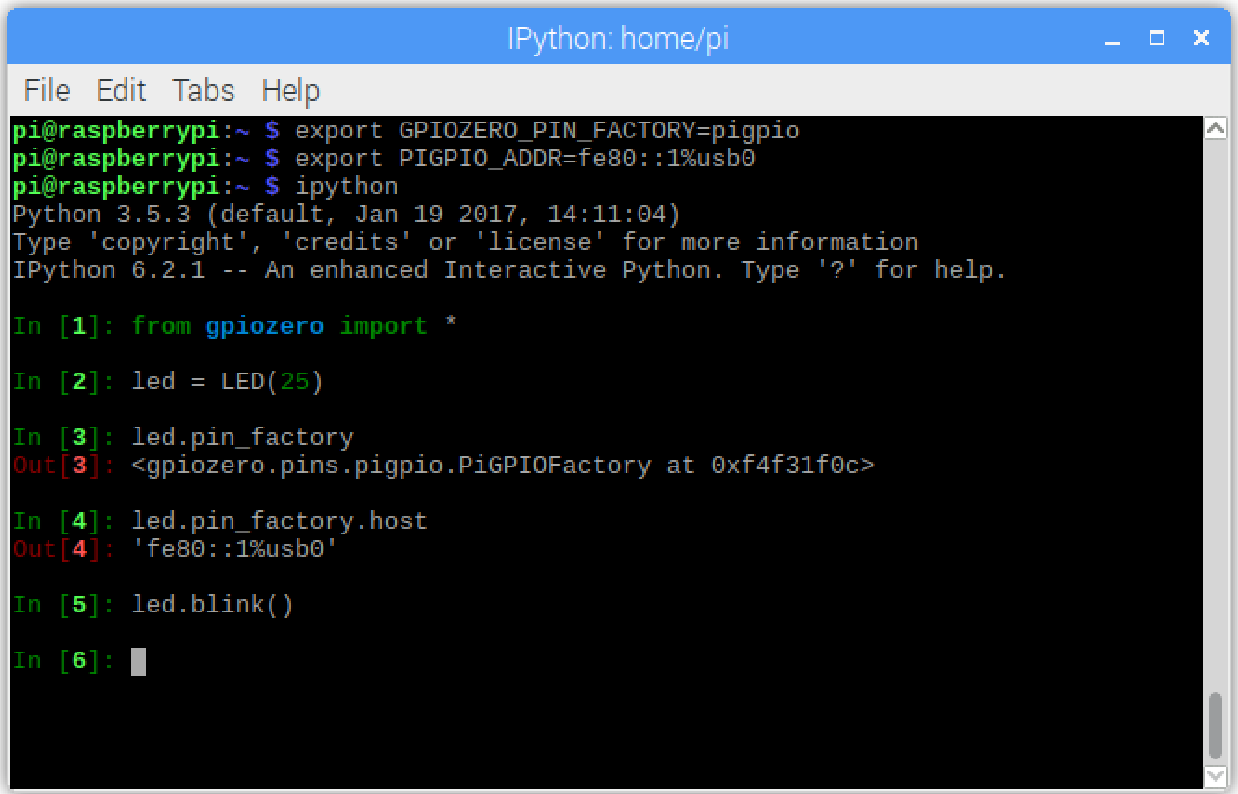
It will take 30 seconds or so to flash it, then the dialogue will disappear.

Raspberry Pi OS will name your Pi Zero connection `usb0`. On Ubuntu, this will likely be something else. You can ping it using the address `fe80::1%` followed by the connection string. You can look this up using `ifconfig`.

Set the *GPIOZERO_PIN_FACTORY* (page 80) and *PIGPIO_ADDR* (page 80) environment variables on your PC so GPIO Zero connects to the "remote" Pi Zero:

```
$ export GPIOZERO_PIN_FACTORY=pigpio
$ export PIGPIO_ADDR=fe80::1%usb0
```

Now any GPIO Zero code you run on the PC will use the GPIOs of the attached Pi Zero:



Alternatively, you can set the pin factory in-line, as explained in *Configuring Remote GPIO* (page 49).

Read more on the GPIO expander in blog posts on raspberrypi.org[42] and bennuttall.com[43].

6.2 Legacy method - SD card required

The legacy method requires the Pi Zero to have an SD card with Raspberry Pi OS inserted.

Start by creating a Raspberry Pi OS (desktop or lite) SD card, and then configure the boot partition like so:

1. Edit `config.txt` and add `dtoverlay=dwc2` on a new line, then save the file.
2. Create an empty file called `ssh` (no file extension) and save it in the boot partition.
3. Edit `cmdline.txt`` and insert `modules-load=dwc2,g_ether` after `rootwait`.

(See guides on blog.gbaman.info[44] and learn.adafruit.com[45] for more detailed instructions)

Then connect the Pi Zero to your computer using a micro USB cable (connecting it to the USB port, not the power port). You'll see the indicator LED flashing as the Pi Zero boots. When it's ready, you will be able to ping and SSH into it using the hostname `raspberrypi.local`. SSH into the Pi Zero, install pigpio and run the pigpio daemon.

Then, drop out of the SSH session and you can run Python code on your computer to control devices attached to the Pi Zero, referencing it by its hostname (or IP address if you know it), for example:

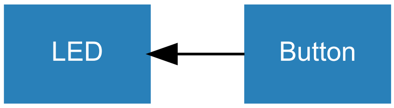
[42] https://www.raspberrypi.org/blog/gpio-expander/
[43] http://bennuttall.com/raspberry-pi-zero-gpio-expander/
[44] http://blog.gbaman.info/?p=791
[45] https://learn.adafruit.com/turning-your-raspberry-pi-zero-into-a-usb-gadget/ethernet-gadget

```
$ GPIOZERO_PIN_FACTORY=pigpio PIGPIO_ADDR=raspberrypi.local python3 led.py
```

CHAPTER 7

Source/Values

GPIO Zero provides a method of using the declarative programming paradigm to connect devices together: feeding the values of one device into another, for example the values of a button into an LED:




```
from gpiozero import LED, Button
from signal import pause

led = LED(17)
button = Button(2)

led.source = button

pause()
```

which is equivalent to:

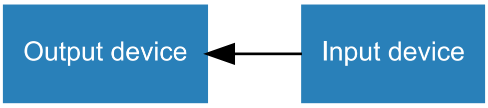
```
from gpiozero import LED, Button
from time import sleep

led = LED(17)
button = Button(2)

while True:
    led.value = button.value
    sleep(0.01)
```

except that the former is updated in a background thread, which enables you to do other things at the same time.

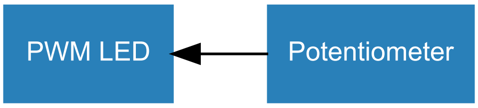
Every device has a *value* (page 201) property (the device's current value). Input devices (like buttons) can only have their values read, but output devices (like LEDs) can also have their value set to alter the state of the device:

```
>>> led = PWMLED(17)
>>> led.value  # LED is initially off
0.0
>>> led.on()  # LED is now on
>>> led.value
1.0
>>> led.value = 0  # LED is now off
```

Every device also has a *values* (page 202) property (a generator[46] continuously yielding the device's current value). All output devices have a *source* (page 202) property which can be set to any iterator[47]. The device will iterate over the values of the device provided, setting the device's value to each element at a rate specified in the *source_delay* (page 202) property (the default is 0.01 seconds).



The most common use case for this is to set the source of an output device to match the values of an input device, like the example above. A more interesting example would be a potentiometer controlling the brightness of an LED:




```
from gpiozero import PWMLED, MCP3008
from signal import pause

led = PWMLED(17)
pot = MCP3008()

led.source = pot

pause()
```

The way this works is that the input device's *values* (page 202) property is used to feed values into the output device. Prior to v1.5, the *source* (page 202) had to be set directly to a device's *values* (page 202) property:

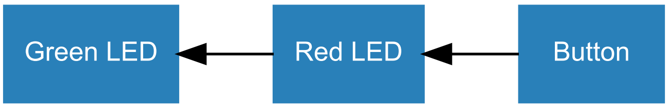
```
from gpiozero import PWMLED, MCP3008
from signal import pause

led = PWMLED(17)
pot = MCP3008()

led.source = pot.values

pause()
```

Note: Although this method is still supported, the recommended way is now to set the *source* (page 202) to a device object.

It is also possible to set an output device's *source* (page 202) to another output device, to keep them matching. In this example, the red LED is set to match the button, and the green LED is set to match

[46] https://wiki.python.org/moin/Generators
[47] https://wiki.python.org/moin/Iterator

the red LED, so both LEDs will be on when the button is pressed:

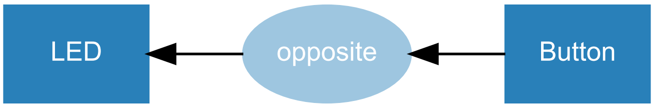



```
from gpiozero import LED, Button
from signal import pause

red = LED(14)
green = LED(15)
button = Button(17)

red.source = button
green.source = red

pause()
```

7.1 Processing values

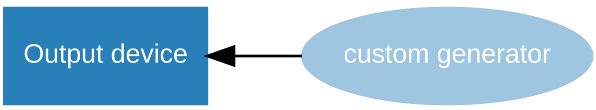
The device's values can also be processed before they are passed to the *source* (page 202):

For example, writing a generator function to pass the opposite of the Button value into the LED:

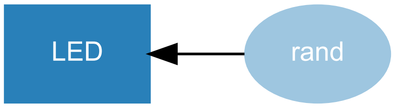



```
from gpiozero import Button, LED
from signal import pause

def opposite(device):
    for value in device.values:
        yield not value

led = LED(4)
btn = Button(17)

led.source = opposite(btn)

pause()
```

Alternatively, a custom generator can be used to provide values from an artificial source:



For example, writing a generator function to randomly yield 0 or 1:




```
from gpiozero import LED
from random import randint
from signal import pause

def rand():
    while True:
        yield randint(0, 1)

led = LED(17)
led.source = rand()

pause()
```

If the iterator is infinite (i.e. an infinite generator), the elements will be processed until the *source* (page 202) is changed or set to `None`[48].

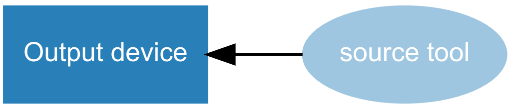
If the iterator is finite (e.g. a list), this will terminate once all elements are processed (leaving the device's value at the final element):

```
from gpiozero import LED
from signal import pause

led = LED(17)
led.source_delay = 1
led.source = [1, 0, 1, 1, 1, 0, 0, 1, 0, 1]

pause()
```

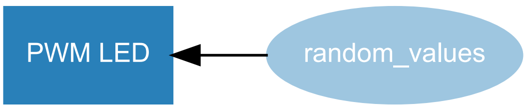
7.2 Source Tools

GPIO Zero provides a set of ready-made functions for dealing with source/values, called source tools. These are available by importing from *gpiozero.tools* (page 205).

Some of these source tools are artificial sources which require no input:



In this example, random values between 0 and 1 are passed to the LED, giving it a flickering candle effect:




```
from gpiozero import PWMLED
from gpiozero.tools import random_values
from signal import pause

```

(continues on next page)

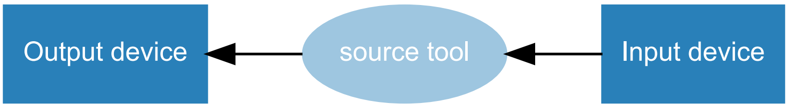
[48] https://docs.python.org/3.7/library/constants.html#None

(continued from previous page)

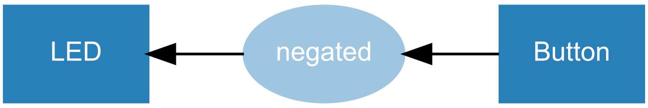
```
led = PWMLED(4)
led.source = random_values()
led.source_delay = 0.1

pause()
```

Note that in the above example, *source_delay* (page 202) is used to make the LED iterate over the random values slightly slower. *source_delay* (page 202) can be set to a larger number (e.g. 1 for a one second delay) or set to 0 to disable any delay.

Some tools take a single source and process its values:



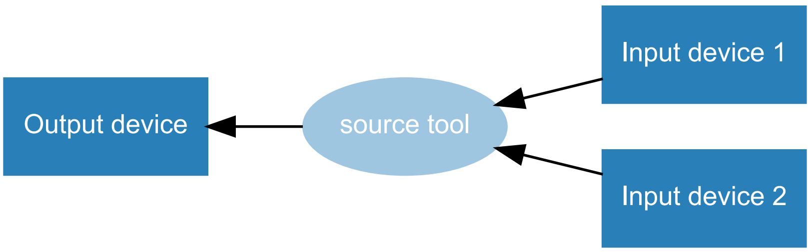
In this example, the LED is lit only when the button is not pressed:




```
from gpiozero import Button, LED
from gpiozero.tools import negated
from signal import pause

led = LED(4)
btn = Button(17)

led.source = negated(btn)

pause()
```

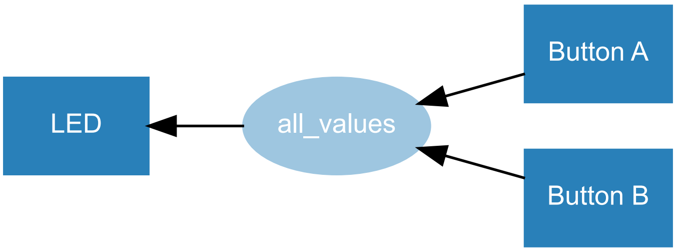
Note: Note that source tools which take one or more `value` parameters support passing either *ValuesMixin* (page 202) derivatives, or iterators, including a device's *values* (page 202) property.

Some tools combine the values of multiple sources:



In this example, the LED is lit only if both buttons are pressed (like an AND[49] gate):

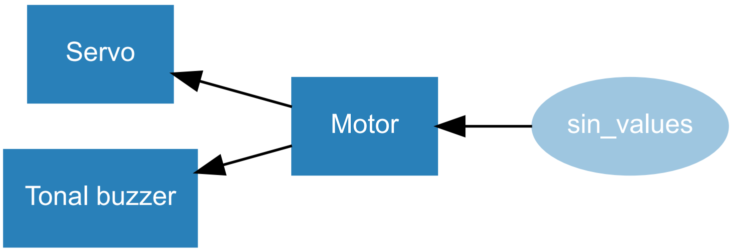
[49] https://en.wikipedia.org/wiki/AND_gate




```
from gpiozero import Button, LED
from gpiozero.tools import all_values
from signal import pause

button_a = Button(2)
button_b = Button(3)
led = LED(17)

led.source = all_values(button_a, button_b)

pause()
```

Similarly, *any_values()* (page 209) with two buttons would simulate an OR[50] gate.

While most devices have a *value* (page 201) range between 0 and 1, some have a range between -1 and 1 (e.g. *Motor* (page 132), *Servo* (page 135) and *TonalBuzzer* (page 131)). Some source tools output values between -1 and 1, which are ideal for these devices, for example passing *sin_values()* (page 212) in:




```
from gpiozero import Motor, Servo, TonalBuzzer
from gpiozero.tools import sin_values
from signal import pause

motor = Motor(2, 3)
servo = Servo(4)
buzzer = TonalBuzzer(5)

motor.source = sin_values()
servo.source = motor
buzzer.source = motor

pause()
```

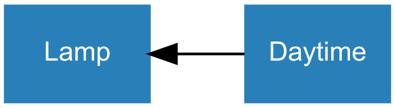
In this example, all three devices are following the sine wave[51]. The motor value ramps up from 0 (stopped) to 1 (full speed forwards), then back down to 0 and on to -1 (full speed backwards) in a cycle. Similarly, the servo moves from its mid point to the right, then towards the left; and the buzzer starts with its mid tone, gradually raises its frequency, to its highest tone, then down towards its lowest tone. Note that setting *source_delay* (page 202) will alter the speed at which the device iterates through the

[50] https://en.wikipedia.org/wiki/OR_gate
[51] https://en.wikipedia.org/wiki/Sine_wave

values. Alternatively, the tool *cos_values()* (page 211) could be used to start from -1 and go up to 1, and so on.

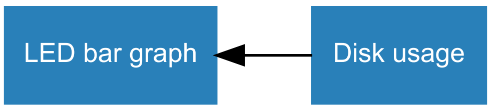
7.3 Internal devices

GPIO Zero also provides several *internal devices* (page 189) which represent facilities provided by the operating system itself. These can be used to react to things like the time of day, or whether a server is available on the network. These classes include a *values* (page 202) property which can be used to feed values into a device's *source* (page 202). For example, a lamp connected to an *Energenie* (page 179) socket can be controlled by a *TimeOfDay* (page 190) object so that it is on between the hours of 8am and 8pm:



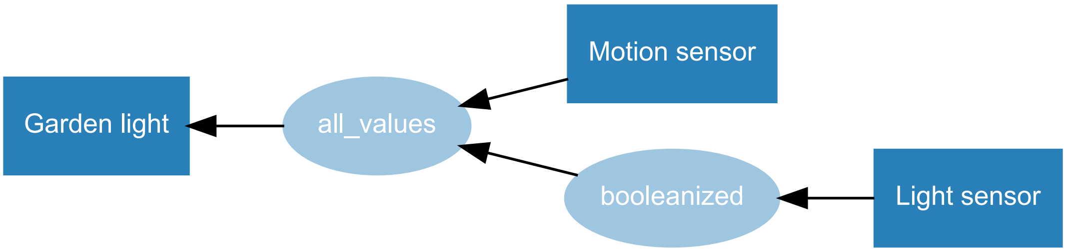

```
from gpiozero import Energenie, TimeOfDay
from datetime import time
from signal import pause

lamp = Energenie(1)
daytime = TimeOfDay(time(8), time(20))

daytime.when_activated = lamp.on
daytime.when_deactivated = lamp.off

pause()
```

Using the *DiskUsage* (page 195) class with *LEDBarGraph* (page 158) can show your Pi's disk usage percentage on a bar graph:




```
from gpiozero import DiskUsage, LEDBarGraph
from signal import pause

disk = DiskUsage()
graph = LEDBarGraph(2, 3, 4, 5, 6, 7, 8)

graph.source = disk

pause()
```

Demonstrating a garden light system whereby the light comes on if it's dark and there's motion is simple enough, but it requires using the *booleanized()* (page 205) source tool to convert the light sensor from a float value into a boolean:



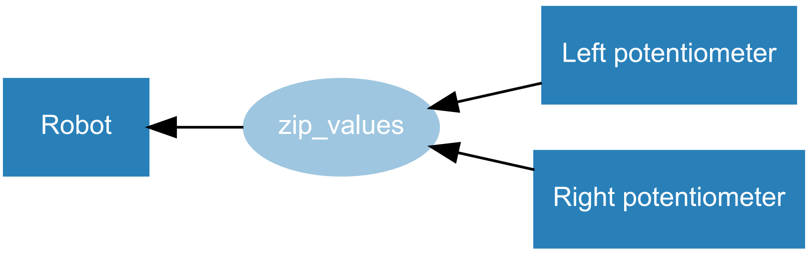

```
from gpiozero import LED, MotionSensor, LightSensor
from gpiozero.tools import booleanized, all_values
from signal import pause

garden = LED(2)
motion = MotionSensor(4)
light = LightSensor(5)

garden.source = all_values(booleanized(light, 0, 0.1), motion)

pause()
```

7.4 Composite devices

The *value* (page 201) of a composite device made up of the nested values of its devices. For example, the value of a *Robot* (page 175) object is a 2-tuple containing its left and right motor values:

```
>>> from gpiozero import Robot
>>> robot = Robot(left=(14, 15), right=(17, 18))
>>> robot.value
RobotValue(left_motor=0.0, right_motor=0.0)
>>> tuple(robot.value)
(0.0, 0.0)
>>> robot.forward()
>>> tuple(robot.value)
(1.0, 1.0)
>>> robot.backward()
>>> tuple(robot.value)
(-1.0, -1.0)
>>> robot.value = (1, 1)  # robot is now driven forwards
```

Use two potentiometers to control the left and right motor speed of a robot:




```
from gpiozero import Robot, MCP3008
from gpiozero.tools import zip_values
from signal import pause

```

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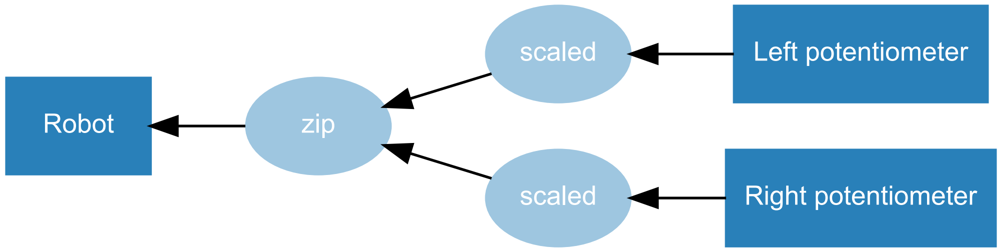
```
robot = Robot(left=(4, 14), right=(17, 18))

left_pot = MCP3008(0)
right_pot = MCP3008(1)

robot.source = zip_values(left_pot, right_pot)

pause()
```

To include reverse direction, scale the potentiometer values from 0->1 to -1->1:




```
from gpiozero import Robot, MCP3008
from gpiozero.tools import scaled
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))

left_pot = MCP3008(0)
right_pot = MCP3008(1)

robot.source = zip(scaled(left_pot, -1, 1), scaled(right_pot, -1, 1))

pause()
```

Note that this example uses the built-in `zip()`[52] rather than the tool *`zip_values()`* (page 210) as the *`scaled()`* (page 208) tool yields values which do not need converting, just zipping. Also note that this use of `zip()`[53] will not work in Python 2, instead use izip[54].

[52] https://docs.python.org/3.7/library/functions.html#zip
[53] https://docs.python.org/3.7/library/functions.html#zip
[54] https://docs.python.org/2/library/itertools.html#itertools.izip

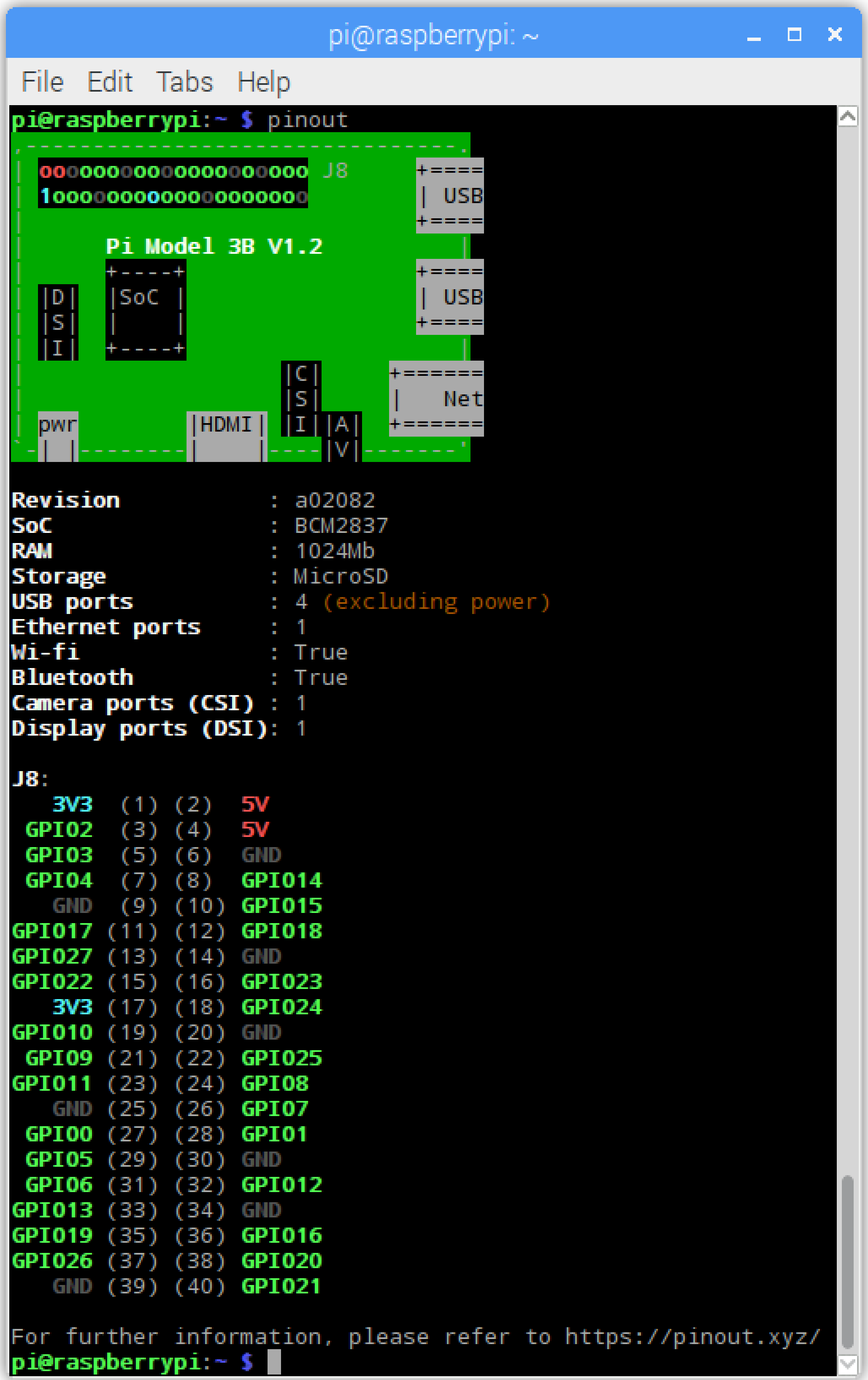
CHAPTER 8

Command-line Tools

The gpiozero package contains a database of information about the various revisions of Raspberry Pi. This is queried by the **pinout** command-line tool to output details of the GPIO pins available.

Note: Note that only the Python 3 version of the Debian package includes the pinout command line tool, so as not to create a conflict if both versions are installed. If you only installed the `python-gpiozero` apt package, the pinout tool will not be available. Instead, you can additionally install the `python3-gpiozero` package, or alternatively install gpiozero using pip.

8.1 pinout


pi@raspberrypi: ~
File Edit Tabs Help
pi@raspberrypi:~ $ pinout
J8
USB
Pi Model 3B V1.2
SoC
USB
DSI
CSI
Net
pwr
HDMI
A V
Revision : a02082
SoC : BCM2837
RAM : 1024Mb
Storage : MicroSD
USB ports : 4 (excluding power)
Ethernet ports : 1
Wi-fi : True
Bluetooth : True
Camera ports (CSI) : 1
Display ports (DSI): 1
J8:
3V3 (1) (2) 5V
GPIO2 (3) (4) 5V
GPIO3 (5) (6) GND
GPIO4 (7) (8) GPIO14
GND (9) (10) GPIO15
GPIO17 (11) (12) GPIO18
GPIO27 (13) (14) GND
GPIO22 (15) (16) GPIO23
3V3 (17) (18) GPIO24
GPIO10 (19) (20) GND
GPIO9 (21) (22) GPIO25
GPIO11 (23) (24) GPIO8
GND (25) (26) GPIO7
GPIO0 (27) (28) GPIO1
GPIO5 (29) (30) GND
GPIO6 (31) (32) GPIO12
GPIO13 (33) (34) GND
GPIO19 (35) (36) GPIO16
GPIO26 (37) (38) GPIO20
GND (39) (40) GPIO21
For further information, please refer to https://pinout.xyz/
pi@raspberrypi:~ $

8.1.1 Synopsis

```
pinout [-h] [-r REVISION] [-c] [-m] [-x]
```

8.1.2 Description

A utility for querying Raspberry Pi GPIO pin-out information. Running **pinout** on its own will output a board diagram, and GPIO header diagram for the current Raspberry Pi. It is also possible to manually specify a revision of Pi, or (by *Configuring Remote GPIO* (page 49)) to output information about a remote Pi.

8.1.3 Options

-h, --help
show this help message and exit

-r REVISION, --revision REVISION
RPi revision. Default is to autodetect revision of current device

-c, --color
Force colored output (by default, the output will include ANSI color codes if run in a color-capable terminal). See also *--monochrome* (page 77)

-m, --monochrome
Force monochrome output. See also *--color* (page 77)

-x, --xyz
Open pinout.xyz[55] in the default web browser

8.1.4 Examples

To output information about the current Raspberry Pi:

```
$ pinout
```

For a Raspberry Pi model 3B, this will output something like the following:

```
,--------------------------------.
| oooooooooooooooooooo J8     +====
| 1ooooooooooooooooooo        | USB
|                             +====
|      Pi Model 3B V1.1          |
|      +----+                 +====
| |D|  |SoC |                 | USB
| |S|  |    |                 +====
| |I|  +----+                    |
|                   |C|     +======
|                   |S|     |   Net
| pwr        |HDMI| |I||A|  +======
`-| |--------|    |----|V|-------'

Revision           : a02082
SoC                : BCM2837
RAM                : 1024Mb
Storage            : MicroSD
```

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55 https://pinout.xyz/

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```
USB ports           : 4 (excluding power)
Ethernet ports      : 1
Wi-fi               : True
Bluetooth           : True
Camera ports (CSI) : 1
Display ports (DSI): 1

J8:
   3V3  (1) (2)  5V
 GPIO2  (3) (4)  5V
 GPIO3  (5) (6)  GND
 GPIO4  (7) (8)  GPIO14
   GND  (9) (10) GPIO15
GPIO17 (11) (12) GPIO18
GPIO27 (13) (14) GND
GPIO22 (15) (16) GPIO23
   3V3 (17) (18) GPIO24
GPIO10 (19) (20) GND
 GPIO9 (21) (22) GPIO25
GPIO11 (23) (24) GPIO8
   GND (25) (26) GPIO7
 GPIO0 (27) (28) GPIO1
 GPIO5 (29) (30) GND
 GPIO6 (31) (32) GPIO12
GPIO13 (33) (34) GND
GPIO19 (35) (36) GPIO16
GPIO26 (37) (38) GPIO20
   GND (39) (40) GPIO21
```

By default, if stdout is a console that supports color, ANSI codes will be used to produce color output. Output can be forced to be *--monochrome* (page 77):

```
$ pinout --monochrome
```

Or forced to be *--color* (page 77), in case you are redirecting to something capable of supporting ANSI codes:

```
$ pinout --color | less -SR
```

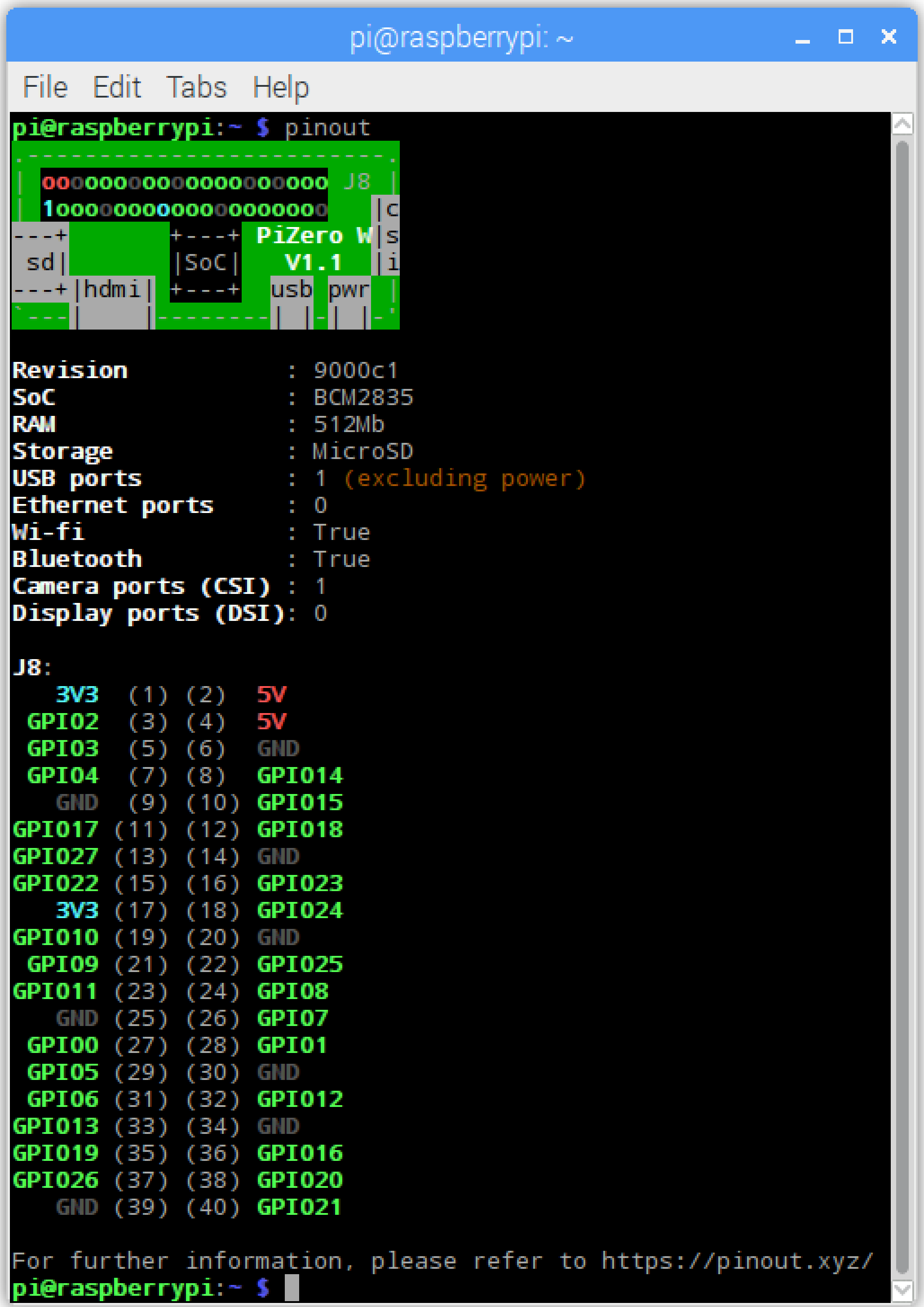
To manually specify the revision of Pi you want to query, use *--revision* (page 77). The tool understands both old-style revision codes[56] (such as for the model B):

```
$ pinout -r 000d
```

Or new-style revision codes[57] (such as for the Pi Zero W):

```
$ pinout -r 9000c1
```

[56] https://www.raspberrypi.org/documentation/hardware/raspberrypi/revision-codes/README.md
[57] https://www.raspberrypi.org/documentation/hardware/raspberrypi/revision-codes/README.md



You can also use the tool with *Configuring Remote GPIO* (page 49) to query remote Raspberry Pi's:

```
$ GPIOZERO_PIN_FACTORY=pigpio PIGPIO_ADDR=other_pi pinout
```

Or run the tool directly on a PC using the mock pin implementation (although in this case you'll almost certainly want to specify the Pi revision manually):

```
$ GPIOZERO_PIN_FACTORY=mock pinout -r a22042
```

8.1.5 Environment Variables

`GPIOZERO_PIN_FACTORY`
: The library to use when communicating with the GPIO pins. Defaults to attempting to load RPi.GPIO, then RPIO, then pigpio, and finally uses a native Python implementation. Valid values include "rpigpio", "rpio", "pigpio", "native", and "mock". The latter is most useful on non-Pi platforms as it emulates a Raspberry Pi model 3B (by default).

`PIGPIO_ADDR`
: The hostname of the Raspberry Pi the pigpio library should attempt to connect to (if the pigpio pin factory is being used). Defaults to `localhost`.

`PIGPIO_PORT`
: The port number the pigpio library should attempt to connect to (if the pigpio pin factory is being used). Defaults to `8888`.

CHAPTER 9

Frequently Asked Questions

9.1 How do I keep my script running?

The following script looks like it should turn an *LED* (page 123) on:

```
from gpiozero import LED

led = LED(17)
led.on()
```

And it does, if you're using the Python or IPython shell, or the IDLE, Thonny or Mu editors. However, if you saved this script as a Python file and ran it, it would flash on briefly, then the script would end and it would turn off.

The following file includes an intentional `pause()`[58] to keep the script alive:

```
from gpiozero import LED
from signal import pause

led = LED(17)
led.on()

pause()
```

Now the script will stay running, leaving the LED on, until it is terminated manually (e.g. by pressing Ctrl+C). Similarly, when setting up callbacks on button presses or other input devices, the script needs to be running for the events to be detected:

```
from gpiozero import Button
from signal import pause

def hello():
    print("Hello")

button = Button(2)
```

(continues on next page)

[58] https://docs.python.org/3.7/library/signal.html#signal.pause

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```
button.when_pressed = hello

pause()
```

9.2 What's the difference between when_pressed, is_pressed and wait_for_press?

gpiozero provides a range of different approaches to reading input devices. Sometimes you want to ask if a button's pressed, sometimes you want to do something until it's pressed, and sometimes you want something to happen *when* it's been pressed, regardless of what else is going on.

In a simple example where the button is the only device in play, all of the options would be equally effective. But as soon as you introduce an extra element, like another GPIO device, you might need to choose the right approach depending on your use case.

- *is_pressed* (page 105) is an attribute which reveals whether the button is currently pressed by returning True or False:

```
while True:
    if btn.is_pressed:
        print("Pressed")
    else:
        print("Not pressed")
```

- *wait_for_press()* (page 104) as a method which blocks the code from continuing until the button is pressed. Also see *wait_for_release()* (page 104):

```
while True:
    print("Released. Waiting for press..")
    btn.wait_for_press()
    print("Pressed. Waiting for release...")
    btn.wait_for_release()
```

- *when_pressed* (page 105) is an attribute which assigns a callback function to the event of the button being pressed. Every time the button is pressed, the callback function is executed in a separate thread. Also see *when_released* (page 105):

```
def pressed():
    print("Pressed")

def released():
    print("Released")

btn.when_pressed = pressed
btn.when_released = released
```

This pattern of options is common among many devices. All *input devices* (page 103) and *internal devices* (page 189) have is_active, when_activated, when_deactivated, wait_for_active and wait_for_inactive, and many provide aliases (such as "pressed" for "activated").

Also see a more advanced approach in the *Source/Values* (page 65) page.

9.3 My event handler isn't being called

When assigning event handlers, don't call the function you're assigning. For example:

```
from gpiozero import Button

def pushed():
    print("Don't push the button!")

b = Button(17)
b.when_pressed = pushed()
```

In the case above, when assigning to *when_pressed* (page 105), the thing that is assigned is the *result of calling* the pushed function. Because pushed doesn't explicitly return anything, the result is None[59]. Hence this is equivalent to doing:

```
b.when_pressed = None
```

This doesn't raise an error because it's perfectly valid: it's what you assign when you don't want the event handler to do anything. Instead, you want to do the following:

```
b.when_pressed = pushed
```

This will assign the function to the event handler *without calling it*. This is the crucial difference between my_function (a reference to a function) and my_function() (the result of calling a function).

Note: Note that as of v1.5, setting a callback to None[60] when it was previously None[61] will raise a *CallbackSetToNone* (page 250) warning, with the intention of alerting users when callbacks are set to None[62] accidentally. However, if this is intentional, the warning can be suppressed. See the warnings[63] module for reference.

9.4 Why do I get PinFactoryFallback warnings when I import gpiozero?

You are most likely working in a virtual Python environment and have forgotten to install a pin driver library like RPi.GPIO. GPIO Zero relies upon lower level pin drivers to handle interfacing to the GPIO pins on the Raspberry Pi, so you can eliminate the warning simply by installing GPIO Zero's first preference:

```
$ pip install rpi.gpio
```

When GPIO Zero is imported it attempts to find a pin driver by importing them in a preferred order (detailed in *API - Pins* (page 225)). If it fails to load its first preference (RPi.GPIO) it notifies you with a warning, then falls back to trying its second preference and so on. Eventually it will fall back all the way to the native implementation. This is a pure Python implementation built into GPIO Zero itself. While this will work for most things it's almost certainly not what you want (it doesn't support PWM, and it's quite slow at certain things).

If you want to use a pin driver other than the default, and you want to suppress the warnings you've got a couple of options:

1. Explicitly specify what pin driver you want via the *GPIOZERO_PIN_FACTORY* (page 80) environment variable. For example:

[59] https://docs.python.org/3.7/library/constants.html#None
[60] https://docs.python.org/3.7/library/constants.html#None
[61] https://docs.python.org/3.7/library/constants.html#None
[62] https://docs.python.org/3.7/library/constants.html#None
[63] https://docs.python.org/3.7/library/warnings.html#module-warnings

```
$ GPIOZERO_PIN_FACTORY=pigpio python3
```

In this case no warning is issued because there's no fallback; either the specified factory loads or it fails in which case an ImportError[64] will be raised.

2. Suppress the warnings and let the fallback mechanism work:

```
>>> import warnings
>>> warnings.simplefilter('ignore')
>>> import gpiozero
```

Refer to the warnings[65] module documentation for more refined ways to filter out specific warning classes.

9.5 How can I tell what version of gpiozero I have installed?

The gpiozero library relies on the setuptools package for installation services. You can use the setuptools `pkg_resources` API to query which version of gpiozero is available in your Python environment like so:

```
>>> from pkg_resources import require
>>> require('gpiozero')
[gpiozero 1.6.0 (/usr/lib/python3/dist-packages)]
>>> require('gpiozero')[0].version
'1.6.0'
```

If you have multiple versions installed (e.g. from **pip** and **apt**) they will not show up in the list returned by the `pkg_resources.require()` method. However, the first entry in the list will be the version that `import gpiozero` will import.

If you receive the error "No module named pkg_resources", you need to install **pip**. This can be done with the following command in Raspberry Pi OS:

```
$ sudo apt install python3-pip
```

Alternatively, install pip with get-pip[66].

9.6 Why do I get "command not found" when running pinout?

The gpiozero library is available as a Debian package for Python 2 and Python 3, but the cli_pinout tool cannot be made available by both packages, so it's only included with the Python 3 version of the package. To make sure the cli_pinout tool is available, the "python3-gpiozero" package must be installed:

```
$ sudo apt install python3-gpiozero
```

Alternatively, installing gpiozero using **pip** will install the command line tool, regardless of Python version:

```
$ sudo pip3 install gpiozero
```

or:

64 https://docs.python.org/3.7/library/exceptions.html#ImportError
65 https://docs.python.org/3.7/library/warnings.html#module-warnings
66 https://pip.pypa.io/en/stable/installing/

```
$ sudo pip install gpiozero
```

9.7 The pinout command line tool incorrectly identifies my Raspberry Pi model

If your Raspberry Pi model is new, it's possible it wasn't known about at the time of the gpiozero release you are using. Ensure you have the latest version installed (remember, the cli_pinout tool usually comes from the Python 3 version of the package as noted in the previous FAQ).

If the Pi model you are using isn't known to gpiozero, it may have been added since the last release. You can check the GitHub issues[67] to see if it's been reported before, or check the commits[68] on GitHub since the last release to see if it's been added. The model determination can be found in `gpiozero/pins/data.py`.

9.8 What's the gpiozero equivalent of GPIO.cleanup()?

Many people ask how to do the equivalent of the `cleanup` function from `RPi.GPIO`. In gpiozero, at the end of your script, cleanup is run automatically, restoring your GPIO pins to the state they were found.

To explicitly close a connection to a pin, you can manually call the *close()* (page 201) method on a device object:

```
>>> led = LED(2)
>>> led.on()
>>> led
<gpiozero.LED object on pin GPIO2, active_high=True, is_active=True>
>>> led.close()
>>> led
<gpiozero.LED object closed>
```

This means that you can reuse the pin for another device, and that despite turning the LED on (and hence, the pin high), after calling *close()* (page 201) it is restored to its previous state (LED off, pin low).

Read more about *Migrating from RPi.GPIO* (page 89).

9.9 How do I use button.when_pressed and button.when_held together?

The *Button* (page 103) class provides a *when_held* (page 105) property which is used to set a callback for when the button is held down for a set amount of time (as determined by the *hold_time* (page 105) property). If you want to set *when_held* (page 105) as well as *when_pressed* (page 105), you'll notice that both callbacks will fire. Sometimes, this is acceptable, but often you'll want to only fire the *when_pressed* (page 105) callback when the button has not been held, only pressed.

The way to achieve this is to *not* set a callback on *when_pressed* (page 105), and instead use *when_released* (page 105) to work out whether it had been held or just pressed:

[67] https://github.com/gpiozero/gpiozero/issues
[68] https://github.com/gpiozero/gpiozero/commits/master

```
from gpiozero import Button

Button.was_held = False

def held(btn):
    btn.was_held = True
    print("button was held not just pressed")

def released(btn):
    if not btn.was_held:
        pressed()
    btn.was_held = False

def pressed():
    print("button was pressed not held")

btn = Button(2)

btn.when_held = held
btn.when_released = released
```

9.10 Why do I get "ImportError: cannot import name" when trying to import from gpiozero?

It's common to see people name their first gpiozero script `gpiozero.py`. Unfortunately, this will cause your script to try to import itself, rather than the gpiozero library from the libraries path. You'll see an error like this:

```
Traceback (most recent call last):
  File "gpiozero.py", line 1, in <module>
    from gpiozero import LED
  File "/home/pi/gpiozero.py", line 1, in <module>
    from gpiozero import LED
ImportError: cannot import name 'LED'
```

Simply rename your script to something else, and run it again. Be sure not to name any of your scripts the same name as a Python module you may be importing, such as `picamera.py`.

9.11 Why do I get an AttributeError trying to set attributes on a device object?

If you try to add an attribute to a gpiozero device object after its initialization, you'll find you can't:

```
>>> from gpiozero import Button
>>> btn = Button(2)
>>> btn.label = 'alarm'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "/usr/lib/python3/dist-packages/gpiozero/devices.py", line 118, in __setattr__
    self.__class__.__name__, name))
AttributeError: 'Button' object has no attribute 'label'
```

This is in order to prevent users accidentally setting new attributes by mistake. Because gpiozero provides functionality through setting attributes via properties, such as callbacks on buttons (and often there is no immediate feedback when setting a property), this could lead to bugs very difficult to find. Consider the following example:

```
from gpiozero import Button

def hello():
    print("hello")

btn = Button(2)

btn.pressed = hello
```

This is perfectly valid Python code, and no errors would occur, but the program would not behave as expected: pressing the button would do nothing, because the property for setting a callback is `when_pressed` not `pressed`. But without gpiozero preventing this non-existent attribute from being set, the user would likely struggle to see the mistake.

If you really want to set a new attribute on a device object, you need to create it in the class before initializing your object:

```
>>> from gpiozero import Button
>>> Button.label = ''
>>> btn = Button(2)
>>> btn.label = 'alarm'
>>> def press(btn):
...:    print(btn.label, "was pressed")
>>> btn.when_pressed = press
```

9.12 Why is it called GPIO Zero? Does it only work on Pi Zero?

gpiozero works on all Raspberry Pi models, not just the Pi Zero.

The "zero" is part of a naming convention for "zero-boilerplate" education friendly libraries, which started with Pygame Zero[69], and has been followed by NetworkZero[70], guizero[71] and more.

These libraries aim to remove barrier to entry and provide a smooth learning curve for beginners by making it easy to get started and easy to build up to more advanced projects.

[69] https://pygame-zero.readthedocs.io/en/stable/
[70] https://networkzero.readthedocs.io/en/latest/
[71] https://lawsie.github.io/guizero/

CHAPTER 10

Migrating from RPi.GPIO

If you are familiar with the RPi.GPIO[72] library, you will be used to writing code which deals with *pins* and the *state of pins*. You will see from the examples in this documentation that we generally refer to things like LEDs and Buttons rather than input pins and output pins.

GPIO Zero provides classes which represent *devices*, so instead of having a pin number and telling it to go high, you have an LED and you tell it to turn on, and instead of having a pin number and asking if it's high or low, you have a button and ask if it's pressed. There is also no boilerplate code to get started — you just import the parts you need.

GPIO Zero provides many device classes, each with specific methods and properties bespoke to that device. For example, the functionality for an HC-SR04 Distance Sensor can be found in the *DistanceSensor* (page 111) class.

As well as specific device classes, we provide base classes *InputDevice* (page 120) and *OutputDevice* (page 142). One main difference between these and the equivalents in RPi.GPIO is that they are classes, not functions, which means that you initialize one to begin, and provide its pin number, but then you never need to use the pin number again, as it's stored by the object.

GPIO Zero was originally just a layer on top of RPi.GPIO, but we later added support for various other underlying pin libraries. RPi.GPIO is currently the default pin library used. Read more about this in *Changing the pin factory* (page 227).

