Lab 11 - Transistor as a Switch

Purpose:

To control a high voltage device using a small 5 volt source

To be submitted:

1. **Deadline**: One week after the lab.
2. **No formal report required**.
   - Answer all the questions in the lab in the blank space provided (try to use a different color). If calculation is involved, clearly show all the working steps involved.

Theory See slides week 12

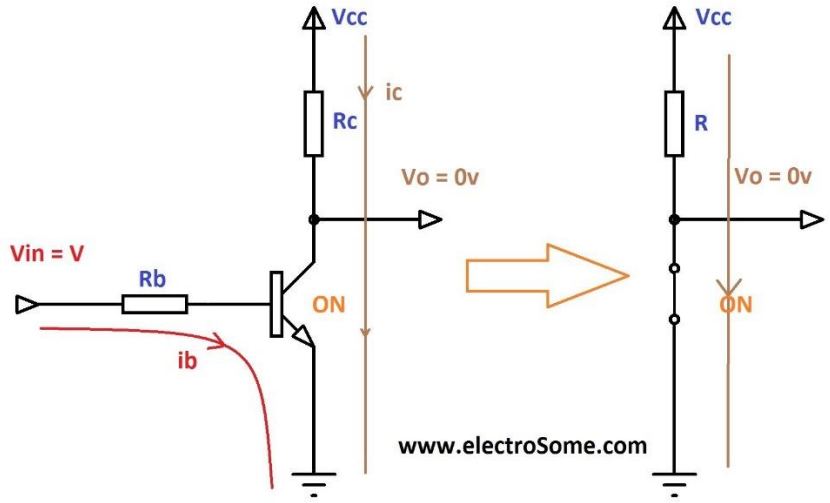

Figure 1 Switch ON

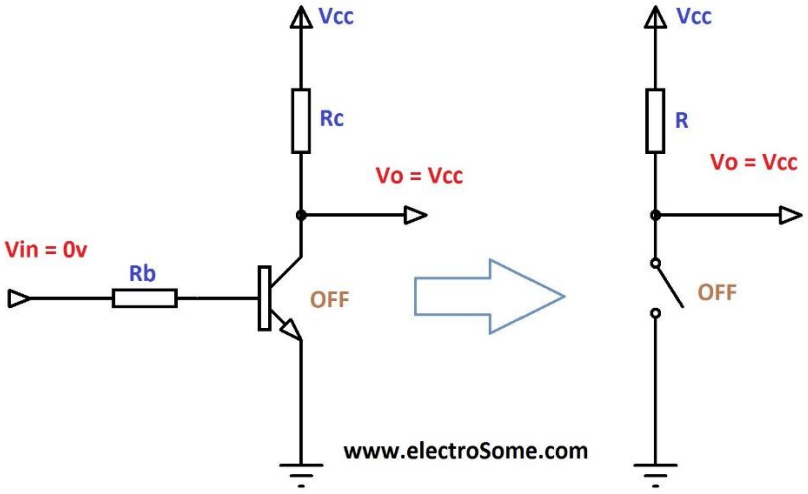

Figure 2 Switch is OFF

Lab Work:

Watch the video to help you to implement the lab:
https://youtu.be/kRMAqYUVD3g

Part 1: Observe the voltages in a BJT as a switch

1. Built the circuit in Figure 3 and record the measurements in Table 1.

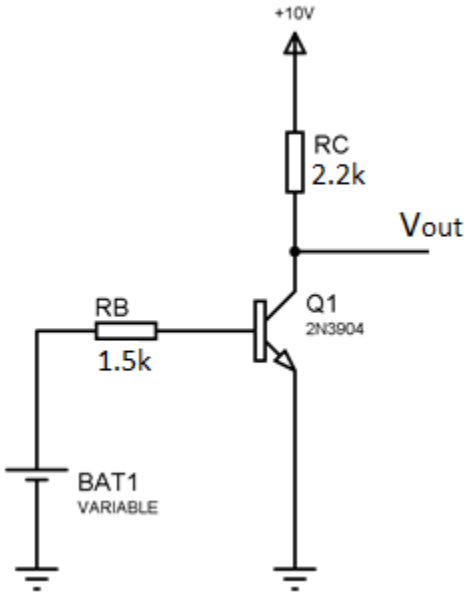

Figure 3 Switch using Transistor

Value of BAT1 in VOLTS	Value of V_{OUT}	Switch mode OPEN/CLOSED
0	10V	Open
1	100 mV	Closed
2	60 mV	Closed
3	50 mV	Closed
4	50 mV	Closed
5	40 mV	Closed

