Experiment no.5

§ Transistor as a Switch §

5.1 Objective:

In this Transistor tutorial, we will learn about the working of a Transistor as a Switch. Switching and Amplification are the two areas of applications of Transistors and Transistor as a Switch is the basis for many digital circuits.

5.2 Theory:

"William Shockley" invented the transistor in 1947. A transistor is a three-terminal semiconductor device which can be used for switching applications, amplification of weak signals and in quantities of thousands and millions of transistors are interconnected and embedded into a tiny integrated circuit/chip, which makes computer memories. A Transistor switch, which is used for opening or closing of a circuit that means the transistor, is commonly used as a switch in the electronic devices only for the low voltage applications because of its low power consumption. Transistor work as a switch when it is in cutoff and saturation regions. In this article, we will discuss how to use a transistor as a switch.

Figure (1)

5.2.1 Types of BJT transistors:

A transistor consists of two PN junctions; these junctions are formed by sandwiching either N-type or P-type semiconductor material between a pair of opposite type of semiconductor materials.

Bipolar junction transistors are classified into two types:

- **NPN**
- **PNP**

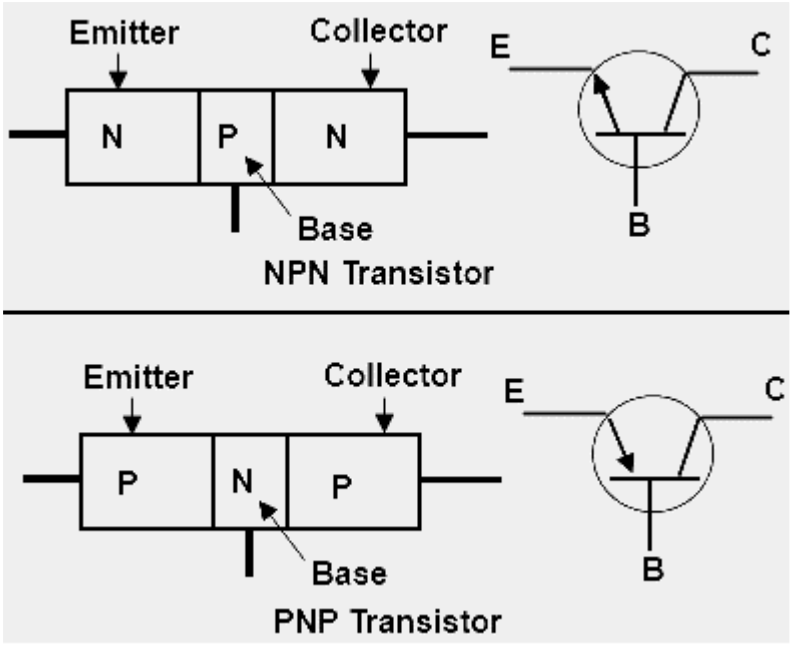

Figure (2)

The transistor has three terminals, namely **Base, Emitter,** and **Collector**.

1. **The emitter** is a heavily doped terminal and it emits the electrons into the Base region.

2. **The Base** terminal is lightly doped and passes the emitter-injected electrons onto the collector.

3. **The collector** terminal is intermediately doped and collects electrons from the Base.

- **NPN-type** transistor is the composition of two N-type doped semiconductor materials between a P-type doped semiconductor layer as shown above.

- **PNP-type** transistors are the composition of two P-type doped semiconductor materials between an N-type doped semiconductor layers as shown above. The functioning of both NPN and PNP transistor is same but differ in terms of their biasing and power supply polarity.

5.2.2 Transistor as a Switch:

If either the circuit uses the BJT transistor as a switch, then the biasing of the transistor, NPN or PNP is arranged to operate the transistor at the both sides of the I-V characteristics curves shown below. A transistor can be operated in three modes, active region, saturation region and cut-off region:

In the active region, transistor works as an amplifier. The two operating regions of transistor Saturation Region (fully ON) and the Cut-off Region (fully OFF) were used to operate a transistor switch.