10.1 Output devices

Turning an LED on in RPi.GPIO[73]:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(2, GPIO.OUT)

GPIO.output(2, GPIO.HIGH)
```

[72] https://pypi.org/project/RPi.GPIO/
[73] https://pypi.org/project/RPi.GPIO/

Turning an LED on in GPIO Zero:

```
from gpiozero import LED

led = LED(2)

led.on()
```

The *LED* (page 123) class also supports threaded blinking through the *blink()* (page 124) method.

OutputDevice (page 142) is the base class for output devices, and can be used in a similar way to output devices in RPi.GPIO.

See a full list of supported *output devices* (page 123). Other output devices have similar property and method names. There is commonality in naming at base level, such as `OutputDevice.is_active`, which is aliased in a device class, such as *LED.is_lit* (page 124).

10.2 Input devices

Reading a button press in RPi.GPIO[74]:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(4, GPIO.IN, GPIO.PUD_UP)

if not GPIO.input(4):
    print("button is pressed")
```

Reading a button press in GPIO Zero:

```
from gpiozero import Button

btn = Button(4)

if btn.is_pressed:
    print("button is pressed")
```

Note that in the RPi.GPIO example, the button is set up with the option `GPIO.PUD_UP` which means "pull-up", and therefore when the button is not pressed, the pin is high. When the button is pressed, the pin goes low, so the condition requires negation (`if not`). If the button was configured as pull-down, the logic is reversed and the condition would become `if GPIO.input(4)`:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(4, GPIO.IN, GPIO.PUD_DOWN)

if GPIO.input(4):
    print("button is pressed")
```

In GPIO Zero, the default configuration for a button is pull-up, but this can be configured at initialization, and the rest of the code stays the same:

[74] https://pypi.org/project/RPi.GPIO/

```
from gpiozero import Button

btn = Button(4, pull_up=False)

if btn.is_pressed:
    print("button is pressed")
```

RPi.GPIO also supports blocking edge detection.

Wait for a pull-up button to be pressed in RPi.GPIO:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(4, GPIO.IN, GPIO.PUD_UP)

GPIO.wait_for_edge(4, GPIO.FALLING):
print("button was pressed")
```

The equivalent in GPIO Zero:

```
from gpiozero import Buttons

btn = Button(4)

btn.wait_for_press()
print("button was pressed")
```

Again, if the button is pulled down, the logic is reversed. Instead of waiting for a falling edge, we're waiting for a rising edge:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(4, GPIO.IN, GPIO.PUD_UP)

GPIO.wait_for_edge(4, GPIO.FALLING):
print("button was pressed")
```

Again, in GPIO Zero, the only difference is in the initialization:

```
from gpiozero import Buttons

btn = Button(4, pull_up=False)

btn.wait_for_press()
print("button was pressed")
```

RPi.GPIO has threaded callbacks. You create a function (which must take one argument), and pass it in to `add_event_detect`, along with the pin number and the edge direction:

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
```

(continues on next page)

(continued from previous page)

```
GPIO.setwarnings(False)

def pressed(pin):
    print("button was pressed")

def released(pin):
    print("button was released")

GPIO.setup(4, GPIO.IN, GPIO.PUD_UP)

GPIO.add_event_detect(4, GPIO.FALLING, pressed)
GPIO.add_event_detect(4, GPIO.RISING, released)
```

In GPIO Zero, you assign the *when_pressed* (page 105) and *when_released* (page 105) properties to set up callbacks on those actions:

```
from gpiozero import Buttons

def pressed():
    print("button was pressed")

def released():
    print("button was released")

btn = Button(4)

btn.when_pressed = pressed
btn.when_released = released
```

when_held (page 105) is also provided, where the length of time considered a "hold" is configurable.

The callback functions don't have to take any arguments, but if they take one, the button object is passed in, allowing you to determine which button called the function.

InputDevice (page 120) is the base class for input devices, and can be used in a similar way to input devices in RPi.GPIO.

See a full list of *input devices* (page 103). Other input devices have similar property and method names. There is commonality in naming at base level, such as *InputDevice.is_active* (page 121), which is aliased in a device class, such as *Button.is_pressed* (page 105) and *LightSensor.light_detected* (page 111).

10.3 Composite devices, boards and accessories

Some devices require connections to multiple pins, for example a distance sensor, a combination of LEDs or a HAT. Some GPIO Zero devices comprise multiple device connections within one object, such as *RGBLED* (page 127), *LEDBoard* (page 155), *DistanceSensor* (page 111), *Motor* (page 132) and *Robot* (page 175).

With RPi.GPIO, you would have one output pin for the trigger, and one input pin for the echo. You would time the echo and calculate the distance. With GPIO Zero, you create a single *DistanceSensor* (page 111) object, specifying the trigger and echo pins, and you would read the *DistanceSensor.distance* (page 113) property which automatically calculates the distance within the implementation of the class.

The *Motor* (page 132) class controls two output pins to drive the motor forwards or backwards. The *Robot* (page 175) class controls four output pins (two motors) in the right combination to drive a robot forwards or backwards, and turn left and right.

The *LEDBoard* (page 155) class takes an arbitrary number of pins, each controlling a single LED. The resulting *LEDBoard* (page 155) object can be used to control all LEDs together (all on / all off), or individually by index. Also the object can be iterated over to turn LEDs on in order. See examples of this (including slicing) in the *advanced recipes* (page 39).

10.4 PWM (Pulse-width modulation)

Both libraries support software PWM control on any pin. Depending on the pin library used, GPIO Zero can also support hardware PWM (using `RPIOPin` or `PiGPIOPin`).

A simple example of using PWM is to control the brightness of an LED.

In RPi.GPIO[75]:

```
import RPi.GPIO as GPIO
from time import sleep

GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

GPIO.setup(2, GPIO.OUT)
pwm = GPIO.PWM(2, 100)
pwm.start(0)

for dc in range(101):
    pwm.changeDutyCycle(dc)
    sleep(0.01)
```

In GPIO Zero:

```
from gpiozero import PWMLED
from time import sleep

led = PWMLED(2)

for b in range(101):
    led.value = b / 100.0
    sleep(0.01)
```

PWMLED (page 125) has a *blink()* (page 125) method which can be used the same was as *LED* (page 123)'s *blink()* (page 124) method, but its PWM capabilities allow for `fade_in` and `fade_out` options to be provided. There is also the *pulse()* (page 126) method which provides a neat way to have an LED fade in and out repeatedly.

Other devices can make use of PWM, such as motors (for variable speed) and servos. See the *Motor* (page 132), *Servo* (page 135) and *AngularServo* (page 137) classes for information on those. *Motor* (page 132) and *Robot* (page 175) default to using PWM, but it can be disabled with `pwm=False` at initialization. Servos cannot be used without PWM. Devices containing LEDs default to not using PWM, but `pwm=True` can be specified and any LED objects within the device will be initialized as *PWMLED* (page 125) objects.

10.5 Cleanup

Pin state cleanup is explicit in RPi.GPIO, and is done manually with `GPIO.cleanup()` but in GPIO Zero, cleanup is automatically performed on every pin used, at the end of the script. Manual cleanup is

[75] https://pypi.org/project/RPi.GPIO/

possible by use of the *close()* (page 201) method on the device.

Note that cleanup only occurs at the point of normal termination of the script. If the script exits due to a program error, cleanup will not be performed. To ensure that cleanup is performed after an exception is raised, the exception must be handled, for example:

```
from gpiozero import Button

btn = Button(4)

while True:
    try:
        if btn.is_pressed:
            print("Pressed")
    except KeyboardInterrupt:
        print("Ending program")
```

Read more in the relevant FAQ: *What's the gpiozero equivalent of GPIO.cleanup()?* (page 85)

10.6 Pi Information

RPi.GPIO provides information about the Pi you're using. The equivalent in GPIO Zero is the function *pi_info()* (page 219):

```
>>> from gpiozero import pi_info
>>> pi = pi_info()
>>> pi
PiBoardInfo(revision='a02082', model='3B', pcb_revision='1.2', released='2016Q1', soc=
↪'BCM2837', manufacturer='Sony', memory=1024, storage='MicroSD', usb=4, ethernet=1,
↪wifi=True, bluetooth=True, csi=1, dsi=1, headers=..., board=...)
>>> pi.soc
'BCM2837'
>>> pi.wifi
True
```

Read more about what *PiBoardInfo* (page 219) provides.

10.7 More

GPIO Zero provides more than just GPIO device support, it includes some support for *SPI devices* (page 145) including a range of analog to digital converters.

Device classes which are compatible with other GPIO devices, but have no relation to GPIO pins, such as *CPUTemperature* (page 192), *TimeOfDay* (page 190), *PingServer* (page 191) and *LoadAverage* (page 194) are also provided.

GPIO Zero features support for multiple pin libraries. The default is to use `RPi.GPIO` to control the pins, but you can choose to use another library, such as `pigpio`, which supports network controlled GPIO. See *Changing the pin factory* (page 227) and *Configuring Remote GPIO* (page 49) for more information.

It is possible to run GPIO Zero on your PC, both for remote GPIO and for testing purposes, using *Mock pins* (page 229).

Another feature of this library is configuring devices to be connected together in a logical way, for example in one line you can say that an LED and button are "paired", i.e. the button being pressed turns the LED on. Read about this in *Source/Values* (page 65).

10.8 FAQs

Note the following FAQs which may catch out users too familiar with RPi.GPIO:

- *How do I keep my script running?* (page 81)
- *Why do I get PinFactoryFallback warnings when I import gpiozero?* (page 83)
- *What's the gpiozero equivalent of GPIO.cleanup()?* (page 85)

CHAPTER 11

Contributing

Contributions to the library are welcome! Here are some guidelines to follow.

11.1 Suggestions

Please make suggestions for additional components or enhancements to the codebase by opening an issue[76] explaining your reasoning clearly.

11.2 Bugs

Please submit bug reports by opening an issue[77] explaining the problem clearly using code examples.

11.3 Documentation

The documentation source lives in the docs[78] folder. Contributions to the documentation are welcome but should be easy to read and understand.

11.4 Commit messages and pull requests

Commit messages should be concise but descriptive, and in the form of a patch description, i.e. instructional not past tense ("Add LED example" not "Added LED example").

Commits which close (or intend to close) an issue should include the phrase "fix #123" or "close #123" where `#123` is the issue number, as well as include a short description, for example: "Add LED example, close #123", and pull requests should aim to match or closely match the corresponding issue title.

Copyrights on submissions are owned by their authors (we don't bother with copyright assignments), and we assume that authors are happy for their code to be released under the project's *license* (page 259).

[76] https://github.com/gpiozero/gpiozero/issues/new
[77] https://github.com/gpiozero/gpiozero/issues/new
[78] https://github.com/gpiozero/gpiozero/tree/master/docs

Do feel free to add your name to the list of contributors in `README.rst` at the top level of the project in your pull request! Don't worry about adding your name to the copyright headers in whatever files you touch; these are updated automatically from the git metadata before each release.

11.5 Backwards compatibility

Since this library reached v1.0 we aim to maintain backwards-compatibility thereafter. Changes which break backwards-compatibility will not be accepted.

11.6 Python 2/3

The library is 100% compatible with both Python 2.7 and Python 3 from version 3.2 onwards. Since Python 2 is now past its end-of-life[79], the 1.6.0 release (2021-03-14) is the last to support Python 2.

[79] http://legacy.python.org/dev/peps/pep-0373/

CHAPTER 12

Development

The main GitHub repository for the project can be found at:

https://github.com/gpiozero/gpiozero

For anybody wishing to hack on the project, we recommend starting off by getting to grips with some simple device classes. Pick something like *LED* (page 123) and follow its heritage backward to *DigitalOutputDevice* (page 139). Follow that back to *OutputDevice* (page 142) and you should have a good understanding of simple output devices along with a grasp of how GPIO Zero relies fairly heavily upon inheritance to refine the functionality of devices. The same can be done for input devices, and eventually more complex devices (composites and SPI based).

12.1 Development installation

If you wish to develop GPIO Zero itself, we recommend obtaining the source by cloning the GitHub repository and then use the "develop" target of the Makefile which will install the package as a link to the cloned repository allowing in-place development (it also builds a tags file for use with vim/emacs with Exuberant's ctags utility). The following example demonstrates this method within a virtual Python environment:

```
$ sudo apt install lsb-release build-essential git exuberant-ctags \
    virtualenvwrapper python-virtualenv python3-virtualenv \
    python-dev python3-dev
```

After installing `virtualenvwrapper` you'll need to restart your shell before commands like **`mkvirtualenv`** will operate correctly. Once you've restarted your shell, continue:

```
$ cd
$ mkvirtualenv -p /usr/bin/python3 gpiozero
$ workon gpiozero
(gpiozero) $ git clone https://github.com/gpiozero/gpiozero.git
(gpiozero) $ cd gpiozero
(gpiozero) $ make develop
```

You will likely wish to install one or more pin implementations within the virtual environment (if you don't, GPIO Zero will use the "native" pin implementation which is usable at this stage, but doesn't support facilities like PWM):

```
(gpiozero) $ pip install rpi.gpio pigpio
```

If you are working on SPI devices you may also wish to install the `spidev` package to provide hardware SPI capabilities (again, GPIO Zero will work without this, but a big-banging software SPI implementation will be used instead which limits bandwidth):

```
(gpiozero) $ pip install spidev
```

To pull the latest changes from git into your clone and update your installation:

```
$ workon gpiozero
(gpiozero) $ cd ~/gpiozero
(gpiozero) $ git pull
(gpiozero) $ make develop
```

To remove your installation, destroy the sandbox and the clone:

```
(gpiozero) $ deactivate
$ rmvirtualenv gpiozero
$ rm -rf ~/gpiozero
```

12.2 Building the docs

If you wish to build the docs, you'll need a few more dependencies. Inkscape is used for conversion of SVGs to other formats, Graphviz is used for rendering certain charts, and TeX Live is required for building PDF output. The following command should install all required dependencies:

```
$ sudo apt install texlive-latex-recommended texlive-latex-extra \
    texlive-fonts-recommended texlive-xetex graphviz inkscape \
    python3-sphinx python3-sphinx-rtd-theme latexmk xindy
```

Once these are installed, you can use the "doc" target to build the documentation:

```
$ workon gpiozero
(gpiozero) $ cd ~/gpiozero
(gpiozero) $ make doc
```

The HTML output is written to `build/html` while the PDF output goes to `build/latex`.

12.3 Test suite

If you wish to run the GPIO Zero test suite, follow the instructions in *Development installation* (page 99) above and then make the "test" target within the sandbox. You'll also need to install some pip packages:

```
$ workon gpiozero
(gpiozero) $ pip install coverage mock pytest
(gpiozero) $ cd ~/gpiozero
(gpiozero) $ make test
```

The test suite expects pins 22 and 27 (by default) to be wired together in order to run the "real" pin tests. The pins used by the test suite can be overridden with the environment variables `GPIOZERO_TEST_PIN` (defaults to 22) and `GPIOZERO_TEST_INPUT_PIN` (defaults to 27).

> **Warning:** When wiring GPIOs together, ensure a load (like a 1KΩ resistor) is placed between them. Failure to do so may lead to blown GPIO pins (your humble author has a fried GPIO27 as a result of such laziness, although it did take *many* runs of the test suite before this occurred!).

The test suite is also setup for usage with the **tox** utility, in which case it will attempt to execute the test suite with all supported versions of Python. If you are developing under Ubuntu you may wish to look into the Dead Snakes PPA[80] in order to install old/new versions of Python; the tox setup *should* work with the version of tox shipped with Ubuntu Xenial, but more features (like parallel test execution) are available with later versions.

On the subject of parallel test execution, this is also supported in the tox setup, including the "real" pin tests (a file-system level lock is used to ensure different interpreters don't try to access the physical pins simultaneously).

For example, to execute the test suite under tox, skipping interpreter versions which are not installed:

```
$ tox -s
```

To execute the test suite under all installed interpreter versions in parallel, using as many parallel tasks as there are CPUs, then displaying a combined report of coverage from all environments:

```
$ tox -p auto -s
$ coverage combine --rcfile coverage.cfg
$ coverage report --rcfile coverage.cfg
```

12.4 Mock pins

The test suite largely depends on the existence of the mock pin factory `MockFactory` (page 242), which is also useful for manual testing, for example in the Python shell or another REPL. See the section on *Mock pins* (page 229) in the *API - Pins* (page 225) chapter for more information.

[80] https://launchpad.net/~deadsnakes/%2Barchive/ubuntu/ppa

CHAPTER 13

API - Input Devices

These input device component interfaces have been provided for simple use of everyday components. Components must be wired up correctly before use in code.

Note: All GPIO pin numbers use Broadcom (BCM) numbering by default. See the *Pin Numbering* (page 3) section for more information.

13.1 Regular Classes

The following classes are intended for general use with the devices they represent. All classes in this section are concrete (not abstract).

13.1.1 Button

class gpiozero.Button(*pin*, **, *pull_up=True*, *active_state=None*, *bounce_time=None*, *hold_time=1*, *hold_repeat=False*, *pin_factory=None*)

Extends `DigitalInputDevice` (page 117) and represents a simple push button or switch.

Connect one side of the button to a ground pin, and the other to any GPIO pin. Alternatively, connect one side of the button to the 3V3 pin, and the other to any GPIO pin, then set *pull_up* to `False`[81] in the `Button` (page 103) constructor.

The following example will print a line of text when the button is pushed:

```
from gpiozero import Button

button = Button(4)
button.wait_for_press()
print("The button was pressed!")
```

Parameters

[81] https://docs.python.org/3.7/library/constants.html#False

- **pin** (*int*[82] *or str*[83]) – The GPIO pin which the button is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[84] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[85] *or None*[86]) – If True[87] (the default), the GPIO pin will be pulled high by default. In this case, connect the other side of the button to ground. If False[88], the GPIO pin will be pulled low by default. In this case, connect the other side of the button to 3V3. If None[89], the pin will be floating, so it must be externally pulled up or down and the `active_state` parameter must be set accordingly.
- **active_state** (*bool*[90] *or None*[91]) – See description under *InputDevice* (page 120) for more information.
- **bounce_time** (*float*[92] *or None*[93]) – If None[94] (the default), no software bounce compensation will be performed. Otherwise, this is the length of time (in seconds) that the component will ignore changes in state after an initial change.
- **hold_time** (*float*[95]) – The length of time (in seconds) to wait after the button is pushed, until executing the *when_held* (page 105) handler. Defaults to `1`.
- **hold_repeat** (*bool*[96]) – If True[97], the *when_held* (page 105) handler will be repeatedly executed as long as the device remains active, every *hold_time* seconds. If False[98] (the default) the *when_held* (page 105) handler will be only be executed once per hold.
- **pin_factory** (Factory (page 230) *or None*[99]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_press(*timeout=None*)

Pause the script until the device is activated, or the timeout is reached.

Parameters **timeout** (*float*[100] *or None*[101]) – Number of seconds to wait before proceeding. If this is None[102] (the default), then wait indefinitely until the device is active.

wait_for_release(*timeout=None*)

Pause the script until the device is deactivated, or the timeout is reached.

Parameters **timeout** (*float*[103] *or None*[104]) – Number of seconds to wait before proceeding. If this is None[105] (the default), then wait indefinitely until the device is inactive.

82 https://docs.python.org/3.7/library/functions.html#int
83 https://docs.python.org/3.7/library/stdtypes.html#str
84 https://docs.python.org/3.7/library/constants.html#None
85 https://docs.python.org/3.7/library/functions.html#bool
86 https://docs.python.org/3.7/library/constants.html#None
87 https://docs.python.org/3.7/library/constants.html#True
88 https://docs.python.org/3.7/library/constants.html#False
89 https://docs.python.org/3.7/library/constants.html#None
90 https://docs.python.org/3.7/library/functions.html#bool
91 https://docs.python.org/3.7/library/constants.html#None
92 https://docs.python.org/3.7/library/functions.html#float
93 https://docs.python.org/3.7/library/constants.html#None
94 https://docs.python.org/3.7/library/constants.html#None
95 https://docs.python.org/3.7/library/functions.html#float
96 https://docs.python.org/3.7/library/functions.html#bool
97 https://docs.python.org/3.7/library/constants.html#True
98 https://docs.python.org/3.7/library/constants.html#False
99 https://docs.python.org/3.7/library/constants.html#None
100 https://docs.python.org/3.7/library/functions.html#float
101 https://docs.python.org/3.7/library/constants.html#None
102 https://docs.python.org/3.7/library/constants.html#None
103 https://docs.python.org/3.7/library/functions.html#float
104 https://docs.python.org/3.7/library/constants.html#None
105 https://docs.python.org/3.7/library/constants.html#None

held_time
The length of time (in seconds) that the device has been held for. This is counted from the first execution of the *when_held* (page 105) event rather than when the device activated, in contrast to *active_time* (page 203). If the device is not currently held, this is None[106].

hold_repeat
If True[107], *when_held* (page 105) will be executed repeatedly with *hold_time* (page 105) seconds between each invocation.

hold_time
The length of time (in seconds) to wait after the device is activated, until executing the *when_held* (page 105) handler. If *hold_repeat* (page 105) is True, this is also the length of time between invocations of *when_held* (page 105).

is_held
When True[108], the device has been active for at least *hold_time* (page 105) seconds.

is_pressed
Returns True[109] if the device is currently active and False[110] otherwise. This property is usually derived from *value* (page 105). Unlike *value* (page 105), this is *always* a boolean.

pin
The *Pin* (page 231) that the device is connected to. This will be None[111] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

pull_up
If True[112], the device uses a pull-up resistor to set the GPIO pin "high" by default.

value
Returns 1 if the button is currently pressed, and 0 if it is not.

when_held
The function to run when the device has remained active for *hold_time* (page 105) seconds.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated will be passed as that parameter.

Set this property to None[113] (the default) to disable the event.

when_pressed
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None[114] (the default) to disable the event.

when_released
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like).

[106] https://docs.python.org/3.7/library/constants.html#None
[107] https://docs.python.org/3.7/library/constants.html#True
[108] https://docs.python.org/3.7/library/constants.html#True
[109] https://docs.python.org/3.7/library/constants.html#True
[110] https://docs.python.org/3.7/library/constants.html#False
[111] https://docs.python.org/3.7/library/constants.html#None
[112] https://docs.python.org/3.7/library/constants.html#True
[113] https://docs.python.org/3.7/library/constants.html#None
[114] https://docs.python.org/3.7/library/constants.html#None

If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to None[115] (the default) to disable the event.

13.1.2 LineSensor (TRCT5000)

class gpiozero.**LineSensor**(*pin*, ***, *queue_len=5*, *sample_rate=100*, *threshold=0.5*, *partial=False*, *pin_factory=None*)

Extends *SmoothedInputDevice* (page 119) and represents a single pin line sensor like the TCRT5000 infra-red proximity sensor found in the CamJam #3 EduKit[116].

A typical line sensor has a small circuit board with three pins: VCC, GND, and OUT. VCC should be connected to a 3V3 pin, GND to one of the ground pins, and finally OUT to the GPIO specified as the value of the *pin* parameter in the constructor.

The following code will print a line of text indicating when the sensor detects a line, or stops detecting a line:

```
from gpiozero import LineSensor
from signal import pause

sensor = LineSensor(4)
sensor.when_line = lambda: print('Line detected')
sensor.when_no_line = lambda: print('No line detected')
pause()
```

Parameters

- **pin** (*int*[117] *or str*[118]) – The GPIO pin which the sensor is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[119] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[120] *or None*[121]) – See description under *InputDevice* (page 120) for more information.
- **active_state** (*bool*[122] *or None*[123]) – See description under *InputDevice* (page 120) for more information.
- **queue_len** (*int*[124]) – The length of the queue used to store values read from the sensor. This defaults to 5.
- **sample_rate** (*float*[125]) – The number of values to read from the device (and append to the internal queue) per second. Defaults to 100.
- **threshold** (*float*[126]) – Defaults to 0.5. When the average of all values in the internal queue rises above this value, the sensor will be considered "active" by the *is_active* (page 120) property, and all appropriate events will be fired.

[115] https://docs.python.org/3.7/library/constants.html#None
[116] http://camjam.me/?page_id=1035
[117] https://docs.python.org/3.7/library/functions.html#int
[118] https://docs.python.org/3.7/library/stdtypes.html#str
[119] https://docs.python.org/3.7/library/constants.html#None
[120] https://docs.python.org/3.7/library/functions.html#bool
[121] https://docs.python.org/3.7/library/constants.html#None
[122] https://docs.python.org/3.7/library/functions.html#bool
[123] https://docs.python.org/3.7/library/constants.html#None
[124] https://docs.python.org/3.7/library/functions.html#int
[125] https://docs.python.org/3.7/library/functions.html#float
[126] https://docs.python.org/3.7/library/functions.html#float

- **partial** (*bool*[127]) – When False[128] (the default), the object will not return a value for *is_active* (page 120) until the internal queue has filled with values. Only set this to True[129] if you require values immediately after object construction.
- **pin_factory** (Factory (page 230) *or None*[130]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_line(*timeout=None*)
Pause the script until the device is deactivated, or the timeout is reached.

Parameters timeout (*float*[131] *or None*[132]) – Number of seconds to wait before proceeding. If this is None[133] (the default), then wait indefinitely until the device is inactive.

wait_for_no_line(*timeout=None*)
Pause the script until the device is activated, or the timeout is reached.

Parameters timeout (*float*[134] *or None*[135]) – Number of seconds to wait before proceeding. If this is None[136] (the default), then wait indefinitely until the device is active.

pin
The *Pin* (page 231) that the device is connected to. This will be None[137] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query pin.number to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
Returns a value representing the average of the queued values. This is nearer 0 for black under the sensor, and nearer 1 for white under the sensor.

when_line
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to None[138] (the default) to disable the event.

when_no_line
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None[139] (the default) to disable the event.

[127] https://docs.python.org/3.7/library/functions.html#bool
[128] https://docs.python.org/3.7/library/constants.html#False
[129] https://docs.python.org/3.7/library/constants.html#True
[130] https://docs.python.org/3.7/library/constants.html#None
[131] https://docs.python.org/3.7/library/functions.html#float
[132] https://docs.python.org/3.7/library/constants.html#None
[133] https://docs.python.org/3.7/library/constants.html#None
[134] https://docs.python.org/3.7/library/functions.html#float
[135] https://docs.python.org/3.7/library/constants.html#None
[136] https://docs.python.org/3.7/library/constants.html#None
[137] https://docs.python.org/3.7/library/constants.html#None
[138] https://docs.python.org/3.7/library/constants.html#None
[139] https://docs.python.org/3.7/library/constants.html#None

13.1.3 MotionSensor (D-SUN PIR)

class gpiozero.MotionSensor(*pin*, ***, *queue_len=1*, *sample_rate=10*, *threshold=0.5*, *partial=False*, *pin_factory=None*)

Extends *SmoothedInputDevice* (page 119) and represents a passive infra-red (PIR) motion sensor like the sort found in the CamJam #2 EduKit[140].

A typical PIR device has a small circuit board with three pins: VCC, OUT, and GND. VCC should be connected to a 5V pin, GND to one of the ground pins, and finally OUT to the GPIO specified as the value of the *pin* parameter in the constructor.

The following code will print a line of text when motion is detected:

```
from gpiozero import MotionSensor

pir = MotionSensor(4)
pir.wait_for_motion()
print("Motion detected!")
```

Parameters

- **pin** (*int*[141] *or str*[142]) – The GPIO pin which the sensor is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[143] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[144] *or None*[145]) – See description under *InputDevice* (page 120) for more information.
- **active_state** (*bool*[146] *or None*[147]) – See description under *InputDevice* (page 120) for more information.
- **queue_len** (*int*[148]) – The length of the queue used to store values read from the sensor. This defaults to 1 which effectively disables the queue. If your motion sensor is particularly "twitchy" you may wish to increase this value.
- **sample_rate** (*float*[149]) – The number of values to read from the device (and append to the internal queue) per second. Defaults to 10.
- **threshold** (*float*[150]) – Defaults to 0.5. When the average of all values in the internal queue rises above this value, the sensor will be considered "active" by the *is_active* (page 120) property, and all appropriate events will be fired.
- **partial** (*bool*[151]) – When False[152] (the default), the object will not return a value for *is_active* (page 120) until the internal queue has filled with values. Only set this to True[153] if you require values immediately after object construction.
- **pin_factory** (Factory (page 230) *or None*[154]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

[140] http://camjam.me/?page_id=623
[141] https://docs.python.org/3.7/library/functions.html#int
[142] https://docs.python.org/3.7/library/stdtypes.html#str
[143] https://docs.python.org/3.7/library/constants.html#None
[144] https://docs.python.org/3.7/library/functions.html#bool
[145] https://docs.python.org/3.7/library/constants.html#None
[146] https://docs.python.org/3.7/library/functions.html#bool
[147] https://docs.python.org/3.7/library/constants.html#None
[148] https://docs.python.org/3.7/library/functions.html#int
[149] https://docs.python.org/3.7/library/functions.html#float
[150] https://docs.python.org/3.7/library/functions.html#float
[151] https://docs.python.org/3.7/library/functions.html#bool
[152] https://docs.python.org/3.7/library/constants.html#False
[153] https://docs.python.org/3.7/library/constants.html#True
[154] https://docs.python.org/3.7/library/constants.html#None

wait_for_motion(*timeout=None*)
Pause the script until the device is activated, or the timeout is reached.

Parameters timeout (*float*[155] *or None*[156]) – Number of seconds to wait before proceeding. If this is None[157] (the default), then wait indefinitely until the device is active.

wait_for_no_motion(*timeout=None*)
Pause the script until the device is deactivated, or the timeout is reached.

Parameters timeout (*float*[158] *or None*[159]) – Number of seconds to wait before proceeding. If this is None[160] (the default), then wait indefinitely until the device is inactive.

motion_detected
Returns True[161] if the *value* (page 120) currently exceeds *threshold* (page 120) and False[162] otherwise.

pin
The *Pin* (page 231) that the device is connected to. This will be None[163] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query pin.number to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
With the default *queue_len* of 1, this is effectively boolean where 0 means no motion detected and 1 means motion detected. If you specify a *queue_len* greater than 1, this will be an averaged value where values closer to 1 imply motion detection.

when_motion
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None[164] (the default) to disable the event.

when_no_motion
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to None[165] (the default) to disable the event.

13.1.4 LightSensor (LDR)

class gpiozero.LightSensor(*pin*, ***, *queue_len=5*, *charge_time_limit=0.01*, *threshold=0.1*, *partial=False*, *pin_factory=None*)
Extends *SmoothedInputDevice* (page 119) and represents a light dependent resistor (LDR).

[155] https://docs.python.org/3.7/library/functions.html#float
[156] https://docs.python.org/3.7/library/constants.html#None
[157] https://docs.python.org/3.7/library/constants.html#None
[158] https://docs.python.org/3.7/library/functions.html#float
[159] https://docs.python.org/3.7/library/constants.html#None
[160] https://docs.python.org/3.7/library/constants.html#None
[161] https://docs.python.org/3.7/library/constants.html#True
[162] https://docs.python.org/3.7/library/constants.html#False
[163] https://docs.python.org/3.7/library/constants.html#None
[164] https://docs.python.org/3.7/library/constants.html#None
[165] https://docs.python.org/3.7/library/constants.html#None

Connect one leg of the LDR to the 3V3 pin; connect one leg of a 1µF capacitor to a ground pin; connect the other leg of the LDR and the other leg of the capacitor to the same GPIO pin. This class repeatedly discharges the capacitor, then times the duration it takes to charge (which will vary according to the light falling on the LDR).

The following code will print a line of text when light is detected:

```
from gpiozero import LightSensor

ldr = LightSensor(18)
ldr.wait_for_light()
print("Light detected!")
```

Parameters

- **pin** (*int*[166] *or str*[167]) – The GPIO pin which the sensor is attached to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[168] a *GPIODeviceError* (page 247) will be raised.
- **queue_len** (*int*[169]) – The length of the queue used to store values read from the circuit. This defaults to 5.
- **charge_time_limit** (*float*[170]) – If the capacitor in the circuit takes longer than this length of time to charge, it is assumed to be dark. The default (0.01 seconds) is appropriate for a 1µF capacitor coupled with the LDR from the CamJam #2 EduKit[171]. You may need to adjust this value for different valued capacitors or LDRs.
- **threshold** (*float*[172]) – Defaults to 0.1. When the average of all values in the internal queue rises above this value, the area will be considered "light", and all appropriate events will be fired.
- **partial** (*bool*[173]) – When `False`[174] (the default), the object will not return a value for *is_active* (page 120) until the internal queue has filled with values. Only set this to `True`[175] if you require values immediately after object construction.
- **pin_factory** (`Factory` (page 230) *or None*[176]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_dark(*timeout=None*)

Pause the script until the device is deactivated, or the timeout is reached.

Parameters **timeout** (*float*[177] *or None*[178]) – Number of seconds to wait before proceeding. If this is `None`[179] (the default), then wait indefinitely until the device is inactive.

wait_for_light(*timeout=None*)

Pause the script until the device is activated, or the timeout is reached.

[166] https://docs.python.org/3.7/library/functions.html#int
[167] https://docs.python.org/3.7/library/stdtypes.html#str
[168] https://docs.python.org/3.7/library/constants.html#None
[169] https://docs.python.org/3.7/library/functions.html#int
[170] https://docs.python.org/3.7/library/functions.html#float
[171] http://camjam.me/?page_id=623
[172] https://docs.python.org/3.7/library/functions.html#float
[173] https://docs.python.org/3.7/library/functions.html#bool
[174] https://docs.python.org/3.7/library/constants.html#False
[175] https://docs.python.org/3.7/library/constants.html#True
[176] https://docs.python.org/3.7/library/constants.html#None
[177] https://docs.python.org/3.7/library/functions.html#float
[178] https://docs.python.org/3.7/library/constants.html#None
[179] https://docs.python.org/3.7/library/constants.html#None

Parameters **timeout** (*float*[180] *or None*[181]) – Number of seconds to wait before proceeding. If this is `None`[182] (the default), then wait indefinitely until the device is active.

light_detected
Returns `True`[183] if the *value* (page 120) currently exceeds *threshold* (page 120) and `False`[184] otherwise.

pin
The *Pin* (page 231) that the device is connected to. This will be `None`[185] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
Returns a value between 0 (dark) and 1 (light).

when_dark
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to `None`[186] (the default) to disable the event.

when_light
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to `None`[187] (the default) to disable the event.

13.1.5 DistanceSensor (HC-SR04)

class gpiozero.DistanceSensor(*echo*, *trigger*, *, *queue_len=30*, *max_distance=1*, *threshold_distance=0.3*, *partial=False*, *pin_factory=None*)
Extends *SmoothedInputDevice* (page 119) and represents an HC-SR04 ultrasonic distance sensor, as found in the CamJam #3 EduKit[188].

The distance sensor requires two GPIO pins: one for the *trigger* (marked TRIG on the sensor) and another for the *echo* (marked ECHO on the sensor). However, a voltage divider is required to ensure the 5V from the ECHO pin doesn't damage the Pi. Wire your sensor according to the following instructions:

1. Connect the GND pin of the sensor to a ground pin on the Pi.
2. Connect the TRIG pin of the sensor a GPIO pin.
3. Connect one end of a 330Ω resistor to the ECHO pin of the sensor.
4. Connect one end of a 470Ω resistor to the GND pin of the sensor.

[180] https://docs.python.org/3.7/library/functions.html#float
[181] https://docs.python.org/3.7/library/constants.html#None
[182] https://docs.python.org/3.7/library/constants.html#None
[183] https://docs.python.org/3.7/library/constants.html#True
[184] https://docs.python.org/3.7/library/constants.html#False
[185] https://docs.python.org/3.7/library/constants.html#None
[186] https://docs.python.org/3.7/library/constants.html#None
[187] https://docs.python.org/3.7/library/constants.html#None
[188] http://camjam.me/?page_id=1035

5. Connect the free ends of both resistors to another GPIO pin. This forms the required voltage divider[189].
6. Finally, connect the VCC pin of the sensor to a 5V pin on the Pi.

Alternatively, the 3V3 tolerant HC-SR04P sensor (which does not require a voltage divider) will work with this class.

Note: If you do not have the precise values of resistor specified above, don't worry! What matters is the *ratio* of the resistors to each other.

You also don't need to be absolutely precise; the voltage divider[190] given above will actually output ~3V (rather than 3.3V). A simple 2:3 ratio will give 3.333V which implies you can take three resistors of equal value, use one of them instead of the 330Ω resistor, and two of them in series instead of the 470Ω resistor.

The following code will periodically report the distance measured by the sensor in cm assuming the TRIG pin is connected to GPIO17, and the ECHO pin to GPIO18:

```
from gpiozero import DistanceSensor
from time import sleep

sensor = DistanceSensor(echo=18, trigger=17)
while True:
    print('Distance: ', sensor.distance * 100)
    sleep(1)
```

Note: For improved accuracy, use the pigpio pin driver rather than the default RPi.GPIO driver (pigpio uses DMA sampling for much more precise edge timing). This is particularly relevant if you're using Pi 1 or Pi Zero. See *Changing the pin factory* (page 227) for further information.

Parameters

- **echo** (*int*[191] *or str*[192]) – The GPIO pin which the ECHO pin is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[193] a *GPIODeviceError* (page 247) will be raised.
- **trigger** (*int*[194] *or str*[195]) – The GPIO pin which the TRIG pin is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[196] a *GPIODeviceError* (page 247) will be raised.
- **queue_len** (*int*[197]) – The length of the queue used to store values read from the sensor. This defaults to 9.
- **max_distance** (*float*[198]) – The *value* (page 113) attribute reports a normalized value between 0 (too close to measure) and 1 (maximum distance). This parameter specifies the maximum distance expected in meters. This defaults to 1.

189 https://en.wikipedia.org/wiki/Voltage_divider
190 https://en.wikipedia.org/wiki/Voltage_divider
191 https://docs.python.org/3.7/library/functions.html#int
192 https://docs.python.org/3.7/library/stdtypes.html#str
193 https://docs.python.org/3.7/library/constants.html#None
194 https://docs.python.org/3.7/library/functions.html#int
195 https://docs.python.org/3.7/library/stdtypes.html#str
196 https://docs.python.org/3.7/library/constants.html#None
197 https://docs.python.org/3.7/library/functions.html#int
198 https://docs.python.org/3.7/library/functions.html#float

- **threshold_distance** (*float*[199]) – Defaults to 0.3. This is the distance (in meters) that will trigger the `in_range` and `out_of_range` events when crossed.
- **partial** (*bool*[200]) – When `False`[201] (the default), the object will not return a value for *is_active* (page 120) until the internal queue has filled with values. Only set this to `True`[202] if you require values immediately after object construction.
- **pin_factory** (`Factory` (page 230) *or None*[203]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_in_range(*timeout=None*)
Pause the script until the device is deactivated, or the timeout is reached.

Parameters timeout (*float*[204] *or None*[205]) – Number of seconds to wait before proceeding. If this is `None`[206] (the default), then wait indefinitely until the device is inactive.

wait_for_out_of_range(*timeout=None*)
Pause the script until the device is activated, or the timeout is reached.

Parameters timeout (*float*[207] *or None*[208]) – Number of seconds to wait before proceeding. If this is `None`[209] (the default), then wait indefinitely until the device is active.

distance
Returns the current distance measured by the sensor in meters. Note that this property will have a value between 0 and *max_distance* (page 113).

echo
Returns the *Pin* (page 231) that the sensor's echo is connected to. This is simply an alias for the usual *pin* (page 122) attribute.

max_distance
The maximum distance that the sensor will measure in meters. This value is specified in the constructor and is used to provide the scaling for the *value* (page 120) attribute. When *distance* (page 113) is equal to *max_distance* (page 113), *value* (page 120) will be 1.

threshold_distance
The distance, measured in meters, that will trigger the *when_in_range* (page 113) and *when_out_of_range* (page 114) events when crossed. This is simply a meter-scaled variant of the usual *threshold* (page 120) attribute.

trigger
Returns the *Pin* (page 231) that the sensor's trigger is connected to.

value
Returns a value between 0, indicating the reflector is either touching the sensor or is sufficiently near that the sensor can't tell the difference, and 1, indicating the reflector is at or beyond the specified *max_distance*.

when_in_range
The function to run when the device changes state from active to inactive.

[199] https://docs.python.org/3.7/library/functions.html#float
[200] https://docs.python.org/3.7/library/functions.html#bool
[201] https://docs.python.org/3.7/library/constants.html#False
[202] https://docs.python.org/3.7/library/constants.html#True
[203] https://docs.python.org/3.7/library/constants.html#None
[204] https://docs.python.org/3.7/library/functions.html#float
[205] https://docs.python.org/3.7/library/constants.html#None
[206] https://docs.python.org/3.7/library/constants.html#None
[207] https://docs.python.org/3.7/library/functions.html#float
[208] https://docs.python.org/3.7/library/constants.html#None
[209] https://docs.python.org/3.7/library/constants.html#None

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to `None`[210] (the default) to disable the event.

when_out_of_range
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to `None`[211] (the default) to disable the event.

13.1.6 RotaryEncoder

class gpiozero.RotaryEncoder(*a, b, *, bounce_time=None, max_steps=16, threshold_steps=(0, 0), wrap=False, pin_factory=None*)

Represents a simple two-pin incremental rotary encoder[212] device.

These devices typically have three pins labelled "A", "B", and "C". Connect A and B directly to two GPIO pins, and C ("common") to one of the ground pins on your Pi. Then simply specify the A and B pins as the arguments when constructing this classs.

For example, if your encoder's A pin is connected to GPIO 21, and the B pin to GPIO 20 (and presumably the C pin to a suitable GND pin), while an LED (with a suitable 300Ω resistor) is connected to GPIO 5, the following session will result in the brightness of the LED being controlled by dialling the rotary encoder back and forth:

```
>>> from gpiozero import RotaryEncoder
>>> from gpiozero.tools import scaled_half
>>> rotor = RotaryEncoder(21, 20)
>>> led = PWMLED(5)
>>> led.source = scaled_half(rotor.values)
```

Parameters

- **a** (*int*[213] *or str*[214]) – The GPIO pin connected to the "A" output of the rotary encoder.
- **b** (*int*[215] *or str*[216]) – The GPIO pin connected to the "B" output of the rotary encoder.
- **bounce_time** (*float*[217] *or None*[218]) – If `None`[219] (the default), no software bounce compensation will be performed. Otherwise, this is the length of time (in seconds) that the component will ignore changes in state after an initial change.
- **max_steps** (*int*[220]) – The number of steps clockwise the encoder takes to change the *value* (page 116) from 0 to 1, or counter-clockwise from 0 to -1. If this is 0,

[210] https://docs.python.org/3.7/library/constants.html#None
[211] https://docs.python.org/3.7/library/constants.html#None
[212] https://en.wikipedia.org/wiki/Rotary_encoder
[213] https://docs.python.org/3.7/library/functions.html#int
[214] https://docs.python.org/3.7/library/stdtypes.html#str
[215] https://docs.python.org/3.7/library/functions.html#int
[216] https://docs.python.org/3.7/library/stdtypes.html#str
[217] https://docs.python.org/3.7/library/functions.html#float
[218] https://docs.python.org/3.7/library/constants.html#None
[219] https://docs.python.org/3.7/library/constants.html#None
[220] https://docs.python.org/3.7/library/functions.html#int

then the encoder's *value* (page 116) never changes, but you can still read *steps* (page 115) to determine the integer number of steps the encoder has moved clockwise or counter clockwise.

- **threshold_steps** (*tuple of int*) – A (min, max) tuple of steps between which the device will be considered "active", inclusive. In other words, when *steps* (page 115) is greater than or equal to the *min* value, and less than or equal the *max* value, the active property will be True[221] and the appropriate events (when_activated, when_deactivated) will be fired. Defaults to (0, 0).
- **wrap** (*bool*[222]) – If True[223] and *max_steps* is non-zero, when the *steps* (page 115) reaches positive or negative *max_steps* it wraps around by negation. Defaults to False[224].
- **pin_factory** (Factory (page 230) *or None*[225]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_rotate(*timeout=None*)
Pause the script until the encoder is rotated at least one step in either direction, or the timeout is reached.

Parameters timeout (*float*[226] *or None*[227]) – Number of seconds to wait before proceeding. If this is None[228] (the default), then wait indefinitely until the encoder is rotated.

wait_for_rotate_clockwise(*timeout=None*)
Pause the script until the encoder is rotated at least one step clockwise, or the timeout is reached.

Parameters timeout (*float*[229] *or None*[230]) – Number of seconds to wait before proceeding. If this is None[231] (the default), then wait indefinitely until the encoder is rotated clockwise.

wait_for_rotate_counter_clockwise(*timeout=None*)
Pause the script until the encoder is rotated at least one step counter-clockwise, or the timeout is reached.

Parameters timeout (*float*[232] *or None*[233]) – Number of seconds to wait before proceeding. If this is None[234] (the default), then wait indefinitely until the encoder is rotated counter-clockwise.

max_steps
The number of discrete steps the rotary encoder takes to move *value* (page 116) from 0 to 1 clockwise, or 0 to -1 counter-clockwise. In another sense, this is also the total number of discrete states this input can represent.

steps
The "steps" value of the encoder starts at 0. It increments by one for every step the encoder is rotated clockwise, and decrements by one for every step it is rotated counter-clockwise. The steps value is limited by *max_steps* (page 115). It will not advance beyond positive or

221 https://docs.python.org/3.7/library/constants.html#True
222 https://docs.python.org/3.7/library/functions.html#bool
223 https://docs.python.org/3.7/library/constants.html#True
224 https://docs.python.org/3.7/library/constants.html#False
225 https://docs.python.org/3.7/library/constants.html#None
226 https://docs.python.org/3.7/library/functions.html#float
227 https://docs.python.org/3.7/library/constants.html#None
228 https://docs.python.org/3.7/library/constants.html#None
229 https://docs.python.org/3.7/library/functions.html#float
230 https://docs.python.org/3.7/library/constants.html#None
231 https://docs.python.org/3.7/library/constants.html#None
232 https://docs.python.org/3.7/library/functions.html#float
233 https://docs.python.org/3.7/library/constants.html#None
234 https://docs.python.org/3.7/library/constants.html#None

negative *max_steps* (page 115), unless *wrap* (page 116) is True[235] in which case it will roll around by negation. If *max_steps* (page 115) is zero then steps are not limited at all, and will increase infinitely in either direction, but *value* (page 116) will return a constant zero.

Note that, in contrast to most other input devices, because the rotary encoder has no absolute position the *steps* (page 115) attribute (and *value* (page 116) by corollary) is writable.

threshold_steps
The mininum and maximum number of steps between which `is_active` will return True[236]. Defaults to (0, 0).

value
Represents the value of the rotary encoder as a value between -1 and 1. The value is calculated by dividing the value of *steps* (page 115) into the range from negative *max_steps* (page 115) to positive *max_steps* (page 115).

Note that, in contrast to most other input devices, because the rotary encoder has no absolute position the *value* (page 116) attribute is writable.

when_rotated
The function to be run when the encoder is rotated in either direction.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated will be passed as that parameter.

Set this property to None[237] (the default) to disable the event.

when_rotated_clockwise
The function to be run when the encoder is rotated clockwise.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated will be passed as that parameter.

Set this property to None[238] (the default) to disable the event.

when_rotated_counter_clockwise
The function to be run when the encoder is rotated counter-clockwise.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated will be passed as that parameter.

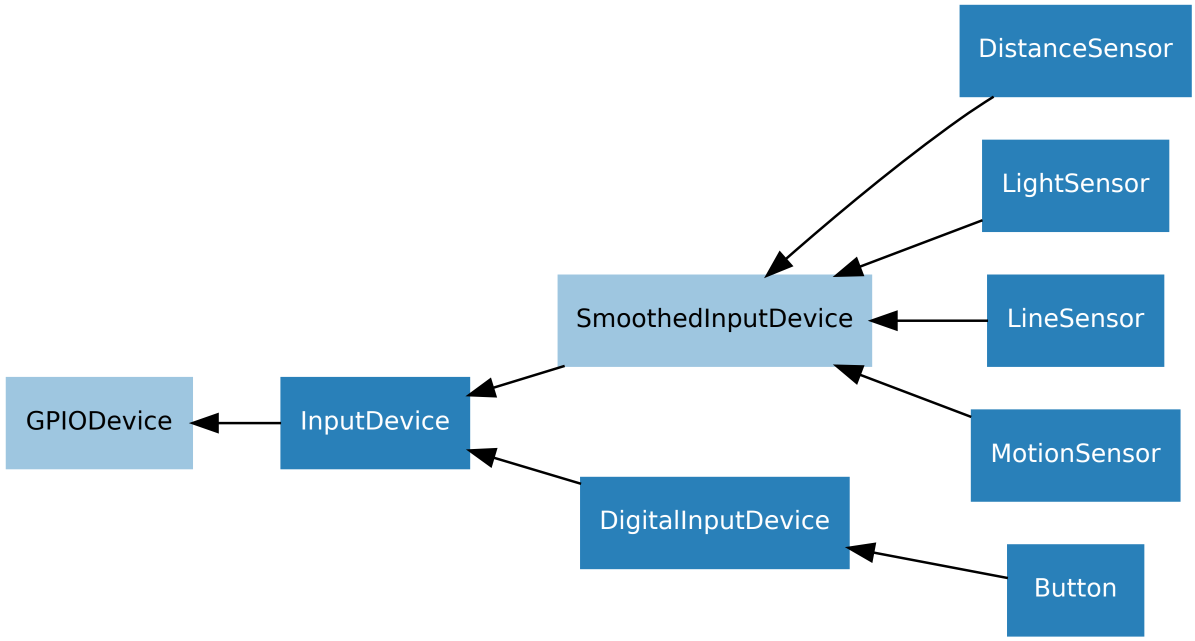
Set this property to None[239] (the default) to disable the event.

wrap
If True[240], when *value* (page 116) reaches its limit (-1 or 1), it "wraps around" to the opposite limit. When False[241], the value (and the corresponding *steps* (page 115) attribute) simply don't advance beyond their limits.

