Practical 2: Construct a driver circuit to control the high current (> 10mA) output devices

Objective

Using transistor as a switch to control a high current device such as relay

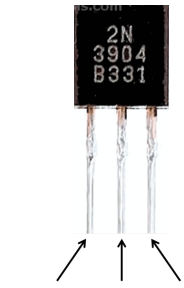
Procedure

Step 1: How to identify and naming the leads of transistor

* Always use ***Internet*** technology to find out the answer (e.g., Google search)

bipolar junction transistor (BJT)

(i) Pick transistor 2N3904, identify the lead labels as __1__ , __2__ and __3__. The names of lead labels are __Emitter__ , __Base__ and __Collector__ , respectively. Fill up the lead labels of the transistor below.



1 Emitter 2 Base 3 Collector

Notes:
1 - Emitter: The outlet for electrical supply (connected to GND)
2 - Base: The gate controller device for the largest electrical supply
3 - Collector: Larger electrical supply

- If the voltage is not compatible or insufficient current to energize the relay's coil, we will use the driver, transistor
- Can act as conductor or insulator
- Get low input current and generate high output current

Question : what is the electronic symbol of a transistor? Include the labels.

Step 2: Understand the relay connectivity and specification

The voltage required to energize the coil is only 5V, then it will generate magnetic field, pull the switch metal and make a contact. Once it makes a contact, it will be close circuit

(i) Pick a relay. Read the printing label on top of the relay, the control voltage is __5VDC__ . Fill up the relay output control rating in the table below then calculate the maximum power (Pmax).

Output Control Rating Type	Voltage (V)	Current (I)	Pmax = V x I
1	250VAC	10A	2.5kW
2	125VAC	10A	1.25kW
3	30VDC	10A	0.3kW
4	28VDC	10A	0.28kW

Notes: 15mA 250V can kill a person.

For Q2, look at the AC (normally the household connected plug is AC device)
- All the figures in the relay (left diagram) is the maximum voltage or current, which cannot exceed it, else it will malfunction
- For 250AC, 10A is the maximum and if exceed it, it might not function properly (i.e. burn or cause fire)

Question : To control the household light bulb, what is the voltage that the relay required to control the light bulb?

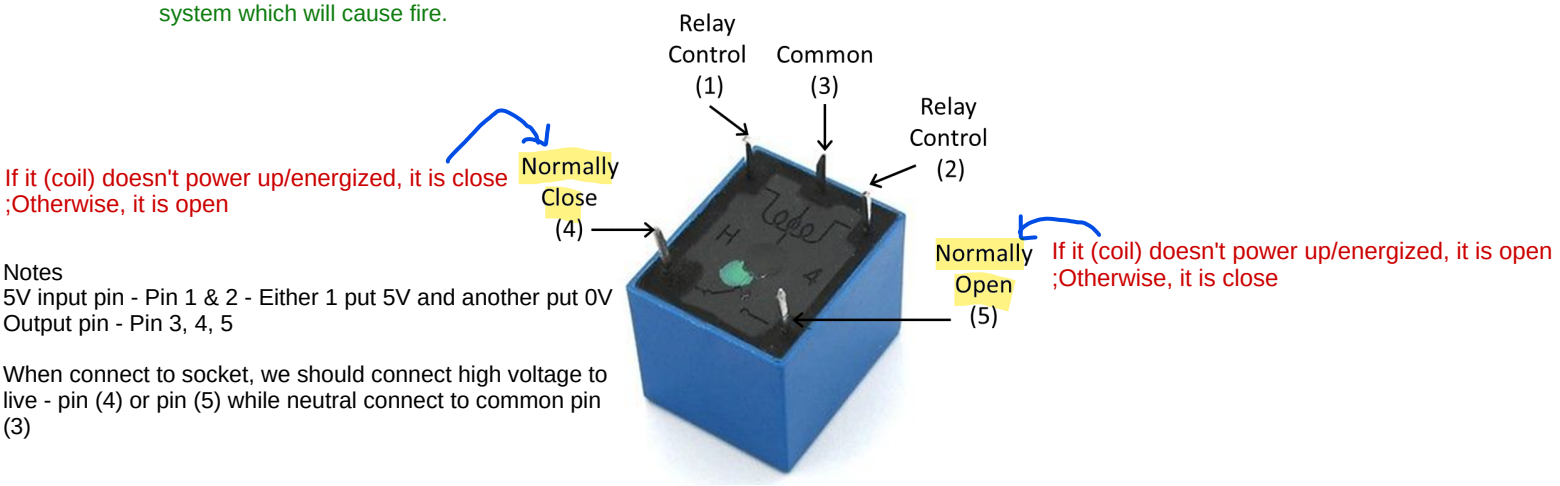
Malaysia : 250V ; America/Japan : 110V - 120V

