

DE1.3 Electronics 1

Tips on Team Projects

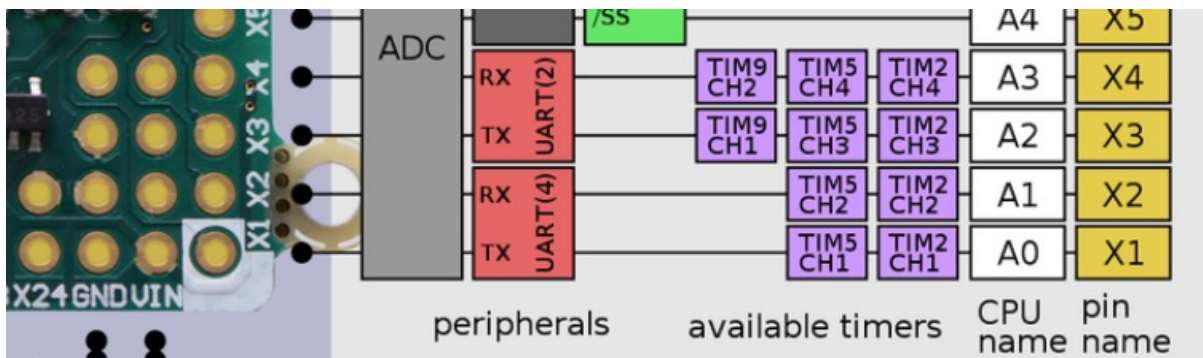
To help you progress with the team project, I have prepared this documents to provide extra instructions that you should find helpful.

1. How can I drive TWO motors with PWM signals?

Lab 4, Task 4 provides an example to control speed of one motor. To drive two motors, you only need to add a second set of control signals AND a second timer channel. See the Appendix for the sample program code with line numbers. Note that you can download this file ([two_motors.py.zip](#)) from the Course webpage.

Lines 21 to 25: Create a second set of control pins for motor B. Note that X2 is used to drive the pwmB signal. X2 is usable ONLY IF YOU HAVE THE SLIDE SWITCHES set in the UP direction. If the switches are DOWN (logic 0), X2 pin is connected to GND.

Line 31, 32: These two lines are using the physical counter hardware on the microcontroller chip, Timer 2, to provide both PWM signals. You need to define two separate PWM signals on 'X1' and 'X2', with two separate channels CH1 and CH2. CH1 is associated with 'X1' and CH2 is associated with 'X2'. How do I know? Here is the extract from the Pyboard Quick Reference diagram:



'X1' and 'X2' can be programmed to do different things, including: ADC input, UART 4 (you used UART 6 in Lab 4), Timer 2 or Timer 5 channels 1 and 2 respectively, or just as a digital pin (input or output). In our case, we use these two pins as channels 1 and 2 output of Timer 2.

Lines 50, 51: Thereafter, you can adjust the speed by specifying the duty cycle for motorA and motorB.

2. What should I use for the “third wheel”?

To make a stable vehicle, you need to add a third wheel. Don't use four wheels – it is much harder to steer with four wheel than three. The third wheel does not need to be wheel at all! A pillar of the right height made of wood, metal or 3D printed materials, attached to the chassis will work well. You may want to “round off” the bottom where it touches the floor to reduce friction. Alternatively you may use one of the following items from my stores.



3. How can I mount the Black Board (BB) onto the wheels?

Each group must design its own mounting. (This is the part that you can exercise what you have learned from Design 1 module.) Appendix B shows the dimension of the PyBoard and the 2-wheel

chassis. For example, you can make a 2-D design with holes to mount the wheel chassis and the third “wheel” underneath, and other means to secure the BlackBoard, sensors and the ping pong ball shooting mechanism on the top. Beware that you need to have enough clearance for the two motor wheels. Workshop has supply of laser-cutting Perspex sheet for this purpose. You also need to plan for the mounting of the USB PowerPack.

I have a “screws box” on the component bench for you to perform fastening of the various part of your vehicle to the chassis. You may use zip-ties for fastening. However, YOU MUST NOT USE GLUE-GUN or STICKY TAPES to construct your vehicles, otherwise marks will be deducted. You are design engineers, and therefore you must learn to do mechanical design properly and professionally.