- **Operating Regions:** We can observe from the above characteristics, the pink shaded area at the bottom of the curves represents the Cut-off region and the blue area to the left represent the Saturation region of the transistor. These transistor regions are defined as

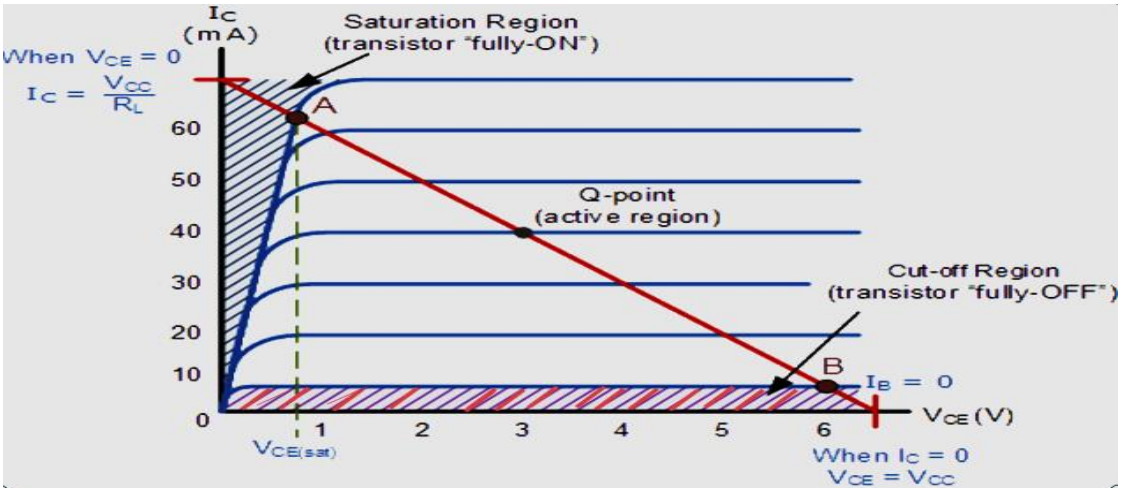

Figure (3)

- **Cut-off Region:** The operating conditions of the transistor are zero input base current (IB=0), zero output collector current(Ic=0), and maximum collector voltage (VCE) which results in a large depletion layer and no current flowing through the device. Therefore, the transistor is switched to “Fully-OFF”. So we can define the cut-off region when using a bipolar transistor as a switch as being, bother the junctions of NPN transistors are reverse biased, VB< 0.7v and Ic=0. Similarly, for PNP transistor, the emitter potential must be –ve with respect to the base of the transistor.

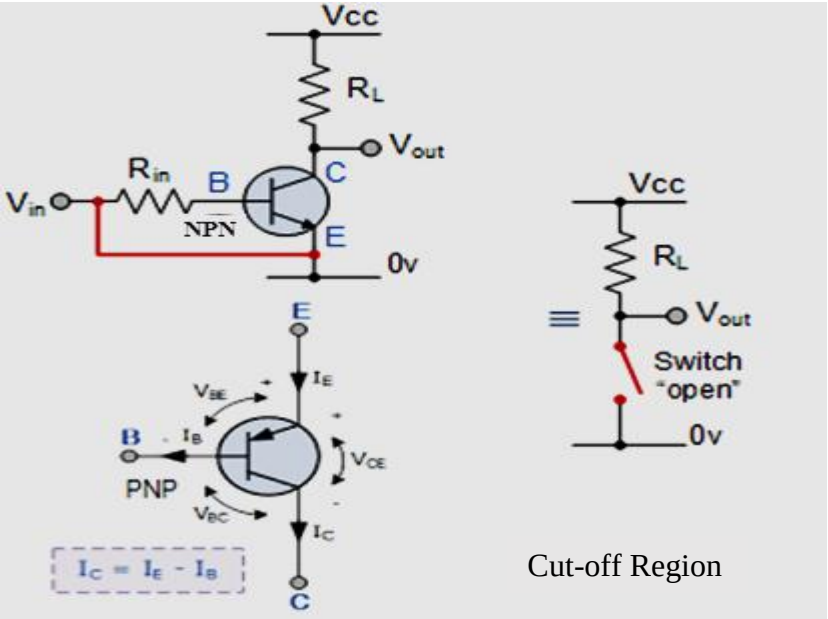

Figure (4)

Then we can define the “cut-off region” or “OFF mode” when using a bipolar transistor as a switch as being, both junctions reverse biased, IC = 0 and VB < 0.7v. For a PNP transistor, the Emitter potential must be -ve with respect to the Base.

- **Saturation Region:** In this region, the transistor will be biased so that the maximum amount of base current (IB) is applied, resulting in maximum collector current(IC=VCC/RL) and then resulting in the minimum collector-emitter voltage (VCE ~ 0) drop. At this condition, the depletion layer becomes as small as the possible and maximum current flowing through the transistor. Therefore, the transistor is switched “Fully-ON”.

