

Raspberry PI Rotary Encoders

Tutorial



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Contents

Introduction	3
Raspberry PI computer	3
Rotary encoder	4
The Rotary Class.....	6
Other rotary class calls.....	7
GPIO Hardware Notes.....	8
Appendix A The rotary encoder class	9
A.1 The rotary_class.py file.....	9
A.2 The test_rotary_class.py file.....	11
A.3 Example using two switches	12
Appendix B Licences.....	13
Acknowledgements.....	13
Glossary.....	14

Tables

Table 1 Rotary encoder sequence (Clockwise)	5
Table 2 Event interpretation using the delta between events	5
Table 3 Wiring list for Rotary Encoders used in the PI internet radio	6

Figures

Figure 1 Raspberry PI Computer	3
Figure 2 Rotary encoder wiring.....	4
Figure 3 Typical incremental rotary encoder	4
Figure 4 Quadrature output table.....	4
Figure 5 Raspberry PI internet radio with Rotary Encoders	6

Introduction

This tutorial has been designed to help students and constructors to understand how to use Rotary Encoders and to use them in their own Raspberry Pi projects. The principle hardware required to build a project using Rotary Encoders consists of the following components:

- A Raspberry Pi computer
- One or more rotary encoders with or without push button
- The rotary_class.py code and associated test programs.

Raspberry Pi computer

The **Raspberry Pi** is a credit-card-sized single-board computer developed in the United Kingdom by the [Raspberry Pi Foundation](http://www.raspberrypi.org/) with the intention of promoting the teaching of basic computer science in schools.

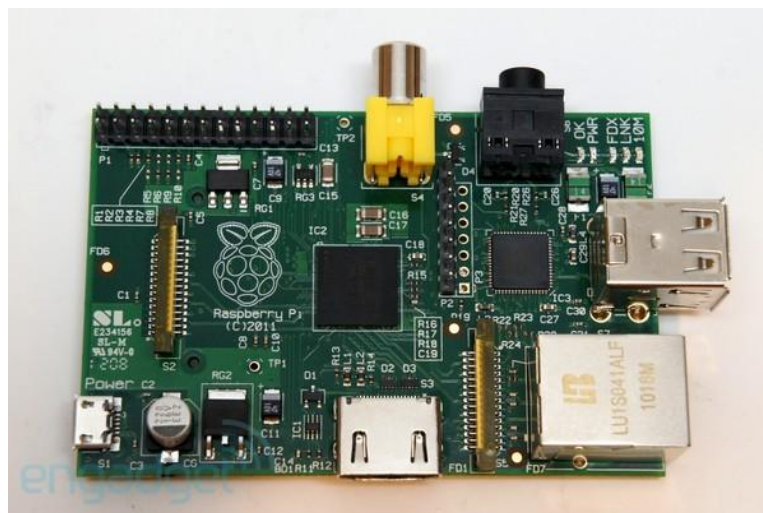


Figure 1 Raspberry Pi Computer

More information on the Raspberry Pi computer may be found here:

http://en.wikipedia.org/wiki/Raspberry_Pi

If you are new to the Raspberry Pi try the following beginners guide. http://elinux.org/RPi_Beginners

Rotary encoder

A good place to start is by taking a look at the following Wikipedia article:

http://en.wikipedia.org/wiki/Rotary_encoder

There are several types of rotary encoder and encoding used. This tutorial is using the so called "Incremental Rotary Encoder". An incremental rotary encoder provides cyclical outputs (only) when the encoder is rotated.

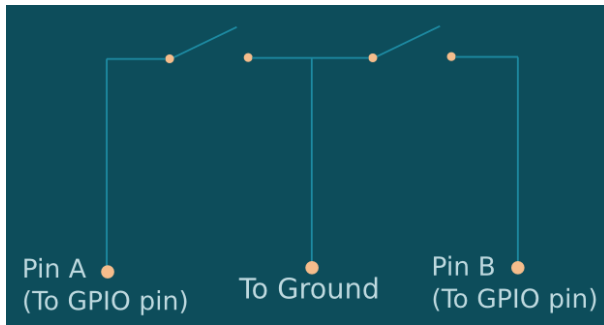


Figure 2 Rotary encoder wiring



Figure 3 Typical incremental rotary encoder

Quadrature Output Table

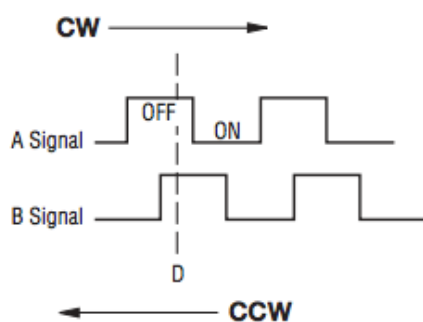


Figure 4 Quadrature output table

Rotary encoders have three inputs namely Ground, Pin A and B as shown in the diagram on the left. Wire the encoders according shown in Table 2 on page 10. If the encoder also has a push button knob then wire one side to ground and the other to the GPIO pin (Not shown in the diagram).