[235] https://docs.python.org/3.7/library/constants.html#True
[236] https://docs.python.org/3.7/library/constants.html#True
[237] https://docs.python.org/3.7/library/constants.html#None
[238] https://docs.python.org/3.7/library/constants.html#None
[239] https://docs.python.org/3.7/library/constants.html#None
[240] https://docs.python.org/3.7/library/constants.html#True
[241] https://docs.python.org/3.7/library/constants.html#False

13.2 Base Classes

The classes in the sections above are derived from a series of base classes, some of which are effectively abstract. The classes form the (partial) hierarchy displayed in the graph below (abstract classes are shaded lighter than concrete classes):



The following sections document these base classes for advanced users that wish to construct classes for their own devices.

13.2.1 DigitalInputDevice

class gpiozero.DigitalInputDevice(*pin*, ***, *pull_up=False*, *active_state=None*, *bounce_time=None*, *pin_factory=None*)

Represents a generic input device with typical on/off behaviour.

This class extends *InputDevice* (page 120) with machinery to fire the active and inactive events for devices that operate in a typical digital manner: straight forward on / off states with (reasonably) clean transitions between the two.

Parameters

- **pin** (*int*[242] *or str*[243]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[244] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[245] *or None*[246]) – See description under *InputDevice* (page 120) for more information.
- **active_state** (*bool*[247] *or None*[248]) – See description under *InputDevice* (page 120) for more information.

[242] https://docs.python.org/3.7/library/functions.html#int
[243] https://docs.python.org/3.7/library/stdtypes.html#str
[244] https://docs.python.org/3.7/library/constants.html#None
[245] https://docs.python.org/3.7/library/functions.html#bool
[246] https://docs.python.org/3.7/library/constants.html#None
[247] https://docs.python.org/3.7/library/functions.html#bool
[248] https://docs.python.org/3.7/library/constants.html#None

- **bounce_time** (*float*[249] *or None*[250]) – Specifies the length of time (in seconds) that the component will ignore changes in state after an initial change. This defaults to None[251] which indicates that no bounce compensation will be performed.
- **pin_factory** (Factory (page 230) *or None*[252]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

wait_for_active(*timeout=None*)
Pause the script until the device is activated, or the timeout is reached.

Parameters timeout (*float*[253] *or None*[254]) – Number of seconds to wait before proceeding. If this is None[255] (the default), then wait indefinitely until the device is active.

wait_for_inactive(*timeout=None*)
Pause the script until the device is deactivated, or the timeout is reached.

Parameters timeout (*float*[256] *or None*[257]) – Number of seconds to wait before proceeding. If this is None[258] (the default), then wait indefinitely until the device is inactive.

active_time
The length of time (in seconds) that the device has been active for. When the device is inactive, this is None[259].

inactive_time
The length of time (in seconds) that the device has been inactive for. When the device is active, this is None[260].

value
Returns a value representing the device's state. Frequently, this is a boolean value, or a number between 0 and 1 but some devices use larger ranges (e.g. -1 to +1) and composite devices usually use tuples to return the states of all their subordinate components.

when_activated
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None[261] (the default) to disable the event.

when_deactivated
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

[249] https://docs.python.org/3.7/library/functions.html#float
[250] https://docs.python.org/3.7/library/constants.html#None
[251] https://docs.python.org/3.7/library/constants.html#None
[252] https://docs.python.org/3.7/library/constants.html#None
[253] https://docs.python.org/3.7/library/functions.html#float
[254] https://docs.python.org/3.7/library/constants.html#None
[255] https://docs.python.org/3.7/library/constants.html#None
[256] https://docs.python.org/3.7/library/functions.html#float
[257] https://docs.python.org/3.7/library/constants.html#None
[258] https://docs.python.org/3.7/library/constants.html#None
[259] https://docs.python.org/3.7/library/constants.html#None
[260] https://docs.python.org/3.7/library/constants.html#None
[261] https://docs.python.org/3.7/library/constants.html#None

Set this property to None[262] (the default) to disable the event.

13.2.2 SmoothedInputDevice

class gpiozero.SmoothedInputDevice(*pin*, ***, *pull_up=False*, *active_state=None*, *threshold=0.5*, *queue_len=5*, *sample_wait=0.0*, *partial=False*, *pin_factory=None*)

Represents a generic input device which takes its value from the average of a queue of historical values.

This class extends *InputDevice* (page 120) with a queue which is filled by a background thread which continually polls the state of the underlying device. The average (a configurable function) of the values in the queue is compared to a threshold which is used to determine the state of the *is_active* (page 120) property.

Note: The background queue is not automatically started upon construction. This is to allow descendents to set up additional components before the queue starts reading values. Effectively this is an abstract base class.

This class is intended for use with devices which either exhibit analog behaviour (such as the charging time of a capacitor with an LDR), or those which exhibit "twitchy" behaviour (such as certain motion sensors).

Parameters

- **pin** (*int*[263] *or str*[264]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[265] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[266] *or None*[267]) – See description under *InputDevice* (page 120) for more information.
- **active_state** (*bool*[268] *or None*[269]) – See description under *InputDevice* (page 120) for more information.
- **threshold** (*float*[270]) – The value above which the device will be considered "on".
- **queue_len** (*int*[271]) – The length of the internal queue which is filled by the background thread.
- **sample_wait** (*float*[272]) – The length of time to wait between retrieving the state of the underlying device. Defaults to 0.0 indicating that values are retrieved as fast as possible.
- **partial** (*bool*[273]) – If False[274] (the default), attempts to read the state of the device (from the *is_active* (page 120) property) will block until the queue has filled. If True[275], a value will be returned immediately, but be aware that this value is likely to fluctuate excessively.

[262] https://docs.python.org/3.7/library/constants.html#None
[263] https://docs.python.org/3.7/library/functions.html#int
[264] https://docs.python.org/3.7/library/stdtypes.html#str
[265] https://docs.python.org/3.7/library/constants.html#None
[266] https://docs.python.org/3.7/library/functions.html#bool
[267] https://docs.python.org/3.7/library/constants.html#None
[268] https://docs.python.org/3.7/library/functions.html#bool
[269] https://docs.python.org/3.7/library/constants.html#None
[270] https://docs.python.org/3.7/library/functions.html#float
[271] https://docs.python.org/3.7/library/functions.html#int
[272] https://docs.python.org/3.7/library/functions.html#float
[273] https://docs.python.org/3.7/library/functions.html#bool
[274] https://docs.python.org/3.7/library/constants.html#False
[275] https://docs.python.org/3.7/library/constants.html#True

- **average** – The function used to average the values in the internal queue. This defaults to `statistics.median()`[276] which is a good selection for discarding outliers from jittery sensors. The function specified must accept a sequence of numbers and return a single number.
- **ignore** (*frozenset*[277] *or None*[278]) – The set of values which the queue should ignore, if returned from querying the device's value.
- **pin_factory** (`Factory` (page 230) *or None*[279]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

is_active
Returns `True`[280] if the *value* (page 120) currently exceeds *threshold* (page 120) and `False`[281] otherwise.

partial
If `False`[282] (the default), attempts to read the *value* (page 120) or *is_active* (page 120) properties will block until the queue has filled.

queue_len
The length of the internal queue of values which is averaged to determine the overall state of the device. This defaults to 5.

threshold
If *value* (page 120) exceeds this amount, then *is_active* (page 120) will return `True`[283].

value
Returns the average of the values in the internal queue. This is compared to *threshold* (page 120) to determine whether *is_active* (page 120) is `True`[284].

13.2.3 InputDevice

class gpiozero.InputDevice(*pin*, ***, *pull_up=False*, *active_state=None*, *pin_factory=None*)
Represents a generic GPIO input device.

This class extends *GPIODevice* (page 121) to add facilities common to GPIO input devices. The constructor adds the optional *pull_up* parameter to specify how the pin should be pulled by the internal resistors. The *is_active* (page 121) property is adjusted accordingly so that `True`[285] still means active regardless of the *pull_up* setting.

Parameters

- **pin** (*int*[286] *or str*[287]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[288] a *GPIODeviceError* (page 247) will be raised.
- **pull_up** (*bool*[289] *or None*[290]) – If `True`[291], the pin will be pulled high with an internal resistor. If `False`[292] (the default), the pin will be pulled low. If `None`[293],

276 https://docs.python.org/3.7/library/statistics.html#statistics.median
277 https://docs.python.org/3.7/library/stdtypes.html#frozenset
278 https://docs.python.org/3.7/library/constants.html#None
279 https://docs.python.org/3.7/library/constants.html#None
280 https://docs.python.org/3.7/library/constants.html#True
281 https://docs.python.org/3.7/library/constants.html#False
282 https://docs.python.org/3.7/library/constants.html#False
283 https://docs.python.org/3.7/library/constants.html#True
284 https://docs.python.org/3.7/library/constants.html#True
285 https://docs.python.org/3.7/library/constants.html#True
286 https://docs.python.org/3.7/library/functions.html#int
287 https://docs.python.org/3.7/library/stdtypes.html#str
288 https://docs.python.org/3.7/library/constants.html#None
289 https://docs.python.org/3.7/library/functions.html#bool
290 https://docs.python.org/3.7/library/constants.html#None
291 https://docs.python.org/3.7/library/constants.html#True
292 https://docs.python.org/3.7/library/constants.html#False
293 https://docs.python.org/3.7/library/constants.html#None

the pin will be floating. As gpiozero cannot automatically guess the active state when not pulling the pin, the *active_state* parameter must be passed.

- **active_state** (*bool*[294] *or None*[295]) – If True[296], when the hardware pin state is HIGH, the software pin is HIGH. If False[297], the input polarity is reversed: when the hardware pin state is HIGH, the software pin state is LOW. Use this parameter to set the active state of the underlying pin when configuring it as not pulled (when *pull_up* is None[298]). When *pull_up* is True[299] or False[300], the active state is automatically set to the proper value.
- **pin_factory** (Factory (page 230) *or None*[301]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

is_active
Returns True[302] if the device is currently active and False[303] otherwise. This property is usually derived from *value* (page 121). Unlike *value* (page 121), this is *always* a boolean.

pull_up
If True[304], the device uses a pull-up resistor to set the GPIO pin "high" by default.

value
Returns a value representing the device's state. Frequently, this is a boolean value, or a number between 0 and 1 but some devices use larger ranges (e.g. -1 to +1) and composite devices usually use tuples to return the states of all their subordinate components.

13.2.4 GPIODevice

class gpiozero.GPIODevice(*pin*, *pin_factory=None*)
Extends *Device* (page 201). Represents a generic GPIO device and provides the services common to all single-pin GPIO devices (like ensuring two GPIO devices do no share a *pin* (page 122)).

Parameters pin (*int*[305] *or str*[306]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[307] a *GPIODeviceError* (page 247) will be raised. If the pin is already in use by another device, *GPIOPinInUse* (page 247) will be raised.

close()
Shut down the device and release all associated resources (such as GPIO pins).

This method is idempotent (can be called on an already closed device without any side-effects). It is primarily intended for interactive use at the command line. It disables the device and releases its pin(s) for use by another device.

You can attempt to do this simply by deleting an object, but unless you've cleaned up all references to the object this may not work (even if you've cleaned up all references, there's still no guarantee the garbage collector will actually delete the object at that point). By contrast, the close method provides a means of ensuring that the object is shut down.

For example, if you have a breadboard with a buzzer connected to pin 16, but then wish to attach an LED instead:

[294] https://docs.python.org/3.7/library/functions.html#bool
[295] https://docs.python.org/3.7/library/constants.html#None
[296] https://docs.python.org/3.7/library/constants.html#True
[297] https://docs.python.org/3.7/library/constants.html#False
[298] https://docs.python.org/3.7/library/constants.html#None
[299] https://docs.python.org/3.7/library/constants.html#True
[300] https://docs.python.org/3.7/library/constants.html#False
[301] https://docs.python.org/3.7/library/constants.html#None
[302] https://docs.python.org/3.7/library/constants.html#True
[303] https://docs.python.org/3.7/library/constants.html#False
[304] https://docs.python.org/3.7/library/constants.html#True
[305] https://docs.python.org/3.7/library/functions.html#int
[306] https://docs.python.org/3.7/library/stdtypes.html#str
[307] https://docs.python.org/3.7/library/constants.html#None

```
>>> from gpiozero import *
>>> bz = Buzzer(16)
>>> bz.on()
>>> bz.off()
>>> bz.close()
>>> led = LED(16)
>>> led.blink()
```

Device (page 201) descendents can also be used as context managers using the `with`[308] statement. For example:

```
>>> from gpiozero import *
>>> with Buzzer(16) as bz:
...     bz.on()
...
>>> with LED(16) as led:
...     led.on()
...
```

closed

Returns `True`[309] if the device is closed (see the *close()* (page 121) method). Once a device is closed you can no longer use any other methods or properties to control or query the device.

pin

The *Pin* (page 231) that the device is connected to. This will be `None`[310] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

value

Returns a value representing the device's state. Frequently, this is a boolean value, or a number between 0 and 1 but some devices use larger ranges (e.g. -1 to +1) and composite devices usually use tuples to return the states of all their subordinate components.

[308] https://docs.python.org/3.7/reference/compound_stmts.html#with
[309] https://docs.python.org/3.7/library/constants.html#True
[310] https://docs.python.org/3.7/library/constants.html#None

CHAPTER 14

API - Output Devices

These output device component interfaces have been provided for simple use of everyday components. Components must be wired up correctly before use in code.

Note: All GPIO pin numbers use Broadcom (BCM) numbering by default. See the *Pin Numbering* (page 3) section for more information.

14.1 Regular Classes

The following classes are intended for general use with the devices they represent. All classes in this section are concrete (not abstract).

14.1.1 LED

class gpiozero.LED(*pin*, **, *active_high=True*, *initial_value=False*, *pin_factory=None*)

Extends `DigitalOutputDevice` (page 139) and represents a light emitting diode (LED).

Connect the cathode (short leg, flat side) of the LED to a ground pin; connect the anode (longer leg) to a limiting resistor; connect the other side of the limiting resistor to a GPIO pin (the limiting resistor can be placed either side of the LED).

The following example will light the LED:

```
from gpiozero import LED

led = LED(17)
led.on()
```

Parameters

- **pin** (*int*[311] *or* *str*[312]) – The GPIO pin which the LED is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[313] a `GPIODeviceError`

[311] https://docs.python.org/3.7/library/functions.html#int
[312] https://docs.python.org/3.7/library/stdtypes.html#str
[313] https://docs.python.org/3.7/library/constants.html#None

(page 247) will be raised.

- **active_high** (*bool*[314]) – If True[315] (the default), the LED will operate normally with the circuit described above. If False[316] you should wire the cathode to the GPIO pin, and the anode to a 3V3 pin (via a limiting resistor).
- **initial_value** (*bool*[317] *or None*[318]) – If False[319] (the default), the LED will be off initially. If None[320], the LED will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[321], the LED will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[322]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

blink(*on_time=1*, *off_time=1*, *n=None*, *background=True*)
Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[323]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[324]) – Number of seconds off. Defaults to 1 second.
- **n** (*int*[325] *or None*[326]) – Number of times to blink; None[327] (the default) means forever.
- **background** (*bool*[328]) – If True[329] (the default), start a background thread to continue blinking and return immediately. If False[330], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turns the device off.

on()
Turns the device on.

toggle()
Reverse the state of the device. If it's on, turn it off; if it's off, turn it on.

is_lit
Returns True[331] if the device is currently active and False[332] otherwise. This property is usually derived from *value* (page 125). Unlike *value* (page 125), this is *always* a boolean.

pin
The *Pin* (page 231) that the device is connected to. This will be None[333] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

314 https://docs.python.org/3.7/library/functions.html#bool
315 https://docs.python.org/3.7/library/constants.html#True
316 https://docs.python.org/3.7/library/constants.html#False
317 https://docs.python.org/3.7/library/functions.html#bool
318 https://docs.python.org/3.7/library/constants.html#None
319 https://docs.python.org/3.7/library/constants.html#False
320 https://docs.python.org/3.7/library/constants.html#None
321 https://docs.python.org/3.7/library/constants.html#True
322 https://docs.python.org/3.7/library/constants.html#None
323 https://docs.python.org/3.7/library/functions.html#float
324 https://docs.python.org/3.7/library/functions.html#float
325 https://docs.python.org/3.7/library/functions.html#int
326 https://docs.python.org/3.7/library/constants.html#None
327 https://docs.python.org/3.7/library/constants.html#None
328 https://docs.python.org/3.7/library/functions.html#bool
329 https://docs.python.org/3.7/library/constants.html#True
330 https://docs.python.org/3.7/library/constants.html#False
331 https://docs.python.org/3.7/library/constants.html#True
332 https://docs.python.org/3.7/library/constants.html#False
333 https://docs.python.org/3.7/library/constants.html#None

value
Returns 1 if the device is currently active and 0 otherwise. Setting this property changes the state of the device.

14.1.2 PWMLED

class gpiozero.PWMLED(*pin*, ***, *active_high=True*, *initial_value=0*, *frequency=100*, *pin_factory=None*)
Extends *PWMOutputDevice* (page 140) and represents a light emitting diode (LED) with variable brightness.

A typical configuration of such a device is to connect a GPIO pin to the anode (long leg) of the LED, and the cathode (short leg) to ground, with an optional resistor to prevent the LED from burning out.

Parameters

- **pin** (*int*[334] *or str*[335]) – The GPIO pin which the LED is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[336] a *GPIODeviceError* (page 247) will be raised.
- **active_high** (*bool*[337]) – If True[338] (the default), the *on()* (page 126) method will set the GPIO to HIGH. If False[339], the *on()* (page 126) method will set the GPIO to LOW (the *off()* (page 126) method always does the opposite).
- **initial_value** (*float*[340]) – If 0 (the default), the LED will be off initially. Other values between 0 and 1 can be specified as an initial brightness for the LED. Note that None[341] cannot be specified (unlike the parent class) as there is no way to tell PWM not to alter the state of the pin.
- **frequency** (*int*[342]) – The frequency (in Hz) of pulses emitted to drive the LED. Defaults to 100Hz.
- **pin_factory** (Factory (page 230) *or None*[343]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

blink(*on_time=1*, *off_time=1*, *fade_in_time=0*, *fade_out_time=0*, *n=None*, *background=True*)
Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[344]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[345]) – Number of seconds off. Defaults to 1 second.
- **fade_in_time** (*float*[346]) – Number of seconds to spend fading in. Defaults to 0.
- **fade_out_time** (*float*[347]) – Number of seconds to spend fading out. Defaults to 0.

334 https://docs.python.org/3.7/library/functions.html#int
335 https://docs.python.org/3.7/library/stdtypes.html#str
336 https://docs.python.org/3.7/library/constants.html#None
337 https://docs.python.org/3.7/library/functions.html#bool
338 https://docs.python.org/3.7/library/constants.html#True
339 https://docs.python.org/3.7/library/constants.html#False
340 https://docs.python.org/3.7/library/functions.html#float
341 https://docs.python.org/3.7/library/constants.html#None
342 https://docs.python.org/3.7/library/functions.html#int
343 https://docs.python.org/3.7/library/constants.html#None
344 https://docs.python.org/3.7/library/functions.html#float
345 https://docs.python.org/3.7/library/functions.html#float
346 https://docs.python.org/3.7/library/functions.html#float
347 https://docs.python.org/3.7/library/functions.html#float

- **n** (*int*[348] *or None*[349]) – Number of times to blink; None[350] (the default) means forever.
- **background** (*bool*[351]) – If True[352] (the default), start a background thread to continue blinking and return immediately. If False[353], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turns the device off.

on()
Turns the device on.

pulse(*fade_in_time=1*, *fade_out_time=1*, *n=None*, *background=True*)
Make the device fade in and out repeatedly.

Parameters

- **fade_in_time** (*float*[354]) – Number of seconds to spend fading in. Defaults to 1.
- **fade_out_time** (*float*[355]) – Number of seconds to spend fading out. Defaults to 1.
- **n** (*int*[356] *or None*[357]) – Number of times to pulse; None[358] (the default) means forever.
- **background** (*bool*[359]) – If True[360] (the default), start a background thread to continue pulsing and return immediately. If False[361], only return when the pulse is finished (warning: the default value of *n* will result in this method never returning).

toggle()
Toggle the state of the device. If the device is currently off (*value* (page 126) is 0.0), this changes it to "fully" on (*value* (page 126) is 1.0). If the device has a duty cycle (*value* (page 126)) of 0.1, this will toggle it to 0.9, and so on.

is_lit
Returns True[362] if the device is currently active (*value* (page 126) is non-zero) and False[363] otherwise.

pin
The *Pin* (page 231) that the device is connected to. This will be None[364] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
The duty cycle of the PWM device. 0.0 is off, 1.0 is fully on. Values in between may be specified for varying levels of power in the device.

348 https://docs.python.org/3.7/library/functions.html#int
349 https://docs.python.org/3.7/library/constants.html#None
350 https://docs.python.org/3.7/library/constants.html#None
351 https://docs.python.org/3.7/library/functions.html#bool
352 https://docs.python.org/3.7/library/constants.html#True
353 https://docs.python.org/3.7/library/constants.html#False
354 https://docs.python.org/3.7/library/functions.html#float
355 https://docs.python.org/3.7/library/functions.html#float
356 https://docs.python.org/3.7/library/functions.html#int
357 https://docs.python.org/3.7/library/constants.html#None
358 https://docs.python.org/3.7/library/constants.html#None
359 https://docs.python.org/3.7/library/functions.html#bool
360 https://docs.python.org/3.7/library/constants.html#True
361 https://docs.python.org/3.7/library/constants.html#False
362 https://docs.python.org/3.7/library/constants.html#True
363 https://docs.python.org/3.7/library/constants.html#False
364 https://docs.python.org/3.7/library/constants.html#None

14.1.3 RGBLED

class gpiozero.RGBLED(*red*, *green*, *blue*, ***, *active_high=True*, *initial_value=(0, 0, 0)*, *pwm=True*, *pin_factory=None*)

Extends *Device* (page 201) and represents a full color LED component (composed of red, green, and blue LEDs).

Connect the common cathode (longest leg) to a ground pin; connect each of the other legs (representing the red, green, and blue anodes) to any GPIO pins. You should use three limiting resistors (one per anode).

The following code will make the LED yellow:

```
from gpiozero import RGBLED

led = RGBLED(2, 3, 4)
led.color = (1, 1, 0)
```

The colorzero[365] library is also supported:

```
from gpiozero import RGBLED
from colorzero import Color

led = RGBLED(2, 3, 4)
led.color = Color('yellow')
```

Parameters

- **red** (*int*[366] *or str*[367]) – The GPIO pin that controls the red component of the RGB LED. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[368] a *GPIODeviceError* (page 247) will be raised.
- **green** (*int*[369] *or str*[370]) – The GPIO pin that controls the green component of the RGB LED.
- **blue** (*int*[371] *or str*[372]) – The GPIO pin that controls the blue component of the RGB LED.
- **active_high** (*bool*[373]) – Set to True[374] (the default) for common cathode RGB LEDs. If you are using a common anode RGB LED, set this to False[375].
- **initial_value** (*Color*[376] *or tuple*[377]) – The initial color for the RGB LED. Defaults to black (0, 0, 0).
- **pwm** (*bool*[378]) – If True[379] (the default), construct *PWMLED* (page 125) instances for each component of the RGBLED. If False[380], construct regular *LED* (page 123) instances, which prevents smooth color graduations.

[365] https://colorzero.readthedocs.io/
[366] https://docs.python.org/3.7/library/functions.html#int
[367] https://docs.python.org/3.7/library/stdtypes.html#str
[368] https://docs.python.org/3.7/library/constants.html#None
[369] https://docs.python.org/3.7/library/functions.html#int
[370] https://docs.python.org/3.7/library/stdtypes.html#str
[371] https://docs.python.org/3.7/library/functions.html#int
[372] https://docs.python.org/3.7/library/stdtypes.html#str
[373] https://docs.python.org/3.7/library/functions.html#bool
[374] https://docs.python.org/3.7/library/constants.html#True
[375] https://docs.python.org/3.7/library/constants.html#False
[376] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[377] https://docs.python.org/3.7/library/stdtypes.html#tuple
[378] https://docs.python.org/3.7/library/functions.html#bool
[379] https://docs.python.org/3.7/library/constants.html#True
[380] https://docs.python.org/3.7/library/constants.html#False

- **pin_factory** (Factory (page 230) *or* *None*[381]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

blink(*on_time=1, off_time=1, fade_in_time=0, fade_out_time=0, on_color=(1, 1, 1), off_color=(0, 0, 0), n=None, background=True*)
Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[382]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[383]) – Number of seconds off. Defaults to 1 second.
- **fade_in_time** (*float*[384]) – Number of seconds to spend fading in. Defaults to 0. Must be 0 if *pwm* was False[385] when the class was constructed (ValueError[386] will be raised if not).
- **fade_out_time** (*float*[387]) – Number of seconds to spend fading out. Defaults to 0. Must be 0 if *pwm* was False[388] when the class was constructed (ValueError[389] will be raised if not).
- **on_color** (*Color*[390] *or* *tuple*[391]) – The color to use when the LED is "on". Defaults to white.
- **off_color** (*Color*[392] *or* *tuple*[393]) – The color to use when the LED is "off". Defaults to black.
- **n** (*int*[394] *or* *None*[395]) – Number of times to blink; None[396] (the default) means forever.
- **background** (*bool*[397]) – If True[398] (the default), start a background thread to continue blinking and return immediately. If False[399], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turn the LED off. This is equivalent to setting the LED color to black `(0, 0, 0)`.

on()
Turn the LED on. This equivalent to setting the LED color to white `(1, 1, 1)`.

pulse(*fade_in_time=1, fade_out_time=1, on_color=(1, 1, 1), off_color=(0, 0, 0), n=None, background=True*)
Make the device fade in and out repeatedly.

Parameters

- **fade_in_time** (*float*[400]) – Number of seconds to spend fading in. Defaults to 1.

[381] https://docs.python.org/3.7/library/constants.html#None
[382] https://docs.python.org/3.7/library/functions.html#float
[383] https://docs.python.org/3.7/library/functions.html#float
[384] https://docs.python.org/3.7/library/functions.html#float
[385] https://docs.python.org/3.7/library/constants.html#False
[386] https://docs.python.org/3.7/library/exceptions.html#ValueError
[387] https://docs.python.org/3.7/library/functions.html#float
[388] https://docs.python.org/3.7/library/constants.html#False
[389] https://docs.python.org/3.7/library/exceptions.html#ValueError
[390] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[391] https://docs.python.org/3.7/library/stdtypes.html#tuple
[392] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[393] https://docs.python.org/3.7/library/stdtypes.html#tuple
[394] https://docs.python.org/3.7/library/functions.html#int
[395] https://docs.python.org/3.7/library/constants.html#None
[396] https://docs.python.org/3.7/library/constants.html#None
[397] https://docs.python.org/3.7/library/functions.html#bool
[398] https://docs.python.org/3.7/library/constants.html#True
[399] https://docs.python.org/3.7/library/constants.html#False
[400] https://docs.python.org/3.7/library/functions.html#float

- **fade_out_time** (*float*[401]) – Number of seconds to spend fading out. Defaults to 1.
- **on_color** (*Color*[402] *or tuple*[403]) – The color to use when the LED is "on". Defaults to white.
- **off_color** (*Color*[404] *or tuple*[405]) – The color to use when the LED is "off". Defaults to black.
- **n** (*int*[406] *or None*[407]) – Number of times to pulse; `None`[408] (the default) means forever.
- **background** (*bool*[409]) – If `True`[410] (the default), start a background thread to continue pulsing and return immediately. If `False`[411], only return when the pulse is finished (warning: the default value of *n* will result in this method never returning).

toggle()

Toggle the state of the device. If the device is currently off (*value* (page 129) is `(0, 0, 0)`), this changes it to "fully" on (*value* (page 129) is `(1, 1, 1)`). If the device has a specific color, this method inverts the color.

blue

Represents the blue element of the LED as a `Blue`[412] object.

color

Represents the color of the LED as a `Color`[413] object.

green

Represents the green element of the LED as a `Green`[414] object.

is_lit

Returns `True`[415] if the LED is currently active (not black) and `False`[416] otherwise.

red

Represents the red element of the LED as a `Red`[417] object.

value

Represents the color of the LED as an RGB 3-tuple of `(red, green, blue)` where each value is between 0 and 1 if *pwm* was `True`[418] when the class was constructed (and only 0 or 1 if not).

For example, red would be `(1, 0, 0)` and yellow would be `(1, 1, 0)`, while orange would be `(1, 0.5, 0)`.

[401] https://docs.python.org/3.7/library/functions.html#float
[402] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[403] https://docs.python.org/3.7/library/stdtypes.html#tuple
[404] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[405] https://docs.python.org/3.7/library/stdtypes.html#tuple
[406] https://docs.python.org/3.7/library/functions.html#int
[407] https://docs.python.org/3.7/library/constants.html#None
[408] https://docs.python.org/3.7/library/constants.html#None
[409] https://docs.python.org/3.7/library/functions.html#bool
[410] https://docs.python.org/3.7/library/constants.html#True
[411] https://docs.python.org/3.7/library/constants.html#False
[412] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Blue
[413] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
[414] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Green
[415] https://docs.python.org/3.7/library/constants.html#True
[416] https://docs.python.org/3.7/library/constants.html#False
[417] https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Red
[418] https://docs.python.org/3.7/library/constants.html#True

14.1.4 Buzzer

class gpiozero.Buzzer(*pin*, ***, *active_high=True*, *initial_value=False*, *pin_factory=None*)

Extends *DigitalOutputDevice* (page 139) and represents a digital buzzer component.

Note: This interface is only capable of simple on/off commands, and is not capable of playing a variety of tones (see *TonalBuzzer* (page 131)).

Connect the cathode (negative pin) of the buzzer to a ground pin; connect the other side to any GPIO pin.

The following example will sound the buzzer:

```
from gpiozero import Buzzer

bz = Buzzer(3)
bz.on()
```

Parameters

- **pin** (*int*[419] *or str*[420]) – The GPIO pin which the buzzer is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[421] a *GPIODeviceError* (page 247) will be raised.
- **active_high** (*bool*[422]) – If True[423] (the default), the buzzer will operate normally with the circuit described above. If False[424] you should wire the cathode to the GPIO pin, and the anode to a 3V3 pin.
- **initial_value** (*bool*[425] *or None*[426]) – If False[427] (the default), the buzzer will be silent initially. If None[428], the buzzer will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[429], the buzzer will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[430]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

beep(*on_time=1*, *off_time=1*, *n=None*, *background=True*)

Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[431]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[432]) – Number of seconds off. Defaults to 1 second.
- **n** (*int*[433] *or None*[434]) – Number of times to blink; None[435] (the default) means forever.

[419] https://docs.python.org/3.7/library/functions.html#int
[420] https://docs.python.org/3.7/library/stdtypes.html#str
[421] https://docs.python.org/3.7/library/constants.html#None
[422] https://docs.python.org/3.7/library/functions.html#bool
[423] https://docs.python.org/3.7/library/constants.html#True
[424] https://docs.python.org/3.7/library/constants.html#False
[425] https://docs.python.org/3.7/library/functions.html#bool
[426] https://docs.python.org/3.7/library/constants.html#None
[427] https://docs.python.org/3.7/library/constants.html#False
[428] https://docs.python.org/3.7/library/constants.html#None
[429] https://docs.python.org/3.7/library/constants.html#True
[430] https://docs.python.org/3.7/library/constants.html#None
[431] https://docs.python.org/3.7/library/functions.html#float
[432] https://docs.python.org/3.7/library/functions.html#float
[433] https://docs.python.org/3.7/library/functions.html#int
[434] https://docs.python.org/3.7/library/constants.html#None
[435] https://docs.python.org/3.7/library/constants.html#None

- **background** (*bool*[436]) – If True[437] (the default), start a background thread to continue blinking and return immediately. If False[438], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turns the device off.

on()
Turns the device on.

toggle()
Reverse the state of the device. If it's on, turn it off; if it's off, turn it on.

is_active
Returns True[439] if the device is currently active and False[440] otherwise. This property is usually derived from *value* (page 131). Unlike *value* (page 131), this is *always* a boolean.

pin
The *Pin* (page 231) that the device is connected to. This will be None[441] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query pin.number to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
Returns 1 if the device is currently active and 0 otherwise. Setting this property changes the state of the device.

14.1.5 TonalBuzzer

class gpiozero.TonalBuzzer(*pin*, *, *initial_value=None*, *mid_tone=Tone('A4')*, *octaves=1*, *pin_factory=None*)
Extends *CompositeDevice* (page 185) and represents a tonal buzzer.

Parameters

- **pin** (*int*[442] *or str*[443]) – The GPIO pin which the buzzer is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[444] a *GPIODeviceError* (page 247) will be raised.
- **initial_value** (*float*[445]) – If None[446] (the default), the buzzer will be off initially. Values between -1 and 1 can be specified as an initial value for the buzzer.
- **mid_tone** (*int*[447] *or str*[448]) – The tone which is represented the device's middle value (0). The default is "A4" (MIDI note 69).
- **octaves** (*int*[449]) – The number of octaves to allow away from the base note. The default is 1, meaning a value of -1 goes one octave below the base note, and one above, i.e. from A3 to A5 with the default base note of A4.
- **pin_factory** (Factory (page 230) *or None*[450]) – See *API - Pins* (page 225) for

436 https://docs.python.org/3.7/library/functions.html#bool
437 https://docs.python.org/3.7/library/constants.html#True
438 https://docs.python.org/3.7/library/constants.html#False
439 https://docs.python.org/3.7/library/constants.html#True
440 https://docs.python.org/3.7/library/constants.html#False
441 https://docs.python.org/3.7/library/constants.html#None
442 https://docs.python.org/3.7/library/functions.html#int
443 https://docs.python.org/3.7/library/stdtypes.html#str
444 https://docs.python.org/3.7/library/constants.html#None
445 https://docs.python.org/3.7/library/functions.html#float
446 https://docs.python.org/3.7/library/constants.html#None
447 https://docs.python.org/3.7/library/functions.html#int
448 https://docs.python.org/3.7/library/stdtypes.html#str
449 https://docs.python.org/3.7/library/functions.html#int
450 https://docs.python.org/3.7/library/constants.html#None

more information (this is an advanced feature which most users can ignore).

Note: Note that this class does not currently work with *PiGPIOFactory* (page 241).

play(*tone*)
Play the given *tone*. This can either be an instance of *Tone* (page 217) or can be anything that could be used to construct an instance of *Tone* (page 217).

For example:

```
>>> from gpiozero import TonalBuzzer
>>> from gpiozero.tones import Tone
>>> b = TonalBuzzer(17)
>>> b.play(Tone("A4"))
>>> b.play(Tone(220.0)) # Hz
>>> b.play(Tone(60)) # middle C in MIDI notation
>>> b.play("A4")
>>> b.play(220.0)
>>> b.play(60)
```

stop()
Turn the buzzer off. This is equivalent to setting *value* (page 132) to None[451].

is_active
Returns True[452] if the buzzer is currently playing, otherwise False[453].

max_tone
The highest tone that the buzzer can play, i.e. the tone played when *value* (page 132) is 1.

mid_tone
The middle tone available, i.e. the tone played when *value* (page 132) is 0.

min_tone
The lowest tone that the buzzer can play, i.e. the tone played when *value* (page 132) is -1.

octaves
The number of octaves available (above and below mid_tone).

tone
Returns the *Tone* (page 217) that the buzzer is currently playing, or None[454] if the buzzer is silent. This property can also be set to play the specified tone.

value
Represents the state of the buzzer as a value between -1 (representing the minimum tone) and 1 (representing the maximum tone). This can also be the special value None[455] indicating that the buzzer is currently silent.

14.1.6 Motor

class gpiozero.Motor(*forward, backward, *, pwm=True, pin_factory=None*)
Extends *CompositeDevice* (page 185) and represents a generic motor connected to a bi-directional motor driver circuit (i.e. an H-bridge[456]).

[451] https://docs.python.org/3.7/library/constants.html#None
[452] https://docs.python.org/3.7/library/constants.html#True
[453] https://docs.python.org/3.7/library/constants.html#False
[454] https://docs.python.org/3.7/library/constants.html#None
[455] https://docs.python.org/3.7/library/constants.html#None
[456] https://en.wikipedia.org/wiki/H_bridge

Attach an H-bridge[457] motor controller to your Pi; connect a power source (e.g. a battery pack or the 5V pin) to the controller; connect the outputs of the controller board to the two terminals of the motor; connect the inputs of the controller board to two GPIO pins.

The following code will make the motor turn "forwards":

```
from gpiozero import Motor

motor = Motor(17, 18)
motor.forward()
```

Parameters

- **forward** (*int*[458] *or* *str*[459]) – The GPIO pin that the forward input of the motor driver chip is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[460] a *GPIODeviceError* (page 247) will be raised.
- **backward** (*int*[461] *or* *str*[462]) – The GPIO pin that the backward input of the motor driver chip is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[463] a *GPIODeviceError* (page 247) will be raised.
- **enable** (*int*[464] *or* *str*[465] *or* *None*[466]) – The GPIO pin that enables the motor. Required for *some* motor controller boards. See *Pin Numbering* (page 3) for valid pin numbers.
- **pwm** (*bool*[467]) – If True[468] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller pins, allowing both direction and variable speed control. If False[469], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or* *None*[470]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

backward(*speed=1*)

Drive the motor backwards.

Parameters **speed** (*float*[471]) – The speed at which the motor should turn. Can be any value between 0 (stopped) and the default 1 (maximum speed) if *pwm* was True[472] when the class was constructed (and only 0 or 1 if not).

forward(*speed=1*)

Drive the motor forwards.

Parameters **speed** (*float*[473]) – The speed at which the motor should turn. Can be any value between 0 (stopped) and the default 1 (maximum speed) if *pwm* was True[474] when the class was constructed (and only 0 or 1 if not).

[457] https://en.wikipedia.org/wiki/H_bridge
[458] https://docs.python.org/3.7/library/functions.html#int
[459] https://docs.python.org/3.7/library/stdtypes.html#str
[460] https://docs.python.org/3.7/library/constants.html#None
[461] https://docs.python.org/3.7/library/functions.html#int
[462] https://docs.python.org/3.7/library/stdtypes.html#str
[463] https://docs.python.org/3.7/library/constants.html#None
[464] https://docs.python.org/3.7/library/functions.html#int
[465] https://docs.python.org/3.7/library/stdtypes.html#str
[466] https://docs.python.org/3.7/library/constants.html#None
[467] https://docs.python.org/3.7/library/functions.html#bool
[468] https://docs.python.org/3.7/library/constants.html#True
[469] https://docs.python.org/3.7/library/constants.html#False
[470] https://docs.python.org/3.7/library/constants.html#None
[471] https://docs.python.org/3.7/library/functions.html#float
[472] https://docs.python.org/3.7/library/constants.html#True
[473] https://docs.python.org/3.7/library/functions.html#float
[474] https://docs.python.org/3.7/library/constants.html#True

reverse()
Reverse the current direction of the motor. If the motor is currently idle this does nothing. Otherwise, the motor's direction will be reversed at the current speed.

stop()
Stop the motor.

is_active
Returns True[475] if the motor is currently running and False[476] otherwise.

value
Represents the speed of the motor as a floating point value between -1 (full speed backward) and 1 (full speed forward), with 0 representing stopped.

14.1.7 PhaseEnableMotor

class gpiozero.**PhaseEnableMotor**(*phase*, *enable*, ***, *pwm=True*, *pin_factory=None*)
Extends *CompositeDevice* (page 185) and represents a generic motor connected to a Phase/Enable motor driver circuit; the phase of the driver controls whether the motor turns forwards or backwards, while enable controls the speed with PWM.

The following code will make the motor turn "forwards":

```
from gpiozero import PhaseEnableMotor
motor = PhaseEnableMotor(12, 5)
motor.forward()
```

Parameters

- **phase** (*int*[477] *or* *str*[478]) – The GPIO pin that the phase (direction) input of the motor driver chip is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[479] a *GPIODeviceError* (page 247) will be raised.
- **enable** (*int*[480] *or* *str*[481]) – The GPIO pin that the enable (speed) input of the motor driver chip is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[482] a *GPIODeviceError* (page 247) will be raised.
- **pwm** (*bool*[483]) – If True[484] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller pins, allowing both direction and variable speed control. If False[485], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or* *None*[486]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

backward(*speed=1*)
Drive the motor backwards.

Parameters speed (*float*[487]) – The speed at which the motor should turn. Can be any value between 0 (stopped) and the default 1 (maximum speed).

[475] https://docs.python.org/3.7/library/constants.html#True
[476] https://docs.python.org/3.7/library/constants.html#False
[477] https://docs.python.org/3.7/library/functions.html#int
[478] https://docs.python.org/3.7/library/stdtypes.html#str
[479] https://docs.python.org/3.7/library/constants.html#None
[480] https://docs.python.org/3.7/library/functions.html#int
[481] https://docs.python.org/3.7/library/stdtypes.html#str
[482] https://docs.python.org/3.7/library/constants.html#None
[483] https://docs.python.org/3.7/library/functions.html#bool
[484] https://docs.python.org/3.7/library/constants.html#True
[485] https://docs.python.org/3.7/library/constants.html#False
[486] https://docs.python.org/3.7/library/constants.html#None
[487] https://docs.python.org/3.7/library/functions.html#float

forward(*speed=1*)
Drive the motor forwards.

Parameters speed (*float*[488]) – The speed at which the motor should turn. Can be any value between 0 (stopped) and the default 1 (maximum speed).

reverse()
Reverse the current direction of the motor. If the motor is currently idle this does nothing. Otherwise, the motor's direction will be reversed at the current speed.

stop()
Stop the motor.

is_active
Returns True[489] if the motor is currently running and False[490] otherwise.

value
Represents the speed of the motor as a floating point value between -1 (full speed backward) and 1 (full speed forward).

14.1.8 Servo

class gpiozero.**Servo**(*pin*, ***, *initial_value=0*, *min_pulse_width=1/1000*, *max_pulse_width=2/1000*, *frame_width=20/1000*, *pin_factory=None*)
Extends *CompositeDevice* (page 185) and represents a PWM-controlled servo motor connected to a GPIO pin.

Connect a power source (e.g. a battery pack or the 5V pin) to the power cable of the servo (this is typically colored red); connect the ground cable of the servo (typically colored black or brown) to the negative of your battery pack, or a GND pin; connect the final cable (typically colored white or orange) to the GPIO pin you wish to use for controlling the servo.

The following code will make the servo move between its minimum, maximum, and mid-point positions with a pause between each:

```
from gpiozero import Servo
from time import sleep

servo = Servo(17)

while True:
    servo.min()
    sleep(1)
    servo.mid()
    sleep(1)
    servo.max()
    sleep(1)
```

You can also use the *value* (page 136) property to move the servo to a particular position, on a scale from -1 (min) to 1 (max) where 0 is the mid-point:

```
from gpiozero import Servo

servo = Servo(17)

servo.value = 0.5
```

488 https://docs.python.org/3.7/library/functions.html#float
489 https://docs.python.org/3.7/library/constants.html#True
490 https://docs.python.org/3.7/library/constants.html#False

Note: To reduce servo jitter, use the pigpio pin driver rather than the default RPi.GPIO driver (pigpio uses DMA sampling for much more precise edge timing). See *Changing the pin factory* (page 227) for further information.

Parameters

- **pin** (*int*[491] *or str*[492]) – The GPIO pin that the servo is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[493] a *GPIODeviceError* (page 247) will be raised.
- **initial_value** (*float*[494]) – If `0` (the default), the device's mid-point will be set initially. Other values between -1 and +1 can be specified as an initial position. `None`[495] means to start the servo un-controlled (see *value* (page 136)).
- **min_pulse_width** (*float*[496]) – The pulse width corresponding to the servo's minimum position. This defaults to 1ms.
- **max_pulse_width** (*float*[497]) – The pulse width corresponding to the servo's maximum position. This defaults to 2ms.
- **frame_width** (*float*[498]) – The length of time between servo control pulses measured in seconds. This defaults to 20ms which is a common value for servos.
- **pin_factory** (`Factory` (page 230) *or None*[499]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

detach()
Temporarily disable control of the servo. This is equivalent to setting *value* (page 136) to `None`[500].

max()
Set the servo to its maximum position.

mid()
Set the servo to its mid-point position.

min()
Set the servo to its minimum position.

frame_width
The time between control pulses, measured in seconds.

is_active
Composite devices are considered "active" if any of their constituent devices have a "truthy" value.

max_pulse_width
The control pulse width corresponding to the servo's maximum position, measured in seconds.

min_pulse_width
The control pulse width corresponding to the servo's minimum position, measured in seconds.

pulse_width
Returns the current pulse width controlling the servo.

[491] https://docs.python.org/3.7/library/functions.html#int
[492] https://docs.python.org/3.7/library/stdtypes.html#str
[493] https://docs.python.org/3.7/library/constants.html#None
[494] https://docs.python.org/3.7/library/functions.html#float
[495] https://docs.python.org/3.7/library/constants.html#None
[496] https://docs.python.org/3.7/library/functions.html#float
[497] https://docs.python.org/3.7/library/functions.html#float
[498] https://docs.python.org/3.7/library/functions.html#float
[499] https://docs.python.org/3.7/library/constants.html#None
[500] https://docs.python.org/3.7/library/constants.html#None

value
Represents the position of the servo as a value between -1 (the minimum position) and +1 (the maximum position). This can also be the special value `None`[501] indicating that the servo is currently "uncontrolled", i.e. that no control signal is being sent. Typically this means the servo's position remains unchanged, but that it can be moved by hand.

14.1.9 AngularServo

class gpiozero.AngularServo(*pin*, ***, *initial_angle=0*, *min_angle=-90*, *max_angle=90*, *min_pulse_width=1/1000*, *max_pulse_width=2/1000*, *frame_width=20/1000*, *pin_factory=None*)

Extends *Servo* (page 135) and represents a rotational PWM-controlled servo motor which can be set to particular angles (assuming valid minimum and maximum angles are provided to the constructor).

Connect a power source (e.g. a battery pack or the 5V pin) to the power cable of the servo (this is typically colored red); connect the ground cable of the servo (typically colored black or brown) to the negative of your battery pack, or a GND pin; connect the final cable (typically colored white or orange) to the GPIO pin you wish to use for controlling the servo.

Next, calibrate the angles that the servo can rotate to. In an interactive Python session, construct a *Servo* (page 135) instance. The servo should move to its mid-point by default. Set the servo to its minimum value, and measure the angle from the mid-point. Set the servo to its maximum value, and again measure the angle:

```
>>> from gpiozero import Servo
>>> s = Servo(17)
>>> s.min() # measure the angle
>>> s.max() # measure the angle
```

You should now be able to construct an *AngularServo* (page 137) instance with the correct bounds:

```
>>> from gpiozero import AngularServo
>>> s = AngularServo(17, min_angle=-42, max_angle=44)
>>> s.angle = 0.0
>>> s.angle
0.0
>>> s.angle = 15
>>> s.angle
15.0
```

Note: You can set *min_angle* greater than *max_angle* if you wish to reverse the sense of the angles (e.g. `min_angle=45, max_angle=-45`). This can be useful with servos that rotate in the opposite direction to your expectations of minimum and maximum.

Parameters

- **pin** (*int*[502] *or* *str*[503]) – The GPIO pin that the servo is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[504] a *GPIODeviceError* (page 247) will be raised.
- **initial_angle** (*float*[505]) – Sets the servo's initial angle to the specified value. The default is 0. The value specified must be between *min_angle* and *max_angle*

[501] https://docs.python.org/3.7/library/constants.html#None
[502] https://docs.python.org/3.7/library/functions.html#int
[503] https://docs.python.org/3.7/library/stdtypes.html#str
[504] https://docs.python.org/3.7/library/constants.html#None
[505] https://docs.python.org/3.7/library/functions.html#float

inclusive. None[506] means to start the servo un-controlled (see *value* (page 138)).

- **min_angle** (*float*[507]) – Sets the minimum angle that the servo can rotate to. This defaults to -90, but should be set to whatever you measure from your servo during calibration.
- **max_angle** (*float*[508]) – Sets the maximum angle that the servo can rotate to. This defaults to 90, but should be set to whatever you measure from your servo during calibration.
- **min_pulse_width** (*float*[509]) – The pulse width corresponding to the servo's minimum position. This defaults to 1ms.
- **max_pulse_width** (*float*[510]) – The pulse width corresponding to the servo's maximum position. This defaults to 2ms.
- **frame_width** (*float*[511]) – The length of time between servo control pulses measured in seconds. This defaults to 20ms which is a common value for servos.
- **pin_factory** (Factory (page 230) *or None*[512]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

max()
Set the servo to its maximum position.

mid()
Set the servo to its mid-point position.

min()
Set the servo to its minimum position.

angle
The position of the servo as an angle measured in degrees. This will only be accurate if *min_angle* (page 138) and *max_angle* (page 138) have been set appropriately in the constructor.