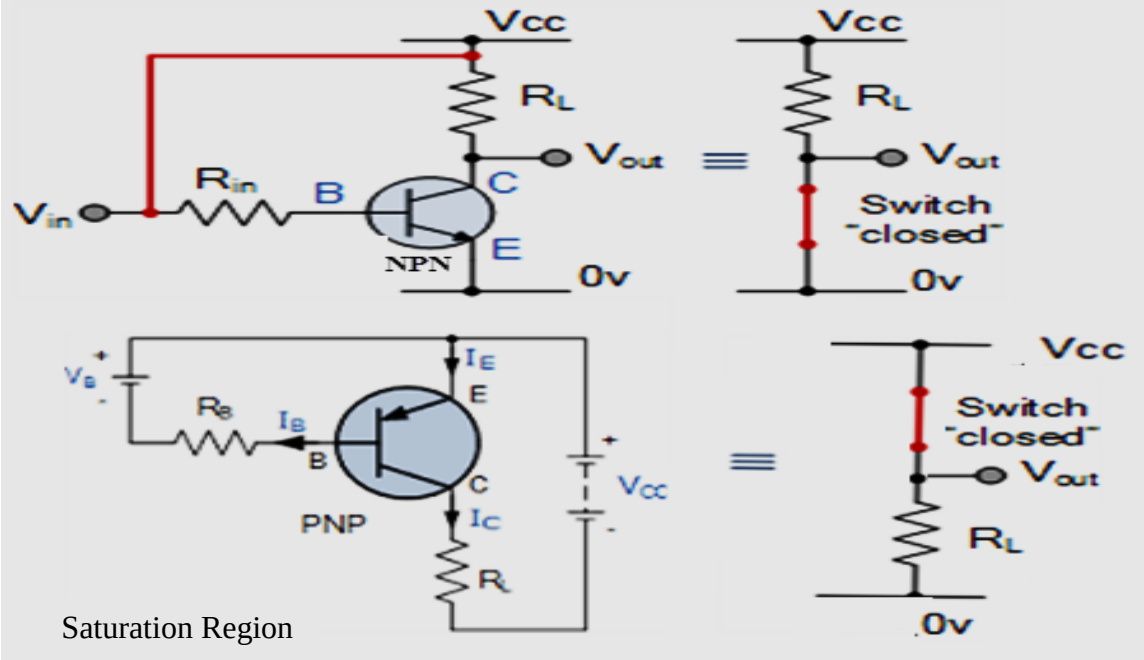

Figure (5)

- ***Saturation Region:*** The definition of "saturation region" or "ON mode" when using a bipolar NPN transistor as a switch as being, both the junctions are forward biased, IC = Maximum and VB > 0.7v. For a PNP transistor, the Emitter potential must be +ve with respect to the Base.

5.3 Procedure:

1. Connect the circuit that shown in the figure below:

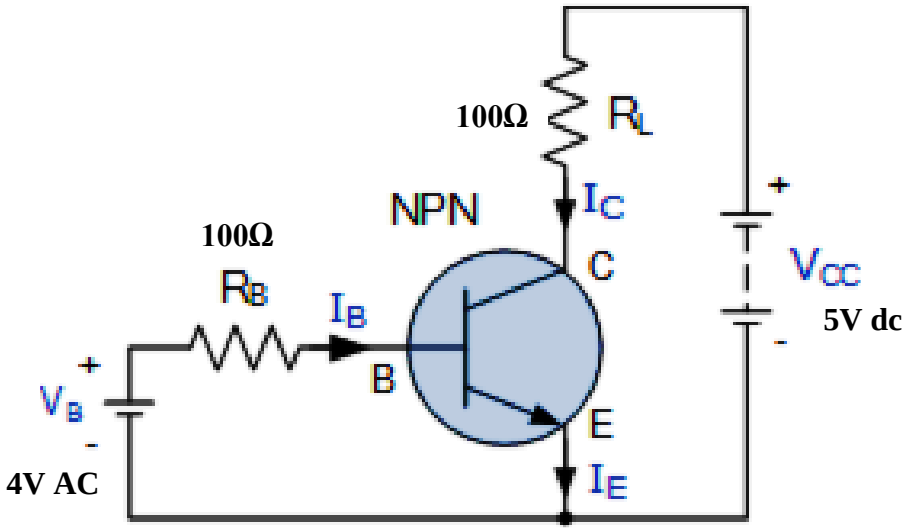

Figure (6)

2. Set the AC source (4V) and frequency (200 HZ) (Square wave) and draw it.
3. Set the oscilloscope (first terminal) at the common terminal of collector and resistance (RL) and (second terminal of OSC) to the emitter of transistor.

4. Draw the wave shown in the screen of the Oscilloscope (Square wave).

5.4 Discussion:

1. What is a transistor? What is it Types? Draw it symbols?
2. What are the transistor working areas?