Question : To control the household light bulb (e.g., 20W one light bulb), what is the maximum number of light bulbs that the relay can control?

P = VI
20 = 250(I)
I = 20/250
= 0.08A
= 80mA

Imax/Ibulb = 10A/0.08A = 125 light bulbs

After calculating, we will know the safe number of lightbulbs to use so that we won't reach the limit. Otherwise it might burn, melt the metal inside the relay as it generates a lot of heats then will burn the relay plastics as well as the rest of the system which will cause fire.



Notes
5V input pin - Pin 1 & 2 - Either 1 put 5V and another put 0V
Output pin - Pin 3, 4, 5

When connect to socket, we should connect high voltage to live - pin (4) or pin (5) while neutral connect to common pin (3)

(ii) Flip the relay to the lead side. Using multimeter, rotate the multimeter selector to 200 Ω range, test the relay leads and fill up the two tables below.

Table 1

Lead	Lead	Relay control coil resistance (Ω)
1	2	72.3

V = IR
5 = I(72.3)
I = 5/72.3
= 0/069A
= 69mA

Using Ohm's Law (Voltage (V) = current (I) x resistance (R)), the estimated current required to control the relay is ___69mA___.

Extra Notes for socket :
Earth (yellow green) - Protection so that we won't get electric shock, safe
Live (Brown) - You can feel the voltage, it is dangerous
Neutral (Blue) - Connected to earth so it is safe (*Sometimes it might connected to live, so have to be careful)

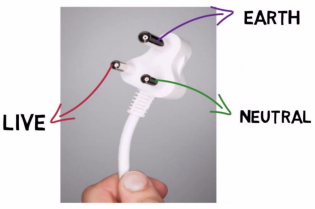
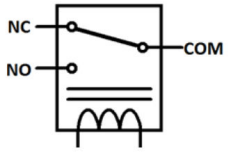


Table 2 (When the coil haven't energized/powered up)

Lead	Lead	Short (Just tick "✓")	Open (Just tick "✓")
3	4	✓	
3	5		✓
4	5		✓

(When coil is energized, normally close (4) will become open circuit while normally open (5) will become short circuit)

Question: What is the electron symbol of relay? Explain the test results in Table 2.



Step 3: Understand the push button switch connectivity

(i) Pick one push button switch. Rotate the multimeter selector to 200 Ω range then test the push button leads and fill up the table below

(When didn't press the push button switch)