This can also be the special value None[513] indicating that the servo is currently "uncontrolled", i.e. that no control signal is being sent. Typically this means the servo's position remains unchanged, but that it can be moved by hand.

is_active
Composite devices are considered "active" if any of their constituent devices have a "truthy" value.

max_angle
The maximum angle that the servo will rotate to when *max()* (page 138) is called.

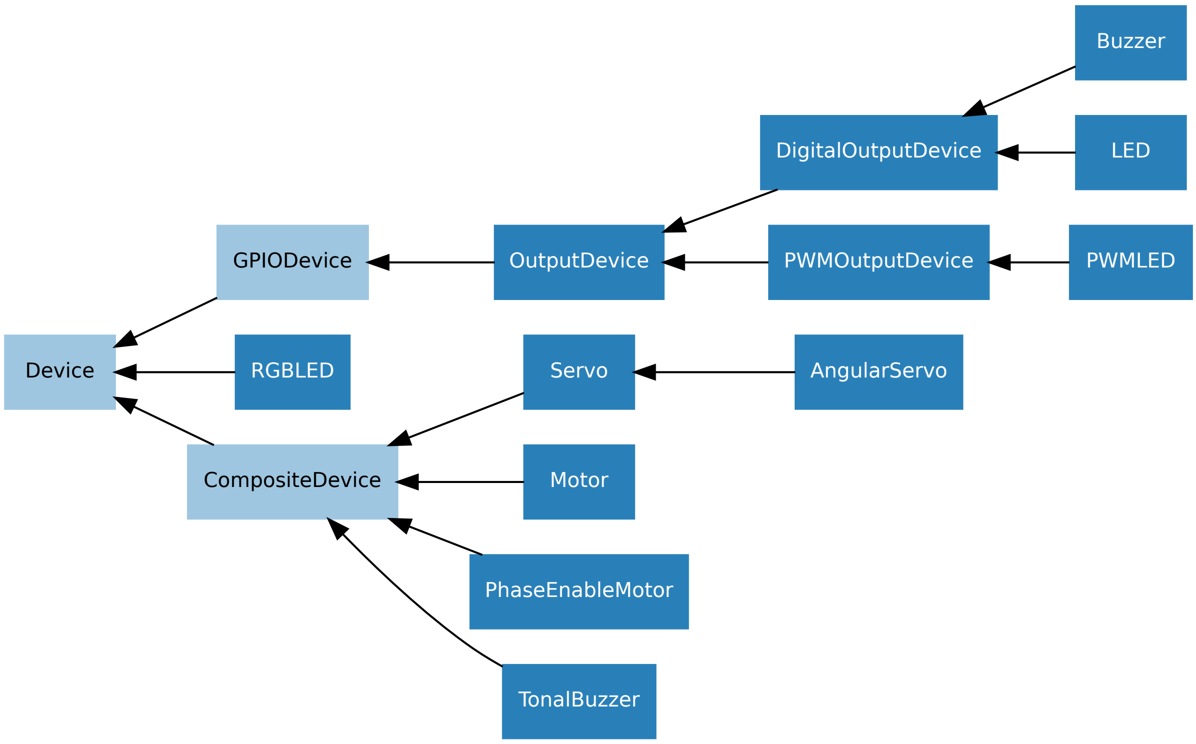
min_angle
The minimum angle that the servo will rotate to when *min()* (page 138) is called.

value
Represents the position of the servo as a value between -1 (the minimum position) and +1 (the maximum position). This can also be the special value None[514] indicating that the servo is currently "uncontrolled", i.e. that no control signal is being sent. Typically this means the servo's position remains unchanged, but that it can be moved by hand.

[506] https://docs.python.org/3.7/library/constants.html#None
[507] https://docs.python.org/3.7/library/functions.html#float
[508] https://docs.python.org/3.7/library/functions.html#float
[509] https://docs.python.org/3.7/library/functions.html#float
[510] https://docs.python.org/3.7/library/functions.html#float
[511] https://docs.python.org/3.7/library/functions.html#float
[512] https://docs.python.org/3.7/library/constants.html#None
[513] https://docs.python.org/3.7/library/constants.html#None
[514] https://docs.python.org/3.7/library/constants.html#None

14.2 Base Classes

The classes in the sections above are derived from a series of base classes, some of which are effectively abstract. The classes form the (partial) hierarchy displayed in the graph below (abstract classes are shaded lighter than concrete classes):



The following sections document these base classes for advanced users that wish to construct classes for their own devices.

14.2.1 DigitalOutputDevice

class gpiozero.DigitalOutputDevice(*pin*, ***, *active_high=True*, *initial_value=False*, *pin_factory=None*)

Represents a generic output device with typical on/off behaviour.

This class extends *OutputDevice* (page 142) with a *blink()* (page 140) method which uses an optional background thread to handle toggling the device state without further interaction.

Parameters

- **pin** (*int*[515] *or str*[516]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[517] a *GPIODeviceError* (page 247) will be raised.
- **active_high** (*bool*[518]) – If `True`[519] (the default), the *on()* (page 140) method will set the GPIO to HIGH. If `False`[520], the *on()* (page 140) method will set the GPIO to LOW (the *off()* (page 140) method always does the opposite).

[515] https://docs.python.org/3.7/library/functions.html#int
[516] https://docs.python.org/3.7/library/stdtypes.html#str
[517] https://docs.python.org/3.7/library/constants.html#None
[518] https://docs.python.org/3.7/library/functions.html#bool
[519] https://docs.python.org/3.7/library/constants.html#True
[520] https://docs.python.org/3.7/library/constants.html#False

- **initial_value** (*bool*[521] *or None*[522]) – If `False`[523] (the default), the device will be off initially. If `None`[524], the device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If `True`[525], the device will be switched on initially.
- **pin_factory** (`Factory` (page 230) *or None*[526]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

blink(*on_time=1*, *off_time=1*, *n=None*, *background=True*)
Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[527]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[528]) – Number of seconds off. Defaults to 1 second.
- **n** (*int*[529] *or None*[530]) – Number of times to blink; `None`[531] (the default) means forever.
- **background** (*bool*[532]) – If `True`[533] (the default), start a background thread to continue blinking and return immediately. If `False`[534], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turns the device off.

on()
Turns the device on.

value
Returns 1 if the device is currently active and 0 otherwise. Setting this property changes the state of the device.

14.2.2 PWMOutputDevice

class gpiozero.PWMOutputDevice(*pin*, ***, *active_high=True*, *initial_value=0*, *frequency=100*, *pin_factory=None*)
Generic output device configured for pulse-width modulation (PWM).

Parameters

- **pin** (*int*[535] *or str*[536]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is `None`[537] a *GPIODeviceError* (page 247) will be raised.

521 https://docs.python.org/3.7/library/functions.html#bool
522 https://docs.python.org/3.7/library/constants.html#None
523 https://docs.python.org/3.7/library/constants.html#False
524 https://docs.python.org/3.7/library/constants.html#None
525 https://docs.python.org/3.7/library/constants.html#True
526 https://docs.python.org/3.7/library/constants.html#None
527 https://docs.python.org/3.7/library/functions.html#float
528 https://docs.python.org/3.7/library/functions.html#float
529 https://docs.python.org/3.7/library/functions.html#int
530 https://docs.python.org/3.7/library/constants.html#None
531 https://docs.python.org/3.7/library/constants.html#None
532 https://docs.python.org/3.7/library/functions.html#bool
533 https://docs.python.org/3.7/library/constants.html#True
534 https://docs.python.org/3.7/library/constants.html#False
535 https://docs.python.org/3.7/library/functions.html#int
536 https://docs.python.org/3.7/library/stdtypes.html#str
537 https://docs.python.org/3.7/library/constants.html#None

- **active_high** (*bool*[538]) – If True[539] (the default), the *on()* (page 141) method will set the GPIO to HIGH. If False[540], the *on()* (page 141) method will set the GPIO to LOW (the *off()* (page 141) method always does the opposite).
- **initial_value** (*float*[541]) – If 0 (the default), the device's duty cycle will be 0 initially. Other values between 0 and 1 can be specified as an initial duty cycle. Note that None[542] cannot be specified (unlike the parent class) as there is no way to tell PWM not to alter the state of the pin.
- **frequency** (*int*[543]) – The frequency (in Hz) of pulses emitted to drive the device. Defaults to 100Hz.
- **pin_factory** (Factory (page 230) *or None*[544]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

blink(*on_time=1, off_time=1, fade_in_time=0, fade_out_time=0, n=None, background=True*)
Make the device turn on and off repeatedly.

Parameters

- **on_time** (*float*[545]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[546]) – Number of seconds off. Defaults to 1 second.
- **fade_in_time** (*float*[547]) – Number of seconds to spend fading in. Defaults to 0.
- **fade_out_time** (*float*[548]) – Number of seconds to spend fading out. Defaults to 0.
- **n** (*int*[549] *or None*[550]) – Number of times to blink; None[551] (the default) means forever.
- **background** (*bool*[552]) – If True[553] (the default), start a background thread to continue blinking and return immediately. If False[554], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off()
Turns the device off.

on()
Turns the device on.

pulse(*fade_in_time=1, fade_out_time=1, n=None, background=True*)
Make the device fade in and out repeatedly.

Parameters

538 https://docs.python.org/3.7/library/functions.html#bool
539 https://docs.python.org/3.7/library/constants.html#True
540 https://docs.python.org/3.7/library/constants.html#False
541 https://docs.python.org/3.7/library/functions.html#float
542 https://docs.python.org/3.7/library/constants.html#None
543 https://docs.python.org/3.7/library/functions.html#int
544 https://docs.python.org/3.7/library/constants.html#None
545 https://docs.python.org/3.7/library/functions.html#float
546 https://docs.python.org/3.7/library/functions.html#float
547 https://docs.python.org/3.7/library/functions.html#float
548 https://docs.python.org/3.7/library/functions.html#float
549 https://docs.python.org/3.7/library/functions.html#int
550 https://docs.python.org/3.7/library/constants.html#None
551 https://docs.python.org/3.7/library/constants.html#None
552 https://docs.python.org/3.7/library/functions.html#bool
553 https://docs.python.org/3.7/library/constants.html#True
554 https://docs.python.org/3.7/library/constants.html#False

- **fade_in_time** (*float*[555]) – Number of seconds to spend fading in. Defaults to 1.
- **fade_out_time** (*float*[556]) – Number of seconds to spend fading out. Defaults to 1.
- **n** (*int*[557] *or None*[558]) – Number of times to pulse; None[559] (the default) means forever.
- **background** (*bool*[560]) – If True[561] (the default), start a background thread to continue pulsing and return immediately. If False[562], only return when the pulse is finished (warning: the default value of *n* will result in this method never returning).

toggle()
Toggle the state of the device. If the device is currently off (*value* (page 142) is 0.0), this changes it to "fully" on (*value* (page 142) is 1.0). If the device has a duty cycle (*value* (page 142)) of 0.1, this will toggle it to 0.9, and so on.

frequency
The frequency of the pulses used with the PWM device, in Hz. The default is 100Hz.

is_active
Returns True[563] if the device is currently active (*value* (page 142) is non-zero) and False[564] otherwise.

value
The duty cycle of the PWM device. 0.0 is off, 1.0 is fully on. Values in between may be specified for varying levels of power in the device.

14.2.3 OutputDevice

class gpiozero.OutputDevice(*pin*, ***, *active_high=True*, *initial_value=False*, *pin_factory=None*)
Represents a generic GPIO output device.

This class extends *GPIODevice* (page 121) to add facilities common to GPIO output devices: an *on()* (page 143) method to switch the device on, a corresponding *off()* (page 143) method, and a *toggle()* (page 143) method.

Parameters

- **pin** (*int*[565] *or str*[566]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[567] a *GPIODeviceError* (page 247) will be raised.
- **active_high** (*bool*[568]) – If True[569] (the default), the *on()* (page 143) method will set the GPIO to HIGH. If False[570], the *on()* (page 143) method will set the GPIO to LOW (the *off()* (page 143) method always does the opposite).

555 https://docs.python.org/3.7/library/functions.html#float
556 https://docs.python.org/3.7/library/functions.html#float
557 https://docs.python.org/3.7/library/functions.html#int
558 https://docs.python.org/3.7/library/constants.html#None
559 https://docs.python.org/3.7/library/constants.html#None
560 https://docs.python.org/3.7/library/functions.html#bool
561 https://docs.python.org/3.7/library/constants.html#True
562 https://docs.python.org/3.7/library/constants.html#False
563 https://docs.python.org/3.7/library/constants.html#True
564 https://docs.python.org/3.7/library/constants.html#False
565 https://docs.python.org/3.7/library/functions.html#int
566 https://docs.python.org/3.7/library/stdtypes.html#str
567 https://docs.python.org/3.7/library/constants.html#None
568 https://docs.python.org/3.7/library/functions.html#bool
569 https://docs.python.org/3.7/library/constants.html#True
570 https://docs.python.org/3.7/library/constants.html#False

- **initial_value** (*bool*[571] *or None*[572]) – If False[573] (the default), the device will be off initially. If None[574], the device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[575], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[576]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

off()
Turns the device off.

on()
Turns the device on.

toggle()
Reverse the state of the device. If it's on, turn it off; if it's off, turn it on.

active_high
When True[577], the *value* (page 143) property is True[578] when the device's *pin* (page 122) is high. When False[579] the *value* (page 143) property is True[580] when the device's pin is low (i.e. the value is inverted).

This property can be set after construction; be warned that changing it will invert *value* (page 143) (i.e. changing this property doesn't change the device's pin state - it just changes how that state is interpreted).

value
Returns 1 if the device is currently active and 0 otherwise. Setting this property changes the state of the device.

14.2.4 GPIODevice

class gpiozero.GPIODevice(*pin*, ***, *pin_factory=None*)
Extends *Device* (page 201). Represents a generic GPIO device and provides the services common to all single-pin GPIO devices (like ensuring two GPIO devices do no share a *pin* (page 122)).

Parameters pin (*int*[581] *or str*[582]) – The GPIO pin that the device is connected to. See *Pin Numbering* (page 3) for valid pin numbers. If this is None[583] a *GPIODeviceError* (page 247) will be raised. If the pin is already in use by another device, *GPIOPinInUse* (page 247) will be raised.

close()
Shut down the device and release all associated resources (such as GPIO pins).

This method is idempotent (can be called on an already closed device without any side-effects). It is primarily intended for interactive use at the command line. It disables the device and releases its pin(s) for use by another device.

You can attempt to do this simply by deleting an object, but unless you've cleaned up all references to the object this may not work (even if you've cleaned up all references, there's still no guarantee the garbage collector will actually delete the object at that point). By contrast, the close method provides a means of ensuring that the object is shut down.

[571] https://docs.python.org/3.7/library/functions.html#bool
[572] https://docs.python.org/3.7/library/constants.html#None
[573] https://docs.python.org/3.7/library/constants.html#False
[574] https://docs.python.org/3.7/library/constants.html#None
[575] https://docs.python.org/3.7/library/constants.html#True
[576] https://docs.python.org/3.7/library/constants.html#None
[577] https://docs.python.org/3.7/library/constants.html#True
[578] https://docs.python.org/3.7/library/constants.html#True
[579] https://docs.python.org/3.7/library/constants.html#False
[580] https://docs.python.org/3.7/library/constants.html#True
[581] https://docs.python.org/3.7/library/functions.html#int
[582] https://docs.python.org/3.7/library/stdtypes.html#str
[583] https://docs.python.org/3.7/library/constants.html#None

For example, if you have a breadboard with a buzzer connected to pin 16, but then wish to attach an LED instead:

```
>>> from gpiozero import *
>>> bz = Buzzer(16)
>>> bz.on()
>>> bz.off()
>>> bz.close()
>>> led = LED(16)
>>> led.blink()
```

Device (page 201) descendents can also be used as context managers using the `with`[584] statement. For example:

```
>>> from gpiozero import *
>>> with Buzzer(16) as bz:
...     bz.on()
...
>>> with LED(16) as led:
...     led.on()
...
```

closed
Returns `True`[585] if the device is closed (see the *close()* (page 121) method). Once a device is closed you can no longer use any other methods or properties to control or query the device.

pin
The *Pin* (page 231) that the device is connected to. This will be `None`[586] if the device has been closed (see the *close()* (page 201) method). When dealing with GPIO pins, query `pin.number` to discover the GPIO pin (in BCM numbering) that the device is connected to.

value
Returns a value representing the device's state. Frequently, this is a boolean value, or a number between 0 and 1 but some devices use larger ranges (e.g. -1 to +1) and composite devices usually use tuples to return the states of all their subordinate components.

[584] https://docs.python.org/3.7/reference/compound_stmts.html#with
[585] https://docs.python.org/3.7/library/constants.html#True
[586] https://docs.python.org/3.7/library/constants.html#None

CHAPTER 15

API - SPI Devices

SPI stands for Serial Peripheral Interface[587] and is a mechanism allowing compatible devices to communicate with the Pi. SPI is a four-wire protocol meaning it usually requires four pins to operate:

- A "clock" pin which provides timing information.
- A "MOSI" pin (Master Out, Slave In) which the Pi uses to send information to the device.
- A "MISO" pin (Master In, Slave Out) which the Pi uses to receive information from the device.
- A "select" pin which the Pi uses to indicate which device it's talking to. This last pin is necessary because multiple devices can share the clock, MOSI, and MISO pins, but only one device can be connected to each select pin.

The gpiozero library provides two SPI implementations:

- A software based implementation. This is always available, can use any four GPIO pins for SPI communication, but is rather slow and won't work with all devices.
- A hardware based implementation. This is only available when the SPI kernel module is loaded, and the Python spidev library is available. It can only use specific pins for SPI communication (GPIO11=clock, GPIO10=MOSI, GPIO9=MISO, while GPIO8 is select for device 0 and GPIO7 is select for device 1). However, it is extremely fast and works with all devices.

15.1 SPI keyword args

When constructing an SPI device there are two schemes for specifying which pins it is connected to:

- You can specify *port* and *device* keyword arguments. The *port* parameter must be 0 (there is only one user-accessible hardware SPI interface on the Pi using GPIO11 as the clock pin, GPIO10 as the MOSI pin, and GPIO9 as the MISO pin), while the *device* parameter must be 0 or 1. If *device* is 0, the select pin will be GPIO8. If *device* is 1, the select pin will be GPIO7.
- Alternatively you can specify *clock_pin*, *mosi_pin*, *miso_pin*, and *select_pin* keyword arguments. In this case the pins can be any 4 GPIO pins (remember that SPI devices can share clock, MOSI, and MISO pins, but not select pins - the gpiozero library will enforce this restriction).

[587] https://en.wikipedia.org/wiki/Serial_Peripheral_Interface_Bus

You cannot mix these two schemes, i.e. attempting to specify *port* and *clock_pin* will result in *SPIBadArgs* (page 247) being raised. However, you can omit any arguments from either scheme. The defaults are:

- *port* and *device* both default to 0.
- *clock_pin* defaults to 11, *mosi_pin* defaults to 10, *miso_pin* defaults to 9, and *select_pin* defaults to 8.
- As with other GPIO based devices you can optionally specify a *pin_factory* argument overriding the default pin factory (see *API - Pins* (page 225) for more information).

Hence the following constructors are all equivalent:

```
from gpiozero import MCP3008

MCP3008(channel=0)
MCP3008(channel=0, device=0)
MCP3008(channel=0, port=0, device=0)
MCP3008(channel=0, select_pin=8)
MCP3008(channel=0, clock_pin=11, mosi_pin=10, miso_pin=9, select_pin=8)
```

Note that the defaults describe equivalent sets of pins and that these pins are compatible with the hardware implementation. Regardless of which scheme you use, gpiozero will attempt to use the hardware implementation if it is available and if the selected pins are compatible, falling back to the software implementation if not.

15.2 Analog to Digital Converters (ADC)

The following classes are intended for general use with the integrated circuits they are named after. All classes in this section are concrete (not abstract).

15.2.1 MCP3001

class gpiozero.MCP3001(*max_voltage=3.3*, ***spi_args*)

The MCP3001[588] is a 10-bit analog to digital converter with 1 channel. Please note that the MCP3001 always operates in differential mode, measuring the value of IN+ relative to IN-.

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.2 MCP3002

class gpiozero.MCP3002(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)

The MCP3002[589] is a 10-bit analog to digital converter with 2 channels (0-1).

channel

The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential

If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

[588] http://www.farnell.com/datasheets/630400.pdf
[589] http://www.farnell.com/datasheets/1599363.pdf

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.3 MCP3004

class gpiozero.MCP3004(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)
The MCP3004[590] is a 10-bit analog to digital converter with 4 channels (0-3).

channel
The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential
If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.4 MCP3008

class gpiozero.MCP3008(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)
The MCP3008[591] is a 10-bit analog to digital converter with 8 channels (0-7).

channel
The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential
If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

[590] http://www.farnell.com/datasheets/808965.pdf
[591] http://www.farnell.com/datasheets/808965.pdf

15.2.5 MCP3201

`class gpiozero.MCP3201(max_voltage=3.3, **spi_args)`

The MCP3201[592] is a 12-bit analog to digital converter with 1 channel. Please note that the MCP3201 always operates in differential mode, measuring the value of IN+ relative to IN-.

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.6 MCP3202

`class gpiozero.MCP3202(channel=0, differential=False, max_voltage=3.3, **spi_args)`

The MCP3202[593] is a 12-bit analog to digital converter with 2 channels (0-1).

channel

The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential

If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.7 MCP3204

`class gpiozero.MCP3204(channel=0, differential=False, max_voltage=3.3, **spi_args)`

The MCP3204[594] is a 12-bit analog to digital converter with 4 channels (0-3).

channel

The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential

If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

[592] http://www.farnell.com/datasheets/1669366.pdf
[593] http://www.farnell.com/datasheets/1669376.pdf
[594] http://www.farnell.com/datasheets/808967.pdf

15.2.8 MCP3208

class gpiozero.**MCP3208**(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)

The MCP3208[595] is a 12-bit analog to digital converter with 8 channels (0-7).

channel

The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential

If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3008* (page 147) in differential mode, channel 0 is read relative to channel 1).

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

15.2.9 MCP3301

class gpiozero.**MCP3301**(*max_voltage=3.3*, ***spi_args*)

The MCP3301[596] is a signed 13-bit analog to digital converter. Please note that the MCP3301 always operates in differential mode measuring the difference between IN+ and IN-. Its output value is scaled from -1 to +1.

value

The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for devices operating in differential mode).

15.2.10 MCP3302

class gpiozero.**MCP3302**(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)

The MCP3302[597] is a 12/13-bit analog to digital converter with 4 channels (0-3). When operated in differential mode, the device outputs a signed 13-bit value which is scaled from -1 to +1. When operated in single-ended mode (the default), the device outputs an unsigned 12-bit value scaled from 0 to 1.

channel

The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential

If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3304* (page 150) in differential mode, channel 0 is read relative to channel 1).

[595] http://www.farnell.com/datasheets/808967.pdf
[596] http://www.farnell.com/datasheets/1669397.pdf
[597] http://www.farnell.com/datasheets/1486116.pdf

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for devices operating in differential mode).

15.2.11 MCP3304

class gpiozero.MCP3304(*channel=0*, *differential=False*, *max_voltage=3.3*, ***spi_args*)
The MCP3304[598] is a 12/13-bit analog to digital converter with 8 channels (0-7). When operated in differential mode, the device outputs a signed 13-bit value which is scaled from -1 to +1. When operated in single-ended mode (the default), the device outputs an unsigned 12-bit value scaled from 0 to 1.

channel
The channel to read data from. The MCP3008/3208/3304 have 8 channels (0-7), while the MCP3004/3204/3302 have 4 channels (0-3), the MCP3002/3202 have 2 channels (0-1), and the MCP3001/3201/3301 only have 1 channel.

differential
If `True`, the device is operated in differential mode. In this mode one channel (specified by the channel attribute) is read relative to the value of a second channel (implied by the chip's design).

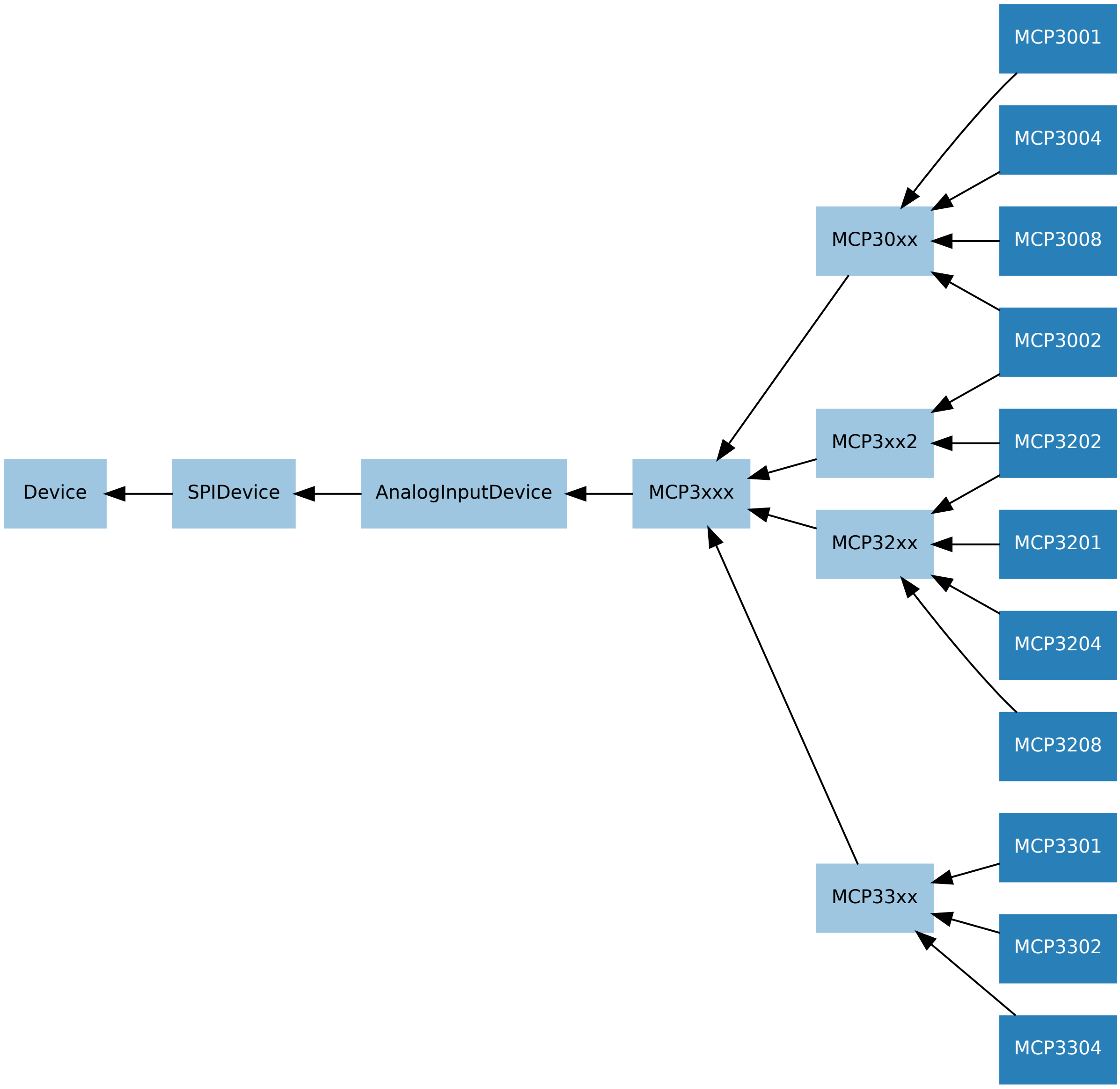
Please refer to the device data-sheet to determine which channel is used as the relative base value (for example, when using an *MCP3304* (page 150) in differential mode, channel 0 is read relative to channel 1).

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for devices operating in differential mode).

15.3 Base Classes

The classes in the sections above are derived from a series of base classes, some of which are effectively abstract. The classes form the (partial) hierarchy displayed in the graph below (abstract classes are shaded lighter than concrete classes):

598 http://www.farnell.com/datasheets/1486116.pdf



The following sections document these base classes for advanced users that wish to construct classes for their own devices.

15.3.1 AnalogInputDevice

class gpiozero.AnalogInputDevice(*bits*, *max_voltage=3.3*, ***spi_args*)

Represents an analog input device connected to SPI (serial interface).

Typical analog input devices are analog to digital converters[599] (ADCs). Several classes are provided for specific ADC chips, including *MCP3004* (page 147), *MCP3008* (page 147), *MCP3204* (page 148), and *MCP3208* (page 149).

The following code demonstrates reading the first channel of an MCP3008 chip attached to the Pi's SPI pins:

```
from gpiozero import MCP3008

pot = MCP3008(0)
print(pot.value)
```

599 https://en.wikipedia.org/wiki/Analog-to-digital_converter

The `value` (page 152) attribute is normalized such that its value is always between 0.0 and 1.0 (or in special cases, such as differential sampling, -1 to +1). Hence, you can use an analog input to control the brightness of a `PWMLED` (page 125) like so:

```
from gpiozero import MCP3008, PWMLED

pot = MCP3008(0)
led = PWMLED(17)
led.source = pot
```

The `voltage` (page 152) attribute reports values between 0.0 and *max_voltage* (which defaults to 3.3, the logic level of the GPIO pins).

bits
The bit-resolution of the device/channel.

max_voltage
The voltage required to set the device's value to 1.

raw_value
The raw value as read from the device.

value
The current value read from the device, scaled to a value between 0 and 1 (or -1 to +1 for certain devices operating in differential mode).

voltage
The current voltage read from the device. This will be a value between 0 and the *max_voltage* parameter specified in the constructor.

15.3.2 SPIDevice

class gpiozero.SPIDevice(*spi_args*)**
Extends `Device` (page 201). Represents a device that communicates via the SPI protocol.

See *SPI keyword args* (page 145) for information on the keyword arguments that can be specified with the constructor.

close()
Shut down the device and release all associated resources (such as GPIO pins).

This method is idempotent (can be called on an already closed device without any side-effects). It is primarily intended for interactive use at the command line. It disables the device and releases its pin(s) for use by another device.

You can attempt to do this simply by deleting an object, but unless you've cleaned up all references to the object this may not work (even if you've cleaned up all references, there's still no guarantee the garbage collector will actually delete the object at that point). By contrast, the close method provides a means of ensuring that the object is shut down.

For example, if you have a breadboard with a buzzer connected to pin 16, but then wish to attach an LED instead:

```
>>> from gpiozero import *
>>> bz = Buzzer(16)
>>> bz.on()
>>> bz.off()
>>> bz.close()
>>> led = LED(16)
>>> led.blink()
```

Device (page 201) descendents can also be used as context managers using the `with`[600] statement. For example:

```
>>> from gpiozero import *
>>> with Buzzer(16) as bz:
...     bz.on()
...
>>> with LED(16) as led:
...     led.on()
...
```

closed

Returns `True`[601] if the device is closed (see the *close()* (page 152) method). Once a device is closed you can no longer use any other methods or properties to control or query the device.

600 https://docs.python.org/3.7/reference/compound_stmts.html#with
601 https://docs.python.org/3.7/library/constants.html#True

CHAPTER 16

API - Boards and Accessories

These additional interfaces are provided to group collections of components together for ease of use, and as examples. They are composites made up of components from the various *API - Input Devices* (page 103) and *API - Output Devices* (page 123) provided by GPIO Zero. See those pages for more information on using components individually.

Note: All GPIO pin numbers use Broadcom (BCM) numbering by default. See the *Pin Numbering* (page 3) section for more information.

16.1 Regular Classes

The following classes are intended for general use with the devices they are named after. All classes in this section are concrete (not abstract).

16.1.1 LEDBoard

class gpiozero.LEDBoard(**pins, pwm=False, active_high=True, initial_value=False, pin_factory=None, **named_pins*)

Extends *LEDCollection* (page 184) and represents a generic LED board or collection of LEDs.

The following example turns on all the LEDs on a board containing 5 LEDs attached to GPIO pins 2 through 6:

```
from gpiozero import LEDBoard

leds = LEDBoard(2, 3, 4, 5, 6)
leds.on()
```

Parameters

- ***pins** – Specify the GPIO pins that the LEDs of the board are attached to. See *Pin Numbering* (page 3) for valid pin numbers. You can designate as many pins as necessary. You can also specify *LEDBoard* (page 155) instances to create trees of LEDs.

- **pwm** (*bool*[602]) – If `True`[603], construct *PWMLED* (page 125) instances for each pin. If `False`[604] (the default), construct regular *LED* (page 123) instances.
- **active_high** (*bool*[605]) – If `True`[606] (the default), the *on()* (page 157) method will set all the associated pins to HIGH. If `False`[607], the *on()* (page 157) method will set all pins to LOW (the *off()* (page 157) method always does the opposite).
- **initial_value** (*bool*[608] *or None*[609]) – If `False`[610] (the default), all LEDs will be off initially. If `None`[611], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If `True`[612], the device will be switched on initially.
- **pin_factory** (`Factory` (page 230) *or None*[613]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).
- ****named_pins** – Specify GPIO pins that LEDs of the board are attached to, associating each LED with a property name. You can designate as many pins as necessary and use any names, provided they're not already in use by something else. You can also specify *LEDBoard* (page 155) instances to create trees of LEDs.

blink(*on_time=1, off_time=1, fade_in_time=0, fade_out_time=0, n=None, background=True*)

Make all the LEDs turn on and off repeatedly.

Parameters

- **on_time** (*float*[614]) – Number of seconds on. Defaults to 1 second.
- **off_time** (*float*[615]) – Number of seconds off. Defaults to 1 second.
- **fade_in_time** (*float*[616]) – Number of seconds to spend fading in. Defaults to 0. Must be 0 if `pwm` was `False`[617] when the class was constructed (`ValueError`[618] will be raised if not).
- **fade_out_time** (*float*[619]) – Number of seconds to spend fading out. Defaults to 0. Must be 0 if `pwm` was `False`[620] when the class was constructed (`ValueError`[621] will be raised if not).
- **n** (*int*[622] *or None*[623]) – Number of times to blink; `None`[624] (the default) means forever.
- **background** (*bool*[625]) – If `True`[626], start a background thread to continue

602 https://docs.python.org/3.7/library/functions.html#bool
603 https://docs.python.org/3.7/library/constants.html#True
604 https://docs.python.org/3.7/library/constants.html#False
605 https://docs.python.org/3.7/library/functions.html#bool
606 https://docs.python.org/3.7/library/constants.html#True
607 https://docs.python.org/3.7/library/constants.html#False
608 https://docs.python.org/3.7/library/functions.html#bool
609 https://docs.python.org/3.7/library/constants.html#None
610 https://docs.python.org/3.7/library/constants.html#False
611 https://docs.python.org/3.7/library/constants.html#None
612 https://docs.python.org/3.7/library/constants.html#True
613 https://docs.python.org/3.7/library/constants.html#None
614 https://docs.python.org/3.7/library/functions.html#float
615 https://docs.python.org/3.7/library/functions.html#float
616 https://docs.python.org/3.7/library/functions.html#float
617 https://docs.python.org/3.7/library/constants.html#False
618 https://docs.python.org/3.7/library/exceptions.html#ValueError
619 https://docs.python.org/3.7/library/functions.html#float
620 https://docs.python.org/3.7/library/constants.html#False
621 https://docs.python.org/3.7/library/exceptions.html#ValueError
622 https://docs.python.org/3.7/library/functions.html#int
623 https://docs.python.org/3.7/library/constants.html#None
624 https://docs.python.org/3.7/library/constants.html#None
625 https://docs.python.org/3.7/library/functions.html#bool
626 https://docs.python.org/3.7/library/constants.html#True

blinking and return immediately. If False[627], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

off(**args*)
If no arguments are specified, turn all the LEDs off. If arguments are specified, they must be the indexes of the LEDs you wish to turn off. For example:

```
from gpiozero import LEDBoard

leds = LEDBoard(2, 3, 4, 5)
leds.on()      # turn on all LEDs
leds.off(0)    # turn off the first LED (pin 2)
leds.off(-1)   # turn off the last LED (pin 5)
leds.off(1, 2) # turn off the middle LEDs (pins 3 and 4)
leds.on()      # turn on all LEDs
```

If *blink()* (page 156) is currently active, it will be stopped first.

Parameters args (*int*[628]) – The index(es) of the LED(s) to turn off. If no indexes are specified turn off all LEDs.

on(**args*)
If no arguments are specified, turn all the LEDs on. If arguments are specified, they must be the indexes of the LEDs you wish to turn on. For example:

```
from gpiozero import LEDBoard

leds = LEDBoard(2, 3, 4, 5)
leds.on(0)    # turn on the first LED (pin 2)
leds.on(-1)   # turn on the last LED (pin 5)
leds.on(1, 2) # turn on the middle LEDs (pins 3 and 4)
leds.off()    # turn off all LEDs
leds.on()     # turn on all LEDs
```

If *blink()* (page 156) is currently active, it will be stopped first.

Parameters args (*int*[629]) – The index(es) of the LED(s) to turn on. If no indexes are specified turn on all LEDs.

pulse(*fade_in_time=1*, *fade_out_time=1*, *n=None*, *background=True*)
Make all LEDs fade in and out repeatedly. Note that this method will only work if the *pwm* parameter was True[630] at construction time.

Parameters

- **fade_in_time** (*float*[631]) – Number of seconds to spend fading in. Defaults to 1.
- **fade_out_time** (*float*[632]) – Number of seconds to spend fading out. Defaults to 1.
- **n** (*int*[633] *or None*[634]) – Number of times to blink; None[635] (the default) means forever.

[627] https://docs.python.org/3.7/library/constants.html#False
[628] https://docs.python.org/3.7/library/functions.html#int
[629] https://docs.python.org/3.7/library/functions.html#int
[630] https://docs.python.org/3.7/library/constants.html#True
[631] https://docs.python.org/3.7/library/functions.html#float
[632] https://docs.python.org/3.7/library/functions.html#float
[633] https://docs.python.org/3.7/library/functions.html#int
[634] https://docs.python.org/3.7/library/constants.html#None
[635] https://docs.python.org/3.7/library/constants.html#None

- **background** (*bool*[636]) – If True[637] (the default), start a background thread to continue blinking and return immediately. If False[638], only return when the blink is finished (warning: the default value of *n* will result in this method never returning).

toggle(**args*)

If no arguments are specified, toggle the state of all LEDs. If arguments are specified, they must be the indexes of the LEDs you wish to toggle. For example:

```
from gpiozero import LEDBoard

leds = LEDBoard(2, 3, 4, 5)
leds.toggle(0)   # turn on the first LED (pin 2)
leds.toggle(-1)  # turn on the last LED (pin 5)
leds.toggle()    # turn the first and last LED off, and the
                 # middle pair on
```

If *blink()* (page 156) is currently active, it will be stopped first.

Parameters args (*int*[639]) – The index(es) of the LED(s) to toggle. If no indexes are specified toggle the state of all LEDs.

16.1.2 LEDBarGraph

class gpiozero.LEDBarGraph(**pins, pwm=False, active_high=True, initial_value=0, pin_factory=None*)

Extends *LEDCollection* (page 184) to control a line of LEDs representing a bar graph. Positive values (0 to 1) light the LEDs from first to last. Negative values (-1 to 0) light the LEDs from last to first.

The following example demonstrates turning on the first two and last two LEDs in a board containing five LEDs attached to GPIOs 2 through 6:

```
from gpiozero import LEDBarGraph
from time import sleep

graph = LEDBarGraph(2, 3, 4, 5, 6)
graph.value = 2/5  # Light the first two LEDs only
sleep(1)
graph.value = -2/5 # Light the last two LEDs only
sleep(1)
graph.off()
```

As with all other output devices, *source* (page 159) and *values* (page 159) are supported:

```
from gpiozero import LEDBarGraph, MCP3008
from signal import pause

graph = LEDBarGraph(2, 3, 4, 5, 6, pwm=True)
pot = MCP3008(channel=0)

graph.source = pot

pause()
```

[636] https://docs.python.org/3.7/library/functions.html#bool
[637] https://docs.python.org/3.7/library/constants.html#True
[638] https://docs.python.org/3.7/library/constants.html#False
[639] https://docs.python.org/3.7/library/functions.html#int

Parameters

- ***pins** – Specify the GPIO pins that the LEDs of the bar graph are attached to. See *Pin Numbering* (page 3) for valid pin numbers. You can designate as many pins as necessary.
- **pwm** (*bool*[640]) – If True[641], construct *PWMLED* (page 125) instances for each pin. If False[642] (the default), construct regular *LED* (page 123) instances. This parameter can only be specified as a keyword parameter.
- **active_high** (*bool*[643]) – If True[644] (the default), the on() method will set all the associated pins to HIGH. If False[645], the on() method will set all pins to LOW (the off() method always does the opposite). This parameter can only be specified as a keyword parameter.
- **initial_value** (*float*[646]) – The initial *value* (page 159) of the graph given as a float between -1 and +1. Defaults to 0.0. This parameter can only be specified as a keyword parameter.
- **pin_factory** (Factory (page 230) *or None*[647]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

lit_count

The number of LEDs on the bar graph actually lit up. Note that just like *value* (page 159), this can be negative if the LEDs are lit from last to first.

source

The iterable to use as a source of values for *value* (page 159).

value

The value of the LED bar graph. When no LEDs are lit, the value is 0. When all LEDs are lit, the value is 1. Values between 0 and 1 light LEDs linearly from first to last. Values between 0 and -1 light LEDs linearly from last to first.

To light a particular number of LEDs, simply divide that number by the number of LEDs. For example, if your graph contains 3 LEDs, the following will light the first:

```
from gpiozero import LEDBarGraph

graph = LEDBarGraph(12, 16, 19)
graph.value = 1/3
```

Note: Setting value to -1 will light all LEDs. However, querying it subsequently will return 1 as both representations are the same in hardware. The readable range of *value* (page 159) is effectively -1 < value <= 1.

values

An infinite iterator of values read from *value* (page 159).

[640] https://docs.python.org/3.7/library/functions.html#bool
[641] https://docs.python.org/3.7/library/constants.html#True
[642] https://docs.python.org/3.7/library/constants.html#False
[643] https://docs.python.org/3.7/library/functions.html#bool
[644] https://docs.python.org/3.7/library/constants.html#True
[645] https://docs.python.org/3.7/library/constants.html#False
[646] https://docs.python.org/3.7/library/functions.html#float
[647] https://docs.python.org/3.7/library/constants.html#None

16.1.3 LEDCharDisplay

class gpiozero.**LEDCharDisplay**(**pins, dp=None, font=None, pwm=False, active_high=True, initial_value=' ', pin_factory=None*)

Extends *LEDCollection* (page 184) for a multi-segment LED display.

Multi-segment LED displays[648] typically have 7 pins (labelled "a" through "g") representing 7 LEDs layed out in a figure-of-8 fashion. Frequently, an eigth pin labelled "dp" is included for a trailing decimal-point:

```
     a

f        b
    g

e        c

       • dp
     d
```

Other common layouts are 9, 14, and 16 segment displays which include additional segments permitting more accurate renditions of alphanumerics. For example:

```
     a

f  i j  b
     k
  g   h
e    n  c
   l m
       • dp
     d
```

Such displays have either a common anode, or common cathode pin. This class defaults to the latter; when using a common anode display *active_high* should be set to False[649].

Instances of this class can be used to display characters or control individual LEDs on the display. For example:

```
from gpiozero import LEDCharDisplay

char = LEDCharDisplay(4, 5, 6, 7, 8, 9, 10, active_high=False)
char.value = 'C'
```

If the class is constructed with 7 or 14 segments, a default *font* (page 161) will be loaded, mapping some ASCII characters to typical layouts. In other cases, the default mapping will simply assign " " (space) to all LEDs off. You can assign your own mapping at construction time or after instantiation.

While the example above shows the display with a str[650] value, theoretically the *font* can map any value that can be the key in a dict[651], so the value of the display can be likewise be any valid key value (e.g. you could map integer digits to LED patterns). That said, there is one exception to this: when *dp* is specified to enable the decimal-point, the *value* (page 161) must be a str[652] as the presence or absence of a "." suffix indicates whether the *dp* LED is lit.

Parameters

648 https://en.wikipedia.org/wiki/Seven-segment_display
649 https://docs.python.org/3.7/library/constants.html#False
650 https://docs.python.org/3.7/library/stdtypes.html#str
651 https://docs.python.org/3.7/library/stdtypes.html#dict
652 https://docs.python.org/3.7/library/stdtypes.html#str

- **`*pins`** – Specify the GPIO pins that the multi-segment display is attached to. Pins should be in the LED segment order A, B, C, D, E, F, G, and will be named automatically by the class. If a decimal-point pin is present, specify it separately as the *dp* parameter.
- **`dp`** (*int*[653] *or str*[654]) – If a decimal-point segment is present, specify it as this named parameter.
- **`font`** (*dict*[655] *or None*[656]) – A mapping of values (typically characters, but may also be numbers) to tuples of LED states. A default mapping for ASCII characters is provided for 7 and 14 segment displays.
- **`pwm`** (*bool*[657]) – If `True`[658], construct *PWMLED* (page 125) instances for each pin. If `False`[659] (the default), construct regular *LED* (page 123) instances.
- **`active_high`** (*bool*[660]) – If `True`[661] (the default), the `on()` method will set all the associated pins to HIGH. If `False`[662], the `on()` method will set all pins to LOW (the `off()` method always does the opposite).
- **`initial_value`** – The initial value to display. Defaults to space (" ") which typically maps to all LEDs being inactive. If `None`[663], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on).
- **`pin_factory`** (`Factory` (page 230) *or None*[664]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

`font`

An *LEDCharFont* (page 163) mapping characters to tuples of LED states. The font is mutable after construction. You can assign a tuple of LED states to a character to modify the font, delete an existing character in the font, or assign a mapping of characters to tuples to replace the entire font.

Note that modifying the *font* (page 161) never alters the underlying LED states. Only assignment to *value* (page 161), or calling the inherited *LEDCollection* (page 184) methods (`on()`, `off()`, etc.) modifies LED states. However, modifying the font may alter the character returned by querying *value* (page 161).

`value`

The character the display should show. This is mapped by the current *font* (page 161) to a tuple of LED states which is applied to the underlying LED objects when this attribute is set.

When queried, the current LED states are looked up in the font to determine the character shown. If the current LED states do not correspond to any character in the *font* (page 161), the value is `None`[665].

It is possible for multiple characters in the font to map to the same LED states (e.g. S and 5). In this case, if the font was constructed from an ordered mapping (which is the default), then the first matching mapping will always be returned. This also implies that the value queried need not match the value set.

653 https://docs.python.org/3.7/library/functions.html#int
654 https://docs.python.org/3.7/library/stdtypes.html#str
655 https://docs.python.org/3.7/library/stdtypes.html#dict
656 https://docs.python.org/3.7/library/constants.html#None
657 https://docs.python.org/3.7/library/functions.html#bool
658 https://docs.python.org/3.7/library/constants.html#True
659 https://docs.python.org/3.7/library/constants.html#False
660 https://docs.python.org/3.7/library/functions.html#bool
661 https://docs.python.org/3.7/library/constants.html#True
662 https://docs.python.org/3.7/library/constants.html#False
663 https://docs.python.org/3.7/library/constants.html#None
664 https://docs.python.org/3.7/library/constants.html#None
665 https://docs.python.org/3.7/library/constants.html#None

16.1.4 LEDMultiCharDisplay

class gpiozero.LEDMultiCharDisplay(*char*, **pins*, *active_high=True*, *initial_value=None*, *pin_factory=None*)

Wraps *LEDCharDisplay* (page 160) for multi-character multiplexed[666] LED character displays.

The class is constructed with a *char* which is an instance of the *LEDCharDisplay* (page 160) class, capable of controlling the LEDs in one character of the display, and an additional set of *pins* that represent the common cathode (or anode) of each character.

> **Warning:** You should not attempt to connect the common cathode (or anode) off each character directly to a GPIO. Rather, use a set of transistors (or some other suitable component capable of handling the current of all the segment LEDs simultaneously) to connect the common cathode to ground (or the common anode to the supply) and control those transistors from the GPIOs specified under *pins*.

The *active_high* parameter defaults to `True`[667]. Note that it only applies to the specified *pins*, which are assumed to be controlling a set of transistors (hence the default). The specified *char* will use its own *active_high* parameter. Finally, *initial_value* defaults to a tuple of *value* (page 161) attribute of the specified display multiplied by the number of *pins* provided.

When the *value* (page 162) is set such that one or more characters in the display differ in value, a background thread is implicitly started to rotate the active character, relying on persistence of vision[668] to display the complete value.

plex_delay

The delay (measured in seconds) in the loop used to switch each character in the multiplexed display on. Defaults to 0.005 seconds which is generally sufficient to provide a “stable” (non-flickery) display.

value

The sequence of values to display.