4. How sophisticated should I make my designs for various milestones?

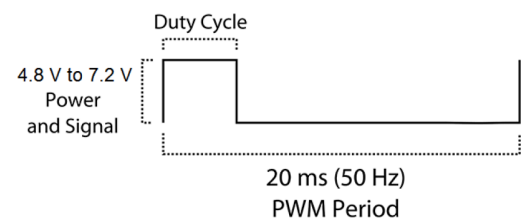
You may be tempted to make very complex designs. For example, someone was planning to mount the infrared sensor on a rotating motor to “scan” for obstacles. Remember that you only have 3+ weeks before the demonstration on the 18th of June. You still have other things to do: preparation for the DE1.3 examination, the Python programming course, and the Design 1 Project. My recommendation is to be as simple as possible. However, if you are confident and want to experiment with new ideas, do go ahead – just remember that it is better to have a simple design that works than a complex, clever design that does not work.

5. Where are the ultrasound and magnet on the lizard?

In milestone 2, you need to determine one of three types of lizards: just lizard, ultrasonic lizard or magnetic lizard. The ultrasound signal (if it is there) will come out of lizard’s mouth. A magnetic lizard will have the magnet on its back, the location of which is indicated by a red dot.. You can design a sensing probe that sticks out (say at the front or back) with a fixed clearance. Alternatively you could design something that can lower the sensor as required (using a servo motor).

6. How can I use a servo motor for milestones 2 or 3?

I provide two types of servo motors: a small SG90, and a larger MG996R. They have three terminals: V+ or 5V (Red), GND (Brown) and PWM (Orange). The PWM signal is as shown here.



The period is 50Hz and the high pulse width (mis-labelled as “duty cycle” in the datasheet) is between 1ms and 2ms. This corresponds to the two extreme angles of the motor’s arm. Both motors can rotate its motor arm to an angle of $\pm 60^\circ$.

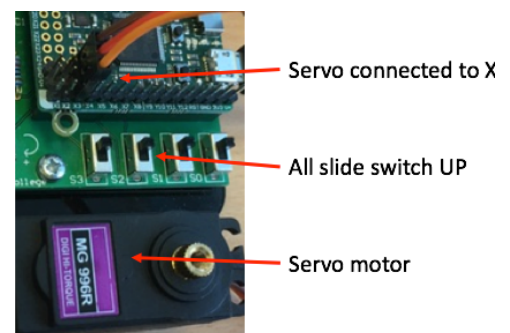
The Pyboard has FOUR possible output locations for servo motors: X1, X2, X3 and X4. These are conveniently located alongside a 5V and GND terminals, so that you can plug the servo motor directly onto the board. Since X1 and X2 are already used for driving the DC motors, I recommend you to use X3 and X4 for up to two servo motor drives.

There are internal driver chips INSIDE the servo motor. Therefore, unlike the DC motor, the Pyboard can drive the servo motor directly. To move the servo motor arm (connected to X3) to a given angle (say 45 degrees), you only need the following code:

```

import pyb
sm = pyb.Servo(3)    # create a servo object on
pin X3
sm.angle(45)

```



Note that the argument is always \pm angle, where 0 is the mid-point of the arm position.

7. For milestone 3, is the ball stationary on the floor or can we carry the ball with us?

You can do either – the important thing is that you move to the penalty spot and then shoot at the goal.

8. If I need other components, where can I find them?

I provide various components in my stores. See the link on the course webpage. I encourage you limiting yourself to these components. If you need something that you cannot find in my store, come and ask me. Given that we do not have much time, I would probably suggest alternative solutions that do not require ordering new stuff.