On the left is a typical hobbyist incremental rotary encoder. The one illustrated is the COM-09117 12-step rotary encoder from Sparkfun.com. It also has a select switch (Operated by pushing in on the knob in). This is the rotary encoder used in this tutorial.

The rotary encoder uses pins A and B as outputs. The A and B outputs to the GPIO inputs on the Raspberry PI will use the internal pull-up resistors, so that they read high when the contacts are open and low when closed. The inputs generate the sequence of values as shown on the left. As the inputs combined can have four states it is known as the quadrature sequence.

It is necessary to determine which direction the rotary encoder has been turned from these events.

Table 1 Rotary encoder sequence (Clockwise)

Sequence	A	B	A^B (C)	Value
0	0	0	0	0
1	1	0	1	5
2	1	1	0	6
3	0	1	1	3

The trick is to use the bitwise XOR value $A \oplus B$ to transform the input bits into an ordinal sequence number. There is no reason behind the XOR operation other than it to provide the bit sequence. For anti-clockwise the sequence is reversed.

The next task is to determine what direction the rotary encoder has been turned. This is first done by determining the delta (change) between the the previous state ($A + B + (A \oplus B)$) and the new state. The following code achieves this:

```
delta = (new_state - last_state) % 4
```

The %4 means give the remainder of a divide by 4 operation. The above code produces a value between 0 and 3 as shown in the following table:

Table 2 Event interpretation using the delta between events

Delta	Meaning
0	No change
1	On step clockwise
2	Two steps clockwise or counter-clockwise
3	On step counter-clockwise

The whole sequence of code (Python) is shown below:

```
# Get pin A state
if GPIO.input(pinA):
    rotary_a = 1
else:
    rotary_a = 0

# Get pin B state
if GPIO.input(pinB):
    self.rotary_b = 1
else:
    self.rotary_b = 0

# Create bit sequence
rotary_c = rotary_a ^ rotary_b

# Get the new rotary encoder state
new_state = rotary_a * 4 + rotary_b * 2 + rotary_c * 1

# Get the delta (difference) between the previous state and the new state
delta = (new_state - last_state) % 4

# Store the state for next time around
last_state = new_state
```

Why is **rotary_a** and **rotary_b** multiplied by 4 and 2 respectively? This is done to produce the value shown in the last column of Table 1 on page 5. The value of **rotary_c** will always be 0 or 1.

The Rotary Class

This tutorial uses the `rotary_class.py` Python class as shown in *Appendix A The rotary encoder class*. A class is like a blue print for an object, in this case a rotary encoder. Why use a class? There are a lot of reasons but lets take a practical example. I wished to use rotary encoders in a project for building and Internet Radio using the Raspberry PI. For details of this project See:

http://www.bobrathbone.com/raspberrypi_radio.htm



Figure 5 Raspberry PI internet radio with Rotary Encoders

In this project I wish to use one rotary encoder for the volume control and mute functions and the other for the tuner and menu functions. The following table shows how the rotary encoders are wired. Of course other GPIO inputs may be used instead in your own project.

Table 3 Wiring list for Rotary Encoders used in the PI internet radio

GPIO Pin	Description	Function	Rotary Encoder 1 (Tuner)	Rotary Encoder 2 (Volume)
6	GND	Zero volts	Common	Common
7	GPIO 4	Mute volume		Knob Switch
8	GPIO 14	Volume down		Output A
9	Reserved			
10	GPIO 15	Volume up		Output B
11	GPIO 17	Channel Up	Output B	
12	GPIO 18	Channel Down	Output A	
22	GPIO 25	Menu Switch	Knob Switch	

To use the rotary class it must first be imported into the program that wishes to use it.

```
from rotary_class import RotaryEncoder
```

The general call for the rotary_class is:

```
knob = RotaryEncoder(PIN_A, PIN_B, BUTTON, event_handler)
```

Where **PIN_A** is the rotary encoder A output, **PIN_B** is the rotary encoder B output, **BUTTON** is the push button and **event_handler** is the routine (callback) which will handle the events. The new switch object is called **knob**.