This can be any sequence containing keys from the *font* (page 161) of the associated character display. For example, if the value consists only of single-character strings, it’s valid to assign a string to this property (as a string is simply a sequence of individual character keys):

```
from gpiozero import LEDCharDisplay, LEDMultiCharDisplay

c = LEDCharDisplay(4, 5, 6, 7, 8, 9, 10)
d = LEDMultiCharDisplay(c, 19, 20, 21, 22)
d.value = 'LEDS'
```

However, things get more complicated if a decimal point is in use as then this class needs to know explicitly where to break the value for use on each character of the display. This can be handled by simply assigning a sequence of strings thus:

```
from gpiozero import LEDCharDisplay, LEDMultiCharDisplay

c = LEDCharDisplay(4, 5, 6, 7, 8, 9, 10)
d = LEDMultiCharDisplay(c, 19, 20, 21, 22)
d.value = ('L.', 'E', 'D', 'S')
```

This is how the value will always be represented when queried (as a tuple of individual values) as it neatly handles dealing with heterogeneous types and the aforementioned decimal point issue.

[666] https://en.wikipedia.org/wiki/Multiplexed_display
[667] https://docs.python.org/3.7/library/constants.html#True
[668] https://en.wikipedia.org/wiki/Persistence_of_vision

Note: The value also controls whether a background thread is in use to multiplex the display. When all positions in the value are equal the background thread is disabled and all characters are simultaneously enabled.

16.1.5 LEDCharFont

class gpiozero.**LEDCharFont**(*font*)

Contains a mapping of values to tuples of LED states.

This effectively acts as a "font" for *LEDCharDisplay* (page 160), and two default fonts (for 7-segment and 14-segment displays) are shipped with GPIO Zero by default. You can construct your own font instance from a dict[669] which maps values (usually single-character strings) to a tuple of LED states:

```
from gpiozero import LEDCharDisplay, LEDCharFont

my_font = LEDCharFont({
    ' ': (0, 0, 0, 0, 0, 0, 0),
    'D': (1, 1, 1, 1, 1, 1, 0),
    'A': (1, 1, 1, 0, 1, 1, 1),
    'd': (0, 1, 1, 1, 1, 0, 1),
    'a': (1, 1, 1, 1, 1, 0, 1),
})
display = LEDCharDisplay(26, 13, 12, 22, 17, 19, 6, dp=5, font=my_font)
display.value = 'D'
```

Font instances are mutable and can be changed while actively in use by an instance of *LEDCharDisplay* (page 160). However, changing the font will *not* change the state of the LEDs in the display (though it may change the *value* (page 161) of the display when next queried).

Note: Your custom mapping should always include a value (typically space) which represents all the LEDs off. This will usually be the default value for an instance of *LEDCharDisplay* (page 160).

You may also wish to load fonts from a friendly text-based format. A simple parser for such formats (supporting an arbitrary number of segments) is provided by *gpiozero.fonts.load_segment_font()* (page 214).

16.1.6 ButtonBoard

class gpiozero.**ButtonBoard**(**pins, pull_up=True, active_state=None, bounce_time=None, hold_time=1, hold_repeat=False, pin_factory=None, **named_pins*)

Extends *CompositeDevice* (page 185) and represents a generic button board or collection of buttons. The *value* (page 165) of the button board is a tuple of all the buttons states. This can be used to control all the LEDs in a *LEDBoard* (page 155) with a *ButtonBoard* (page 163):

```
from gpiozero import LEDBoard, ButtonBoard
from signal import pause

leds = LEDBoard(2, 3, 4, 5)
btns = ButtonBoard(6, 7, 8, 9)
leds.source = btns
```

(continues on next page)

[669] https://docs.python.org/3.7/library/stdtypes.html#dict

(continued from previous page)

```
pause()
```

Alternatively you could represent the number of pressed buttons with an *LEDBarGraph* (page 158):

```
from gpiozero import LEDBarGraph, ButtonBoard
from statistics import mean
from signal import pause

graph = LEDBarGraph(2, 3, 4, 5)
bb = ButtonBoard(6, 7, 8, 9)
graph.source = (mean(values) for values in bb.values)

pause()
```

Parameters

- **`*pins`** – Specify the GPIO pins that the buttons of the board are attached to. See *Pin Numbering* (page 3) for valid pin numbers. You can designate as many pins as necessary.
- **`pull_up`** (*bool*[670] *or None*[671]) – If `True`[672] (the default), the GPIO pins will be pulled high by default. In this case, connect the other side of the buttons to ground. If `False`[673], the GPIO pins will be pulled low by default. In this case, connect the other side of the buttons to 3V3. If `None`[674], the pin will be floating, so it must be externally pulled up or down and the `active_state` parameter must be set accordingly.
- **`active_state`** (*bool*[675] *or None*[676]) – See description under *InputDevice* (page 120) for more information.
- **`bounce_time`** (*float*[677]) – If `None`[678] (the default), no software bounce compensation will be performed. Otherwise, this is the length of time (in seconds) that the buttons will ignore changes in state after an initial change.
- **`hold_time`** (*float*[679]) – The length of time (in seconds) to wait after any button is pushed, until executing the `when_held` handler. Defaults to `1`.
- **`hold_repeat`** (*bool*[680]) – If `True`[681], the `when_held` handler will be repeatedly executed as long as any buttons remain held, every *hold_time* seconds. If `False`[682] (the default) the `when_held` handler will be only be executed once per hold.
- **`pin_factory`** (`Factory` (page 230) *or None*[683]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).
- **`**named_pins`** – Specify GPIO pins that buttons of the board are attached to, associating each button with a property name. You can designate as many pins

[670] https://docs.python.org/3.7/library/functions.html#bool
[671] https://docs.python.org/3.7/library/constants.html#None
[672] https://docs.python.org/3.7/library/constants.html#True
[673] https://docs.python.org/3.7/library/constants.html#False
[674] https://docs.python.org/3.7/library/constants.html#None
[675] https://docs.python.org/3.7/library/functions.html#bool
[676] https://docs.python.org/3.7/library/constants.html#None
[677] https://docs.python.org/3.7/library/functions.html#float
[678] https://docs.python.org/3.7/library/constants.html#None
[679] https://docs.python.org/3.7/library/functions.html#float
[680] https://docs.python.org/3.7/library/functions.html#bool
[681] https://docs.python.org/3.7/library/constants.html#True
[682] https://docs.python.org/3.7/library/constants.html#False
[683] https://docs.python.org/3.7/library/constants.html#None

as necessary and use any names, provided they're not already in use by something else.

wait_for_press(*timeout=None*)
Pause the script until the device is activated, or the timeout is reached.

Parameters timeout (*float*[684] *or None*[685]) – Number of seconds to wait before proceeding. If this is None[686] (the default), then wait indefinitely until the device is active.

wait_for_release(*timeout=None*)
Pause the script until the device is deactivated, or the timeout is reached.

Parameters timeout (*float*[687] *or None*[688]) – Number of seconds to wait before proceeding. If this is None[689] (the default), then wait indefinitely until the device is inactive.

is_pressed
Composite devices are considered "active" if any of their constituent devices have a "truthy" value.

pressed_time
The length of time (in seconds) that the device has been active for. When the device is inactive, this is None[690].

value
A namedtuple()[691] containing a value for each subordinate device. Devices with names will be represented as named elements. Unnamed devices will have a unique name generated for them, and they will appear in the position they appeared in the constructor.

when_pressed
The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None[692] (the default) to disable the event.

when_released
The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to None[693] (the default) to disable the event.

16.1.7 TrafficLights

class gpiozero.TrafficLights(*red, amber, green, *, yellow=None, pwm=False, initial_value=False, pin_factory=None*)
Extends *LEDBoard* (page 155) for devices containing red, yellow, and green LEDs.

[684] https://docs.python.org/3.7/library/functions.html#float
[685] https://docs.python.org/3.7/library/constants.html#None
[686] https://docs.python.org/3.7/library/constants.html#None
[687] https://docs.python.org/3.7/library/functions.html#float
[688] https://docs.python.org/3.7/library/constants.html#None
[689] https://docs.python.org/3.7/library/constants.html#None
[690] https://docs.python.org/3.7/library/constants.html#None
[691] https://docs.python.org/3.7/library/collections.html#collections.namedtuple
[692] https://docs.python.org/3.7/library/constants.html#None
[693] https://docs.python.org/3.7/library/constants.html#None

The following example initializes a device connected to GPIO pins 2, 3, and 4, then lights the amber (yellow) LED attached to GPIO 3:

```
from gpiozero import TrafficLights

traffic = TrafficLights(2, 3, 4)
traffic.amber.on()
```

Parameters

- **red** (*int*[694] *or* *str*[695]) – The GPIO pin that the red LED is attached to. See *Pin Numbering* (page 3) for valid pin numbers.
- **amber** (*int*[696] *or* *str*[697] *or* *None*[698]) – The GPIO pin that the amber LED is attached to. See *Pin Numbering* (page 3) for valid pin numbers.
- **yellow** (*int*[699] *or* *str*[700] *or* *None*[701]) – The GPIO pin that the yellow LED is attached to. This is merely an alias for the `amber` parameter; you can't specify both `amber` and `yellow`. See *Pin Numbering* (page 3) for valid pin numbers.
- **green** (*int*[702] *or* *str*[703]) – The GPIO pin that the green LED is attached to. See *Pin Numbering* (page 3) for valid pin numbers.
- **pwm** (*bool*[704]) – If `True`[705], construct *PWMLED* (page 125) instances to represent each LED. If `False`[706] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[707] *or* *None*[708]) – If `False`[709] (the default), all LEDs will be off initially. If `None`[710], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If `True`[711], the device will be switched on initially.
- **pin_factory** (`Factory` (page 230) *or* *None*[712]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

red
The red *LED* (page 123) or *PWMLED* (page 125).

amber
The amber *LED* (page 123) or *PWMLED* (page 125). Note that this attribute will not be present when the instance is constructed with the *yellow* keyword parameter.

yellow
The yellow *LED* (page 123) or *PWMLED* (page 125). Note that this attribute will only be present when the instance is constructed with the *yellow* keyword parameter.

green
The green *LED* (page 123) or *PWMLED* (page 125).

[694] https://docs.python.org/3.7/library/functions.html#int
[695] https://docs.python.org/3.7/library/stdtypes.html#str
[696] https://docs.python.org/3.7/library/functions.html#int
[697] https://docs.python.org/3.7/library/stdtypes.html#str
[698] https://docs.python.org/3.7/library/constants.html#None
[699] https://docs.python.org/3.7/library/functions.html#int
[700] https://docs.python.org/3.7/library/stdtypes.html#str
[701] https://docs.python.org/3.7/library/constants.html#None
[702] https://docs.python.org/3.7/library/functions.html#int
[703] https://docs.python.org/3.7/library/stdtypes.html#str
[704] https://docs.python.org/3.7/library/functions.html#bool
[705] https://docs.python.org/3.7/library/constants.html#True
[706] https://docs.python.org/3.7/library/constants.html#False
[707] https://docs.python.org/3.7/library/functions.html#bool
[708] https://docs.python.org/3.7/library/constants.html#None
[709] https://docs.python.org/3.7/library/constants.html#False
[710] https://docs.python.org/3.7/library/constants.html#None
[711] https://docs.python.org/3.7/library/constants.html#True
[712] https://docs.python.org/3.7/library/constants.html#None

16.1.8 TrafficLightsBuzzer

class gpiozero.**TrafficLightsBuzzer**(*lights*, *buzzer*, *button*, ***, *pin_factory=None*)

Extends *CompositeOutputDevice* (page 185) and is a generic class for HATs with traffic lights, a button and a buzzer.

Parameters

- **lights** (TrafficLights (page 165)) – An instance of *TrafficLights* (page 165) representing the traffic lights of the HAT.
- **buzzer** (Buzzer (page 130)) – An instance of *Buzzer* (page 130) representing the buzzer on the HAT.
- **button** (Button (page 103)) – An instance of *Button* (page 103) representing the button on the HAT.
- **pin_factory** (Factory (page 230) *or* None[713]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

lights

The *TrafficLights* (page 165) instance passed as the *lights* parameter.

buzzer

The *Buzzer* (page 130) instance passed as the *buzzer* parameter.

button

The *Button* (page 103) instance passed as the *button* parameter.

16.1.9 PiHutXmasTree

class gpiozero.**PiHutXmasTree**(***, *pwm=False*, *initial_value=False*, *pin_factory=None*)

Extends *LEDBoard* (page 155) for The Pi Hut's Xmas board[714]: a 3D Christmas tree board with 24 red LEDs and a white LED as a star on top.

The 24 red LEDs can be accessed through the attributes led0, led1, led2, and so on. The white star LED is accessed through the *star* (page 168) attribute. Alternatively, as with all descendents of *LEDBoard* (page 155), you can treat the instance as a sequence of LEDs (the first element is the *star* (page 168)).

The Xmas Tree board pins are fixed and therefore there's no need to specify them when constructing this class. The following example turns all the LEDs on one at a time:

```
from gpiozero import PiHutXmasTree
from time import sleep

tree = PiHutXmasTree()

for light in tree:
    light.on()
    sleep(1)
```

The following example turns the star LED on and sets all the red LEDs to flicker randomly:

```
from gpiozero import PiHutXmasTree
from gpiozero.tools import random_values
from signal import pause

tree = PiHutXmasTree(pwm=True)
```

(continues on next page)

713 https://docs.python.org/3.7/library/constants.html#None
714 https://thepihut.com/xmas

(continued from previous page)

```
tree.star.on()

for led in tree[1:]:
    led.source_delay = 0.1
    led.source = random_values()

pause()
```

Parameters

- **pwm** (*bool*[715]) – If True[716], construct *PWMLED* (page 125) instances for each pin. If False[717] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[718] *or None*[719]) – If False[720] (the default), all LEDs will be off initially. If None[721], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[722], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[723]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

star
Returns the *LED* (page 123) or *PWMLED* (page 125) representing the white star on top of the tree.

led0, led1, led2, ...
Returns the *LED* (page 123) or *PWMLED* (page 125) representing one of the red LEDs. There are actually 24 of these properties named led0, led1, and so on but for the sake of brevity we represent all 24 under this section.

16.1.10 LedBorg

class gpiozero.LedBorg(**, pwm=True, initial_value=(0, 0, 0), pin_factory=None*)
Extends *RGBLED* (page 127) for the PiBorg LedBorg[724]: an add-on board containing a very bright RGB LED.

The LedBorg pins are fixed and therefore there's no need to specify them when constructing this class. The following example turns the LedBorg purple:

```
from gpiozero import LedBorg

led = LedBorg()
led.color = (1, 0, 1)
```

Parameters

[715] https://docs.python.org/3.7/library/functions.html#bool
[716] https://docs.python.org/3.7/library/constants.html#True
[717] https://docs.python.org/3.7/library/constants.html#False
[718] https://docs.python.org/3.7/library/functions.html#bool
[719] https://docs.python.org/3.7/library/constants.html#None
[720] https://docs.python.org/3.7/library/constants.html#False
[721] https://docs.python.org/3.7/library/constants.html#None
[722] https://docs.python.org/3.7/library/constants.html#True
[723] https://docs.python.org/3.7/library/constants.html#None
[724] https://www.piborg.org/ledborg

- **initial_value** (*Color*[725] *or tuple*[726]) – The initial color for the LedBorg. Defaults to black `(0, 0, 0)`.
- **pwm** (*bool*[727]) – If `True`[728] (the default), construct *PWMLED* (page 125) instances for each component of the LedBorg. If `False`[729], construct regular *LED* (page 123) instances, which prevents smooth color graduations.
- **pin_factory** (`Factory` (page 230) *or None*[730]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.11 PiLiter

class gpiozero.PiLiter(**, pwm=False, initial_value=False, pin_factory=None*)

Extends *LEDBoard* (page 155) for the Ciseco Pi-LITEr[731]: a strip of 8 very bright LEDs.

The Pi-LITEr pins are fixed and therefore there's no need to specify them when constructing this class. The following example turns on all the LEDs of the Pi-LITEr:

```
from gpiozero import PiLiter

lite = PiLiter()
lite.on()
```

Parameters

- **pwm** (*bool*[732]) – If `True`[733], construct *PWMLED* (page 125) instances for each pin. If `False`[734] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[735] *or None*[736]) – If `False`[737] (the default), all LEDs will be off initially. If `None`[738], each LED will be left in whatever state the pin is found in when configured for output (warning: this can be on). If `True`[739], the each LED will be switched on initially.
- **pin_factory** (`Factory` (page 230) *or None*[740]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.12 PiLiterBarGraph

class gpiozero.PiLiterBarGraph(**, pwm=False, initial_value=False, pin_factory=None*)

Extends *LEDBarGraph* (page 158) to treat the Ciseco Pi-LITEr[741] as an 8-segment bar graph.

The Pi-LITEr pins are fixed and therefore there's no need to specify them when constructing this class. The following example sets the graph value to 0.5:

725 https://colorzero.readthedocs.io/en/latest/api_color.html#colorzero.Color
726 https://docs.python.org/3.7/library/stdtypes.html#tuple
727 https://docs.python.org/3.7/library/functions.html#bool
728 https://docs.python.org/3.7/library/constants.html#True
729 https://docs.python.org/3.7/library/constants.html#False
730 https://docs.python.org/3.7/library/constants.html#None
731 http://shop.ciseco.co.uk/pi-liter-8-led-strip-for-the-raspberry-pi/
732 https://docs.python.org/3.7/library/functions.html#bool
733 https://docs.python.org/3.7/library/constants.html#True
734 https://docs.python.org/3.7/library/constants.html#False
735 https://docs.python.org/3.7/library/functions.html#bool
736 https://docs.python.org/3.7/library/constants.html#None
737 https://docs.python.org/3.7/library/constants.html#False
738 https://docs.python.org/3.7/library/constants.html#None
739 https://docs.python.org/3.7/library/constants.html#True
740 https://docs.python.org/3.7/library/constants.html#None
741 http://shop.ciseco.co.uk/pi-liter-8-led-strip-for-the-raspberry-pi/

```
from gpiozero import PiLiterBarGraph

graph = PiLiterBarGraph()
graph.value = 0.5
```

Parameters

- **pwm** (*bool*[742]) – If True[743], construct *PWMLED* (page 125) instances for each pin. If False[744] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*float*[745]) – The initial value of the graph given as a float between -1 and +1. Defaults to 0.0.
- **pin_factory** (Factory (page 230) *or None*[746]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.13 PiTraffic

class gpiozero.PiTraffic(**, pwm=False, initial_value=False, pin_factory=None*)

Extends *TrafficLights* (page 165) for the Low Voltage Labs PI-TRAFFIC[747] vertical traffic lights board when attached to GPIO pins 9, 10, and 11.

There's no need to specify the pins if the PI-TRAFFIC is connected to the default pins (9, 10, 11). The following example turns on the amber LED on the PI-TRAFFIC:

```
from gpiozero import PiTraffic

traffic = PiTraffic()
traffic.amber.on()
```

To use the PI-TRAFFIC board when attached to a non-standard set of pins, simply use the parent class, *TrafficLights* (page 165).

Parameters

- **pwm** (*bool*[748]) – If True[749], construct *PWMLED* (page 125) instances to represent each LED. If False[750] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[751]) – If False[752] (the default), all LEDs will be off initially. If None[753], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[754], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[755]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

[742] https://docs.python.org/3.7/library/functions.html#bool
[743] https://docs.python.org/3.7/library/constants.html#True
[744] https://docs.python.org/3.7/library/constants.html#False
[745] https://docs.python.org/3.7/library/functions.html#float
[746] https://docs.python.org/3.7/library/constants.html#None
[747] http://lowvoltagelabs.com/products/pi-traffic/
[748] https://docs.python.org/3.7/library/functions.html#bool
[749] https://docs.python.org/3.7/library/constants.html#True
[750] https://docs.python.org/3.7/library/constants.html#False
[751] https://docs.python.org/3.7/library/functions.html#bool
[752] https://docs.python.org/3.7/library/constants.html#False
[753] https://docs.python.org/3.7/library/constants.html#None
[754] https://docs.python.org/3.7/library/constants.html#True
[755] https://docs.python.org/3.7/library/constants.html#None

16.1.14 PiStop

class gpiozero.PiStop(*location*, ***, *pwm=False*, *initial_value=False*, *pin_factory=None*)

Extends *TrafficLights* (page 165) for the PiHardware Pi-Stop[756]: a vertical traffic lights board.

The following example turns on the amber LED on a Pi-Stop connected to location `A+`:

```
from gpiozero import PiStop

traffic = PiStop('A+')
traffic.amber.on()
```

Parameters

- **location** (*str*[757]) – The location[758] on the GPIO header to which the Pi-Stop is connected. Must be one of: `A`, `A+`, `B`, `B+`, `C`, `D`.
- **pwm** (*bool*[759]) – If `True`[760], construct *PWMLED* (page 125) instances to represent each LED. If `False`[761] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[762]) – If `False`[763] (the default), all LEDs will be off initially. If `None`[764], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If `True`[765], the device will be switched on initially.
- **pin_factory** (`Factory` (page 230) *or None*[766]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.15 FishDish

class gpiozero.FishDish(***, *pwm=False*, *pin_factory=None*)

Extends *CompositeOutputDevice* (page 185) for the Pi Supply FishDish[767]: traffic light LEDs, a button and a buzzer.

The FishDish pins are fixed and therefore there's no need to specify them when constructing this class. The following example waits for the button to be pressed on the FishDish, then turns on all the LEDs:

```
from gpiozero import FishDish

fish = FishDish()
fish.button.wait_for_press()
fish.lights.on()
```

Parameters

[756] https://pihw.wordpress.com/meltwaters-pi-hardware-kits/pi-stop/
[757] https://docs.python.org/3.7/library/stdtypes.html#str
[758] https://github.com/PiHw/Pi-Stop/blob/master/markdown_source/markdown/Discover-PiStop.md
[759] https://docs.python.org/3.7/library/functions.html#bool
[760] https://docs.python.org/3.7/library/constants.html#True
[761] https://docs.python.org/3.7/library/constants.html#False
[762] https://docs.python.org/3.7/library/functions.html#bool
[763] https://docs.python.org/3.7/library/constants.html#False
[764] https://docs.python.org/3.7/library/constants.html#None
[765] https://docs.python.org/3.7/library/constants.html#True
[766] https://docs.python.org/3.7/library/constants.html#None
[767] https://www.pi-supply.com/product/fish-dish-raspberry-pi-led-buzzer-board/

- **pwm** (*bool*[768]) – If True[769], construct *PWMLED* (page 125) instances to represent each LED. If False[770] (the default), construct regular *LED* (page 123) instances.
- **pin_factory** (Factory (page 230) *or None*[771]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.16 TrafficHat

class gpiozero.TrafficHat(**, pwm=False, pin_factory=None*)

Extends *CompositeOutputDevice* (page 185) for the Pi Supply Traffic HAT[772]: a board with traffic light LEDs, a button and a buzzer.

The Traffic HAT pins are fixed and therefore there's no need to specify them when constructing this class. The following example waits for the button to be pressed on the Traffic HAT, then turns on all the LEDs:

```
from gpiozero import TrafficHat

hat = TrafficHat()
hat.button.wait_for_press()
hat.lights.on()
```

Parameters

- **pwm** (*bool*[773]) – If True[774], construct *PWMLED* (page 125) instances to represent each LED. If False[775] (the default), construct regular *LED* (page 123) instances.
- **pin_factory** (Factory (page 230) *or None*[776]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.17 TrafficpHat

class gpiozero.TrafficpHat(**, pwm=False, pin_factory=None*)

Extends *TrafficLights* (page 165) for the Pi Supply Traffic pHAT[777]: a small board with traffic light LEDs.

The Traffic pHAT pins are fixed and therefore there's no need to specify them when constructing this class. The following example then turns on all the LEDs:

```
from gpiozero import TrafficpHat
phat = TrafficpHat()
phat.red.on()
phat.blink()
```

Parameters

- **pwm** (*bool*[778]) – If True[779], construct *PWMLED* (page 125) instances to represent each LED. If False[780] (the default), construct regular *LED* (page 123) instances.

[768] https://docs.python.org/3.7/library/functions.html#bool
[769] https://docs.python.org/3.7/library/constants.html#True
[770] https://docs.python.org/3.7/library/constants.html#False
[771] https://docs.python.org/3.7/library/constants.html#None
[772] https://uk.pi-supply.com/products/traffic-hat-for-raspberry-pi
[773] https://docs.python.org/3.7/library/functions.html#bool
[774] https://docs.python.org/3.7/library/constants.html#True
[775] https://docs.python.org/3.7/library/constants.html#False
[776] https://docs.python.org/3.7/library/constants.html#None
[777] http://pisupp.ly/trafficphat
[778] https://docs.python.org/3.7/library/functions.html#bool
[779] https://docs.python.org/3.7/library/constants.html#True
[780] https://docs.python.org/3.7/library/constants.html#False

- **initial_value** (*bool*[781] *or None*[782]) – If False[783] (the default), all LEDs will be off initially. If None[784], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[785], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[786]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.18 JamHat

class gpiozero.JamHat(**, pwm=False, pin_factory=None*)

Extends *CompositeOutputDevice* (page 185) for the ModMyPi JamHat[787] board.

There are 6 LEDs, two buttons and a tonal buzzer. The pins are fixed. Usage:

```
from gpiozero import JamHat

hat = JamHat()

hat.button_1.wait_for_press()
hat.lights_1.on()
hat.buzzer.play('C4')
hat.button_2.wait_for_press()
hat.off()
```

Parameters

- **pwm** (*bool*[788]) – If True[789], construct *PWMLED* (page 125) instances to represent each LED on the board. If False[790] (the default), construct regular *LED* (page 123) instances.
- **pin_factory** (Factory (page 230) *or None*[791]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

lights_1, lights_2

Two *LEDBoard* (page 155) instances representing the top (lights_1) and bottom (lights_2) rows of LEDs on the JamHat.

red, yellow, green

LED (page 123) or *PWMLED* (page 125) instances representing the red, yellow, and green LEDs along the top row.

button_1, button_2

The left (button_1) and right (button_2) *Button* (page 103) objects on the JamHat.

buzzer

The *TonalBuzzer* (page 131) at the bottom right of the JamHat.

off()

Turns all the LEDs off and stops the buzzer.

[781] https://docs.python.org/3.7/library/functions.html#bool
[782] https://docs.python.org/3.7/library/constants.html#None
[783] https://docs.python.org/3.7/library/constants.html#False
[784] https://docs.python.org/3.7/library/constants.html#None
[785] https://docs.python.org/3.7/library/constants.html#True
[786] https://docs.python.org/3.7/library/constants.html#None
[787] https://thepihut.com/products/jam-hat
[788] https://docs.python.org/3.7/library/functions.html#bool
[789] https://docs.python.org/3.7/library/constants.html#True
[790] https://docs.python.org/3.7/library/constants.html#False
[791] https://docs.python.org/3.7/library/constants.html#None

on()
Turns all the LEDs on and makes the buzzer play its mid tone.

16.1.19 Pibrella

class gpiozero.Pibrella(*, *pwm=False*, *pin_factory=None*)
Extends *CompositeOutputDevice* (page 185) for the Cyntech/Pimoroni Pibrella[792] board.

The Pibrella board comprises 3 LEDs, a button, a tonal buzzer, four general purpose input channels, and four general purpose output channels (with LEDs).

This class exposes the LEDs, button and buzzer.

Usage:

```
from gpiozero import Pibrella

pb = Pibrella()

pb.button.wait_for_press()
pb.lights.on()
pb.buzzer.play('A4')
pb.off()
```

The four input and output channels are exposed so you can create GPIO Zero devices using these pins without looking up their respective pin numbers:

```
from gpiozero import Pibrella, LED, Button

pb = Pibrella()
btn = Button(pb.inputs.a, pull_up=False)
led = LED(pb.outputs.e)

btn.when_pressed = led.on
```

Parameters

- **pwm** (*bool*[793]) – If True[794], construct *PWMLED* (page 125) instances to represent each LED on the board, otherwise if False[795] (the default), construct regular *LED* (page 123) instances.
- **pin_factory** (Factory (page 230) *or None*[796]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

lights
TrafficLights (page 165) instance representing the three LEDs

red, amber, green
LED (page 123) or *PWMLED* (page 125) instances representing the red, amber, and green LEDs

button
The red *Button* (page 103) object on the Pibrella

buzzer
A *TonalBuzzer* (page 131) object representing the buzzer

[792] http://www.pibrella.com/
[793] https://docs.python.org/3.7/library/functions.html#bool
[794] https://docs.python.org/3.7/library/constants.html#True
[795] https://docs.python.org/3.7/library/constants.html#False
[796] https://docs.python.org/3.7/library/constants.html#None

inputs
A namedtuple()[797] of the input pin numbers

a, b, c, d

outputs
A namedtuple()[798] of the output pin numbers

e, f, g, h

off()
Turns all the LEDs off and stops the buzzer.

on()
Turns all the LEDs on and makes the buzzer play its mid tone.

16.1.20 Robot

class gpiozero.Robot(*left*, *right*, ***, *pwm=True*, *pin_factory=None*)
Extends *CompositeDevice* (page 185) to represent a generic dual-motor robot.

This class is constructed with two tuples representing the forward and backward pins of the left and right controllers respectively. For example, if the left motor's controller is connected to GPIOs 4 and 14, while the right motor's controller is connected to GPIOs 17 and 18 then the following example will drive the robot forward:

```
from gpiozero import Robot

robot = Robot(left=(4, 14), right=(17, 18))
robot.forward()
```

Parameters

- **left** (*tuple*[799]) – A tuple of two (or three) GPIO pins representing the forward and backward inputs of the left motor's controller. Use three pins if your motor controller requires an enable pin.
- **right** (*tuple*[800]) – A tuple of two (or three) GPIO pins representing the forward and backward inputs of the right motor's controller. Use three pins if your motor controller requires an enable pin.
- **pwm** (*bool*[801]) – If True[802] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller pins, allowing both direction and variable speed control. If False[803], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or None*[804]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

left_motor
The *Motor* (page 132) on the left of the robot.

right_motor
The *Motor* (page 132) on the right of the robot.

797 https://docs.python.org/3.7/library/collections.html#collections.namedtuple
798 https://docs.python.org/3.7/library/collections.html#collections.namedtuple
799 https://docs.python.org/3.7/library/stdtypes.html#tuple
800 https://docs.python.org/3.7/library/stdtypes.html#tuple
801 https://docs.python.org/3.7/library/functions.html#bool
802 https://docs.python.org/3.7/library/constants.html#True
803 https://docs.python.org/3.7/library/constants.html#False
804 https://docs.python.org/3.7/library/constants.html#None

backward(*speed=1*, ***kwargs*)
Drive the robot backward by running both motors backward.

Parameters

- **speed** (*float*[805]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.
- **curve_left** (*float*[806]) – The amount to curve left while moving backwards, by driving the left motor at a slower speed. Maximum *curve_left* is 1, the default is 0 (no curve). This parameter can only be specified as a keyword parameter, and is mutually exclusive with *curve_right*.
- **curve_right** (*float*[807]) – The amount to curve right while moving backwards, by driving the right motor at a slower speed. Maximum *curve_right* is 1, the default is 0 (no curve). This parameter can only be specified as a keyword parameter, and is mutually exclusive with *curve_left*.

forward(*speed=1*, ***kwargs*)
Drive the robot forward by running both motors forward.

Parameters

- **speed** (*float*[808]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.
- **curve_left** (*float*[809]) – The amount to curve left while moving forwards, by driving the left motor at a slower speed. Maximum *curve_left* is 1, the default is 0 (no curve). This parameter can only be specified as a keyword parameter, and is mutually exclusive with *curve_right*.
- **curve_right** (*float*[810]) – The amount to curve right while moving forwards, by driving the right motor at a slower speed. Maximum *curve_right* is 1, the default is 0 (no curve). This parameter can only be specified as a keyword parameter, and is mutually exclusive with *curve_left*.

left(*speed=1*)
Make the robot turn left by running the right motor forward and left motor backward.

Parameters speed (*float*[811]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

reverse()
Reverse the robot's current motor directions. If the robot is currently running full speed forward, it will run full speed backward. If the robot is turning left at half-speed, it will turn right at half-speed. If the robot is currently stopped it will remain stopped.

right(*speed=1*)
Make the robot turn right by running the left motor forward and right motor backward.

Parameters speed (*float*[812]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

stop()
Stop the robot.

value
Represents the motion of the robot as a tuple of (left_motor_speed, right_motor_speed)

[805] https://docs.python.org/3.7/library/functions.html#float
[806] https://docs.python.org/3.7/library/functions.html#float
[807] https://docs.python.org/3.7/library/functions.html#float
[808] https://docs.python.org/3.7/library/functions.html#float
[809] https://docs.python.org/3.7/library/functions.html#float
[810] https://docs.python.org/3.7/library/functions.html#float
[811] https://docs.python.org/3.7/library/functions.html#float
[812] https://docs.python.org/3.7/library/functions.html#float

with `(-1, -1)` representing full speed backwards, `(1, 1)` representing full speed forwards, and `(0, 0)` representing stopped.

16.1.21 PhaseEnableRobot

class gpiozero.PhaseEnableRobot(*left*, *right*, ***, *pwm=True*, *pin_factory=None*)

Extends *CompositeDevice* (page 185) to represent a dual-motor robot based around a Phase/Enable motor board.

This class is constructed with two tuples representing the phase (direction) and enable (speed) pins of the left and right controllers respectively. For example, if the left motor's controller is connected to GPIOs 12 and 5, while the right motor's controller is connected to GPIOs 13 and 6 so the following example will drive the robot forward:

```
from gpiozero import PhaseEnableRobot

robot = PhaseEnableRobot(left=(5, 12), right=(6, 13))
robot.forward()
```

Parameters

- **left** (*tuple*[813]) – A tuple of two GPIO pins representing the phase and enable inputs of the left motor's controller.
- **right** (*tuple*[814]) – A tuple of two GPIO pins representing the phase and enable inputs of the right motor's controller.
- **pwm** (*bool*[815]) – If `True`[816] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller's enable pins, allowing both direction and variable speed control. If `False`[817], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (`Factory` (page 230) *or None*[818]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

left_motor

The *PhaseEnableMotor* (page 134) on the left of the robot.

right_motor

The *PhaseEnableMotor* (page 134) on the right of the robot.

backward(*speed=1*)

Drive the robot backward by running both motors backward.

Parameters speed (*float*[819]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

forward(*speed=1*)

Drive the robot forward by running both motors forward.

Parameters speed (*float*[820]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

left(*speed=1*)

Make the robot turn left by running the right motor forward and left motor backward.

813 https://docs.python.org/3.7/library/stdtypes.html#tuple
814 https://docs.python.org/3.7/library/stdtypes.html#tuple
815 https://docs.python.org/3.7/library/functions.html#bool
816 https://docs.python.org/3.7/library/constants.html#True
817 https://docs.python.org/3.7/library/constants.html#False
818 https://docs.python.org/3.7/library/constants.html#None
819 https://docs.python.org/3.7/library/functions.html#float
820 https://docs.python.org/3.7/library/functions.html#float

Parameters speed (*float*[821]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

reverse()

Reverse the robot's current motor directions. If the robot is currently running full speed forward, it will run full speed backward. If the robot is turning left at half-speed, it will turn right at half-speed. If the robot is currently stopped it will remain stopped.

right(*speed=1*)

Make the robot turn right by running the left motor forward and right motor backward.

Parameters speed (*float*[822]) – Speed at which to drive the motors, as a value between 0 (stopped) and 1 (full speed). The default is 1.

stop()

Stop the robot.

value

Returns a tuple of two floating point values (-1 to 1) representing the speeds of the robot's two motors (left and right). This property can also be set to alter the speed of both motors.

16.1.22 RyanteckRobot

class gpiozero.**RyanteckRobot**(**, pwm=True, pin_factory=None*)

Extends *Robot* (page 175) for the Ryanteck motor controller board[823].

The Ryanteck MCB pins are fixed and therefore there's no need to specify them when constructing this class. The following example drives the robot forward:

```
from gpiozero import RyanteckRobot

robot = RyanteckRobot()
robot.forward()
```

Parameters

- **pwm** (*bool*[824]) – If True[825] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller pins, allowing both direction and variable speed control. If False[826], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or None*[827]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.23 CamJamKitRobot

class gpiozero.**CamJamKitRobot**(**, pwm=True, pin_factory=None*)

Extends *Robot* (page 175) for the CamJam #3 EduKit[828] motor controller board.

The CamJam robot controller pins are fixed and therefore there's no need to specify them when constructing this class. The following example drives the robot forward:

[821] https://docs.python.org/3.7/library/functions.html#float
[822] https://docs.python.org/3.7/library/functions.html#float
[823] https://uk.pi-supply.com/products/ryanteck-rtk-000-001-motor-controller-board-kit-raspberry-pi
[824] https://docs.python.org/3.7/library/functions.html#bool
[825] https://docs.python.org/3.7/library/constants.html#True
[826] https://docs.python.org/3.7/library/constants.html#False
[827] https://docs.python.org/3.7/library/constants.html#None
[828] http://camjam.me/?page_id=1035

```
from gpiozero import CamJamKitRobot

robot = CamJamKitRobot()
robot.forward()
```

Parameters

- **pwm** (*bool*[829]) – If True[830] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller pins, allowing both direction and variable speed control. If False[831], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or None*[832]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.24 PololuDRV8835Robot

class gpiozero.PololuDRV8835Robot(**, pwm=True, pin_factory=None*)

Extends *PhaseEnableRobot* (page 177) for the Pololu DRV8835 Dual Motor Driver Kit[833].

The Pololu DRV8835 pins are fixed and therefore there's no need to specify them when constructing this class. The following example drives the robot forward:

```
from gpiozero import PololuDRV8835Robot

robot = PololuDRV8835Robot()
robot.forward()
```

Parameters

- **pwm** (*bool*[834]) – If True[835] (the default), construct *PWMOutputDevice* (page 140) instances for the motor controller's enable pins, allowing both direction and variable speed control. If False[836], construct *DigitalOutputDevice* (page 139) instances, allowing only direction control.
- **pin_factory** (Factory (page 230) *or None*[837]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

16.1.25 Energenie

class gpiozero.Energenie(*socket, *, initial_value=False, pin_factory=None*)

Extends *Device* (page 201) to represent an Energenie socket[838] controller.

This class is constructed with a socket number and an optional initial state (defaults to False[839], meaning off). Instances of this class can be used to switch peripherals on and off. For example:

[829] https://docs.python.org/3.7/library/functions.html#bool
[830] https://docs.python.org/3.7/library/constants.html#True
[831] https://docs.python.org/3.7/library/constants.html#False
[832] https://docs.python.org/3.7/library/constants.html#None
[833] https://www.pololu.com/product/2753
[834] https://docs.python.org/3.7/library/functions.html#bool
[835] https://docs.python.org/3.7/library/constants.html#True
[836] https://docs.python.org/3.7/library/constants.html#False
[837] https://docs.python.org/3.7/library/constants.html#None
[838] https://energenie4u.co.uk/index.php/catalogue/product/ENER002-2PI
[839] https://docs.python.org/3.7/library/constants.html#False

```
from gpiozero import Energenie

lamp = Energenie(1)
lamp.on()
```

Parameters

- **socket** (*int*[840]) – Which socket this instance should control. This is an integer number between 1 and 4.
- **initial_value** (*bool*[841] *or None*[842]) – The initial state of the socket. As Energenie sockets provide no means of reading their state, you may provide an initial state for the socket, which will be set upon construction. This defaults to False[843] which will switch the socket off. Specifying None[844] will not set any initial state nor transmit any control signal to the device.
- **pin_factory** (Factory (page 230) *or None*[845]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

off()
Turns the socket off.

on()
Turns the socket on.

socket
Returns the socket number.

value
Returns True[846] if the socket is on and False[847] if the socket is off. Setting this property changes the state of the socket. Returns None[848] only when constructed with initial_value set to None[849] and neither *on()* (page 180) nor *off()* (page 180) have been called since construction.

16.1.26 StatusZero

class gpiozero.StatusZero(**labels, pwm=False, active_high=True, initial_value=False, pin_factory=None*)

Extends *LEDBoard* (page 155) for The Pi Hut's STATUS Zero[850]: a Pi Zero sized add-on board with three sets of red/green LEDs to provide a status indicator.

The following example designates the first strip the label "wifi" and the second "raining", and turns them green and red respectfully:

```
from gpiozero import StatusZero

status = StatusZero('wifi', 'raining')
status.wifi.green.on()
status.raining.red.on()
```

840 https://docs.python.org/3.7/library/functions.html#int
841 https://docs.python.org/3.7/library/functions.html#bool
842 https://docs.python.org/3.7/library/constants.html#None
843 https://docs.python.org/3.7/library/constants.html#False
844 https://docs.python.org/3.7/library/constants.html#None
845 https://docs.python.org/3.7/library/constants.html#None
846 https://docs.python.org/3.7/library/constants.html#True
847 https://docs.python.org/3.7/library/constants.html#False
848 https://docs.python.org/3.7/library/constants.html#None
849 https://docs.python.org/3.7/library/constants.html#None
850 https://thepihut.com/statuszero

Each designated label will contain two *LED* (page 123) objects named "red" and "green".

Parameters

- ***labels** (*str*[851]) – Specify the names of the labels you wish to designate the strips to. You can list up to three labels. If no labels are given, three strips will be initialised with names 'one', 'two', and 'three'. If some, but not all strips are given labels, any remaining strips will not be initialised.
- **pin_factory** (Factory (page 230) *or* *None*[852]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

your-label-here, your-label-here, ...

This entry represents one of the three labelled attributes supported on the STATUS Zero board. It is an *LEDBoard* (page 155) which contains:

red

The *LED* (page 123) or *PWMLED* (page 125) representing the red LED next to the label.

green

The *LED* (page 123) or *PWMLED* (page 125) representing the green LED next to the label.

16.1.27 StatusBoard

class gpiozero.StatusBoard(**labels, pwm=False, active_high=True, initial_value=False, pin_factory=None***)**

Extends *CompositeOutputDevice* (page 185) for The Pi Hut's STATUS[853] board: a HAT sized add-on board with five sets of red/green LEDs and buttons to provide a status indicator with additional input.

The following example designates the first strip the label "wifi" and the second "raining", turns the wifi green and then activates the button to toggle its lights when pressed:

```
from gpiozero import StatusBoard

status = StatusBoard('wifi', 'raining')
status.wifi.lights.green.on()
status.wifi.button.when_pressed = status.wifi.lights.toggle
```

Each designated label will contain a "lights" *LEDBoard* (page 155) containing two *LED* (page 123) objects named "red" and "green", and a *Button* (page 103) object named "button".

Parameters

- ***labels** (*str*[854]) – Specify the names of the labels you wish to designate the strips to. You can list up to five labels. If no labels are given, five strips will be initialised with names 'one' to 'five'. If some, but not all strips are given labels, any remaining strips will not be initialised.
- **pin_factory** (Factory (page 230) *or* *None*[855]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

your-label-here, your-label-here, ...

This entry represents one of the five labelled attributes supported on the STATUS board. It is an *CompositeOutputDevice* (page 185) which contains:

lights

A *LEDBoard* (page 155) representing the lights next to the label. It contains:

[851] https://docs.python.org/3.7/library/stdtypes.html#str
[852] https://docs.python.org/3.7/library/constants.html#None
[853] https://thepihut.com/status
[854] https://docs.python.org/3.7/library/stdtypes.html#str
[855] https://docs.python.org/3.7/library/constants.html#None

red
The *LED* (page 123) or *PWMLED* (page 125) representing the red LED next to the label.

green
The *LED* (page 123) or *PWMLED* (page 125) representing the green LED next to the label.

button
A *Button* (page 103) representing the button next to the label.

16.1.28 SnowPi

class gpiozero.SnowPi(**, pwm=False, initial_value=False, pin_factory=None*)
Extends *LEDBoard* (page 155) for the Ryanteck SnowPi[856] board.

The SnowPi pins are fixed and therefore there's no need to specify them when constructing this class. The following example turns on the eyes, sets the nose pulsing, and the arms blinking:

```
from gpiozero import SnowPi

snowman = SnowPi(pwm=True)
snowman.eyes.on()
snowman.nose.pulse()
snowman.arms.blink()
```

Parameters

- **pwm** (*bool*[857]) – If True[858], construct *PWMLED* (page 125) instances to represent each LED. If False[859] (the default), construct regular *LED* (page 123) instances.
- **initial_value** (*bool*[860]) – If False[861] (the default), all LEDs will be off initially. If None[862], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[863], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[864]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

arms
A *LEDBoard* (page 155) representing the arms of the snow man. It contains the following attributes:

left, right
Two *LEDBoard* (page 155) objects representing the left and right arms of the snow-man. They contain:

top, middle, bottom
The *LED* (page 123) or *PWMLED* (page 125) down the snow-man's arms.

eyes
A *LEDBoard* (page 155) representing the eyes of the snow-man. It contains:

left, right
The *LED* (page 123) or *PWMLED* (page 125) for the snow-man's eyes.

856 https://ryanteck.uk/raspberry-pi/114-snowpi-the-gpio-snowman-for-raspberry-pi-0635648608303.html
857 https://docs.python.org/3.7/library/functions.html#bool
858 https://docs.python.org/3.7/library/constants.html#True
859 https://docs.python.org/3.7/library/constants.html#False
860 https://docs.python.org/3.7/library/functions.html#bool
861 https://docs.python.org/3.7/library/constants.html#False
862 https://docs.python.org/3.7/library/constants.html#None
863 https://docs.python.org/3.7/library/constants.html#True
864 https://docs.python.org/3.7/library/constants.html#None

nose
The *LED* (page 123) or *PWMLED* (page 125) for the snow-man's nose.

16.1.29 PumpkinPi

class gpiozero.PumpkinPi(**, pwm=False, initial_value=False, pin_factory=None*)
Extends *LEDBoard* (page 155) for the ModMyPi PumpkinPi[865] board.

There are twelve LEDs connected up to individual pins, so for the PumpkinPi the pins are fixed. For example:

```
from gpiozero import PumpkinPi

pumpkin = PumpkinPi(pwm=True)
pumpkin.sides.pulse()
pumpkin.off()
```

Parameters

- **pwm** (*bool*[866]) – If True[867], construct *PWMLED* (page 125) instances to represent each LED. If False[868] (the default), construct regular *LED* (page 123) instances
- **initial_value** (*bool*[869] *or None*[870]) – If False[871] (the default), all LEDs will be off initially. If None[872], each device will be left in whatever state the pin is found in when configured for output (warning: this can be on). If True[873], the device will be switched on initially.
- **pin_factory** (Factory (page 230) *or None*[874]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

sides
A *LEDBoard* (page 155) representing the LEDs around the edge of the pumpkin. It contains:

left, right
Two *LEDBoard* (page 155) instances representing the LEDs on the left and right sides of the pumpkin. They each contain:

top, midtop, middle, midbottom, bottom
Each *LED* (page 123) or *PWMLED* (page 125) around the specified side of the pumpkin.

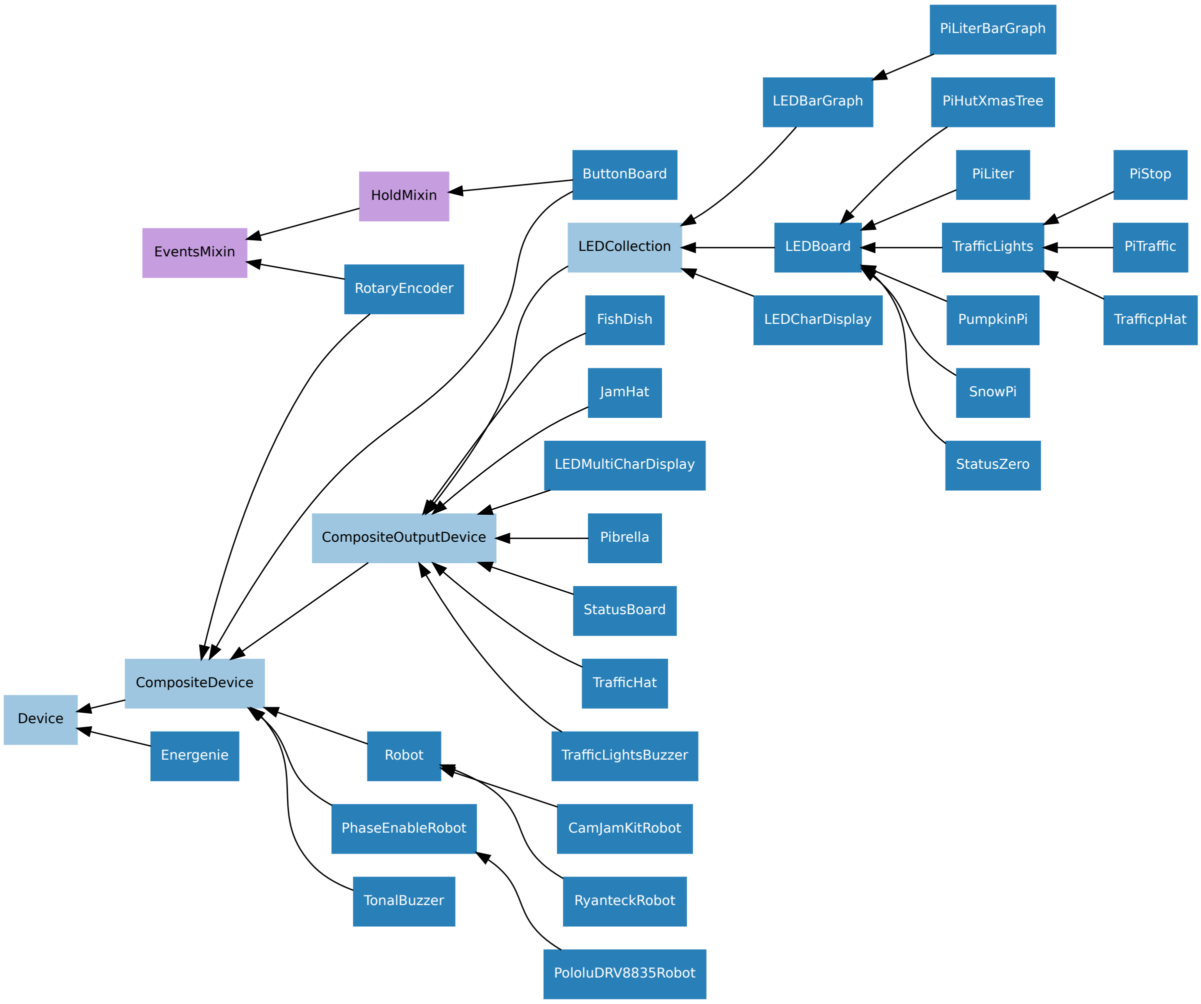
eyes
A *LEDBoard* (page 155) representing the eyes of the pumpkin. It contains:

left, right
The *LED* (page 123) or *PWMLED* (page 125) for each of the pumpkin's eyes.