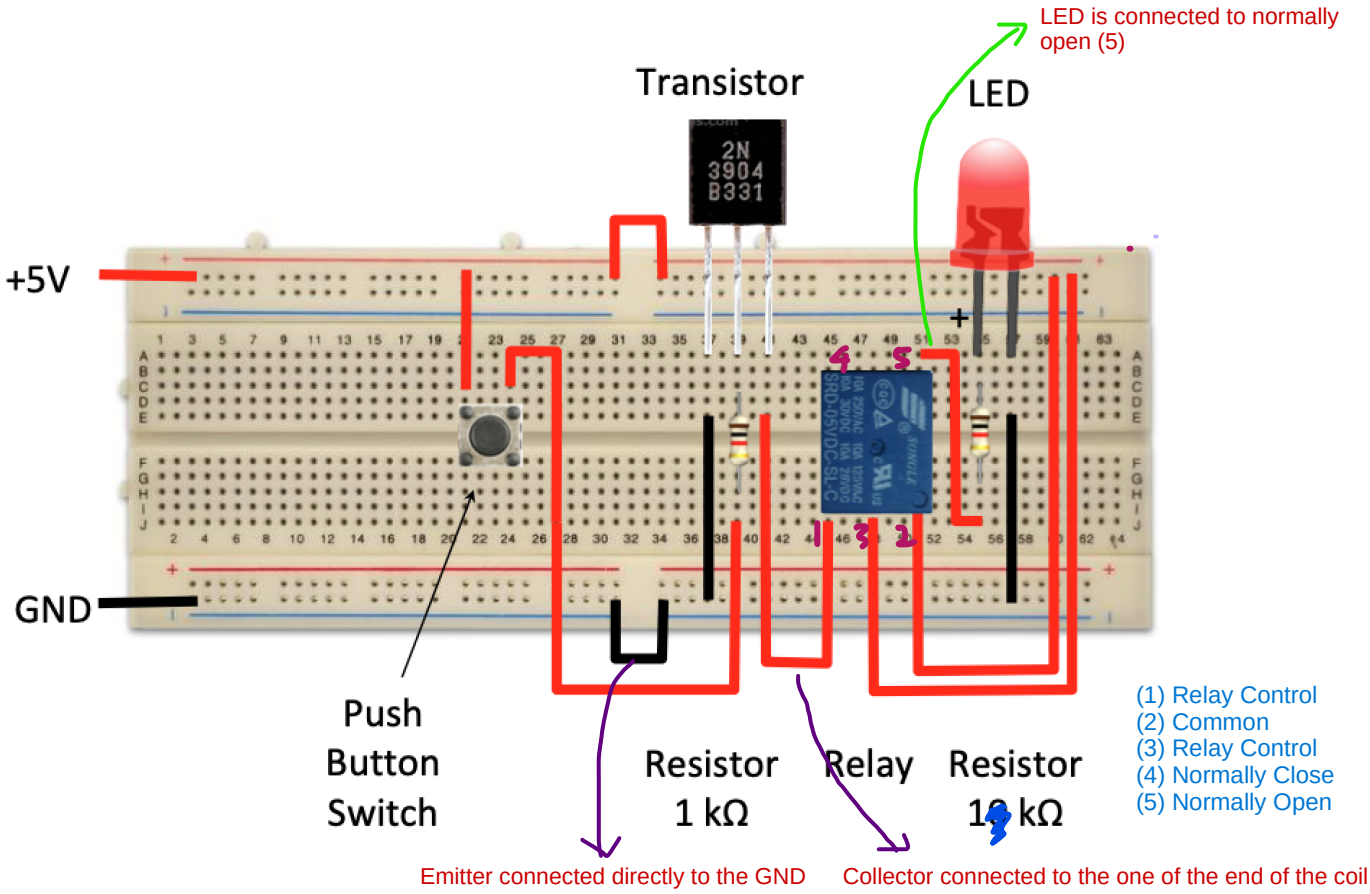
Lead	Lead	Short (Just tick "✓")	Open (Just tick "✓")	(When press the push button switch)
1	2	✓		No difference when press the button (short circuit)
2	3		✓	Change to connected when the button pressed
3	4	✓		No difference when press the button (short circuit)
4	1		✓	Change to connected when the button pressed
1	3		✓	Change to connected when the button pressed
2	4		✓	Change to connected when the button pressed

Question : What is the electronic symbol of the push button ? Explain the test result in the table.

