Experiment no.6

§ Transistor as Oscillator §

6.1 Objective:

In this experiment, we will show how to build a relaxation oscillator with a single transistor and a few other components such as a resistor and capacitor.

6.2 Theory:

A relaxation oscillator is an oscillator that repeats itself repeatedly from the charging of a capacitor to some event threshold and then the discharging of the capacitor.

Therefore, the repetitive charging up of the capacitor and discharging of the capacitor creates the oscillations in a relaxation oscillator circuit.

The recharge and discharge time of the capacitor determines the period and, thus, frequency of the signal.

Figure (1)

A **sawtooth waveform** is one in which the incline of the signal is non-linear. Since a capacitor does not charge up linearly, it does not produce a linear ramp.
In this circuit, with the values we use, the frequency will be rather small, so that you can easily see the flickering on and off the LED. But we will show how you can make modifications to the circuit so that you can change the frequency as well as the amplitude either up or down.

How this circuit works?

When the power is supplied to the circuit, the capacitor charges up through the resistor. It charges up, charges up, and charges up. This represents the positive, exponential slope that is present on the first half of the sawtooth waveform. Once the voltage across the capacitor reaches a certain threshold level, the transistor is turned on. Once the transistor is turned on, it can conduct current across from collector to emitter.

So at this voltage threshold, the capacitor stops charging up and begins to discharge. This point represents the peak of the waveform. Once the threshold is reached to turn on the transistor, the capacitor begins to discharge all of its charge. This makes creates current flow from the capacitor, through the LED, and through the transistor. The capacitor once the capacitor has discharged its current, then the process starts all over again. The current from the power supply charges it up again. And this creates the infinite sawtooth waveform.

How this circuit works is based on the principle of the transistor being connected reverse biased. The emitter is connected to the anode of the capacitor. The emitter has a relatively low reverse breakdown voltage. If this breakdown voltage is exceeded, then the transistor junction at this region will break down and conduct electricity across from emitter to the collector. This is why we have to use a relatively large voltage of about 12V. If the voltage is too low, say, 5V, for instance, the transistor will not be reached, so that the LED will never light up. If you were to connect the transistor forward biased, with the

collector connected to the anode of the capacitor, the circuit will not work at all. The LED will not light up. This is because the collector region has a very large breakdown voltage. In fact, you can go to a transistor's datasheet and see these voltage points. The voltage, which we're concerned about in this circuit, is the emitter-base voltage. This is when the transistor is reverse biased, when we're apply positive voltage to the emitter of the transistor. Looking at the datasheet for the 2N4401 transistor, it has an emitter-base breakdown voltage of about 6V. This means that if we apply any more than 6V to the emitter, it can cause the transistor region to break down and conduct current. On the other than, the collector-base breakdown voltage is much higher

Another point about this circuit is that the base does not need to be connected in order for the circuit to work. This is because if enough voltage is applied to the emitter junction, the emitter-base junction breaks down and the transistor conducts current.

6.3 Procedure:

1. Connect the circuit shown in the figure (2).

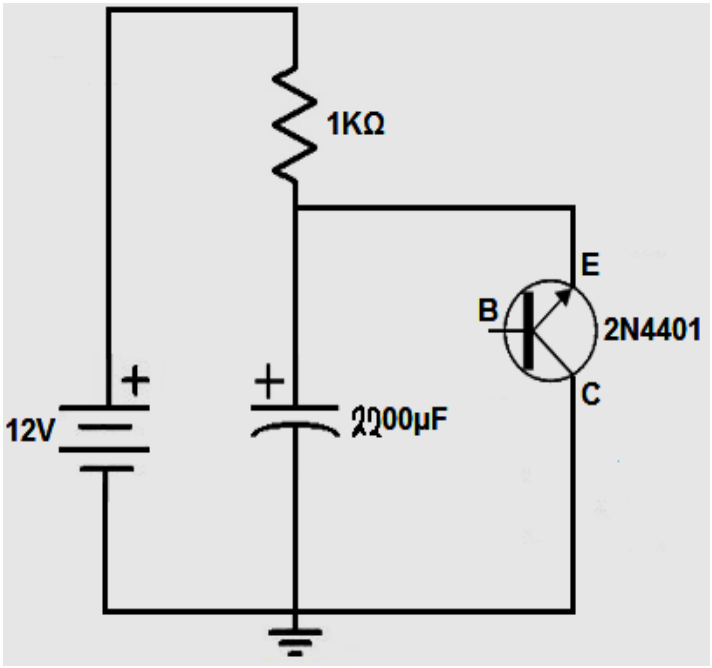

Figure (2)

2. Use 12VDC of power for this circuit. Actually any voltage from 12V-15V will work. But voltages much below 12V will not allow the circuit to work.
3. In parallel to this voltage source, we place a 1KΩ resistor and a 2200μF electrolytic capacitor in parallel. Then in parallel to the capacitor, we place 2N3904 NPN transistor in series

4. Draw the output waveform shown in the screen of the Oscilloscope.

6.4 Discussion:

1. What is the benefit of use of the transistor as an oscillator?

2. Do you connect the **base** of the transistor in the oscillator circuit? And why?

3. What is a sawtooth waveform?