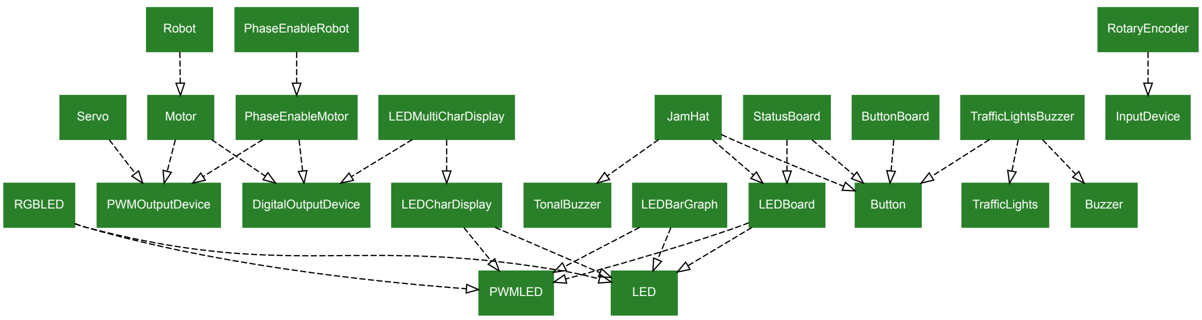
16.2 Base Classes

The classes in the sections above are derived from a series of base classes, some of which are effectively abstract. The classes form the (partial) hierarchy displayed in the graph below:

[865] https://www.modmypi.com/halloween-pumpkin-programmable-kit
[866] https://docs.python.org/3.7/library/functions.html#bool
[867] https://docs.python.org/3.7/library/constants.html#True
[868] https://docs.python.org/3.7/library/constants.html#False
[869] https://docs.python.org/3.7/library/functions.html#bool
[870] https://docs.python.org/3.7/library/constants.html#None
[871] https://docs.python.org/3.7/library/constants.html#False
[872] https://docs.python.org/3.7/library/constants.html#None
[873] https://docs.python.org/3.7/library/constants.html#True
[874] https://docs.python.org/3.7/library/constants.html#None



For composite devices, the following chart shows which devices are composed of which other devices:



The following sections document these base classes for advanced users that wish to construct classes for their own devices.

16.2.1 LEDCollection

class gpiozero.LEDCollection(**pins, pwm=False, active_high=True, initial_value=False, pin_factory=None, **named_pins*)

Extends *CompositeOutputDevice* (page 185). Abstract base class for *LEDBoard* (page 155) and *LEDBarGraph* (page 158).

is_lit

Composite devices are considered "active" if any of their constituent devices have a "truthy" value.

leds
A flat tuple of all LEDs contained in this collection (and all sub-collections).

16.2.2 CompositeOutputDevice

class gpiozero.CompositeOutputDevice(**args*, *_order=None*, *pin_factory=None*, ***kwargs*)
Extends *CompositeDevice* (page 185) with *on()* (page 185), *off()* (page 185), and *toggle()* (page 185) methods for controlling subordinate output devices. Also extends *value* (page 185) to be writeable.

Parameters

- ***args** (Device (page 201)) – The un-named devices that belong to the composite device. The *value* (page 201) attributes of these devices will be represented within the composite device's tuple *value* (page 185) in the order specified here.
- **_order** (*list*[875] *or None*[876]) – If specified, this is the order of named items specified by keyword arguments (to ensure that the *value* (page 185) tuple is constructed with a specific order). All keyword arguments *must* be included in the collection. If omitted, an alphabetically sorted order will be selected for keyword arguments.
- **pin_factory** (Factory (page 230) *or None*[877]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).
- ****kwargs** (Device (page 201)) – The named devices that belong to the composite device. These devices will be accessible as named attributes on the resulting device, and their *value* (page 185) attributes will be accessible as named elements of the composite device's tuple *value* (page 185).

off()
Turn all the output devices off.

on()
Turn all the output devices on.

toggle()
Toggle all the output devices. For each device, if it's on, turn it off; if it's off, turn it on.

value
A tuple containing a value for each subordinate device. This property can also be set to update the state of all subordinate output devices.

16.2.3 CompositeDevice

class gpiozero.CompositeDevice(**args*, *_order=None*, *pin_factory=None*, ***kwargs*)
Extends *Device* (page 201). Represents a device composed of multiple devices like simple HATs, H-bridge motor controllers, robots composed of multiple motors, etc.

The constructor accepts subordinate devices as positional or keyword arguments. Positional arguments form unnamed devices accessed by treating the composite device as a container, while keyword arguments are added to the device as named (read-only) attributes.

For example:

```
>>> from gpiozero import *
>>> d = CompositeDevice(LED(2), LED(3), LED(4), btn=Button(17))
>>> d[0]
```

(continues on next page)

[875] https://docs.python.org/3.7/library/stdtypes.html#list
[876] https://docs.python.org/3.7/library/constants.html#None
[877] https://docs.python.org/3.7/library/constants.html#None

(continued from previous page)

```
<gpiozero.LED object on pin GPIO2, active_high=True, is_active=False>
>>> d[1]
<gpiozero.LED object on pin GPIO3, active_high=True, is_active=False>
>>> d[2]
<gpiozero.LED object on pin GPIO4, active_high=True, is_active=False>
>>> d.btn
<gpiozero.Button object on pin GPIO17, pull_up=True, is_active=False>
>>> d.value
CompositeDeviceValue(device_0=False, device_1=False, device_2=False, btn=False)
```

Parameters

- ***args** (`Device` (page 201)) – The un-named devices that belong to the composite device. The *value* (page 187) attributes of these devices will be represented within the composite device's tuple *value* (page 187) in the order specified here.
- **_order** (*list*[878] *or None*[879]) – If specified, this is the order of named items specified by keyword arguments (to ensure that the *value* (page 187) tuple is constructed with a specific order). All keyword arguments *must* be included in the collection. If omitted, an alphabetically sorted order will be selected for keyword arguments.
- **pin_factory** (`Factory` (page 230) *or None*[880]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).
- ****kwargs** (`Device` (page 201)) – The named devices that belong to the composite device. These devices will be accessible as named attributes on the resulting device, and their *value* (page 187) attributes will be accessible as named elements of the composite device's tuple *value* (page 187).

close()

Shut down the device and release all associated resources (such as GPIO pins).

This method is idempotent (can be called on an already closed device without any side-effects). It is primarily intended for interactive use at the command line. It disables the device and releases its pin(s) for use by another device.

You can attempt to do this simply by deleting an object, but unless you've cleaned up all references to the object this may not work (even if you've cleaned up all references, there's still no guarantee the garbage collector will actually delete the object at that point). By contrast, the close method provides a means of ensuring that the object is shut down.

For example, if you have a breadboard with a buzzer connected to pin 16, but then wish to attach an LED instead:

```
>>> from gpiozero import *
>>> bz = Buzzer(16)
>>> bz.on()
>>> bz.off()
>>> bz.close()
>>> led = LED(16)
>>> led.blink()
```

Device (page 201) descendents can also be used as context managers using the `with`[881] statement. For example:

[878] https://docs.python.org/3.7/library/stdtypes.html#list
[879] https://docs.python.org/3.7/library/constants.html#None
[880] https://docs.python.org/3.7/library/constants.html#None
[881] https://docs.python.org/3.7/reference/compound_stmts.html#with

```
>>> from gpiozero import *
>>> with Buzzer(16) as bz:
...     bz.on()
...
>>> with LED(16) as led:
...     led.on()
...
```

closed
Returns True[882] if the device is closed (see the *close()* (page 186) method). Once a device is closed you can no longer use any other methods or properties to control or query the device.

is_active
Composite devices are considered "active" if any of their constituent devices have a "truthy" value.

namedtuple
The namedtuple()[883] type constructed to represent the value of the composite device. The *value* (page 187) attribute returns values of this type.

value
A namedtuple()[884] containing a value for each subordinate device. Devices with names will be represented as named elements. Unnamed devices will have a unique name generated for them, and they will appear in the position they appeared in the constructor.

[882] https://docs.python.org/3.7/library/constants.html#True
[883] https://docs.python.org/3.7/library/collections.html#collections.namedtuple
[884] https://docs.python.org/3.7/library/collections.html#collections.namedtuple

CHAPTER 17

API - Internal Devices

GPIO Zero also provides several "internal" devices which represent facilities provided by the operating system itself. These can be used to react to things like the time of day, or whether a server is available on the network.

These devices provide an API similar to and compatible with GPIO devices so that internal device events can trigger changes to GPIO output devices the way input devices can. In the same way a `Button` (page 103) object is *active* when it's pressed, and can be used to trigger other devices when its state changes, a `TimeOfDay` (page 190) object is *active* during a particular time period.

Consider the following code in which a `Button` (page 103) object is used to control an `LED` (page 123) object:

```
from gpiozero import LED, Button
from signal import pause

led = LED(2)
btn = Button(3)

btn.when_pressed = led.on
btn.when_released = led.off

pause()
```

Now consider the following example in which a `TimeOfDay` (page 190) object is used to control an `LED` (page 123) using the same method:

```
from gpiozero import LED, TimeOfDay
from datetime import time
from signal import pause

led = LED(2)
tod = TimeOfDay(time(9), time(10))

tod.when_activated = led.on
tod.when_deactivated = led.off

pause()
```

Here, rather than the LED being controlled by the press of a button, it's controlled by the time. When the time reaches 09:00AM, the LED comes on, and at 10:00AM it goes off.

Like the *Button* (page 103) object, internal devices like the *TimeOfDay* (page 190) object has *value* (page 191), `values`, *is_active* (page 191), *when_activated* (page 191) and *when_deactivated* (page 191) attributes, so alternative methods using the other paradigms would also work.

Note: Note that although the constructor parameter `pin_factory` is available for internal devices, and is required to be valid, the pin factory chosen will not make any practical difference. Reading a remote Pi's CPU temperature, for example, is not currently possible.

17.1 Regular Classes

The following classes are intended for general use with the devices they are named after. All classes in this section are concrete (not abstract).

17.1.1 TimeOfDay

class gpiozero.TimeOfDay(*start_time*, *end_time*, ***, *utc=True*, *event_delay=10.0*, *pin_factory=None*)

Extends *PolledInternalDevice* (page 197) to provide a device which is active when the computer's clock indicates that the current time is between *start_time* and *end_time* (inclusive) which are `time`[885] instances.

The following example turns on a lamp attached to an *Energenie* (page 179) plug between 07:00AM and 08:00AM:

```
from gpiozero import TimeOfDay, Energenie
from datetime import time
from signal import pause

lamp = Energenie(1)
morning = TimeOfDay(time(7), time(8))

morning.when_activated = lamp.on
morning.when_deactivated = lamp.off

pause()
```

Note that *start_time* may be greater than *end_time*, indicating a time period which crosses midnight.

Parameters

- **start_time** (*time*[886]) – The time from which the device will be considered active.
- **end_time** (*time*[887]) – The time after which the device will be considered inactive.
- **utc** (*bool*[888]) – If `True`[889] (the default), a naive UTC time will be used for the comparison rather than a local time-zone reading.
- **event_delay** (*float*[890]) – The number of seconds between file reads (defaults

[885] https://docs.python.org/3.7/library/datetime.html#datetime.time
[886] https://docs.python.org/3.7/library/datetime.html#datetime.time
[887] https://docs.python.org/3.7/library/datetime.html#datetime.time
[888] https://docs.python.org/3.7/library/functions.html#bool
[889] https://docs.python.org/3.7/library/constants.html#True
[890] https://docs.python.org/3.7/library/functions.html#float

to 10 seconds).

- **pin_factory** (Factory (page 230) *or* *None*[891]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

end_time
The time of day after which the device will be considered inactive.

is_active
Returns True[892] if the device is currently active and False[893] otherwise. This property is usually derived from *value* (page 191). Unlike *value* (page 191), this is *always* a boolean.

start_time
The time of day after which the device will be considered active.

utc
If True[894], use a naive UTC time reading for comparison instead of a local timezone reading.

value
Returns 1 when the system clock reads between *start_time* (page 191) and *end_time* (page 191), and 0 otherwise. If *start_time* (page 191) is greater than *end_time* (page 191) (indicating a period that crosses midnight), then this returns 1 when the current time is greater than *start_time* (page 191) or less than *end_time* (page 191).

when_activated
The function to run when the device changes state from inactive to active (time reaches *start_time*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

when_deactivated
The function to run when the device changes state from active to inactive (time reaches *end_time*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

17.1.2 PingServer

class gpiozero.PingServer(*host*, **, *event_delay=10.0*, *pin_factory=None*)
Extends *PolledInternalDevice* (page 197) to provide a device which is active when a *host* (domain name or IP address) can be pinged.

The following example lights an LED while google.com is reachable:

```
from gpiozero import PingServer, LED
from signal import pause

google = PingServer('google.com')
led = LED(4)
```

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891 https://docs.python.org/3.7/library/constants.html#None
892 https://docs.python.org/3.7/library/constants.html#True
893 https://docs.python.org/3.7/library/constants.html#False
894 https://docs.python.org/3.7/library/constants.html#True

(continued from previous page)

```
google.when_activated = led.on
google.when_deactivated = led.off

pause()
```

Parameters

- **host** (*str*[895]) – The hostname or IP address to attempt to ping.
- **event_delay** (*float*[896]) – The number of seconds between pings (defaults to 10 seconds).
- **pin_factory** (Factory (page 230) *or None*[897]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

host
The hostname or IP address to test whenever value (page 192) is queried.

is_active
Returns True[898] if the device is currently active and False[899] otherwise. This property is usually derived from value (page 192). Unlike value (page 192), this is *always* a boolean.

value
Returns 1 if the host returned a single ping, and 0 otherwise.

when_activated
The function to run when the device changes state from inactive (host unresponsive) to active (host responsive).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

when_deactivated
The function to run when the device changes state from inactive (host responsive) to active (host unresponsive).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

17.1.3 CPUTemperature

class gpiozero.CPUTemperature(*sensor_file='/sys/class/thermal/thermal_zone0/temp'*, *, *min_temp=0.0*, *max_temp=100.0*, *threshold=80.0*, *event_delay=5.0*, *pin_factory=None*)

Extends *PolledInternalDevice* (page 197) to provide a device which is active when the CPU temperature exceeds the *threshold* value.

The following example plots the CPU's temperature on an LED bar graph:

895 https://docs.python.org/3.7/library/stdtypes.html#str
896 https://docs.python.org/3.7/library/functions.html#float
897 https://docs.python.org/3.7/library/constants.html#None
898 https://docs.python.org/3.7/library/constants.html#True
899 https://docs.python.org/3.7/library/constants.html#False

```
from gpiozero import LEDBarGraph, CPUTemperature
from signal import pause

# Use minimums and maximums that are closer to "normal" usage so the
# bar graph is a bit more "lively"
cpu = CPUTemperature(min_temp=50, max_temp=90)

print('Initial temperature: {}C'.format(cpu.temperature))

graph = LEDBarGraph(5, 6, 13, 19, 25, pwm=True)
graph.source = cpu

pause()
```

Parameters

- **sensor_file** (*str*[900]) – The file from which to read the temperature. This defaults to the sysfs file `/sys/class/thermal/thermal_zone0/temp`. Whatever file is specified is expected to contain a single line containing the temperature in milli-degrees celsius.
- **min_temp** (*float*[901]) – The temperature at which `value` (page 193) will read 0.0. This defaults to 0.0.
- **max_temp** (*float*[902]) – The temperature at which `value` (page 193) will read 1.0. This defaults to 100.0.
- **threshold** (*float*[903]) – The temperature above which the device will be considered "active". (see `is_active` (page 193)). This defaults to 80.0.
- **event_delay** (*float*[904]) – The number of seconds between file reads (defaults to 5 seconds).
- **pin_factory** (`Factory` (page 230) *or None*[905]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

is_active

Returns `True`[906] when the CPU `temperature` (page 193) exceeds the *threshold*.

temperature

Returns the current CPU temperature in degrees celsius.

value

Returns the current CPU temperature as a value between 0.0 (representing the *min_temp* value) and 1.0 (representing the *max_temp* value). These default to 0.0 and 100.0 respectively, hence `value` (page 193) is `temperature` (page 193) divided by 100 by default.

when_activated

The function to run when the device changes state from inactive to active (temperature reaches *threshold*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

900 https://docs.python.org/3.7/library/stdtypes.html#str
901 https://docs.python.org/3.7/library/functions.html#float
902 https://docs.python.org/3.7/library/functions.html#float
903 https://docs.python.org/3.7/library/functions.html#float
904 https://docs.python.org/3.7/library/functions.html#float
905 https://docs.python.org/3.7/library/constants.html#None
906 https://docs.python.org/3.7/library/constants.html#True

Set this property to `None` (the default) to disable the event.

when_deactivated
The function to run when the device changes state from active to inactive (temperature drops below *threshold*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to `None` (the default) to disable the event.

17.1.4 LoadAverage

class gpiozero.LoadAverage(*load_average_file='/proc/loadavg'*, ***, *min_load_average=0.0*, *max_load_average=1.0*, *threshold=0.8*, *minutes=5*, *event_delay=10.0*, *pin_factory=None*)
Extends *PolledInternalDevice* (page 197) to provide a device which is active when the CPU load average exceeds the *threshold* value.

The following example plots the load average on an LED bar graph:

```
from gpiozero import LEDBarGraph, LoadAverage
from signal import pause

la = LoadAverage(min_load_average=0, max_load_average=2)
graph = LEDBarGraph(5, 6, 13, 19, 25, pwm=True)

graph.source = la

pause()
```

Parameters

- **load_average_file** (*str*[907]) – The file from which to read the load average. This defaults to the proc file `/proc/loadavg`. Whatever file is specified is expected to contain three space-separated load averages at the beginning of the file, representing 1 minute, 5 minute and 15 minute averages respectively.
- **min_load_average** (*float*[908]) – The load average at which *value* (page 195) will read 0.0. This defaults to 0.0.
- **max_load_average** (*float*[909]) – The load average at which *value* (page 195) will read 1.0. This defaults to 1.0.
- **threshold** (*float*[910]) – The load average above which the device will be considered "active". (see *is_active* (page 195)). This defaults to 0.8.
- **minutes** (*int*[911]) – The number of minutes over which to average the load. Must be 1, 5 or 15. This defaults to 5.
- **event_delay** (*float*[912]) – The number of seconds between file reads (defaults to 10 seconds).

[907] https://docs.python.org/3.7/library/stdtypes.html#str
[908] https://docs.python.org/3.7/library/functions.html#float
[909] https://docs.python.org/3.7/library/functions.html#float
[910] https://docs.python.org/3.7/library/functions.html#float
[911] https://docs.python.org/3.7/library/functions.html#int
[912] https://docs.python.org/3.7/library/functions.html#float

- **pin_factory** (Factory (page 230) *or* *None*[913]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

is_active
Returns True[914] when the *load_average* (page 195) exceeds the *threshold*.

load_average
Returns the current load average.

value
Returns the current load average as a value between 0.0 (representing the *min_load_average* value) and 1.0 (representing the *max_load_average* value). These default to 0.0 and 1.0 respectively.

when_activated
The function to run when the device changes state from inactive to active (load average reaches *threshold*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

when_deactivated
The function to run when the device changes state from active to inactive (load average drops below *threshold*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

17.1.5 DiskUsage

class gpiozero.**DiskUsage**(*filesystem='/'*, ***, *threshold=90.0*, *event_delay=30.0*, *pin_factory=None*)

Extends *PolledInternalDevice* (page 197) to provide a device which is active when the disk space used exceeds the *threshold* value.

The following example plots the disk usage on an LED bar graph:

```
from gpiozero import LEDBarGraph, DiskUsage
from signal import pause

disk = DiskUsage()

print('Current disk usage: {}%'.format(disk.usage))

graph = LEDBarGraph(5, 6, 13, 19, 25, pwm=True)
graph.source = disk

pause()
```

Parameters

[913] https://docs.python.org/3.7/library/constants.html#None
[914] https://docs.python.org/3.7/library/constants.html#True

- **filesystem** (*str*[915]) – A path within the filesystem for which the disk usage needs to be computed. This defaults to /, which is the root filesystem.
- **threshold** (*float*[916]) – The disk usage percentage above which the device will be considered "active" (see *is_active* (page 196)). This defaults to 90.0.
- **event_delay** (*float*[917]) – The number of seconds between file reads (defaults to 30 seconds).
- **pin_factory** (Factory (page 230) *or None*[918]) – See *API - Pins* (page 225) for more information (this is an advanced feature which most users can ignore).

is_active
Returns True[919] when the disk *usage* (page 196) exceeds the *threshold*.

usage
Returns the current disk usage in percentage.

value
Returns the current disk usage as a value between 0.0 and 1.0 by dividing *usage* (page 196) by 100.

when_activated
The function to run when the device changes state from inactive to active (disk usage reaches *threshold*).

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

when_deactivated
The function to run when the device changes state from active to inactive (disk usage drops below *threshold*).

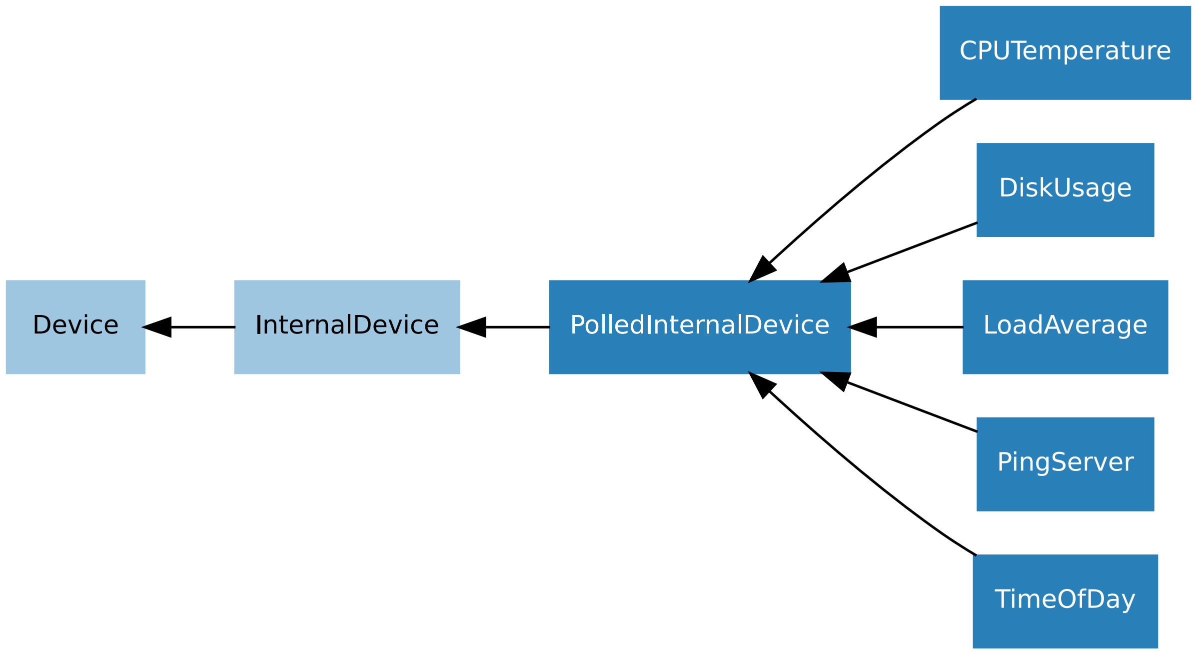
This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to None (the default) to disable the event.

17.2 Base Classes

The classes in the sections above are derived from a series of base classes, some of which are effectively abstract. The classes form the (partial) hierarchy displayed in the graph below (abstract classes are shaded lighter than concrete classes):

915 https://docs.python.org/3.7/library/stdtypes.html#str
916 https://docs.python.org/3.7/library/functions.html#float
917 https://docs.python.org/3.7/library/functions.html#float
918 https://docs.python.org/3.7/library/constants.html#None
919 https://docs.python.org/3.7/library/constants.html#True



The following sections document these base classes for advanced users that wish to construct classes for their own devices.

17.2.1 PolledInternalDevice

`class gpiozero.PolledInternalDevice(`*, *event_delay=1.0*, *pin_factory=None*`)`

Extends *InternalDevice* (page 197) to provide a background thread to poll internal devices that lack any other mechanism to inform the instance of changes.

17.2.2 InternalDevice

`class gpiozero.InternalDevice(`*, *pin_factory=None*`)`

Extends *Device* (page 201) to provide a basis for devices which have no specific hardware representation. These are effectively pseudo-devices and usually represent operating system services like the internal clock, file systems or network facilities.

CHAPTER 18

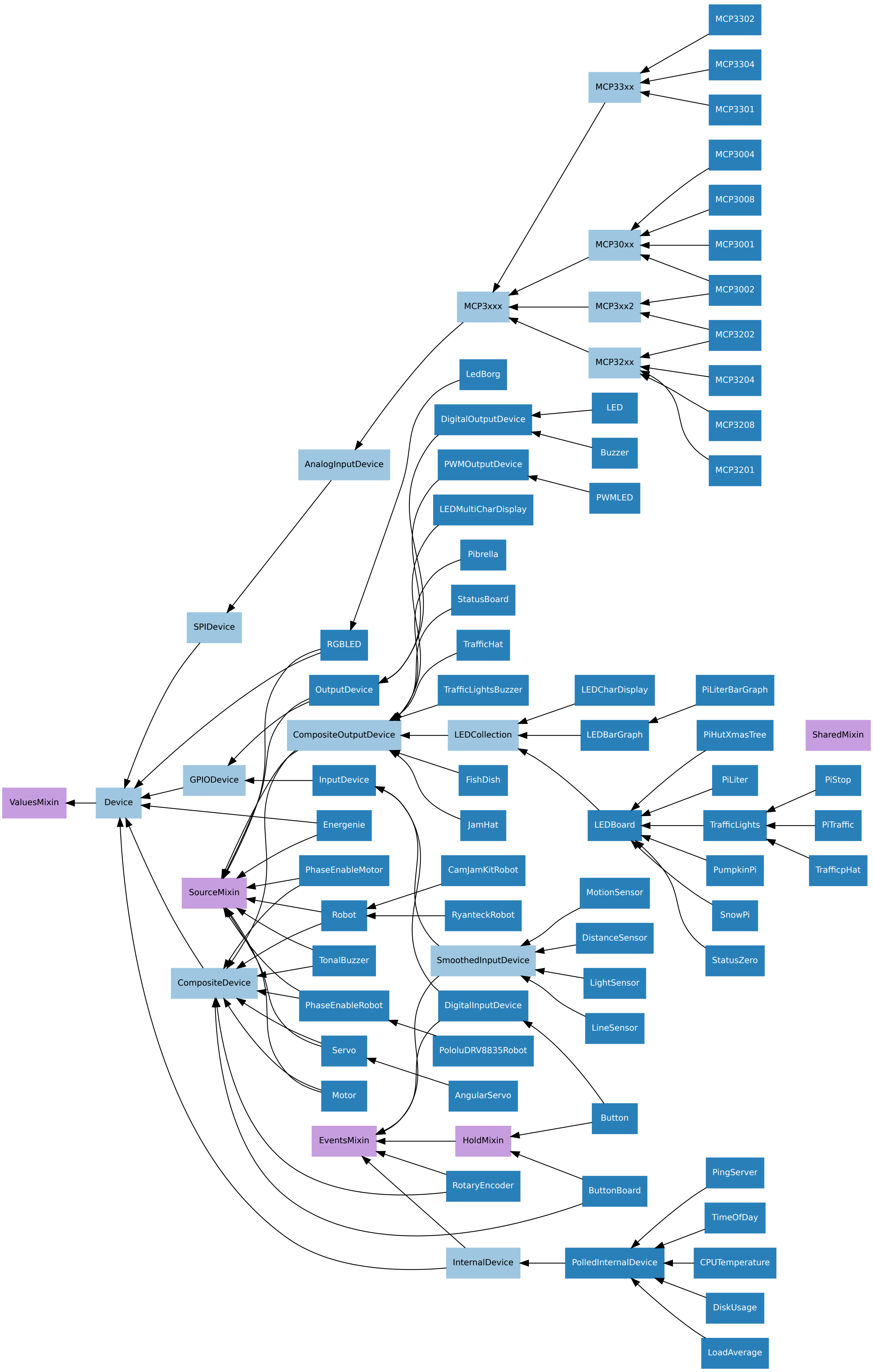
API - Generic Classes

The GPIO Zero class hierarchy is quite extensive. It contains several base classes (most of which are documented in their corresponding chapters):

- *Device* (page 201) is the root of the hierarchy, implementing base functionality like *close()* (page 201) and context manager handlers.
- *GPIODevice* (page 121) represents individual devices that attach to a single GPIO pin
- *SPIDevice* (page 152) represents devices that communicate over an SPI interface (implemented as four GPIO pins)
- *InternalDevice* (page 197) represents devices that are entirely internal to the Pi (usually operating system related services)
- *CompositeDevice* (page 185) represents devices composed of multiple other devices like HATs

There are also several mixin classes[920] for adding important functionality at numerous points in the hierarchy, which is illustrated below (mixin classes are represented in purple, while abstract classes are shaded lighter):

[920] https://en.wikipedia.org/wiki/Mixin


MCP3302
MCP3304
MCP3301
MCP33xx
MCP3004
MCP3008
MCP3001
MCP30xx
MCP3002
MCP3xxx
MCP3xx2
MCP3202
MCP32xx
MCP3204
MCP3208
MCP3201
LedBorg
LED
DigitalOutputDevice
Buzzer
AnalogInputDevice
PWMOutputDevice
PWMLED
LEDMultiCharDisplay
Pibrella
StatusBoard
SPIDevice
RGBLED
TrafficHat
OutputDevice
TrafficLightsBuzzer
LEDCharDisplay
PiLiterBarGraph
CompositeOutputDevice
LEDCollection
LEDBarGraph
PiHutXmasTree
SharedMixin
GPIODevice
InputDevice
FishDish
PiLiter
PiStop
ValuesMixin
Device
Energenie
JamHat
LEDBoard
TrafficLights
PiTraffic
PhaseEnableMotor
CamJamKitRobot
PumpkinPi
TrafficHat
SourceMixin
MotionSensor
Robot
RyanteckRobot
SnowPi
DistanceSensor
TonalBuzzer
SmoothedInputDevice
StatusZero
CompositeDevice
LightSensor
PhaseEnableRobot
DigitalInputDevice
LineSensor
Servo
PololuDRV8835Robot
Motor
AngularServo
Button
EventsMixin
HoldMixin
PingServer
RotaryEncoder
ButtonBoard
TimeOfDay
InternalDevice
PolledInternalDevice
CPUTemperature
DiskUsage
LoadAverage

18.1 Device

class gpiozero.Device(**, pin_factory=None*)

Represents a single device of any type; GPIO-based, SPI-based, I2C-based, etc. This is the base class of the device hierarchy. It defines the basic services applicable to all devices (specifically the *is_active* (page 201) property, the *value* (page 201) property, and the *close()* (page 201) method).

pin_factory

This attribute exists at both a class level (representing the default pin factory used to construct devices when no *pin_factory* parameter is specified), and at an instance level (representing the pin factory that the device was constructed with).

The pin factory provides various facilities to the device including allocating pins, providing low level interfaces (e.g. SPI), and clock facilities (querying and calculating elapsed times).

close()

Shut down the device and release all associated resources (such as GPIO pins).

This method is idempotent (can be called on an already closed device without any side-effects). It is primarily intended for interactive use at the command line. It disables the device and releases its pin(s) for use by another device.

You can attempt to do this simply by deleting an object, but unless you've cleaned up all references to the object this may not work (even if you've cleaned up all references, there's still no guarantee the garbage collector will actually delete the object at that point). By contrast, the close method provides a means of ensuring that the object is shut down.

For example, if you have a breadboard with a buzzer connected to pin 16, but then wish to attach an LED instead:

```
>>> from gpiozero import *
>>> bz = Buzzer(16)
>>> bz.on()
>>> bz.off()
>>> bz.close()
>>> led = LED(16)
>>> led.blink()
```

Device (page 201) descendents can also be used as context managers using the `with`[921] statement. For example:

```
>>> from gpiozero import *
>>> with Buzzer(16) as bz:
...     bz.on()
...
>>> with LED(16) as led:
...     led.on()
...
```

closed

Returns `True`[922] if the device is closed (see the *close()* (page 201) method). Once a device is closed you can no longer use any other methods or properties to control or query the device.

is_active

Returns `True`[923] if the device is currently active and `False`[924] otherwise. This property is usually derived from *value* (page 201). Unlike *value* (page 201), this is *always* a boolean.

921 https://docs.python.org/3.7/reference/compound_stmts.html#with
922 https://docs.python.org/3.7/library/constants.html#True
923 https://docs.python.org/3.7/library/constants.html#True
924 https://docs.python.org/3.7/library/constants.html#False

value
Returns a value representing the device's state. Frequently, this is a boolean value, or a number between 0 and 1 but some devices use larger ranges (e.g. -1 to +1) and composite devices usually use tuples to return the states of all their subordinate components.

18.2 ValuesMixin

class gpiozero.ValuesMixin(...)
Adds a *values* (page 202) property to the class which returns an infinite generator of readings from the *value* (page 201) property. There is rarely a need to use this mixin directly as all base classes in GPIO Zero include it.

Note: Use this mixin *first* in the parent class list.

values
An infinite iterator of values read from `value`.

18.3 SourceMixin

class gpiozero.SourceMixin(...)
Adds a *source* (page 202) property to the class which, given an iterable or a *ValuesMixin* (page 202) descendent, sets *value* (page 201) to each member of that iterable until it is exhausted. This mixin is generally included in novel output devices to allow their state to be driven from another device.

Note: Use this mixin *first* in the parent class list.

source
The iterable to use as a source of values for `value`.

source_delay
The delay (measured in seconds) in the loop used to read values from *source* (page 202). Defaults to 0.01 seconds which is generally sufficient to keep CPU usage to a minimum while providing adequate responsiveness.

18.4 SharedMixin

class gpiozero.SharedMixin(...)
This mixin marks a class as "shared". In this case, the meta-class (GPIOMeta) will use *_shared_key()* (page 202) to convert the constructor arguments to an immutable key, and will check whether any existing instances match that key. If they do, they will be returned by the constructor instead of a new instance. An internal reference counter is used to determine how many times an instance has been "constructed" in this way.

When *close()* (page 201) is called, an internal reference counter will be decremented and the instance will only close when it reaches zero.

classmethod _shared_key(args*, ***kwargs*)**
This is called with the constructor arguments to generate a unique key (which must be storable in a `dict`[925] and, thus, immutable and hashable) representing the instance that can be shared. This must be overridden by descendents.

[925] https://docs.python.org/3.7/library/stdtypes.html#dict

The default simply assumes all positional arguments are immutable and returns this as the key but this is almost never the "right" thing to do and almost all descendents should override this method.

18.5 EventsMixin

class gpiozero.EventsMixin(...)

Adds edge-detected *when_activated()* (page 203) and *when_deactivated()* (page 203) events to a device based on changes to the *is_active* (page 201) property common to all devices. Also adds *wait_for_active()* (page 203) and *wait_for_inactive()* (page 203) methods for level-waiting.

Note: Note that this mixin provides no means of actually firing its events; call `_fire_events()` in sub-classes when device state changes to trigger the events. This should also be called once at the end of initialization to set initial states.

wait_for_active(*timeout=None*)

Pause the script until the device is activated, or the timeout is reached.

Parameters **timeout** (*float*[926] *or None*[927]) – Number of seconds to wait before proceeding. If this is `None`[928] (the default), then wait indefinitely until the device is active.

wait_for_inactive(*timeout=None*)

Pause the script until the device is deactivated, or the timeout is reached.

Parameters **timeout** (*float*[929] *or None*[930]) – Number of seconds to wait before proceeding. If this is `None`[931] (the default), then wait indefinitely until the device is inactive.

active_time

The length of time (in seconds) that the device has been active for. When the device is inactive, this is `None`[932].

inactive_time

The length of time (in seconds) that the device has been inactive for. When the device is active, this is `None`[933].

when_activated

The function to run when the device changes state from inactive to active.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated it will be passed as that parameter.

Set this property to `None`[934] (the default) to disable the event.

when_deactivated

The function to run when the device changes state from active to inactive.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like).

[926] https://docs.python.org/3.7/library/functions.html#float
[927] https://docs.python.org/3.7/library/constants.html#None
[928] https://docs.python.org/3.7/library/constants.html#None
[929] https://docs.python.org/3.7/library/functions.html#float
[930] https://docs.python.org/3.7/library/constants.html#None
[931] https://docs.python.org/3.7/library/constants.html#None
[932] https://docs.python.org/3.7/library/constants.html#None
[933] https://docs.python.org/3.7/library/constants.html#None
[934] https://docs.python.org/3.7/library/constants.html#None

If the function accepts a single mandatory parameter, the device that deactivated it will be passed as that parameter.

Set this property to `None`[935] (the default) to disable the event.

18.6 HoldMixin

class gpiozero.HoldMixin(...)

Extends *EventsMixin* (page 203) to add the *when_held* (page 204) event and the machinery to fire that event repeatedly (when *hold_repeat* (page 204) is `True`[936]) at internals defined by *hold_time* (page 204).

held_time

The length of time (in seconds) that the device has been held for. This is counted from the first execution of the *when_held* (page 204) event rather than when the device activated, in contrast to *active_time* (page 203). If the device is not currently held, this is `None`[937].

hold_repeat

If `True`[938], *when_held* (page 204) will be executed repeatedly with *hold_time* (page 204) seconds between each invocation.

hold_time

The length of time (in seconds) to wait after the device is activated, until executing the *when_held* (page 204) handler. If *hold_repeat* (page 204) is True, this is also the length of time between invocations of *when_held* (page 204).

is_held

When `True`[939], the device has been active for at least *hold_time* (page 204) seconds.

when_held

The function to run when the device has remained active for *hold_time* (page 204) seconds.

This can be set to a function which accepts no (mandatory) parameters, or a Python function which accepts a single mandatory parameter (with as many optional parameters as you like). If the function accepts a single mandatory parameter, the device that activated will be passed as that parameter.

Set this property to `None`[940] (the default) to disable the event.

935 https://docs.python.org/3.7/library/constants.html#None
936 https://docs.python.org/3.7/library/constants.html#True
937 https://docs.python.org/3.7/library/constants.html#None
938 https://docs.python.org/3.7/library/constants.html#True
939 https://docs.python.org/3.7/library/constants.html#True
940 https://docs.python.org/3.7/library/constants.html#None

CHAPTER 19

API - Device Source Tools

GPIO Zero includes several utility routines which are intended to be used with the *Source/Values* (page 65) attributes common to most devices in the library. These utility routines are in the `tools` module of GPIO Zero and are typically imported as follows:

```
from gpiozero.tools import scaled, negated, all_values
```

Given that `source` (page 202) and `values` (page 202) deal with infinite iterators, another excellent source of utilities is the `itertools`[941] module in the standard library.

19.1 Single source conversions

`gpiozero.tools.absoluted(values)`

Returns *values* with all negative elements negated (so that they're positive). For example:

```
from gpiozero import PWMLED, Motor, MCP3008
from gpiozero.tools import absoluted, scaled
from signal import pause

led = PWMLED(4)
motor = Motor(22, 27)
pot = MCP3008(channel=0)

motor.source = scaled(pot, -1, 1)
led.source = absoluted(motor)

pause()
```

`gpiozero.tools.booleanized(values, min_value, max_value, hysteresis=0)`

Returns True for each item in *values* between *min_value* and *max_value*, and False otherwise. *hysteresis* can optionally be used to add hysteresis[942] which prevents the output value rapidly flipping when the input value is fluctuating near the *min_value* or *max_value* thresholds. For example, to light an LED only when a potentiometer is between ¼ and ¾ of its full range:

941 https://docs.python.org/3.7/library/itertools.html#module-itertools
942 https://en.wikipedia.org/wiki/Hysteresis

```
from gpiozero import LED, MCP3008
from gpiozero.tools import booleanized
from signal import pause

led = LED(4)
pot = MCP3008(channel=0)

led.source = booleanized(pot, 0.25, 0.75)

pause()
```

gpiozero.tools.**clamped**(*values*, *output_min=0*, *output_max=1*)

Returns *values* clamped from *output_min* to *output_max*, i.e. any items less than *output_min* will be returned as *output_min* and any items larger than *output_max* will be returned as *output_max* (these default to 0 and 1 respectively). For example:

```
from gpiozero import PWMLED, MCP3008
from gpiozero.tools import clamped
from signal import pause

led = PWMLED(4)
pot = MCP3008(channel=0)

led.source = clamped(pot, 0.5, 1.0)

pause()
```

gpiozero.tools.**inverted**(*values*, *input_min=0*, *input_max=1*)

Returns the inversion of the supplied values (*input_min* becomes *input_max*, *input_max* becomes *input_min*, *input_min + 0.1* becomes *input_max - 0.1*, etc.). All items in *values* are assumed to be between *input_min* and *input_max* (which default to 0 and 1 respectively), and the output will be in the same range. For example:

```
from gpiozero import MCP3008, PWMLED
from gpiozero.tools import inverted
from signal import pause

led = PWMLED(4)
pot = MCP3008(channel=0)

led.source = inverted(pot)

pause()
```

gpiozero.tools.**negated**(*values*)

Returns the negation of the supplied values (`True`[943] becomes `False`[944], and `False`[945] becomes `True`[946]). For example:

```
from gpiozero import Button, LED
from gpiozero.tools import negated
from signal import pause

led = LED(4)
```

(continues on next page)

[943] https://docs.python.org/3.7/library/constants.html#True
[944] https://docs.python.org/3.7/library/constants.html#False
[945] https://docs.python.org/3.7/library/constants.html#False
[946] https://docs.python.org/3.7/library/constants.html#True

(continued from previous page)

```
btn = Button(17)

led.source = negated(btn)

pause()
```

gpiozero.tools.**post_delayed**(*values*, *delay*)

Waits for *delay* seconds after returning each item from *values*.

gpiozero.tools.**post_periodic_filtered**(*values*, *repeat_after*, *block*)

After every *repeat_after* items, blocks the next *block* items from *values*. Note that unlike *pre_periodic_filtered()* (page 207), *repeat_after* can't be 0. For example, to block every tenth item read from an ADC:

```
from gpiozero import MCP3008
from gpiozero.tools import post_periodic_filtered

adc = MCP3008(channel=0)

for value in post_periodic_filtered(adc, 9, 1):
    print(value)
```

gpiozero.tools.**pre_delayed**(*values*, *delay*)

Waits for *delay* seconds before returning each item from *values*.

gpiozero.tools.**pre_periodic_filtered**(*values*, *block*, *repeat_after*)

Blocks the first *block* items from *values*, repeating the block after every *repeat_after* items, if *repeat_after* is non-zero. For example, to discard the first 50 values read from an ADC:

```
from gpiozero import MCP3008
from gpiozero.tools import pre_periodic_filtered

adc = MCP3008(channel=0)

for value in pre_periodic_filtered(adc, 50, 0):
    print(value)
```

Or to only display every even item read from an ADC:

```
from gpiozero import MCP3008
from gpiozero.tools import pre_periodic_filtered

adc = MCP3008(channel=0)

for value in pre_periodic_filtered(adc, 1, 1):
    print(value)
```

gpiozero.tools.**quantized**(*values*, *steps*, *input_min=0*, *input_max=1*)

Returns *values* quantized to *steps* increments. All items in *values* are assumed to be between *input_min* and *input_max* (which default to 0 and 1 respectively), and the output will be in the same range.