So to define a volume control this would become:

```
VOLUME_UP = 15    # GPIO pin 10
VOLUME_DOWN = 14  # GPIO pin 8
MUTE_SWITCH = 4   # GPIO pin 7
volumeknob = RotaryEncoder(VOLUME_UP, VOLUME_DOWN, MUTE_SWITCH, volume_event)
```

We also need to define a routine called **volume_event** to handle the rotary encoder and push button events.

Events are defined in the rotary_class.py file.

```
CLOCKWISE=1
ANTICLOCKWISE=2
BUTTONDOWN=3
BUTTONUP=4
```

The event handler looks something like below:

```
# Call back routine for the volume control knob
def volume_event(event):
    global volumeknob
    if event == RotaryEncoder.CLOCKWISE:
        ... Code to handle volume increase

    elif event == RotaryEncoder.ANTICLOCKWISE:
        ... Code to handle volume decrease

    elif event == RotaryEncoder.BUTTONDOWN:
        ... Code to handle mute function

    return
```

In the same way we can define the tuner knob using a separate Rotary_Class definition

```
CHANNEL_UP = 18    # GPIO pin 12
CHANNEL_DOWN = 17 # GPIO pin 11
MENU_SWITCH = 25   # GPIO pin 25
tunerknob = RotaryEncoder(CHANNEL_UP, CHANNEL_DOWN, MENU_SWITCH, tuner_event)
```

Note that a different routine **tuner_event** is defined for the tuner event. Now it can be seen that a single class can be used to define more than one object. In this case the **volume_knob** and **tuner_knob** objects.

Other rotary class calls

The state of the rotary encoder push switch can be read with the **getSwitchState** function.

```
MutePressed = tunerknob.getSwitchState(MENU_SWITCH)
```


GPIO Hardware Notes

The following shows the pin outs for the GPIO pins. For more information see:

http://elinux.org/RPi_Low-level_peripherals



Note: On rev 2 boards GPIO21 is now GPIO27

Appendix A The rotary encoder class

The source of these files is available on the Bob Rathbone website.

A.1 The rotary_class.py file

```
#!/usr/bin/env python
#
# Raspberry Pi Rotary Encoder Class
# $Id: rotary_class.py,v 1.2 2014/01/14 07:30:07 bob Exp $
#
# Author : Bob Rathbone
# Site   : http://www.bobrathbone.com
#
# This class uses standard rotary encoder with push switch
#
#

import RPi.GPIO as GPIO

class RotaryEncoder:

    CLOCKWISE=1
    ANTICLOCKWISE=2
    BUTTONDOWN=3
    BUTTONUP=4

    rotary_a = 0
    rotary_b = 0
    rotary_c = 0
    last_state = 0
    direction = 0

    # Initialise rotary encoder object
    def __init__(self,pinA,pinB,button,callback):
        self.pinA = pinA
        self.pinB = pinB
        self.button = button
        self.callback = callback

        GPIO.setmode(GPIO.BCM)

        # The following lines enable the internal pull-up resistors
        # on version 2 (latest) boards
        GPIO.setwarnings(False)
        GPIO.setup(self.pinA, GPIO.IN, pull_up_down=GPIO.PUD_UP)
        GPIO.setup(self.pinB, GPIO.IN, pull_up_down=GPIO.PUD_UP)
        GPIO.setup(self.button, GPIO.IN, pull_up_down=GPIO.PUD_UP)

        # For version 1 (old) boards comment out the above four lines
        # and un-comment the following 3 lines
        #GPIO.setup(self.pinA, GPIO.IN)
        #GPIO.setup(self.pinB, GPIO.IN)
        #GPIO.setup(self.button, GPIO.IN)

        # Add event detection to the GPIO inputs
        GPIO.add_event_detect(self.pinA, GPIO.FALLING,
callback=self.switch_event)
        GPIO.add_event_detect(self.pinB, GPIO.FALLING,
callback=self.switch_event)
        GPIO.add_event_detect(self.button, GPIO.BOTH,
callback=self.button_event, bouncetime=200)
        return

    # Call back routine called by switch events
    def switch_event(self,switch):
        if GPIO.input(self.pinA):
```

```

        self.rotary_a = 1
    else:
        self.rotary_a = 0

    if GPIO.input(self.pinB):
        self.rotary_b = 1
    else:
        self.rotary_b = 0

    self.rotary_c = self.rotary_a ^ self.rotary_b
    new_state = self.rotary_a * 4 + self.rotary_b * 2 + self.rotary_c * 1
    delta = (new_state - self.last_state) % 4
    self.last_state = new_state
    event = 0

    if delta == 1:
        if self.direction == self.CLOCKWISE:
            # print "Clockwise"
            event = self.direction
        else:
            self.direction = self.CLOCKWISE
    elif delta == 3:
        if self.direction == self.ANTICLOCKWISE:
            # print "Anticlockwise"
            event = self.direction
        else:
            self.direction = self.ANTICLOCKWISE

    if event > 0:
        self.callback(event)
    return

# Push button event
def button_event(self,button):
    if GPIO.input(button):
        event = self.BUTTONUP
    else:
        event = self.BUTTONDOWN
    self.callback(event)
    return

# Get a switch state
def getSwitchState(self, switch):
    return GPIO.input(switch)

# End of RotaryEncoder class