Step 4: Construct a driver circuit to drive the relay

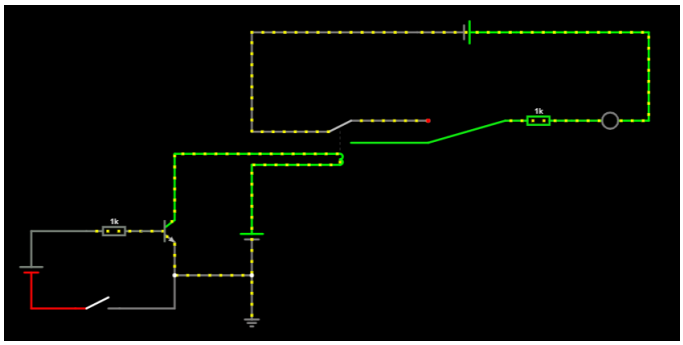
*** Please refer to the Additional Notes for extra precaution on circuit design.**

(i) Pick transistor 2N3904, relay, LED and two 1 kΩ resistors, press them into the breadboard. Pulling copper wires and press into the breadboard as shown below. Then turn on the Raspberry board. (*note: make sure all connectivities are correct before turn on the Raspberry board*)



(ii) Press the push button switch, the LED light is __on__ , release the push button, the LED light is __off__ .

(iii) When the push button switch is pressed and released, a mechanical noise has __heard__. (select heard or not heard)

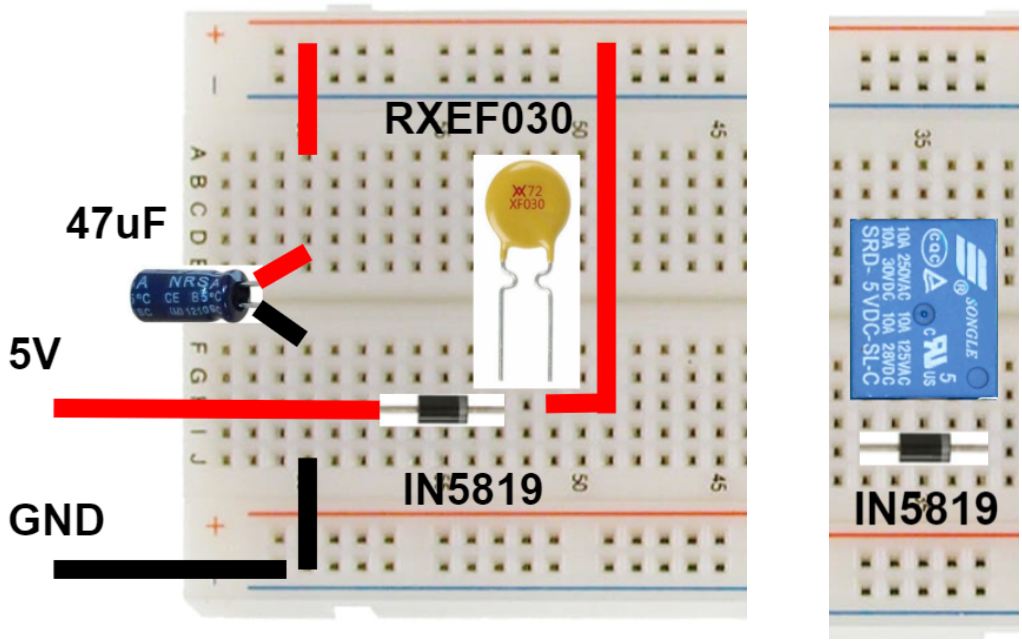


Question : Draw the electronic circuit diagram and explain the simple working principle of the circuit.

* You can use Windows “Paint” to draw a simple circuit, save as an image file and upload to google classroom.

Additional Note

We strongly suggest providing additional protection in our circuit design, by adding a 47uF capacitor, a 1N5819 diode and aRXEF030 resettable fuse, if it is available in the laboratory.



1. RXEF030 300mA resettable fuse is to mitigate damage to the +5V source due to short circuit while our hands muck around with the breadboard. Note that prolonged short circuit of 5V from Raspberry Pi can damage the PCB tracks and power regulator(s) on the board.

2. The 1N5819 Schottky diode after the +5V source is to prevent current from flowing back to the source (and damage it -- especially Raspberry Pi +5V). This might not be needed if there is no other external voltage source greater than 5V on the breadboard.

3. The 1N5819 (1A/40V) Schottky diode across pins 1 and 2 of the relay (see right) is to avoid voltage spike due to inductive kickback from the relay coil, when a NPN transistor abruptly switches off.