For example, to quantize values between 0 and 1 to 5 "steps" (0.0, 0.25, 0.5, 0.75, 1.0):

```
from gpiozero import PWMLED, MCP3008
from gpiozero.tools import quantized
from signal import pause

```

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```
led = PWMLED(4)
pot = MCP3008(channel=0)

led.source = quantized(pot, 4)

pause()
```

gpiozero.tools.**queued**(*values, qsize*)

Queues up readings from *values* (the number of readings queued is determined by *qsize*) and begins yielding values only when the queue is full. For example, to "cascade" values along a sequence of LEDs:

```
from gpiozero import LEDBoard, Button
from gpiozero.tools import queued
from signal import pause

leds = LEDBoard(5, 6, 13, 19, 26)
btn = Button(17)

for i in range(4):
    leds[i].source = queued(leds[i + 1], 5)
    leds[i].source_delay = 0.01

leds[4].source = btn

pause()
```

gpiozero.tools.**smoothed**(*values, qsize, average=<function mean>*)

Queues up readings from *values* (the number of readings queued is determined by *qsize*) and begins yielding the *average* of the last *qsize* values when the queue is full. The larger the *qsize*, the more the values are smoothed. For example, to smooth the analog values read from an ADC:

```
from gpiozero import MCP3008
from gpiozero.tools import smoothed

adc = MCP3008(channel=0)

for value in smoothed(adc, 5):
    print(value)
```

gpiozero.tools.**scaled**(*values, output_min, output_max, input_min=0, input_max=1*)

Returns *values* scaled from *output_min* to *output_max*, assuming that all items in *values* lie between *input_min* and *input_max* (which default to 0 and 1 respectively). For example, to control the direction of a motor (which is represented as a value between -1 and 1) using a potentiometer (which typically provides values between 0 and 1):

```
from gpiozero import Motor, MCP3008
from gpiozero.tools import scaled
from signal import pause

motor = Motor(20, 21)
pot = MCP3008(channel=0)

motor.source = scaled(pot, -1, 1)

pause()
```

> **Warning:** If *values* contains elements that lie outside *input_min* to *input_max* (inclusive) then the function will not produce values that lie within *output_min* to *output_max* (inclusive).

19.2 Combining sources

gpiozero.tools.**all_values**(**values*)

Returns the logical conjunction[947] of all supplied values (the result is only `True`[948] if and only if all input values are simultaneously `True`[949]). One or more *values* can be specified. For example, to light an *LED* (page 123) only when *both* buttons are pressed:

```
from gpiozero import LED, Button
from gpiozero.tools import all_values
from signal import pause

led = LED(4)
btn1 = Button(20)
btn2 = Button(21)

led.source = all_values(btn1, btn2)

pause()
```

gpiozero.tools.**any_values**(**values*)

Returns the logical disjunction[950] of all supplied values (the result is `True`[951] if any of the input values are currently `True`[952]). One or more *values* can be specified. For example, to light an *LED* (page 123) when *any* button is pressed:

```
from gpiozero import LED, Button
from gpiozero.tools import any_values
from signal import pause

led = LED(4)
btn1 = Button(20)
btn2 = Button(21)

led.source = any_values(btn1, btn2)

pause()
```

gpiozero.tools.**averaged**(**values*)

Returns the mean of all supplied values. One or more *values* can be specified. For example, to light a *PWMLED* (page 125) as the average of several potentiometers connected to an *MCP3008* (page 147) ADC:

```
from gpiozero import MCP3008, PWMLED
from gpiozero.tools import averaged
from signal import pause

pot1 = MCP3008(channel=0)
```

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947 https://en.wikipedia.org/wiki/Logical_conjunction
948 https://docs.python.org/3.7/library/constants.html#True
949 https://docs.python.org/3.7/library/constants.html#True
950 https://en.wikipedia.org/wiki/Logical_disjunction
951 https://docs.python.org/3.7/library/constants.html#True
952 https://docs.python.org/3.7/library/constants.html#True

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```
pot2 = MCP3008(channel=1)
pot3 = MCP3008(channel=2)
led = PWMLED(4)

led.source = averaged(pot1, pot2, pot3)

pause()
```

gpiozero.tools.**multiplied**(**values*)

Returns the product of all supplied values. One or more *values* can be specified. For example, to light a *PWMLED* (page 125) as the product (i.e. multiplication) of several potentiometers connected to an *MCP3008* (page 147) ADC:

```
from gpiozero import MCP3008, PWMLED
from gpiozero.tools import multiplied
from signal import pause

pot1 = MCP3008(channel=0)
pot2 = MCP3008(channel=1)
pot3 = MCP3008(channel=2)
led = PWMLED(4)

led.source = multiplied(pot1, pot2, pot3)

pause()
```

gpiozero.tools.**summed**(**values*)

Returns the sum of all supplied values. One or more *values* can be specified. For example, to light a *PWMLED* (page 125) as the (scaled) sum of several potentiometers connected to an *MCP3008* (page 147) ADC:

```
from gpiozero import MCP3008, PWMLED
from gpiozero.tools import summed, scaled
from signal import pause

pot1 = MCP3008(channel=0)
pot2 = MCP3008(channel=1)
pot3 = MCP3008(channel=2)
led = PWMLED(4)

led.source = scaled(summed(pot1, pot2, pot3), 0, 1, 0, 3)

pause()
```

gpiozero.tools.**zip_values**(**devices*)

Provides a source constructed from the values of each item, for example:

```
from gpiozero import MCP3008, Robot
from gpiozero.tools import zip_values
from signal import pause

robot = Robot(left=(4, 14), right=(17, 18))

left = MCP3008(0)
right = MCP3008(1)

robot.source = zip_values(left, right)
```

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```
pause()
```

`zip_values(left, right)` is equivalent to `zip(left.values, right.values)`.

19.3 Artificial sources

`gpiozero.tools.alternating_values`(*initial_value=False*)

Provides an infinite source of values alternating between `True`[953] and `False`[954], starting wth *initial_value* (which defaults to `False`[955]). For example, to produce a flashing LED:

```
from gpiozero import LED
from gpiozero.tools import alternating_values
from signal import pause

red = LED(2)

red.source_delay = 0.5
red.source = alternating_values()

pause()
```

`gpiozero.tools.cos_values`(*period=360*)

Provides an infinite source of values representing a cosine wave (from -1 to +1) which repeats every *period* values. For example, to produce a "siren" effect with a couple of LEDs that repeats once a second:

```
from gpiozero import PWMLED
from gpiozero.tools import cos_values, scaled_half, inverted
from signal import pause

red = PWMLED(2)
blue = PWMLED(3)

red.source_delay = 0.01
blue.source_delay = red.source_delay
red.source = scaled_half(cos_values(100))
blue.source = inverted(red)

pause()
```

If you require a different range than -1 to +1, see *`scaled()`* (page 208).

`gpiozero.tools.ramping_values`(*period=360*)

Provides an infinite source of values representing a triangle wave (from 0 to 1 and back again) which repeats every *period* values. For example, to pulse an LED once a second:

```
from gpiozero import PWMLED
from gpiozero.tools import ramping_values
from signal import pause

red = PWMLED(2)
```

(continues on next page)

953 https://docs.python.org/3.7/library/constants.html#True
954 https://docs.python.org/3.7/library/constants.html#False
955 https://docs.python.org/3.7/library/constants.html#False

(continued from previous page)

```
red.source_delay = 0.01
red.source = ramping_values(100)

pause()
```

If you require a wider range than 0 to 1, see *scaled()* (page 208).

gpiozero.tools.**random_values**()

Provides an infinite source of random values between 0 and 1. For example, to produce a "flickering candle" effect with an LED:

```
from gpiozero import PWMLED
from gpiozero.tools import random_values
from signal import pause

led = PWMLED(4)

led.source = random_values()

pause()
```

If you require a wider range than 0 to 1, see *scaled()* (page 208).

gpiozero.tools.**sin_values**(*period=360*)

Provides an infinite source of values representing a sine wave (from -1 to +1) which repeats every *period* values. For example, to produce a "siren" effect with a couple of LEDs that repeats once a second:

```
from gpiozero import PWMLED
from gpiozero.tools import sin_values, scaled_half, inverted
from signal import pause

red = PWMLED(2)
blue = PWMLED(3)

red.source_delay = 0.01
blue.source_delay = red.source_delay
red.source = scaled_half(sin_values(100))
blue.source = inverted(red)

pause()
```

If you require a different range than -1 to +1, see *scaled()* (page 208).

CHAPTER 20

API - Fonts

GPIO Zero includes a concept of "fonts" which is somewhat different to that you may be familiar with. While a typical printing font determines how a particular character is rendered on a page, a GPIO Zero font determines how a particular character is rendered by a series of lights, like LED segments (e.g. with *LEDCharDisplay* (page 160) or *LEDMultiCharDisplay* (page 162)).

As a result, GPIO Zero's fonts are quite crude affairs, being little more than mappings of characters to tuples of LED states. Still, it helps to have a "friendly" format for creating such fonts, and in this module the library provides several routines for this purpose.

The module itself is typically imported as follows:

```
from gpiozero import fonts
```

20.1 Font Parsing

gpiozero.fonts.load_font_7seg(*filename_or_obj*)

Given a filename or a file-like object, parse it as an font definition for a 7-segment display[956], returning a dict[957] suitable for use with *LEDCharDisplay* (page 160).

The file-format is a simple text-based format in which blank and #-prefixed lines are ignored. All other lines are assumed to be groups of character definitions which are cells of 3x3 characters laid out as follows:

```
Ca
fgb
edc
```

Where C is the character being defined, and a-g define the states of the LEDs for that position. a, d, and g are on if they are "_". b, c, e, and f are on if they are "|". Any other character in these positions is considered off. For example, you might define the following characters:

```
 .  0_  1.  2_  3_  4.  5_  6_  7_  8_  9_
... |.| ..| ._| ._| |_| |_. |_. ..| |_| |_|
... |_| ..| |_. ._| ..| ._| |_| ..| |_| ._|
```

[956] https://en.wikipedia.org/wiki/Seven-segment_display
[957] https://docs.python.org/3.7/library/stdtypes.html#dict

In the example above, empty locations are marked with "." but could mostly be left as spaces. However, the first item defines the space (" ") character and needs *some* non-space characters in its definition as the parser also strips empty columns (as typically occur between character definitions). This is also why the definition for "1" must include something to fill the middle column.

gpiozero.fonts.load_font_14seg(*filename_or_obj*)

Given a filename or a file-like object, parse it as a font definition for a 14-segment display[958], returning a `dict`[959] suitable for use with *LEDCharDisplay* (page 160).

The file-format is a simple text-based format in which blank and #-prefixed lines are ignored. All other lines are assumed to be groups of character definitions which are cells of 5x5 characters laid out as follows:

```
X.a..
fijkb
.g.h.
elmnc
..d..
```

Where X is the character being defined, and a-n define the states of the LEDs for that position. a, d, g, and h are on if they are "-". b, c, e, f, j, and m are on if they are "|". i and n are on if they are "". Finally, k and l are on if they are "/". Any other character in these positions is considered off. For example, you might define the following characters:

```
 .... 0---  1..   2---  3---  4     5---  6---  7---. 8---  9---
..... |  /|    /|     |     | |   | |     |        /  |   | |   |
..... | / |     |  ---    --   ---|  ---  |---    |    ---    ---|
..... |/  |     | |         |     |     | |   |   |   |   |     |
.....  ---         ---   ---         ---   ---         ---
```

In the example above, several locations have extraneous characters. For example, the "/" in the center of the "0" definition, or the "-" in the middle of the "8". These locations are ignored, but filled in nonetheless to make the shape more obvious.

These extraneous locations could equally well be left as spaces. However, the first item defines the space (" ") character and needs *some* non-space characters in its definition as the parser also strips empty columns (as typically occur between character definitions) and verifies that definitions are 5 columns wide and 5 rows high.

This also explains why place-holder characters (".") have been inserted at the top of the definition of the "1" character. Otherwise the parser will strip these empty columns and decide the definition is invalid (as the result is only 3 columns wide).

gpiozero.fonts.load_segment_font(*filename_or_obj, width, height, pins*)

A generic function for parsing segment font definition files.

If you're working with "standard" 7-segment[960] or 14-segment[961] displays you *don't* want this function; see *load_font_7seg()* (page 213) or *load_font_14seg()* (page 214) instead. However, if you are working with another style of segmented display and wish to construct a parser for a custom format, this is the function you want.

The *filename_or_obj* parameter is simply the file-like object or filename to load. This is typically passed in from the calling function.

The *width* and *height* parameters give the width and height in characters of each character definition. For example, these are 3 and 3 for 7-segment displays. Finally, *pins* is a list of tuples that defines the position of each pin definition in the character array, and the character that marks that position "active".

958 https://en.wikipedia.org/wiki/Fourteen-segment_display
959 https://docs.python.org/3.7/library/stdtypes.html#dict
960 https://en.wikipedia.org/wiki/Seven-segment_display
961 https://en.wikipedia.org/wiki/Fourteen-segment_display

For example, for 7-segment displays this function is called as follows:

```
load_segment_font(filename_or_obj, width=3, height=3, pins=[
    (1, '_'), (5, '|'), (8, '|'), (7, '_'),
    (6, '|'), (3, '|'), (4, '_')])
```

This dictates that each character will be defined by a 3x3 character grid which will be converted into a nine-character string like so:

```
012
345  ==>  '012345678'
678
```

Position 0 is always assumed to be the character being defined. The *pins* list then specifies: the first pin is the character at position 1 which will be "on" when that character is "_". The second pin is the character at position 5 which will be "on" when that character is "|", and so on.

CHAPTER 21

API - Tones

GPIO Zero includes a *Tone* (page 217) class intended for use with the *TonalBuzzer* (page 131). This class is in the `tones` module of GPIO Zero and is typically imported as follows:

```
from gpiozero.tones import Tone
```

21.1 Tone

class gpiozero.tones.Tone

Represents a frequency of sound in a variety of musical notations.

Tone (page 217) class can be used with the *TonalBuzzer* (page 131) class to easily represent musical tones. The class can be constructed in a variety of ways. For example as a straight frequency in Hz[962] (which is the internal storage format), as an integer MIDI note, or as a string representation of a musical note.

All the following constructors are equivalent ways to construct the typical tuning note, concert A[963] at 440Hz, which is MIDI note #69:

```
>>> from gpiozero.tones import Tone
>>> Tone(440.0)
>>> Tone(69)
>>> Tone('A4')
```

If you do not want the constructor to guess which format you are using (there is some ambiguity between frequencies and MIDI notes at the bottom end of the frequencies, from 128Hz down), you can use one of the explicit constructors, *from_frequency()* (page 218), *from_midi()* (page 218), or *from_note()* (page 218), or you can specify a keyword argument when constructing:

```
>>> Tone.from_frequency(440)
>>> Tone.from_midi(69)
>>> Tone.from_note('A4')
>>> Tone(frequency=440)
```

(continues on next page)

[962] https://en.wikipedia.org/wiki/Hertz
[963] https://en.wikipedia.org/wiki/Concert_pitch

(continued from previous page)

```
>>> Tone(midi=69)
>>> Tone(note='A4')
```

Several attributes are provided to permit conversion to any of the supported construction formats: *frequency* (page 218), *midi* (page 218), and *note* (page 218). Methods are provided to step *up()* (page 218) or *down()* (page 218) to adjacent MIDI notes.

> **Warning:** Currently *Tone* (page 217) derives from `float`[964] and can be used as a floating point number in most circumstances (addition, subtraction, etc). This part of the API is not yet considered "stable"; i.e. we may decide to enhance / change this behaviour in future versions.

down(*n=1*)
Return the *Tone* (page 217) *n* semi-tones below this frequency (*n* defaults to 1).

classmethod from_frequency(*freq*)
Construct a *Tone* (page 217) from a frequency specified in Hz[965] which must be a positive floating-point value in the range 0 < freq <= 20000.

classmethod from_midi(*midi_note*)
Construct a *Tone* (page 217) from a MIDI note, which must be an integer in the range 0 to 127. For reference, A4 (concert A[966] typically used for tuning) is MIDI note #69.

classmethod from_note(*note*)
Construct a *Tone* (page 217) from a musical note which must consist of a capital letter A through G, followed by an optional semi-tone modifier ("b" for flat, "#" for sharp, or their Unicode equivalents), followed by an octave number (0 through 9).

For example concert A[967], the typical tuning note at 440Hz, would be represented as "A4". One semi-tone above this would be "A#4" or alternatively "Bb4". Unicode representations of sharp and flat are also accepted.

up(*n=1*)
Return the *Tone* (page 217) *n* semi-tones above this frequency (*n* defaults to 1).

frequency
Return the frequency of the tone in Hz[968].

midi
Return the (nearest) MIDI note to the tone's frequency. This will be an integer number in the range 0 to 127. If the frequency is outside the range represented by MIDI notes (which is approximately 8Hz to 12.5KHz) `ValueError`[969] exception will be raised.

note
Return the (nearest) note to the tone's frequency. This will be a string in the form accepted by *from_note()* (page 218). If the frequency is outside the range represented by this format ("A0" is approximately 27.5Hz, and "G9" is approximately 12.5Khz) a `ValueError`[970] exception will be raised.

[964] https://docs.python.org/3.7/library/functions.html#float
[965] https://en.wikipedia.org/wiki/Hertz
[966] https://en.wikipedia.org/wiki/Concert_pitch
[967] https://en.wikipedia.org/wiki/Concert_pitch
[968] https://en.wikipedia.org/wiki/Hertz
[969] https://docs.python.org/3.7/library/exceptions.html#ValueError
[970] https://docs.python.org/3.7/library/exceptions.html#ValueError

CHAPTER 22

API - Pi Information

The GPIO Zero library also contains a database of information about the various revisions of the Raspberry Pi computer. This is used internally to raise warnings when non-physical pins are used, or to raise exceptions when pull-downs are requested on pins with physical pull-up resistors attached. The following functions and classes can be used to query this database:

22.1 pi_info

gpiozero.pi_info(*revision=None*)

Returns a *PiBoardInfo* (page 219) instance containing information about a *revision* of the Raspberry Pi.

Parameters **revision** (*str*[971]) – The revision of the Pi to return information about. If this is omitted or None[972] (the default), then the library will attempt to determine the model of Pi it is running on and return information about that.

22.2 PiBoardInfo

class gpiozero.PiBoardInfo

This class is a namedtuple()[973] derivative used to represent information about a particular model of Raspberry Pi. While it is a tuple, it is strongly recommended that you use the following named attributes to access the data contained within. The object can be used in format strings with various custom format specifications:

```
from gpiozero import *

print('{0}'.format(pi_info()))
print('{0:full}'.format(pi_info()))
print('{0:board}'.format(pi_info()))
print('{0:specs}'.format(pi_info()))
print('{0:headers}'.format(pi_info()))
```

[971] https://docs.python.org/3.7/library/stdtypes.html#str
[972] https://docs.python.org/3.7/library/constants.html#None
[973] https://docs.python.org/3.7/library/collections.html#collections.namedtuple

"color" and "mono" can be prefixed to format specifications to force the use of ANSI color codes[974]. If neither is specified, ANSI codes will only be used if stdout is detected to be a tty:

```
print('{0:color board}'.format(pi_info())) # force use of ANSI codes
print('{0:mono board}'.format(pi_info())) # force plain ASCII
```

physical_pin(*function*)
Return the physical pin supporting the specified *function*. If no pins support the desired *function*, this function raises *PinNoPins* (page 249). If multiple pins support the desired *function*, *PinMultiplePins* (page 249) will be raised (use *physical_pins()* (page 220) if you expect multiple pins in the result, such as for electrical ground).

Parameters function (*str*[975]) – The pin function you wish to search for. Usually this is something like "GPIO9" for Broadcom GPIO pin 9.

physical_pins(*function*)
Return the physical pins supporting the specified *function* as tuples of (header, pin_number) where *header* is a string specifying the header containing the *pin_number*. Note that the return value is a set[976] which is not indexable. Use *physical_pin()* (page 220) if you are expecting a single return value.

Parameters function (*str*[977]) – The pin function you wish to search for. Usually this is something like "GPIO9" for Broadcom GPIO pin 9, or "GND" for all the pins connecting to electrical ground.

pprint(*color=None*)
Pretty-print a representation of the board along with header diagrams.

If *color* is None[978] (the default), the diagram will include ANSI color codes if stdout is a color-capable terminal. Otherwise *color* can be set to True[979] or False[980] to force color or monochrome output.

pulled_up(*function*)
Returns a bool indicating whether a physical pull-up is attached to the pin supporting the specified *function*. Either *PinNoPins* (page 249) or *PinMultiplePins* (page 249) may be raised if the function is not associated with a single pin.

Parameters function (*str*[981]) – The pin function you wish to determine pull-up for. Usually this is something like "GPIO9" for Broadcom GPIO pin 9.

to_gpio(*spec*)
Parses a pin *spec*, returning the equivalent Broadcom GPIO port number or raising a ValueError[982] exception if the spec does not represent a GPIO port.

The *spec* may be given in any of the following forms:

- An integer, which will be accepted as a GPIO number
- 'GPIOn' where n is the GPIO number
- 'WPIn' where n is the wiringPi[983] pin number
- 'BCMn' where n is the GPIO number (alias of GPIOn)
- 'BOARDn' where n is the physical pin number on the main header

[974] https://en.wikipedia.org/wiki/ANSI_escape_code
[975] https://docs.python.org/3.7/library/stdtypes.html#str
[976] https://docs.python.org/3.7/library/stdtypes.html#set
[977] https://docs.python.org/3.7/library/stdtypes.html#str
[978] https://docs.python.org/3.7/library/constants.html#None
[979] https://docs.python.org/3.7/library/constants.html#True
[980] https://docs.python.org/3.7/library/constants.html#False
[981] https://docs.python.org/3.7/library/stdtypes.html#str
[982] https://docs.python.org/3.7/library/exceptions.html#ValueError
[983] http://wiringpi.com/pins/

- 'h:n' where h is the header name and n is the physical pin number (for example J8:5 is physical pin 5 on header J8, which is the main header on modern Raspberry Pis)

`revision`
A string indicating the revision of the Pi. This is unique to each revision and can be considered the "key" from which all other attributes are derived. However, in itself the string is fairly meaningless.

`model`
A string containing the model of the Pi (for example, "B", "B+", "A+", "2B", "CM" (for the Compute Module), or "Zero").

`pcb_revision`
A string containing the PCB revision number which is silk-screened onto the Pi (on some models).

Note: This is primarily useful to distinguish between the model B revision 1.0 and 2.0 (not to be confused with the model 2B) which had slightly different pinouts on their 26-pin GPIO headers.

`released`
A string containing an approximate release date for this revision of the Pi (formatted as yyyyQq, e.g. 2012Q1 means the first quarter of 2012).

`soc`
A string indicating the SoC (system on a chip[984]) that this revision of the Pi is based upon.

`manufacturer`
A string indicating the name of the manufacturer (usually "Sony" but a few others exist).

`memory`
An integer indicating the amount of memory (in Mb) connected to the SoC.

Note: This can differ substantially from the amount of RAM available to the operating system as the GPU's memory is shared with the CPU. When the camera module is activated, at least 128Mb of RAM is typically reserved for the GPU.

`storage`
A string indicating the type of bootable storage used with this revision of Pi, e.g. "SD", "MicroSD", or "eMMC" (for the Compute Module).

`usb`
An integer indicating how many USB ports are physically present on this revision of the Pi, of any type.

Note: This does *not* include the micro-USB or USB-C port used to power the Pi.

`usb3`
An integer indicating how many of the USB ports are USB3 ports on this revision of the Pi.

`ethernet`
An integer indicating how many Ethernet ports are physically present on this revision of the Pi.

`eth_speed`
An integer indicating the maximum speed (in Mbps) of the Ethernet ports (if any). If no Ethernet ports are present, this is 0.

[984] https://en.wikipedia.org/wiki/System_on_a_chip

wifi
A bool indicating whether this revision of the Pi has wifi built-in.

bluetooth
A bool indicating whether this revision of the Pi has bluetooth built-in.

csi
An integer indicating the number of CSI (camera) ports available on this revision of the Pi.

dsi
An integer indicating the number of DSI (display) ports available on this revision of the Pi.

headers
A dictionary which maps header labels to *HeaderInfo* (page 222) tuples. For example, to obtain information about header P1 you would query `headers['P1']`. To obtain information about pin 12 on header J8 you would query `headers['J8'].pins[12]`.

A rendered version of this data can be obtained by using the *PiBoardInfo* (page 219) object in a format string:

```
from gpiozero import *
print('{0:headers}'.format(pi_info()))
```

board
An ASCII art rendition of the board, primarily intended for console pretty-print usage. A more usefully rendered version of this data can be obtained by using the *PiBoardInfo* (page 219) object in a format string. For example:

```
from gpiozero import *
print('{0:board}'.format(pi_info()))
```

22.3 HeaderInfo

class gpiozero.HeaderInfo
This class is a `namedtuple()`[985] derivative used to represent information about a pin header on a board. The object can be used in a format string with various custom specifications:

```
from gpiozero import *

print('{0}'.format(pi_info().headers['J8']))
print('{0:full}'.format(pi_info().headers['J8']))
print('{0:col2}'.format(pi_info().headers['P1']))
print('{0:row1}'.format(pi_info().headers['P1']))
```

"color" and "mono" can be prefixed to format specifications to force the use of ANSI color codes[986]. If neither is specified, ANSI codes will only be used if stdout is detected to be a tty:

```
print('{0:color row2}'.format(pi_info().headers['J8'])) # force use of ANSI codes
print('{0:mono row2}'.format(pi_info().headers['P1'])) # force plain ASCII
```

The following attributes are defined:

pprint(*color=None*)
Pretty-print a diagram of the header pins.

If *color* is `None`[987] (the default, the diagram will include ANSI color codes if stdout is a

[985] https://docs.python.org/3.7/library/collections.html#collections.namedtuple
[986] https://en.wikipedia.org/wiki/ANSI_escape_code
[987] https://docs.python.org/3.7/library/constants.html#None

color-capable terminal). Otherwise *color* can be set to `True`[988] or `False`[989] to force color or monochrome output.

name
The name of the header, typically as it appears silk-screened on the board (e.g. "P1" or "J8").

rows
The number of rows on the header.

columns
The number of columns on the header.

pins
A dictionary mapping physical pin numbers to *PinInfo* (page 223) tuples.

22.4 PinInfo

class gpiozero.PinInfo
This class is a `namedtuple()`[990] derivative used to represent information about a pin present on a GPIO header. The following attributes are defined:

number
An integer containing the physical pin number on the header (starting from 1 in accordance with convention).

function
A string describing the function of the pin. Some common examples include "GND" (for pins connecting to ground), "3V3" (for pins which output 3.3 volts), "GPIO9" (for GPIO9 in the Broadcom numbering scheme), etc.

pull_up
A bool indicating whether the pin has a physical pull-up resistor permanently attached (this is usually `False`[991] but GPIO2 and GPIO3 are *usually* `True`[992]). This is used internally by gpiozero to raise errors when pull-down is requested on a pin with a physical pull-up resistor.

row
An integer indicating on which row the pin is physically located in the header (1-based)

col
An integer indicating in which column the pin is physically located in the header (1-based)

988 https://docs.python.org/3.7/library/constants.html#True
989 https://docs.python.org/3.7/library/constants.html#False
990 https://docs.python.org/3.7/library/collections.html#collections.namedtuple
991 https://docs.python.org/3.7/library/constants.html#False
992 https://docs.python.org/3.7/library/constants.html#True

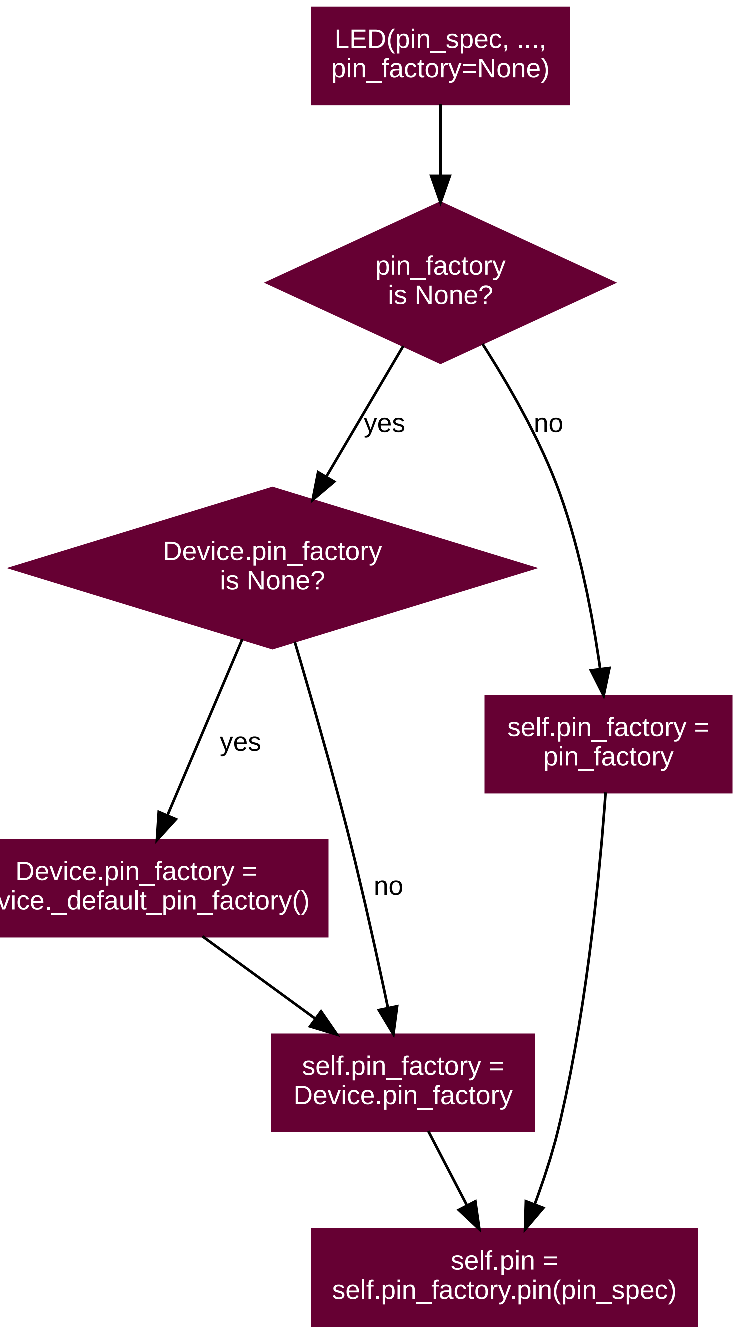
CHAPTER 23

API - Pins

As of release 1.1, the GPIO Zero library can be roughly divided into two things: pins and the devices that are connected to them. The majority of the documentation focuses on devices as pins are below the level that most users are concerned with. However, some users may wish to take advantage of the capabilities of alternative GPIO implementations or (in future) use GPIO extender chips. This is the purpose of the pins portion of the library.

When you construct a device, you pass in a pin specification. This is passed to a pin `Factory` (page 230) which turns it into a `Pin` (page 231) implementation. The default factory can be queried (and changed) with `Device.pin_factory` (page 201). However, all classes (even internal devices) accept a *pin_factory* keyword argument to their constructors permitting the factory to be overridden on a per-device basis (the reason for allowing per-device factories is made apparent in the *Configuring Remote GPIO* (page 49) chapter).

This is illustrated in the following flow-chart:



The default factory is constructed when the first device is initialised; if no default factory can be constructed (e.g. because no GPIO implementations are installed, or all of them fail to load for whatever reason), a *BadPinFactory* (page 246) exception will be raised at construction time.

After importing gpiozero, until constructing a gpiozero device, the pin factory is `None`[993], but at the point of first construction the default pin factory will come into effect:

```
pi@raspberrypi:~ $ python3
Python 3.7.3 (default, Apr  3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from gpiozero import Device, LED
>>> print(Device.pin_factory)
None
```

(continues on next page)

[993] https://docs.python.org/3.7/library/constants.html#None

(continued from previous page)

```
>>> led = LED(2)
>>> Device.pin_factory
<gpiozero.pins.rpigpio.RPiGPIOFactory object at 0xb667ae30>
>>> led.pin_factory
<gpiozero.pins.rpigpio.RPiGPIOFactory object at 0xb6323530>
```

As above, on a Raspberry Pi with the RPi.GPIO library installed, (assuming no environment variables are set), the default pin factory will be *RPiGPIOFactory* (page 239).

On a PC (with no pin libraries installed and no environment variables set), importing will work but attempting to create a device will raise *BadPinFactory* (page 246):

```
ben@magicman:~ $ python3
Python 3.6.8 (default, Aug 20 2019, 17:12:48)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from gpiozero import Device, LED
>>> print(Device.pin_factory)
None
>>> led = LED(2)
...
BadPinFactory: Unable to load any default pin factory!
```

23.1 Changing the pin factory

The default pin factory can be replaced by specifying a value for the *GPIOZERO_PIN_FACTORY* (page 80) environment variable. For example:

```
pi@raspberrypi:~ $ GPIOZERO_PIN_FACTORY=native python3
Python 3.7.3 (default, Apr  3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from gpiozero import Device
>>> Device._default_pin_factory()
<gpiozero.pins.native.NativeFactory object at 0x762c26b0>
```

To set the *GPIOZERO_PIN_FACTORY* (page 80) for the rest of your session you can **export** this value:

```
pi@raspberrypi:~ $ export GPIOZERO_PIN_FACTORY=native
pi@raspberrypi:~ $ python3
Python 3.7.3 (default, Apr  3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import gpiozero
>>> Device._default_pin_factory()
<gpiozero.pins.native.NativeFactory object at 0x762c26b0>
>>> quit()
pi@raspberrypi:~ $ python3
Python 3.7.3 (default, Apr  3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import gpiozero
>>> Device._default_pin_factory()
<gpiozero.pins.native.NativeFactory object at 0x762c26b0>
```

If you add the **export** command to your `~/.bashrc` file, you'll set the default pin factory for all future sessions too.

If the environment variable is set, the corresponding pin factory will be used, otherwise each of the four GPIO pin factories will be attempted to be used in turn.

The following values, and the corresponding *Factory* (page 230) and *Pin* (page 231) classes are listed in the table below. Factories are listed in the order that they are tried by default.

Name	Factory class	Pin class
rpigpio	*gpiozero.pins.rpigpio.RPiGPIOFactory* (page 239)	*gpiozero.pins.rpigpio.RPiGPIOPin* (page 240)
rpio	*gpiozero.pins.rpio.RPIOFactory* (page 240)	*gpiozero.pins.rpio.RPIOPin* (page 241)
pigpio	*gpiozero.pins.pigpio.PiGPIOFactory* (page 241)	*gpiozero.pins.pigpio.PiGPIOPin* (page 241)
native	*gpiozero.pins.native.NativeFactory* (page 242)	*gpiozero.pins.native.NativePin* (page 242)

If you need to change the default pin factory from within a script, either set *Device.pin_factory* (page 201) to the new factory instance to use:

```
from gpiozero.pins.native import NativeFactory
from gpiozero import Device, LED

Device.pin_factory = NativeFactory()

# These will now implicitly use NativePin instead of RPiGPIOPin
led1 = LED(16)
led2 = LED(17)
```

Or use the *pin_factory* keyword parameter mentioned above:

```
from gpiozero.pins.native import NativeFactory
from gpiozero import LED

my_factory = NativeFactory()

# This will use NativePin instead of RPiGPIOPin for led1
# but led2 will continue to use RPiGPIOPin
led1 = LED(16, pin_factory=my_factory)
led2 = LED(17)
```

Certain factories may take default information from additional sources. For example, to default to creating pins with *gpiozero.pins.pigpio.PiGPIOPin* (page 241) on a remote pi called "remote-pi" you can set the *PIGPIO_ADDR* (page 80) environment variable when running your script:

```
$ GPIOZERO_PIN_FACTORY=pigpio PIGPIO_ADDR=remote-pi python3 my_script.py
```

Like the *GPIOZERO_PIN_FACTORY* (page 80) value, these can be exported from your `~/.bashrc` script too.

> **Warning:** The astute and mischievous reader may note that it is possible to mix factories, e.g. using *RPiGPIOFactory* (page 239) for one pin, and *NativeFactory* (page 242) for another. This is unsupported, and if it results in your script crashing, your components failing, or your Raspberry Pi turning into an actual raspberry pie, you have only yourself to blame.
>
> Sensible uses of multiple pin factories are given in *Configuring Remote GPIO* (page 49).

23.2 Mock pins

There's also a *MockFactory* (page 242) which generates entirely fake pins. This was originally intended for GPIO Zero developers who wish to write tests for devices without having to have the physical device wired in to their Pi. However, they have also proven useful in developing GPIO Zero scripts without having a Pi to hand. This pin factory will never be loaded by default; it must be explicitly specified, either by setting an environment variable or setting the pin factory within the script. For example:

```
pi@raspberrypi:~ $ GPIOZERO_PIN_FACTORY=mock python3
```

or:

```
from gpiozero import Device, LED
from gpiozero.pins.mock import MockFactory

Device.pin_factory = MockFactory()

led = LED(2)
```

You can create device objects and inspect their value changing as you'd expect:

```
pi@raspberrypi:~ $ GPIOZERO_PIN_FACTORY=mock python3
Python 3.7.3 (default, Apr  3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> from gpiozero import LED
>>> led = LED(2)
>>> led.value
0
>>> led.on()
>>> led.value
1
```

You can even control pin state changes to simulate device behaviour:

```
>>> from gpiozero import LED, Button

# Construct a couple of devices attached to mock pins 16 and 17, and link the devices
>>> led = LED(17)
>>> btn = Button(16)
>>> led.source = btn

# Initailly the button isn't "pressed" so the LED should be off
>>> led.value
0

# Drive the pin low (this is what would happen electrically when the button is pressed)
>>> btn.pin.drive_low()
# The LED is now on
>>> led.value
1

>>> btn.pin.drive_high()
# The button is now "released", so the LED should be off again
>>> led.value
0
```

Several sub-classes of mock pins exist for emulating various other things (pins that do/don't support PWM, pins that are connected together, pins that drive high after a delay, etc), for example, you have to use *MockPWMPin* (page 242) to be able to use devices requiring PWM:

```
pi@raspberrypi:~ $ GPIOZERO_PIN_FACTORY=mock GPIOZERO_MOCK_PIN_CLASS=mockpwmpin␣
↪python3
```

or:

```
from gpiozero import Device, LED
from gpiozero.pins.mock import MockFactory, MockPWMPin

Device.pin_factory = MockFactory(pin_class=MockPWMPin)

led = LED(2)
```

Interested users are invited to read the GPIO Zero test suite[994] for further examples of usage.

23.3 Base classes

class gpiozero.Factory

Generates pins and SPI interfaces for devices. This is an abstract base class for pin factories. Descendents *must* override the following methods:

- *ticks()* (page 231)
- *ticks_diff()* (page 231)

Descendents *may* override the following methods, if applicable:

- *close()* (page 230)
- *reserve_pins()* (page 231)
- *release_pins()* (page 230)
- *release_all()* (page 230)
- *pin()* (page 230)
- *spi()* (page 231)
- `_get_pi_info()`

close()

Closes the pin factory. This is expected to clean up all resources manipulated by the factory. It it typically called at script termination.

pin(*spec*)

Creates an instance of a *Pin* (page 231) descendent representing the specified pin.

> **Warning:** Descendents must ensure that pin instances representing the same hardware are identical; i.e. two separate invocations of *pin()* (page 230) for the same pin specification must return the same object.

release_all(*reserver*)

Releases all pin reservations taken out by *reserver*. See *release_pins()* (page 230) for further information).

[994] https://github.com/gpiozero/gpiozero/tree/master/tests

release_pins(*reserver*, **pins*)
Releases the reservation of *reserver* against *pins*. This is typically called during *close()* (page 201) to clean up reservations taken during construction. Releasing a reservation that is not currently held will be silently ignored (to permit clean-up after failed / partial construction).

reserve_pins(*requester*, **pins*)
Called to indicate that the device reserves the right to use the specified *pins*. This should be done during device construction. If pins are reserved, you must ensure that the reservation is released by eventually called *release_pins()* (page 230).

spi(***spi_args*)
Returns an instance of an *SPI* (page 234) interface, for the specified SPI *port* and *device*, or for the specified pins (*clock_pin*, *mosi_pin*, *miso_pin*, and *select_pin*). Only one of the schemes can be used; attempting to mix *port* and *device* with pin numbers will raise *SPIBadArgs* (page 247).

ticks()
Return the current ticks, according to the factory. The reference point is undefined and thus the result of this method is only meaningful when compared to another value returned by this method.

The format of the time is also arbitrary, as is whether the time wraps after a certain duration. Ticks should only be compared using the *ticks_diff()* (page 231) method.

ticks_diff(*later*, *earlier*)
Return the time in seconds between two *ticks()* (page 231) results. The arguments are specified in the same order as they would be in the formula *later* - *earlier* but the result is guaranteed to be in seconds, and to be positive even if the ticks "wrapped" between calls to *ticks()* (page 231).

pi_info
Returns a *PiBoardInfo* (page 219) instance representing the Pi that instances generated by this factory will be attached to.

If the pins represented by this class are not *directly* attached to a Pi (e.g. the pin is attached to a board attached to the Pi, or the pins are not on a Pi at all), this may return `None`[995].

class gpiozero.Pin
Abstract base class representing a pin attached to some form of controller, be it GPIO, SPI, ADC, etc.

Descendents should override property getters and setters to accurately represent the capabilities of pins. Descendents *must* override the following methods:

- `_get_function()`
- `_set_function()`
- `_get_state()`

Descendents *may* additionally override the following methods, if applicable:

- *close()* (page 232)
- *output_with_state()* (page 232)
- *input_with_pull()* (page 232)
- `_set_state()`
- `_get_frequency()`
- `_set_frequency()`
- `_get_pull()`

995 https://docs.python.org/3.7/library/constants.html#None

- `_set_pull()`
- `_get_bounce()`
- `_set_bounce()`
- `_get_edges()`
- `_set_edges()`
- `_get_when_changed()`
- `_set_when_changed()`

close()

Cleans up the resources allocated to the pin. After this method is called, this *Pin* (page 231) instance may no longer be used to query or control the pin's state.

input_with_pull(*pull*)

Sets the pin's function to "input" and specifies an initial pull-up for the pin. By default this is equivalent to performing:

```
pin.function = 'input'
pin.pull = pull
```

However, descendents may override this order to provide the smallest possible delay between configuring the pin for input and pulling the pin up/down (which can be important for avoiding "blips" in some configurations).

output_with_state(*state*)

Sets the pin's function to "output" and specifies an initial state for the pin. By default this is equivalent to performing:

```
pin.function = 'output'
pin.state = state
```

However, descendents may override this in order to provide the smallest possible delay between configuring the pin for output and specifying an initial value (which can be important for avoiding "blips" in active-low configurations).

bounce

The amount of bounce detection (elimination) currently in use by edge detection, measured in seconds. If bounce detection is not currently in use, this is `None`[996].

For example, if *edges* (page 233) is currently "rising", *bounce* (page 232) is currently 5/1000 (5ms), then the waveform below will only fire *when_changed* (page 234) on two occasions despite there being three rising edges:

```
TIME 0...1...2...3...4...5...6...7...8...9...10..11..12 ms

bounce elimination   |===================| |==============

HIGH - - - - >       ,--. ,--------------. ,--.
                     |  | |              | |  |
                     |  | |              | |  |
LOW  ----------------'  `-'              `-'  `-----------
                     :                     :
                     :                     :
               when_changed          when_changed
                   fires                 fires
```

[996] https://docs.python.org/3.7/library/constants.html#None

If the pin does not support edge detection, attempts to set this property will raise *PinEdgeDetectUnsupported* (page 248). If the pin supports edge detection, the class must implement bounce detection, even if only in software.

edges

The edge that will trigger execution of the function or bound method assigned to *when_changed* (page 234). This can be one of the strings "both" (the default), "rising", "falling", or "none":

```
HIGH - - - - >           ,--------------.
                         |              |
                         |              |
LOW  --------------------'              `--------------
                         :              :
                         :              :
Fires when_changed     "both"         "both"
when edges is ...     "rising"       "falling"
```

If the pin does not support edge detection, attempts to set this property will raise *PinEdgeDetectUnsupported* (page 248).

frequency

The frequency (in Hz) for the pin's PWM implementation, or `None`[997] if PWM is not currently in use. This value always defaults to `None`[998] and may be changed with certain pin types to activate or deactivate PWM.

If the pin does not support PWM, *PinPWMUnsupported* (page 249) will be raised when attempting to set this to a value other than `None`[999].

function

The function of the pin. This property is a string indicating the current function or purpose of the pin. Typically this is the string "input" or "output". However, in some circumstances it can be other strings indicating non-GPIO related functionality.

With certain pin types (e.g. GPIO pins), this attribute can be changed to configure the function of a pin. If an invalid function is specified, for this attribute, *PinInvalidFunction* (page 248) will be raised.

pull

The pull-up state of the pin represented as a string. This is typically one of the strings "up", "down", or "floating" but additional values may be supported by the underlying hardware.

If the pin does not support changing pull-up state (for example because of a fixed pull-up resistor), attempts to set this property will raise *PinFixedPull* (page 248). If the specified value is not supported by the underlying hardware, *PinInvalidPull* (page 248) is raised.

state

The state of the pin. This is 0 for low, and 1 for high. As a low level view of the pin, no swapping is performed in the case of pull ups (see *pull* (page 233) for more information):

```
HIGH - - - - >       ,----------------------
                     |
                     |
LOW  ----------------'
```

Descendents which implement analog, or analog-like capabilities can return values between 0 and 1. For example, pins implementing PWM (where *frequency* (page 233) is not `None`[1000]) return a value between 0.0 and 1.0 representing the current PWM duty cycle.

[997] https://docs.python.org/3.7/library/constants.html#None
[998] https://docs.python.org/3.7/library/constants.html#None
[999] https://docs.python.org/3.7/library/constants.html#None
[1000] https://docs.python.org/3.7/library/constants.html#None

If a pin is currently configured for input, and an attempt is made to set this attribute, *PinSetInput* (page 248) will be raised. If an invalid value is specified for this attribute, *PinInvalidState* (page 248) will be raised.

when_changed

A function or bound method to be called when the pin's state changes (more specifically when the edge specified by *edges* (page 233) is detected on the pin). The function or bound method must accept two parameters: the first will report the ticks (from *Factory.ticks()* (page 231)) when the pin's state changed, and the second will report the pin's current state.

> **Warning:** Depending on hardware support, the state is *not guaranteed to be accurate*. For instance, many GPIO implementations will provide an interrupt indicating when a pin's state changed but not what it changed to. In this case the pin driver simply reads the pin's current state to supply this parameter, but the pin's state may have changed *since* the interrupt. Exercise appropriate caution when relying upon this parameter.

If the pin does not support edge detection, attempts to set this property will raise *PinEdgeDetectUnsupported* (page 248).

class gpiozero.SPI(***kwargs*)

Abstract interface for Serial Peripheral Interface[1001] (SPI) implementations. Descendents *must* override the following methods:

- *transfer()* (page 234)
- `_get_clock_mode()`

Descendents *may* override the following methods, if applicable:

- *read()* (page 234)
- *write()* (page 234)
- `_set_clock_mode()`
- `_get_lsb_first()`
- `_set_lsb_first()`
- `_get_select_high()`
- `_set_select_high()`
- `_get_bits_per_word()`
- `_set_bits_per_word()`

read(*n*)

Read *n* words of data from the SPI interface, returning them as a sequence of unsigned ints, each no larger than the configured *bits_per_word* (page 235) of the interface.

This method is typically used with read-only devices that feature half-duplex communication. See *transfer()* (page 234) for full duplex communication.

transfer(*data*)

Write *data* to the SPI interface. *data* must be a sequence of unsigned integer words each of which will fit within the configured *bits_per_word* (page 235) of the interface. The method returns the sequence of words read from the interface while writing occurred (full duplex communication).

The length of the sequence returned dictates the number of words of *data* written to the interface. Each word in the returned sequence will be an unsigned integer no larger than the configured *bits_per_word* (page 235) of the interface.

[1001] https://en.wikipedia.org/wiki/Serial_Peripheral_Interface_Bus

write(*data*)

Write *data* to the SPI interface. *data* must be a sequence of unsigned integer words each of which will fit within the configured *bits_per_word* (page 235) of the interface. The method returns the number of words written to the interface (which may be less than or equal to the length of *data*).

This method is typically used with write-only devices that feature half-duplex communication. See *transfer()* (page 234) for full duplex communication.

bits_per_word

Controls the number of bits that make up a word, and thus where the word boundaries appear in the data stream, and the maximum value of a word. Defaults to 8 meaning that words are effectively bytes.

Several implementations do not support non-byte-sized words.

clock_mode

Presents a value representing the *clock_polarity* (page 236) and *clock_phase* (page 235) attributes combined according to the following table:

mode	polarity (CPOL)	phase (CPHA)
0	False	False
1	False	True
2	True	False
3	True	True

Adjusting this value adjusts both the *clock_polarity* (page 236) and *clock_phase* (page 235) attributes simultaneously.

clock_phase

The phase of the SPI clock pin. If this is False[1002] (the default), data will be read from the MISO pin when the clock pin activates. Setting this to True[1003] will cause data to be read from the MISO pin when the clock pin deactivates. On many data sheets this is documented as the CPHA value. Whether the clock edge is rising or falling when the clock is considered activated is controlled by the *clock_polarity* (page 236) attribute (corresponding to CPOL).

The following diagram indicates when data is read when *clock_polarity* (page 236) is False[1004], and *clock_phase* (page 235) is False[1005] (the default), equivalent to CPHA 0:

```
    ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |   |   |   |   |   |   |
    |   |   |   |   |   |   |   |   |   |   |   |   |   |
----'   `---'   `---'   `---'   `---'   `---'   `---'   `-------
    :       :       :       :       :       :       :
MISO---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
  /     \ /     \ /     \ /     \ /     \ /     \ /     \
-{  Bit  X  Bit  X  Bit  X  Bit  X  Bit  X  Bit  X  Bit  }------
  \     / \     / \     / \     / \     / \     / \     /
   `---'   `---'   `---'   `---'   `---'   `---'   `---'
```

The following diagram indicates when data is read when *clock_polarity* (page 236) is False[1006], but *clock_phase* (page 235) is True[1007], equivalent to CPHA 1:

[1002] https://docs.python.org/3.7/library/constants.html#False
[1003] https://docs.python.org/3.7/library/constants.html#True
[1004] https://docs.python.org/3.7/library/constants.html#False
[1005] https://docs.python.org/3.7/library/constants.html#False
[1006] https://docs.python.org/3.7/library/constants.html#False
[1007] https://docs.python.org/3.7/library/constants.html#True

```
       ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |   |   |   |   |   |   |
    |   |   |   |   |   |   |   |   |   |   |   |   |   |
----'   `---'   `---'   `---'   `---'   `---'   `---'   `-------
        :       :       :       :       :       :       :
MISO   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
      /     \ /     \ /     \ /     \ /     \ /     \ /     \
-----{  Bit  X  Bit  X  Bit  X  Bit  X  Bit  X  Bit  X  Bit  }--
      \     / \     / \     / \     / \     / \     / \     /
       `---'   `---'   `---'   `---'   `---'   `---'   `---'
```

clock_polarity

The polarity of the SPI clock pin. If this is `False`[1008] (the default), the clock pin will idle low, and pulse high. Setting this to `True`[1009] will cause the clock pin to idle high, and pulse low. On many data sheets this is documented as the CPOL value.

The following diagram illustrates the waveform when *clock_polarity* (page 236) is `False`[1010] (the default), equivalent to CPOL 0:

```
       on      on      on      on      on      on      on
      ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
CLK   |   |   |   |   |   |   |   |   |   |   |   |   |   |
      |   |   |   |   |   |   |   |   |   |   |   |   |   |
------'   `---'   `---'   `---'   `---'   `---'   `---'   `------
idle       off     off     off     off     off     off       idle
```

The following diagram illustrates the waveform when *clock_polarity* (page 236) is `True`[1011], equivalent to CPOL 1:

```
idle       off     off     off     off     off     off       idle
------.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,------
      |   |   |   |   |   |   |   |   |   |   |   |   |   |
CLK   |   |   |   |   |   |   |   |   |   |   |   |   |   |
      `---'   `---'   `---'   `---'   `---'   `---'   `---'
       on      on      on      on      on      on      on
```

lsb_first

Controls whether words are read and written LSB in (Least Significant Bit first) order. The default is `False`[1012] indicating that words are read and written in MSB (Most Significant Bit first) order. Effectively, this controls the Bit endianness[1013] of the connection.

The following diagram shows the a word containing the number 5 (binary 0101) transmitted on MISO with *bits_per_word* (page 235) set to 4, and *clock_mode* (page 235) set to 0, when *lsb_first* (page 236) is `False`[1014] (the default):