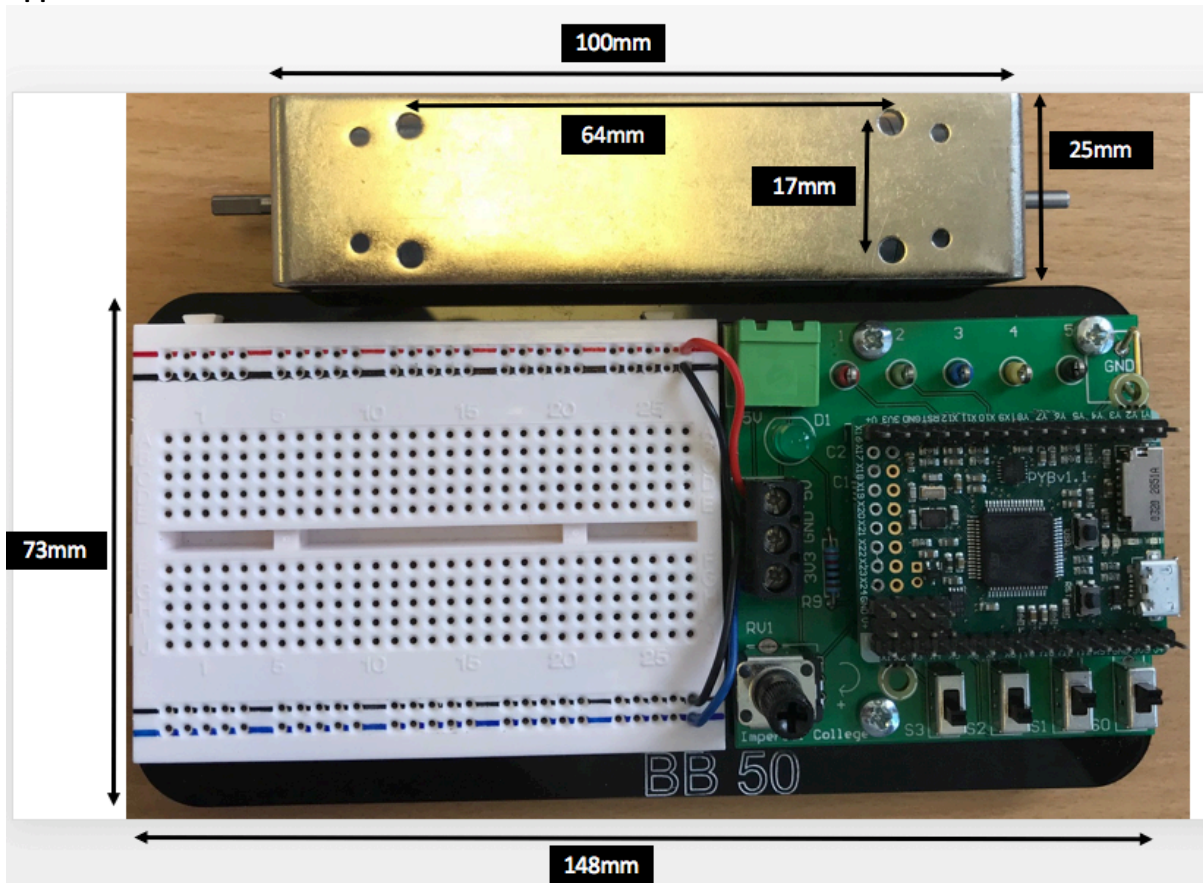
9. I need another two DC motors or a solenoid. How can I drive them?

It is easiest if you drive them digitally, i.e. ON or OFF. Pyboard does not have enough drive current capability for these. So you need a simple circuit with a single transistor switch. This is shown in Appendix B.