Table 1 : Voltage readings

2. Explain the results in Table 1:

   To determine whether or not the transistor is acting like an open switch or a closed switch, we must look at the value of BAT1. If BAT1 is not providing a sufficient amount of voltage to turn the transistor on, then the transistor will remain in the cutoff region (open switch). If BAT1 is providing a sufficient amount of voltage, then the transistor will remain in the saturation region (closed switch). As you can see in table 1 above, depending on the value of BAT1, the transistor will act either in the open or closed position.

3. Show your results to your teacher.

Part 2: Observe the currents in a BJT as a switch

4. Measure the currents as required in Table 2:

Switch mode	I_B	I_C
Open switch	-13.6 pA *(negligible)*	45 pA *(negligible)*
Perfectly Closed switch	2.83 mA	4.52 mA

Table 2: Current readings

5. What is the theoretical value of $I_{C(sat)}$ for closed switch? Does it match your experimental results?

$$I_{C_{(saturation)}} = \frac{V_{CC}}{R_C}$$

$$= \frac{10V}{2.2k}$$

$$I_{C_{(saturation)}} = 4.54\,mA$$

As you can see, the theoretical calculation is very close to the one obtained during the simulation, therefore the results are correct.

6. Calculate the βdc for the closed switch based on your results obtained:

$$ß_{DC} = \frac{I_C}{I_B}$$

$$= \frac{4.52\,mA}{2.83\,mA}$$

$$ß_{DC} = 1.60$$

Part 3: Using the BJT to drive a LED

7. Add a LED in your circuit to match Figure 4.

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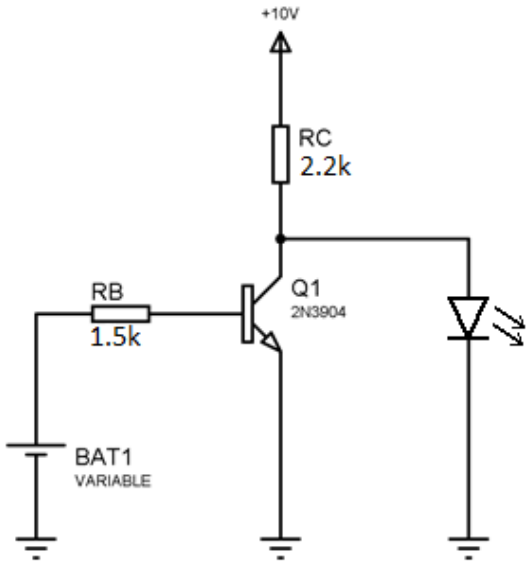

Figure 4 BJT Switch driving a DEL

8. Fill in the Table 3:

Switch mode	DEL status
Open switch	On
Closed switch	Off

Table 3: Current readings

9. Clearly explain the functioning of this circuit:

   Depending on whether the transistor is open or closed, the LED will be on or off (as indicated in table 3 above). When BAT1 isn't sufficient to throw the transistor into the closed position (closed switch and transistor is currently in the open position), V_C will provide the voltage necessary (depending on V_{CC}) to turn on the LED. For example, if V_{CC} was 15V, then the voltage drop across the LED would be 15V. If BAT1 has sufficient voltage to throw the transistor into the closed position (closed switch), then the LED will not turn on at all.

10. Look again at Figure 1 and Figure 2. What happens to the current when the switch is ON? Is this an ideal setup? Explain why:

    When the transistor acts like a closed switch (on position), current will flow from collector to ground, but the LED will remain off because V_O will be 0V. When the transistor acts like an open switch (off position), the LED will remain on because V_O will be equal to V_{CC}. As one can see, this is not ideal because we assume that when the transistor acts like a closed switch (on position), the LED will be on but in reality, it is the exact opposite (as described above). We would want the LED to be on when the transistor is in the closed position and off when the transistor is in the open position. Therefore, the current setup isn't ideal.