```
    ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |
    |   |   |   |   |   |   |   |
----'   `---'   `---'   `---'   `-----
    :     ,-------. :     ,-------.
MISO:     | :     | :     | :     |
    :     | :     | :     | :     |
```

(continues on next page)

[1008] https://docs.python.org/3.7/library/constants.html#False
[1009] https://docs.python.org/3.7/library/constants.html#True
[1010] https://docs.python.org/3.7/library/constants.html#False
[1011] https://docs.python.org/3.7/library/constants.html#True
[1012] https://docs.python.org/3.7/library/constants.html#False
[1013] https://en.wikipedia.org/wiki/Endianness#Bit_endianness
[1014] https://docs.python.org/3.7/library/constants.html#False

(continued from previous page)

```
----------' :     `-------' :     `----
    :       :       :       :
   MSB                     LSB
```

And now with *lsb_first* (page 236) set to `True`[1015] (and all other parameters the same):

```
    ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |
    |   |   |   |   |   |   |   |
----'   `---'   `---'   `---'   `-----
  ,-------. :     ,-------. :
MISO:     | :     | :     | :
  | :     | :     | :     | :
--' :     `-------' :     `-----------
    :       :       :       :
   LSB                     MSB
```

rate

Controls the speed of the SPI interface in Hz (or baud).

Note that most software SPI implementations ignore this property, and will raise `SPIFixedRate` if an attempt is made to set it, as they have no rate control (they simply bit-bang as fast as possible because typically this isn't very fast anyway, and introducing measures to limit the rate would simply slow them down to the point of being useless).

select_high

If `False`[1016] (the default), the chip select line is considered active when it is pulled low. When set to `True`[1017], the chip select line is considered active when it is driven high.

The following diagram shows the waveform of the chip select line, and the clock when *clock_polarity* (page 236) is `False`[1018], and *select_high* (page 237) is `False`[1019] (the default):

```
---.                                                     ,------
__ |                                                     |
CS |      chip is selected, and will react to clock      |  idle
   `-----------------------------------------------------'


    ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |   |   |   |   |   |   |
    |   |   |   |   |   |   |   |   |   |   |   |   |   |
----'   `---'   `---'   `---'   `---'   `---'   `---'   `-------
```

And when *select_high* (page 237) is `True`[1020]:

```
   ,-----------------------------------------------------.
CS |      chip is selected, and will react to clock      |  idle
   |                                                     |
---'                                                     `------


    ,---.   ,---.   ,---.   ,---.   ,---.   ,---.   ,---.
CLK |   |   |   |   |   |   |   |   |   |   |   |   |   |
```

(continues on next page)

[1015] https://docs.python.org/3.7/library/constants.html#True
[1016] https://docs.python.org/3.7/library/constants.html#False
[1017] https://docs.python.org/3.7/library/constants.html#True
[1018] https://docs.python.org/3.7/library/constants.html#False
[1019] https://docs.python.org/3.7/library/constants.html#False
[1020] https://docs.python.org/3.7/library/constants.html#True

(continued from previous page)

```
     |    |    |    |    |    |    |    |    |    |    |    |    |
----'    `---'    `---'    `---'    `---'    `---'    `---'    `-------
```

class gpiozero.pins.pi.PiFactory

Extends *Factory* (page 230). Abstract base class representing hardware attached to a Raspberry Pi. This forms the base of *LocalPiFactory* (page 239).

close()

Closes the pin factory. This is expected to clean up all resources manipulated by the factory. It it typically called at script termination.

pin(*spec*)

Creates an instance of a `Pin` descendent representing the specified pin.

> **Warning:** Descendents must ensure that pin instances representing the same hardware are identical; i.e. two separate invocations of *pin()* (page 238) for the same pin specification must return the same object.

release_pins(*reserver*, **pins*)

Releases the reservation of *reserver* against *pins*. This is typically called during *close()* (page 201) to clean up reservations taken during construction. Releasing a reservation that is not currently held will be silently ignored (to permit clean-up after failed / partial construction).

reserve_pins(*requester*, **pins*)

Called to indicate that the device reserves the right to use the specified *pins*. This should be done during device construction. If pins are reserved, you must ensure that the reservation is released by eventually called *release_pins()* (page 238).

spi(***spi_args*)

Returns an SPI interface, for the specified SPI *port* and *device*, or for the specified pins (*clock_pin*, *mosi_pin*, *miso_pin*, and *select_pin*). Only one of the schemes can be used; attempting to mix *port* and *device* with pin numbers will raise *SPIBadArgs* (page 247).

If the pins specified match the hardware SPI pins (clock on GPIO11, MOSI on GPIO10, MISO on GPIO9, and chip select on GPIO8 or GPIO7), and the spidev module can be imported, a hardware based interface (using spidev) will be returned. Otherwise, a software based interface will be returned which will use simple bit-banging to communicate.

Both interfaces have the same API, support clock polarity and phase attributes, and can handle half and full duplex communications, but the hardware interface is significantly faster (though for many simpler devices this doesn't matter).

class gpiozero.pins.pi.PiPin(*factory*, *number*)

Extends *Pin* (page 231). Abstract base class representing a multi-function GPIO pin attached to a Raspberry Pi. Descendents *must* override the following methods:

- `_get_function()`
- `_set_function()`
- `_get_state()`
- `_call_when_changed()`
- `_enable_event_detect()`
- `_disable_event_detect()`

Descendents *may* additionally override the following methods, if applicable:

- `close()`

- `output_with_state()`
- `input_with_pull()`
- `_set_state()`
- `_get_frequency()`
- `_set_frequency()`
- `_get_pull()`
- `_set_pull()`
- `_get_bounce()`
- `_set_bounce()`
- `_get_edges()`
- `_set_edges()`

class gpiozero.pins.local.LocalPiFactory

Extends *PiFactory* (page 238). Abstract base class representing pins attached locally to a Pi. This forms the base class for local-only pin interfaces (*RPiGPIOPin* (page 240), *RPIOPin* (page 241), and *NativePin* (page 242)).

static ticks()

Return the current ticks, according to the factory. The reference point is undefined and thus the result of this method is only meaningful when compared to another value returned by this method.

The format of the time is also arbitrary, as is whether the time wraps after a certain duration. Ticks should only be compared using the *ticks_diff()* (page 239) method.

static ticks_diff(*later*, *earlier*)

Return the time in seconds between two *ticks()* (page 239) results. The arguments are specified in the same order as they would be in the formula *later* - *earlier* but the result is guaranteed to be in seconds, and to be positive even if the ticks "wrapped" between calls to *ticks()* (page 239).

class gpiozero.pins.local.LocalPiPin(*factory*, *number*)

Extends *PiPin* (page 238). Abstract base class representing a multi-function GPIO pin attached to the local Raspberry Pi.

23.4 RPi.GPIO

class gpiozero.pins.rpigpio.RPiGPIOFactory

Extends *LocalPiFactory* (page 239). Uses the RPi.GPIO[1021] library to interface to the Pi's GPIO pins. This is the default pin implementation if the RPi.GPIO library is installed. Supports all features including PWM (via software).

Because this is the default pin implementation you can use it simply by specifying an integer number for the pin in most operations, e.g.:

```
from gpiozero import LED

led = LED(12)
```

However, you can also construct RPi.GPIO pins manually if you wish:

[1021] https://pypi.python.org/pypi/RPi.GPIO

```
from gpiozero.pins.rpigpio import RPiGPIOFactory
from gpiozero import LED

factory = RPiGPIOFactory()
led = LED(12, pin_factory=factory)
```

class gpiozero.pins.rpigpio.RPiGPIOPin(*factory*, *number*)

Extends *LocalPiPin* (page 239). Pin implementation for the RPi.GPIO[1022] library. See *RPiGPIOFactory* (page 239) for more information.

23.5 lgpio

class gpiozero.pins.lgpio.LGPIOFactory(*chip=0*)

Extends *LocalPiFactory* (page 239). Uses the lgpio[1023] library to interface to the local computer's GPIO pins. The lgpio library simply talks to Linux gpiochip devices; it is not specific to the Raspberry Pi although this class is currently constructed under the assumption that it is running on a Raspberry Pi.

You can construct lgpio pins manually like so:

```
from gpiozero.pins.lgpio import LGPIOFactory
from gpiozero import LED

factory = LGPIOFactory(chip=0)
led = LED(12, pin_factory=factory)
```

The *chip* parameter to the factory constructor specifies which gpiochip device to attempt to open. It defaults to 0 and thus doesn't normally need to be specified (the example above only includes it for completeness).

The lgpio library relies on access to the `/dev/gpiochip*` devices. If you run into issues, please check that your user has read/write access to the specific gpiochip device you are attempting to open (0 by default).

class gpiozero.pins.lgpio.LGPIOPin(*factory*, *number*)

Extends *LocalPiPin* (page 239). Pin implementation for the lgpio[1024] library. See *LGPIOFactory* (page 240) for more information.

23.6 RPIO

class gpiozero.pins.rpio.RPIOFactory

Extends *LocalPiFactory* (page 239). Uses the RPIO[1025] library to interface to the Pi's GPIO pins. This is the default pin implementation if the RPi.GPIO library is not installed, but RPIO is. Supports all features including PWM (hardware via DMA).

Note: Please note that at the time of writing, RPIO is only compatible with Pi 1's; the Raspberry Pi 2 Model B is *not* supported. Also note that root access is required so scripts must typically be run with `sudo`.

You can construct RPIO pins manually like so:

[1022] https://pypi.python.org/pypi/RPi.GPIO
[1023] http://abyz.me.uk/lg/py_lgpio.html
[1024] http://abyz.me.uk/lg/py_lgpio.html
[1025] https://pythonhosted.org/RPIO/

```
from gpiozero.pins.rpio import RPIOFactory
from gpiozero import LED

factory = RPIOFactory()
led = LED(12, pin_factory=factory)
```

class gpiozero.pins.rpio.**RPIOPin**(*factory*, *number*)

Extends *LocalPiPin* (page 239). Pin implementation for the RPIO[1026] library. See *RPIOFactory* (page 240) for more information.

23.7 PiGPIO

class gpiozero.pins.pigpio.**PiGPIOFactory**(*host=None*, *port=None*)

Extends *PiFactory* (page 238). Uses the pigpio[1027] library to interface to the Pi's GPIO pins. The pigpio library relies on a daemon (**pigpiod**) to be running as root to provide access to the GPIO pins, and communicates with this daemon over a network socket.

While this does mean only the daemon itself should control the pins, the architecture does have several advantages:

- Pins can be remote controlled from another machine (the other machine doesn't even have to be a Raspberry Pi; it simply needs the pigpio[1028] client library installed on it)
- The daemon supports hardware PWM via the DMA controller
- Your script itself doesn't require root privileges; it just needs to be able to communicate with the daemon

You can construct pigpio pins manually like so:

```
from gpiozero.pins.pigpio import PiGPIOFactory
from gpiozero import LED

factory = PiGPIOFactory()
led = LED(12, pin_factory=factory)
```

This is particularly useful for controlling pins on a remote machine. To accomplish this simply specify the host (and optionally port) when constructing the pin:

```
from gpiozero.pins.pigpio import PiGPIOFactory
from gpiozero import LED

factory = PiGPIOFactory(host='192.168.0.2')
led = LED(12, pin_factory=factory)
```

Note: In some circumstances, especially when playing with PWM, it does appear to be possible to get the daemon into "unusual" states. We would be most interested to hear any bug reports relating to this (it may be a bug in our pin implementation). A workaround for now is simply to restart the **pigpiod** daemon.

class gpiozero.pins.pigpio.**PiGPIOPin**(*factory*, *number*)

Extends *PiPin* (page 238). Pin implementation for the pigpio[1029] library. See *PiGPIOFactory* (page 241) for more information.

1026 https://pythonhosted.org/RPIO/
1027 http://abyz.me.uk/rpi/pigpio/
1028 http://abyz.me.uk/rpi/pigpio/
1029 http://abyz.me.uk/rpi/pigpio/

23.8 Native

class gpiozero.pins.native.NativeFactory

Extends *LocalPiFactory* (page 239). Uses a built-in pure Python implementation to interface to the Pi's GPIO pins. This is the default pin implementation if no third-party libraries are discovered.

> **Warning:** This implementation does *not* currently support PWM. Attempting to use any class which requests PWM will raise an exception.

You can construct native pin instances manually like so:

```
from gpiozero.pins.native import NativeFactory
from gpiozero import LED

factory = NativeFactory()
led = LED(12, pin_factory=factory)
```

class gpiozero.pins.native.NativePin(*factory*, *number*)

Extends *LocalPiPin* (page 239). Native pin implementation. See *NativeFactory* (page 242) for more information.

class gpiozero.pins.native.Native2835Pin(*factory*, *number*)

Extends *NativePin* (page 242) for Pi hardware prior to the Pi 4 (Pi 0, 1, 2, 3, and 3+).

class gpiozero.pins.native.Native2711Pin(*factory*, *number*)

Extends *NativePin* (page 242) for Pi 4 hardware (Pi 4, CM4, Pi 400 at the time of writing).

23.9 Mock

class gpiozero.pins.mock.MockFactory(*revision=None*, *pin_class=None*)

Factory for generating mock pins. The *revision* parameter specifies what revision of Pi the mock factory pretends to be (this affects the result of the *pi_info* (page 231) attribute as well as where pull-ups are assumed to be). The *pin_class* attribute specifies which mock pin class will be generated by the *pin()* (page 242) method by default. This can be changed after construction by modifying the *pin_class* (page 242) attribute.

pin_class

This attribute stores the *MockPin* (page 242) class (or descendent) that will be used when constructing pins with the *pin()* (page 242) method (if no *pin_class* parameter is used to override it). It defaults on construction to the value of the *pin_class* parameter in the constructor, or *MockPin* (page 242) if that is unspecified.

pin(*spec*, *pin_class=None*, ***kwargs*)

The pin method for *MockFactory* (page 242) additionally takes a *pin_class* attribute which can be used to override the class' *pin_class* (page 242) attribute. Any additional keyword arguments will be passed along to the pin constructor (useful with things like *MockConnectedPin* (page 242) which expect to be constructed with another pin).

reset()

Clears the pins and reservations sets. This is primarily useful in test suites to ensure the pin factory is back in a "clean" state before the next set of tests are run.

class gpiozero.pins.mock.MockPin(*factory*, *number*)

A mock pin used primarily for testing. This class does *not* support PWM.

class gpiozero.pins.mock.MockPWMPin(*factory*, *number*)

This derivative of *MockPin* (page 242) adds PWM support.

class gpiozero.pins.mock.MockConnectedPin(*factory*, *number*, *input_pin=None*)

This derivative of *MockPin* (page 242) emulates a pin connected to another mock pin. This is used in the "real pins" portion of the test suite to check that one pin can influence another.

class gpiozero.pins.mock.MockChargingPin(*factory*, *number*, *charge_time=0.01*)

This derivative of *MockPin* (page 242) emulates a pin which, when set to input, waits a predetermined length of time and then drives itself high (as if attached to, e.g. a typical circuit using an LDR and a capacitor to time the charging rate).

class gpiozero.pins.mock.MockTriggerPin(*factory*, *number*, *echo_pin=None*, *echo_time=0.04*)

This derivative of *MockPin* (page 242) is intended to be used with another *MockPin* (page 242) to emulate a distance sensor. Set *echo_pin* to the corresponding pin instance. When this pin is driven high it will trigger the echo pin to drive high for the echo time.

CHAPTER 24

API - Exceptions

The following exceptions are defined by GPIO Zero. Please note that multiple inheritance is heavily used in the exception hierarchy to make testing for exceptions easier. For example, to capture any exception generated by GPIO Zero's code:

```
from gpiozero import *

led = PWMLED(17)
try:
    led.value = 2
except GPIOZeroError:
    print('A GPIO Zero error occurred')
```

Since all GPIO Zero's exceptions descend from *GPIOZeroError* (page 245), this will work. However, certain specific errors have multiple parents. For example, in the case that an out of range value is passed to *OutputDevice.value* (page 143) you would expect a `ValueError`[1030] to be raised. In fact, a *OutputDeviceBadValue* (page 248) error will be raised. However, note that this descends from both *GPIOZeroError* (page 245) (indirectly) and from `ValueError`[1031] so you can still do the obvious:

```
from gpiozero import *

led = PWMLED(17)
try:
    led.value = 2
except ValueError:
    print('Bad value specified')
```

24.1 Errors

exception gpiozero.**GPIOZeroError**

Bases: `Exception`[1032]

Base class for all exceptions in GPIO Zero

[1030] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1031] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1032] https://docs.python.org/3.7/library/exceptions.html#Exception

exception gpiozero.**DeviceClosed**
Bases: gpiozero.exc.GPIOZeroError

Error raised when an operation is attempted on a closed device

exception gpiozero.**BadEventHandler**
Bases: gpiozero.exc.GPIOZeroError, ValueError[1033]

Error raised when an event handler with an incompatible prototype is specified

exception gpiozero.**BadWaitTime**
Bases: gpiozero.exc.GPIOZeroError, ValueError[1034]

Error raised when an invalid wait time is specified

exception gpiozero.**BadQueueLen**
Bases: gpiozero.exc.GPIOZeroError, ValueError[1035]

Error raised when non-positive queue length is specified

exception gpiozero.**BadPinFactory**
Bases: gpiozero.exc.GPIOZeroError, ImportError[1036]

Error raised when an unknown pin factory name is specified

exception gpiozero.**ZombieThread**
Bases: gpiozero.exc.GPIOZeroError, RuntimeError[1037]

Error raised when a thread fails to die within a given timeout

exception gpiozero.**CompositeDeviceError**
Bases: gpiozero.exc.GPIOZeroError

Base class for errors specific to the CompositeDevice hierarchy

exception gpiozero.**CompositeDeviceBadName**
Bases: gpiozero.exc.CompositeDeviceError, ValueError[1038]

Error raised when a composite device is constructed with a reserved name

exception gpiozero.**CompositeDeviceBadOrder**
Bases: gpiozero.exc.CompositeDeviceError, ValueError[1039]

Error raised when a composite device is constructed with an incomplete order

exception gpiozero.**CompositeDeviceBadDevice**
Bases: gpiozero.exc.CompositeDeviceError, ValueError[1040]

Error raised when a composite device is constructed with an object that doesn't inherit from *Device* (page 201)

exception gpiozero.**EnergenieSocketMissing**
Bases: gpiozero.exc.CompositeDeviceError, ValueError[1041]

Error raised when socket number is not specified

exception gpiozero.**EnergenieBadSocket**
Bases: gpiozero.exc.CompositeDeviceError, ValueError[1042]

Error raised when an invalid socket number is passed to *Energenie* (page 179)

[1033] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1034] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1035] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1036] https://docs.python.org/3.7/library/exceptions.html#ImportError
[1037] https://docs.python.org/3.7/library/exceptions.html#RuntimeError
[1038] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1039] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1040] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1041] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1042] https://docs.python.org/3.7/library/exceptions.html#ValueError

exception gpiozero.SPIError
Bases: gpiozero.exc.GPIOZeroError

Base class for errors related to the SPI implementation

exception gpiozero.SPIBadArgs
Bases: gpiozero.exc.SPIError, ValueError[1043]

Error raised when invalid arguments are given while constructing *SPIDevice* (page 152)

exception gpiozero.SPIBadChannel
Bases: gpiozero.exc.SPIError, ValueError[1044]

Error raised when an invalid channel is given to an *AnalogInputDevice* (page 151)

exception gpiozero.SPIFixedClockMode
Bases: gpiozero.exc.SPIError, AttributeError[1045]

Error raised when the SPI clock mode cannot be changed

exception gpiozero.SPIInvalidClockMode
Bases: gpiozero.exc.SPIError, ValueError[1046]

Error raised when an invalid clock mode is given to an SPI implementation

exception gpiozero.SPIFixedBitOrder
Bases: gpiozero.exc.SPIError, AttributeError[1047]

Error raised when the SPI bit-endianness cannot be changed

exception gpiozero.SPIFixedSelect
Bases: gpiozero.exc.SPIError, AttributeError[1048]

Error raised when the SPI select polarity cannot be changed

exception gpiozero.SPIFixedWordSize
Bases: gpiozero.exc.SPIError, AttributeError[1049]

Error raised when the number of bits per word cannot be changed

exception gpiozero.SPIInvalidWordSize
Bases: gpiozero.exc.SPIError, ValueError[1050]

Error raised when an invalid (out of range) number of bits per word is specified

exception gpiozero.GPIODeviceError
Bases: gpiozero.exc.GPIOZeroError

Base class for errors specific to the GPIODevice hierarchy

exception gpiozero.GPIODeviceClosed
Bases: gpiozero.exc.GPIODeviceError, gpiozero.exc.DeviceClosed

Deprecated descendent of *DeviceClosed* (page 245)

exception gpiozero.GPIOPinInUse
Bases: gpiozero.exc.GPIODeviceError

Error raised when attempting to use a pin already in use by another device

exception gpiozero.GPIOPinMissing
Bases: gpiozero.exc.GPIODeviceError, ValueError[1051]

[1043] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1044] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1045] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1046] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1047] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1048] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1049] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1050] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1051] https://docs.python.org/3.7/library/exceptions.html#ValueError

Error raised when a pin specification is not given

exception gpiozero.**InputDeviceError**
Bases: gpiozero.exc.GPIODeviceError

Base class for errors specific to the InputDevice hierarchy

exception gpiozero.**OutputDeviceError**
Bases: gpiozero.exc.GPIODeviceError

Base class for errors specified to the OutputDevice hierarchy

exception gpiozero.**OutputDeviceBadValue**
Bases: gpiozero.exc.OutputDeviceError, ValueError[1052]

Error raised when **value** is set to an invalid value

exception gpiozero.**PinError**
Bases: gpiozero.exc.GPIOZeroError

Base class for errors related to pin implementations

exception gpiozero.**PinInvalidFunction**
Bases: gpiozero.exc.PinError, ValueError[1053]

Error raised when attempting to change the function of a pin to an invalid value

exception gpiozero.**PinInvalidState**
Bases: gpiozero.exc.PinError, ValueError[1054]

Error raised when attempting to assign an invalid state to a pin

exception gpiozero.**PinInvalidPull**
Bases: gpiozero.exc.PinError, ValueError[1055]

Error raised when attempting to assign an invalid pull-up to a pin

exception gpiozero.**PinInvalidEdges**
Bases: gpiozero.exc.PinError, ValueError[1056]

Error raised when attempting to assign an invalid edge detection to a pin

exception gpiozero.**PinInvalidBounce**
Bases: gpiozero.exc.PinError, ValueError[1057]

Error raised when attempting to assign an invalid bounce time to a pin

exception gpiozero.**PinSetInput**
Bases: gpiozero.exc.PinError, AttributeError[1058]

Error raised when attempting to set a read-only pin

exception gpiozero.**PinFixedPull**
Bases: gpiozero.exc.PinError, AttributeError[1059]

Error raised when attempting to set the pull of a pin with fixed pull-up

exception gpiozero.**PinEdgeDetectUnsupported**
Bases: gpiozero.exc.PinError, AttributeError[1060]

Error raised when attempting to use edge detection on unsupported pins

[1052] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1053] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1054] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1055] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1056] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1057] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1058] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1059] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1060] https://docs.python.org/3.7/library/exceptions.html#AttributeError

exception gpiozero.PinUnsupported
Bases: `gpiozero.exc.PinError`, `NotImplementedError`[1061]

Error raised when attempting to obtain a pin interface on unsupported pins

exception gpiozero.PinSPIUnsupported
Bases: `gpiozero.exc.PinError`, `NotImplementedError`[1062]

Error raised when attempting to obtain an SPI interface on unsupported pins

exception gpiozero.PinPWMError
Bases: `gpiozero.exc.PinError`

Base class for errors related to PWM implementations

exception gpiozero.PinPWMUnsupported
Bases: `gpiozero.exc.PinPWMError`, `AttributeError`[1063]

Error raised when attempting to activate PWM on unsupported pins

exception gpiozero.PinPWMFixedValue
Bases: `gpiozero.exc.PinPWMError`, `AttributeError`[1064]

Error raised when attempting to initialize PWM on an input pin

exception gpiozero.PinUnknownPi
Bases: `gpiozero.exc.PinError`, `RuntimeError`[1065]

Error raised when gpiozero doesn't recognize a revision of the Pi

exception gpiozero.PinMultiplePins
Bases: `gpiozero.exc.PinError`, `RuntimeError`[1066]

Error raised when multiple pins support the requested function

exception gpiozero.PinNoPins
Bases: `gpiozero.exc.PinError`, `RuntimeError`[1067]

Error raised when no pins support the requested function

exception gpiozero.PinInvalidPin
Bases: `gpiozero.exc.PinError`, `ValueError`[1068]

Error raised when an invalid pin specification is provided

24.2 Warnings

exception gpiozero.GPIOZeroWarning
Bases: `Warning`[1069]

Base class for all warnings in GPIO Zero

exception gpiozero.DistanceSensorNoEcho
Bases: `gpiozero.exc.GPIOZeroWarning`

Warning raised when the distance sensor sees no echo at all

[1061] https://docs.python.org/3.7/library/exceptions.html#NotImplementedError
[1062] https://docs.python.org/3.7/library/exceptions.html#NotImplementedError
[1063] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1064] https://docs.python.org/3.7/library/exceptions.html#AttributeError
[1065] https://docs.python.org/3.7/library/exceptions.html#RuntimeError
[1066] https://docs.python.org/3.7/library/exceptions.html#RuntimeError
[1067] https://docs.python.org/3.7/library/exceptions.html#RuntimeError
[1068] https://docs.python.org/3.7/library/exceptions.html#ValueError
[1069] https://docs.python.org/3.7/library/exceptions.html#Warning

exception gpiozero.**SPIWarning**
Bases: `gpiozero.exc.GPIOZeroWarning`

Base class for warnings related to the SPI implementation

exception gpiozero.**SPISoftwareFallback**
Bases: `gpiozero.exc.SPIWarning`

Warning raised when falling back to the SPI software implementation

exception gpiozero.**PinWarning**
Bases: `gpiozero.exc.GPIOZeroWarning`

Base class for warnings related to pin implementations

exception gpiozero.**PinFactoryFallback**
Bases: `gpiozero.exc.PinWarning`

Warning raised when a default pin factory fails to load and a fallback is tried

exception gpiozero.**PinNonPhysical**
Bases: `gpiozero.exc.PinWarning`

Warning raised when a non-physical pin is specified in a constructor

exception gpiozero.**ThresholdOutOfRange**
Bases: `gpiozero.exc.GPIOZeroWarning`

Warning raised when a threshold is out of range specified by min and max values

exception gpiozero.**CallbackSetToNone**
Bases: `gpiozero.exc.GPIOZeroWarning`

Warning raised when a callback is set to None when its previous value was None

CHAPTER 25

Changelog

25.1 Release 1.6.0 (2021-03-14)

- Added *RotaryEncoder* (page 114) class (thanks to Paulo Mateus) (#482[1070], #928[1071])
- Added support for multi-segment character displays with *LEDCharDisplay* (page 160) and *LEDMultiCharDisplay* (page 162) along with "font" support using *LEDCharFont* (page 163) (thanks to Martin O'Hanlon) (#357[1072], #485[1073], #488[1074], #493[1075], #930[1076])
- Added *Pibrella* (page 174) class (thanks to Carl Monk) (#773[1077], #798[1078])
- Added *TrafficpHat* (page 172) class (thanks to Ryan Walmsley) (#845[1079], #846[1080])
- Added support for the lgpio[1081] library as a pin factory (#927[1082]) (*LGPIOFactory* (page 240)) (thanks to Joan for lg) (#927[1083])
- Allow *Motor* (page 132) to pass *pin_factory* (page 201) to its child *OutputDevice* (page 142) objects (thanks to Yisrael Dov Lebow) (#792[1084])
- Small SPI exception fix (thanks to Maksim Levental) (#762[1085])
- Warn users when using default pin factory for Servos and Distance Sensors (thanks to Sofiia Kosovan and Daniele Procida at the EuroPython sprints) (#780[1086], #781[1087])

1070 https://github.com/gpiozero/gpiozero/issues/482
1071 https://github.com/gpiozero/gpiozero/issues/928
1072 https://github.com/gpiozero/gpiozero/issues/357
1073 https://github.com/gpiozero/gpiozero/issues/485
1074 https://github.com/gpiozero/gpiozero/issues/488
1075 https://github.com/gpiozero/gpiozero/issues/493
1076 https://github.com/gpiozero/gpiozero/issues/930
1077 https://github.com/gpiozero/gpiozero/issues/773
1078 https://github.com/gpiozero/gpiozero/issues/798
1079 https://github.com/gpiozero/gpiozero/issues/845
1080 https://github.com/gpiozero/gpiozero/issues/846
1081 http://abyz.me.uk/lg/py_lgpio.html
1082 https://github.com/gpiozero/gpiozero/issues/927
1083 https://github.com/gpiozero/gpiozero/issues/927
1084 https://github.com/gpiozero/gpiozero/issues/792
1085 https://github.com/gpiozero/gpiozero/issues/762
1086 https://github.com/gpiozero/gpiozero/issues/780
1087 https://github.com/gpiozero/gpiozero/issues/781

- Added *pulse_width* (page 136) property to *Servo* (page 135) (suggested by Daniele Procida at the PyCon UK sprints) (#795[1088], #797[1089])
- Added event-driven functionality to *internal devices* (page 189) (#941[1090])
- Allowed *Energenie* (page 179) sockets preserve their state on construction (thanks to Jack Wearden) (#865[1091])
- Added source tools `scaled_half()` and `scaled_full()`
- Added complete Pi 4 support to *NativeFactory* (page 242) (thanks to Andrew Scheller) (#920[1092], #929[1093], #940[1094])
- Updated add-on boards to use BOARD numbering (#349[1095], #860[1096])
- Fixed *ButtonBoard* (page 163) release events (#761[1097])
- Add ASCII art diagrams to **pinout** for Pi 400 and CM4 (#932[1098])
- Cleaned up software SPI (thanks to Andrew Scheller and Kyle Morgan) (#777[1099], #895[1100], #900[1101])
- Added USB3 and Ethernet speed attributes to *pi_info()* (page 219)
- Various docs updates

Warning: This is the last release to support Python 2

25.2 Release 1.5.1 (2019-06-24)

- Added Raspberry Pi 4 data for *pi_info()* (page 219) and **pinout**
- Minor docs updates

25.3 Release 1.5.0 (2019-02-12)

- Introduced pin event timing to increase accuracy of certain devices such as the HC-SR04 *DistanceSensor* (page 111). (#664[1102], #665[1103])
- Further improvements to *DistanceSensor* (page 111) (ignoring missed edges). (#719[1104])
- Allow `source` to take a device object as well as `values` or other `values`. See *Source/Values* (page 65). (#640[1105])

[1088] https://github.com/gpiozero/gpiozero/issues/795
[1089] https://github.com/gpiozero/gpiozero/issues/797
[1090] https://github.com/gpiozero/gpiozero/issues/941
[1091] https://github.com/gpiozero/gpiozero/issues/865
[1092] https://github.com/gpiozero/gpiozero/issues/920
[1093] https://github.com/gpiozero/gpiozero/issues/929
[1094] https://github.com/gpiozero/gpiozero/issues/940
[1095] https://github.com/gpiozero/gpiozero/issues/349
[1096] https://github.com/gpiozero/gpiozero/issues/860
[1097] https://github.com/gpiozero/gpiozero/issues/761
[1098] https://github.com/gpiozero/gpiozero/issues/932
[1099] https://github.com/gpiozero/gpiozero/issues/777
[1100] https://github.com/gpiozero/gpiozero/issues/895
[1101] https://github.com/gpiozero/gpiozero/issues/900
[1102] https://github.com/gpiozero/gpiozero/issues/664
[1103] https://github.com/gpiozero/gpiozero/issues/665
[1104] https://github.com/gpiozero/gpiozero/issues/719
[1105] https://github.com/gpiozero/gpiozero/issues/640

- Added internal device classes *LoadAverage* (page 194) and *DiskUsage* (page 195) (thanks to Jeevan M R for the latter). (#532[1106], #714[1107])
- Added support for colorzero[1108] with *RGBLED* (page 127) (this adds a new dependency). (#655[1109])
- Added *TonalBuzzer* (page 131) with *Tone* (page 217) API for specifying frequencies raw or via MIDI or musical notes. (#681[1110], #717[1111])
- Added *PiHutXmasTree* (page 167). (#502[1112])
- Added *PumpkinPi* (page 183) and *JamHat* (page 173) (thanks to Claire Pollard). (#680[1113], #681[1114], #717[1115])
- Ensured gpiozero can be imported without a valid pin factory set. (#591[1116], #713[1117])
- Reduced import time by not computing default pin factory at the point of import. (#675[1118], #722[1119])
- Added support for various pin numbering mechanisms. (#470[1120])
- *Motor* (page 132) instances now use *DigitalOutputDevice* (page 139) for non-PWM pins.
- Allow non-PWM use of *Robot* (page 175). (#481[1121])
- Added optional `enable` init param to *Motor* (page 132). (#366[1122])
- Added `--xyz` option to `pinout` command line tool to open pinout.xyz[1123] in a web browser. (#604[1124])
- Added 3B+, 3A+ and CM3+ to Pi model data. (#627[1125], #704[1126])
- Minor improvements to *Energenie* (page 179), thanks to Steve Amor. (#629[1127], #634[1128])
- Allow *SmoothedInputDevice* (page 119), *LightSensor* (page 109) and *MotionSensor* (page 108) to have pull-up configured. (#652[1129])
- Allow input devices to be pulled up or down externally, thanks to Philippe Muller. (#593[1130], #658[1131])
- Minor changes to support Python 3.7, thanks to Russel Winder and Rick Ansell. (#666[1132],

1106 https://github.com/gpiozero/gpiozero/issues/532
1107 https://github.com/gpiozero/gpiozero/issues/714
1108 https://colorzero.readthedocs.io/en/stable
1109 https://github.com/gpiozero/gpiozero/issues/655
1110 https://github.com/gpiozero/gpiozero/issues/681
1111 https://github.com/gpiozero/gpiozero/issues/717
1112 https://github.com/gpiozero/gpiozero/issues/502
1113 https://github.com/gpiozero/gpiozero/issues/680
1114 https://github.com/gpiozero/gpiozero/issues/681
1115 https://github.com/gpiozero/gpiozero/issues/717
1116 https://github.com/gpiozero/gpiozero/issues/591
1117 https://github.com/gpiozero/gpiozero/issues/713
1118 https://github.com/gpiozero/gpiozero/issues/675
1119 https://github.com/gpiozero/gpiozero/issues/722
1120 https://github.com/gpiozero/gpiozero/issues/470
1121 https://github.com/gpiozero/gpiozero/issues/481
1122 https://github.com/gpiozero/gpiozero/issues/366
1123 https://pinout.xyz
1124 https://github.com/gpiozero/gpiozero/issues/604
1125 https://github.com/gpiozero/gpiozero/issues/627
1126 https://github.com/gpiozero/gpiozero/issues/704
1127 https://github.com/gpiozero/gpiozero/issues/629
1128 https://github.com/gpiozero/gpiozero/issues/634
1129 https://github.com/gpiozero/gpiozero/issues/652
1130 https://github.com/gpiozero/gpiozero/issues/593
1131 https://github.com/gpiozero/gpiozero/issues/658
1132 https://github.com/gpiozero/gpiozero/issues/666

#668[1133], #669[1134], #671[1135], #673[1136])

- Added *zip_values()* (page 210) source tool.
- Correct row/col numbering logic in *PinInfo* (page 223). (#674[1137])
- Many additional tests, and other improvements to the test suite.
- Many documentation corrections, additions and clarifications.
- Automatic documentation class hierarchy diagram generation.
- Automatic copyright attribution in source files.

25.4 Release 1.4.1 (2018-02-20)

This release is mostly bug-fixes, but a few enhancements have made it in too:

- Added `curve_left` and `curve_right` parameters to *Robot.forward()* (page 176) and *Robot.backward()* (page 175). (#306[1138] and #619[1139])
- Fixed *DistanceSensor* (page 111) returning incorrect readings after a long pause, and added a lock to ensure multiple distance sensors can operate simultaneously in a single project. (#584[1140], #595[1141], #617[1142], #618[1143])
- Added support for phase/enable motor drivers with *PhaseEnableMotor* (page 134), *PhaseEnableRobot* (page 177), and descendants, thanks to Ian Harcombe! (#386[1144])
- A variety of other minor enhancements, largely thanks to Andrew Scheller! (#479[1145], #489[1146], #491[1147], #492[1148])

25.5 Release 1.4.0 (2017-07-26)

- Pin factory is now *configurable from device constructors* (page 227) as well as command line. NOTE: this is a backwards incompatible change for manual pin construction but it's hoped this is (currently) a sufficiently rare use case that this won't affect too many people and the benefits of the new system warrant such a change, i.e. the ability to use remote pin factories with HAT classes that don't accept pin assignations (#279[1149])
- Major work on SPI, primarily to support remote hardware SPI (#421[1150], #459[1151], #465[1152], #468[1153], #575[1154])

[1133] https://github.com/gpiozero/gpiozero/issues/668
[1134] https://github.com/gpiozero/gpiozero/issues/669
[1135] https://github.com/gpiozero/gpiozero/issues/671
[1136] https://github.com/gpiozero/gpiozero/issues/673
[1137] https://github.com/gpiozero/gpiozero/issues/674
[1138] https://github.com/gpiozero/gpiozero/issues/306
[1139] https://github.com/gpiozero/gpiozero/issues/619
[1140] https://github.com/gpiozero/gpiozero/issues/584
[1141] https://github.com/gpiozero/gpiozero/issues/595
[1142] https://github.com/gpiozero/gpiozero/issues/617
[1143] https://github.com/gpiozero/gpiozero/issues/618
[1144] https://github.com/gpiozero/gpiozero/issues/386
[1145] https://github.com/gpiozero/gpiozero/issues/479
[1146] https://github.com/gpiozero/gpiozero/issues/489
[1147] https://github.com/gpiozero/gpiozero/issues/491
[1148] https://github.com/gpiozero/gpiozero/issues/492
[1149] https://github.com/gpiozero/gpiozero/issues/279
[1150] https://github.com/gpiozero/gpiozero/issues/421
[1151] https://github.com/gpiozero/gpiozero/issues/459
[1152] https://github.com/gpiozero/gpiozero/issues/465
[1153] https://github.com/gpiozero/gpiozero/issues/468
[1154] https://github.com/gpiozero/gpiozero/issues/575

- Pin reservation now works properly between GPIO and SPI devices (#459[1155], #468[1156])
- Lots of work on the documentation: *source/values chapter* (page 65), better charts, more recipes, *remote GPIO configuration* (page 49), mock pins, better PDF output (#484[1157], #469[1158], #523[1159], #520[1160], #434[1161], #565[1162], #576[1163])
- Support for `StatusZero` (page 180) and `StatusBoard` (page 181) HATs (#558[1164])
- Added **pinout** command line tool to provide a simple reference to the GPIO layout and information about the associated Pi (#497[1165], #504[1166]) thanks to Stewart Adcock for the initial work
- `pi_info()` (page 219) made more lenient for new (unknown) Pi models (#529[1167])
- Fixed a variety of packaging issues (#535[1168], #518[1169], #519[1170])
- Improved text in factory fallback warnings (#572[1171])

25.6 Release 1.3.2 (2017-03-03)

- Added new Pi models to stop `pi_info()` (page 219) breaking
- Fix issue with `pi_info()` (page 219) breaking on unknown Pi models

25.7 Release 1.3.1 (2016-08-31 … later)

- Fixed hardware SPI support which Dave broke in 1.3.0. Sorry!
- Some minor docs changes

25.8 Release 1.3.0 (2016-08-31)

- Added `ButtonBoard` (page 163) for reading multiple buttons in a single class (#340[1172])
- Added `Servo` (page 135) and `AngularServo` (page 137) classes for controlling simple servo motors (#248[1173])
- Lots of work on supporting easier use of internal and third-party pin implementations (#359[1174])
- `Robot` (page 175) now has a proper `value` (page 176) attribute (#305[1175])
- Added `CPUTemperature` (page 192) as another demo of "internal" devices (#294[1176])

1155 https://github.com/gpiozero/gpiozero/issues/459
1156 https://github.com/gpiozero/gpiozero/issues/468
1157 https://github.com/gpiozero/gpiozero/issues/484
1158 https://github.com/gpiozero/gpiozero/issues/469
1159 https://github.com/gpiozero/gpiozero/issues/523
1160 https://github.com/gpiozero/gpiozero/issues/520
1161 https://github.com/gpiozero/gpiozero/issues/434
1162 https://github.com/gpiozero/gpiozero/issues/565
1163 https://github.com/gpiozero/gpiozero/issues/576
1164 https://github.com/gpiozero/gpiozero/issues/558
1165 https://github.com/gpiozero/gpiozero/issues/497
1166 https://github.com/gpiozero/gpiozero/issues/504
1167 https://github.com/gpiozero/gpiozero/issues/529
1168 https://github.com/gpiozero/gpiozero/issues/535
1169 https://github.com/gpiozero/gpiozero/issues/518
1170 https://github.com/gpiozero/gpiozero/issues/519
1171 https://github.com/gpiozero/gpiozero/issues/572
1172 https://github.com/gpiozero/gpiozero/issues/340
1173 https://github.com/gpiozero/gpiozero/issues/248
1174 https://github.com/gpiozero/gpiozero/issues/359
1175 https://github.com/gpiozero/gpiozero/issues/305
1176 https://github.com/gpiozero/gpiozero/issues/294

- A temporary work-around for an issue with *DistanceSensor* (page 111) was included but a full fix is in the works (#385[1177])
- More work on the documentation (#320[1178], #295[1179], #289[1180], etc.)

Not quite as much as we'd hoped to get done this time, but we're rushing to make a Raspbian freeze. As always, thanks to the community - your suggestions and PRs have been brilliant and even if we don't take stuff exactly as is, it's always great to see your ideas. Onto 1.4!

25.9 Release 1.2.0 (2016-04-10)

- Added *Energenie* (page 179) class for controlling Energenie plugs (#69[1181])
- Added *LineSensor* (page 106) class for single line-sensors (#109[1182])
- Added *DistanceSensor* (page 111) class for HC-SR04 ultra-sonic sensors (#114[1183])
- Added *SnowPi* (page 182) class for the Ryanteck Snow-pi board (#130[1184])
- Added *when_held* (page 105) (and related properties) to *Button* (page 103) (#115[1185])
- Fixed issues with installing GPIO Zero for python 3 on Raspbian Wheezy releases (#140[1186])
- Added support for lots of ADC chips (MCP3xxx family) (#162[1187]) - many thanks to pcopa and lurch!
- Added support for pigpiod as a pin implementation with *PiGPIOPin* (page 241) (#180[1188])
- Many refinements to the base classes mean more consistency in composite devices and several bugs squashed (#164[1189], #175[1190], #182[1191], #189[1192], #193[1193], #229[1194])
- GPIO Zero is now aware of what sort of Pi it's running on via *pi_info()* (page 219) and has a fairly extensive database of Pi information which it uses to determine when users request impossible things (like pull-down on a pin with a physical pull-up resistor) (#222[1195])
- The source/values system was enhanced to ensure normal usage doesn't stress the CPU and lots of utilities were added (#181[1196], #251[1197])

And I'll just add a note of thanks to the many people in the community who contributed to this release: we've had some great PRs, suggestions, and bug reports in this version. Of particular note:

- Schelto van Doorn was instrumental in adding support for numerous ADC chips
- Alex Eames generously donated a RasPiO Analog board which was extremely useful in developing the software SPI interface (and testing the ADC support)

1177 https://github.com/gpiozero/gpiozero/issues/385
1178 https://github.com/gpiozero/gpiozero/issues/320
1179 https://github.com/gpiozero/gpiozero/issues/295
1180 https://github.com/gpiozero/gpiozero/issues/289
1181 https://github.com/gpiozero/gpiozero/issues/69
1182 https://github.com/gpiozero/gpiozero/issues/109
1183 https://github.com/gpiozero/gpiozero/issues/114
1184 https://github.com/gpiozero/gpiozero/issues/130
1185 https://github.com/gpiozero/gpiozero/issues/115
1186 https://github.com/gpiozero/gpiozero/issues/140
1187 https://github.com/gpiozero/gpiozero/issues/162
1188 https://github.com/gpiozero/gpiozero/issues/180
1189 https://github.com/gpiozero/gpiozero/issues/164
1190 https://github.com/gpiozero/gpiozero/issues/175
1191 https://github.com/gpiozero/gpiozero/issues/182
1192 https://github.com/gpiozero/gpiozero/issues/189
1193 https://github.com/gpiozero/gpiozero/issues/193
1194 https://github.com/gpiozero/gpiozero/issues/229
1195 https://github.com/gpiozero/gpiozero/issues/222
1196 https://github.com/gpiozero/gpiozero/issues/181
1197 https://github.com/gpiozero/gpiozero/issues/251

- Andrew Scheller squashed several dozen bugs (usually a day or so after Dave had introduced them ;)

As always, many thanks to the whole community - we look forward to hearing from you more in 1.3!

25.10 Release 1.1.0 (2016-02-08)

- Documentation converted to reST and expanded to include generic classes and several more recipes (#80[1198], #82[1199], #101[1200], #119[1201], #135[1202], #168[1203])
- New *CamJamKitRobot* (page 178) class with the pre-defined motor pins for the new CamJam EduKit
- New *LEDBarGraph* (page 158) class (many thanks to Martin O'Hanlon!) (#126[1204], #176[1205])
- New *Pin* (page 231) implementation abstracts out the concept of a GPIO pin paving the way for alternate library support and IO extenders in future (#141[1206])
- New *LEDBoard.blink()* (page 156) method which works properly even when background is set to `False` (#94[1207], #161[1208])
- New *RGBLED.blink()* (page 128) method which implements (rudimentary) color fading too! (#135[1209], #174[1210])
- New `initial_value` attribute on *OutputDevice* (page 142) ensures consistent behaviour on construction (#118[1211])
- New `active_high` attribute on *PWMOutputDevice* (page 140) and *RGBLED* (page 127) allows use of common anode devices (#143[1212], #154[1213])
- Loads of new ADC chips supported (many thanks to GitHub user pcopa!) (#150[1214])

25.11 Release 1.0.0 (2015-11-16)

- Debian packaging added (#44[1215])
- *PWMLED* (page 125) class added (#58[1216])
- `TemperatureSensor` removed pending further work (#93[1217])
- *Buzzer.beep()* (page 130) alias method added (#75[1218])
- *Motor* (page 132) PWM devices exposed, and *Robot* (page 175) motor devices exposed (#107[1219])

[1198] https://github.com/gpiozero/gpiozero/issues/80
[1199] https://github.com/gpiozero/gpiozero/issues/82
[1200] https://github.com/gpiozero/gpiozero/issues/101
[1201] https://github.com/gpiozero/gpiozero/issues/119
[1202] https://github.com/gpiozero/gpiozero/issues/135
[1203] https://github.com/gpiozero/gpiozero/issues/168
[1204] https://github.com/gpiozero/gpiozero/issues/126
[1205] https://github.com/gpiozero/gpiozero/issues/176
[1206] https://github.com/gpiozero/gpiozero/issues/141
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[1208] https://github.com/gpiozero/gpiozero/issues/161
[1209] https://github.com/gpiozero/gpiozero/issues/135
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[1217] https://github.com/gpiozero/gpiozero/issues/93
[1218] https://github.com/gpiozero/gpiozero/issues/75
[1219] https://github.com/gpiozero/gpiozero/issues/107

25.12 Release 0.9.0 (2015-10-25)

Fourth public beta

- Added source and values properties to all relevant classes (#76[1220])
- Fix names of parameters in *Motor* (page 132) constructor (#79[1221])
- Added wrappers for LED groups on add-on boards (#81[1222])

25.13 Release 0.8.0 (2015-10-16)

Third public beta

- Added generic *AnalogInputDevice* (page 151) class along with specific classes for the *MCP3008* (page 147) and *MCP3004* (page 147) (#41[1223])
- Fixed *DigitalOutputDevice.blink()* (page 140) (#57[1224])

25.14 Release 0.7.0 (2015-10-09)

Second public beta

25.15 Release 0.6.0 (2015-09-28)

First public beta

25.16 Release 0.5.0 (2015-09-24)

25.17 Release 0.4.0 (2015-09-23)

25.18 Release 0.3.0 (2015-09-22)

25.19 Release 0.2.0 (2015-09-21)

Initial release

[1220] https://github.com/gpiozero/gpiozero/issues/76
[1221] https://github.com/gpiozero/gpiozero/issues/79
[1222] https://github.com/gpiozero/gpiozero/issues/81
[1223] https://github.com/gpiozero/gpiozero/issues/41
[1224] https://github.com/gpiozero/gpiozero/issues/57

CHAPTER 26

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