Appendix A: Program Code for two_motors.py

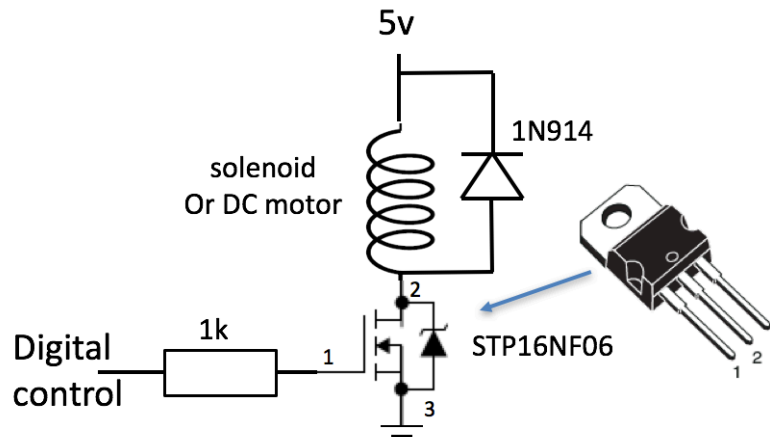
```
1 #
2 # This sample program will drive BOTH left and right motors
3 # Motor_A controls: A1-'Y9' A2 - 'Y10' PWM_A - 'X1'
4 # Motor_B controls: A1-'X9' A2 - 'X10' PWM_A - 'X2'
5 # Note that for X2 to work, you MUST have all slide switches on UP position
6
7 import pyb
8 from pyb import Pin, Timer, ADC
9
10 print('Driving two motors')
11
12 # define various I/O pin for ADC
13 pot = ADC(Pin('X8'))
14
15 # Use Y9 and Y10 for direction control of motor A
16 A1 = Pin('Y9',Pin.OUT_PP)
17 A2 = Pin('Y10',Pin.OUT_PP)
18 # Use X1 for speed control of motor A using PWM
19 pwmA = Pin('X1')
20
21 # Use X9 and X10 for direction control of motor B
22 B1 = Pin('X9',Pin.OUT_PP)
23 B2 = Pin('X10',Pin.OUT_PP)
24 # Use X2 for speed control of motor B using PWM
25 pwmB = Pin('X2')
26
27 # Configure physical timer 2 to produce 1kHz clock signal
28 # Timer 2 is used for BOTH PWM channels (see notes)
29 tim = Timer(2, freq = 1000)
30 # Configure timer to provide two PWM signals
31 motorA = tim.channel(1, Timer.PWM, pin = pwmA)
32 motorB = tim.channel(2, Timer.PWM, pin = pwmB)
33
34 # initially set both motors to stop
35 A1.low()
36 A2.low()
37 B1.low()
38 B2.low()
39
40 MID = 2048
41 DEADZONE = 10
42 # Use potentiometer to control forward/backward and speed
43 while True: # loop forever until CTRL-C
44     speed = int(100*(pot.read()-MID)/MID)
45     if (speed > DEADZONE): # forward
46         A1.high()
47         A2.low()
48         B1.high()
49         B2.low()
50         motorA.pulse_width_percent(speed)
51         motorB.pulse_width_percent(speed)
52     elif (speed < -DEADZONE):
53         A1.low() # backward
54         A2.high()
55         B1.low()
56         B2.high()
57         motorA.pulse_width_percent(abs(speed))
58         motorB.pulse_width_percent(abs(speed))
59     else:
60         A1.low() # stop
61         A2.low()
```

Appendix B: Dimensions of the motor chassis and the Black Board



Appendix C: Digital driver for DC motors or solenoid (ON-OFF only)

The Pyboard digital output cannot deliver sufficient current to drive a solenoid or a DC motor directly. You could use another TB6612 chip, but since we only have one direction and only want a digital drive (i.e. ON/OFF), it is far simpler to use a single MOSFET transistor as shown below.



The digital output from the Pyboard can drive around 20mA at 3.3V when it outputs a '1'. When a voltage of 2.5V or higher is applied across the Gate (1) and Source (3) terminals of the MOSFET transistor STP16NF06, the transistor turns ON, meaning that terminals 2 and 3 has very low resistance ($\sim 50\text{m}\Omega$). If the digital output is '0' (0V), the transistor is OFF and terminals 2 and 3 are isolated (open-circuit).

In this way, we can energize the coil of the solenoid or the DC motor, and activate either device using only the digital output signal. The 1N914 diode is there to protect the transistor. When the transistor switches OFF, the current flowing through the inductor (the coil of the solenoid of the DC motor) changes from around 1A to 0A very fast. Therefore, this can result in a very large output voltage at terminal 2 of the transistor because the voltage across an inductor $V_L = L di/dt$. The diode will limit this voltage to $(5V + V_{\text{diode}})$ which is around 5.7V. This prevents the transistor from breaking down due to a very large voltage across its drain (2) and source (3) terminals.

You don't need to fully understand the working of this circuit because we have not covered transistors in my lecture. However, this circuit should allow you to drive the relay or the DC motor as ON-OFF only device.

The MOSFET transistor is available in my store.