```

A.2 The test_rotary_class.py file

This example uses GPIO pins 7, 8 and 10.

```
#!/usr/bin/env python
#
# Raspberry Pi Rotary Test Encoder Class
#
# Author : Bob Rathbone
# Site   : http://www.bobrathbone.com
#
# This class uses a standard rotary encoder with push switch
#

import sys
import time
from rotary_class import RotaryEncoder

# Define GPIO inputs
PIN_A = 14      # Pin 8
PIN_B = 15      # Pin 10
BUTTON = 4      # Pin 7

# This is the event callback routine to handle events
def switch_event(event):
    if event == RotaryEncoder.CLOCKWISE:
        print "Clockwise"
    elif event == RotaryEncoder.ANTICLOCKWISE:
        print "Anticlockwise"
    elif event == RotaryEncoder.BUTTONDOWN:
        print "Button down"
    elif event == RotaryEncoder.BUTTONUP:
        print "Button up"
    return

# Define the switch
rswitch = RotaryEncoder(PIN_A,PIN_B,BUTTON,switch_event)

while True:
    time.sleep(0.5)
```

A.3 Example using two switches

This example (test_rotary_switches.py) shows how to handle two or more switches.

```
#!/usr/bin/env python
#
# Raspberry Pi Rotary Test Encoder Class
# $Id: test_rotary_switches.py,v 1.3 2014/01/31 13:57:28 bob Exp $
#
# Author : Bob Rathbone
# Site   : http://www.bobrathbone.com
#
# This class uses standard rotary encoder with push switch
#

import sys
import time
from rotary_class import RotaryEncoder

# Switch definitions
RIGHT_BUTTON = 25
LEFT_A = 14
LEFT_B = 15
RIGHT_A = 17
RIGHT_B = 18
LEFT_BUTTON = 4

# This is the event callback routine to handle left knob events
def left_knob_event(event):
    handle_event(event,"Left knob")
    return

# This is the event callback routine to handle right knob events
def right_knob_event(event):
    handle_event(event,"Right knob")
    return

# This is the event callback routine to handle events
def handle_event(event, name):
    if event == RotaryEncoder.CLOCKWISE:
        print name, "Clockwise event =", RotaryEncoder.CLOCKWISE
    elif event == RotaryEncoder.ANTICLOCKWISE:
        print name, "Anticlockwise event =",
RotaryEncoder.BUTTONDOWN
    elif event == RotaryEncoder.BUTTONDOWN:
        print name, "Button down event =", RotaryEncoder.BUTTONDOWN
    elif event == RotaryEncoder.BUTTONUP:
        print name, "Button up event =", RotaryEncoder.BUTTONUP
    return

# Define the left and right knobs
leftknob = RotaryEncoder(LEFT_A,LEFT_B,LEFT_BUTTON,left_knob_event)
rightknob = RotaryEncoder(RIGHT_A,RIGHT_B,RIGHT_BUTTON,right_knob_event)

# Wait for events
while True:
    time.sleep(0.5)
```

Appendix B Licences

The software and documentation for this project is released under the GNU General Public Licence.

The GNU General Public License (GNU GPL or GPL) is the most widely used free software license, which guarantees end users (individuals, organizations, companies) the freedoms to use, study, share (copy), and modify the software. Software that ensures that these rights are retained is called free software. The license was originally written by Richard Stallman of the Free Software Foundation (FSF) for the GNU project.

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See <http://www.gnu.org/licenses/#GPL> for further information on the GNU General Public License.

Acknowledgements

Much of the information in this tutorial comes from an excellent article by [Guy Carpenter](#). See:

<http://guy.carpenter.id.au/gaugette/2013/01/14/rotary-encoder-library-for-the-raspberry-pi/>

Glossary

GPIO General Purpose IO (On the Raspberry PI)