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Upgrade Your Lab

Giving Life to Lab Experiments – Conversion of Lab Experiments into Simple Devices

Justin John *

"Without laboratories, men of science are soldiers without arms" - Louis Pasteur

Physics laboratory is the place where efforts are made to examine the bounds of validity of a theory/principle/law. This is the place where the absoluteness of the 'law' is replaced with approximations and students are encouraged to think 'out of the box'. But, many-a-times it is observed that students blatantly follow the instructions given in the 'lab manual' (even the printing errors).

Doing an experiment without understanding the true purpose is perhaps the most boring experience for a science student. One way to overcome this burden is to make sure that the experiment present the student with an immediate application. It is not imperative that the 'application' is huge, but it should create curiosity and provide a sense of satisfaction.

Many experiments that we do in the BSc and MSc lab could be converted into simple devices with utilitarian value in day -to-day life. In this article, an attempt is made to convert a BSc experiment into two such a simple devices.

1. The Experiment

In B. Sc. Electronics Lab, astable multivibrator is constructed using transistors. The 'ON' and 'OFF" times of transistors are seen and measured using CRO and are compared with the theoretical values. A standard astable multivibrator circuit that you will find in lab manuals is as shown in Fig. 1.

The time through which each transistor is active (ON) is given by the relation

T_{ON} = 0.693 R2 C1 = 0.693 R3 C2

= $0.693 \times 10 \times 10^3 \times 100 \times 10^{-9}$

= 0.693 ms

2. Device 1 – ' The LED flasher'

The Astable Multivibrator we have just seen can easlily be converted into a LED flasher circuit with slight modifications.

*St. Berchmans Autonomous College, Changanacherry, Kottayam Kerala - 686101, Email: justinpjohn@gmail.com

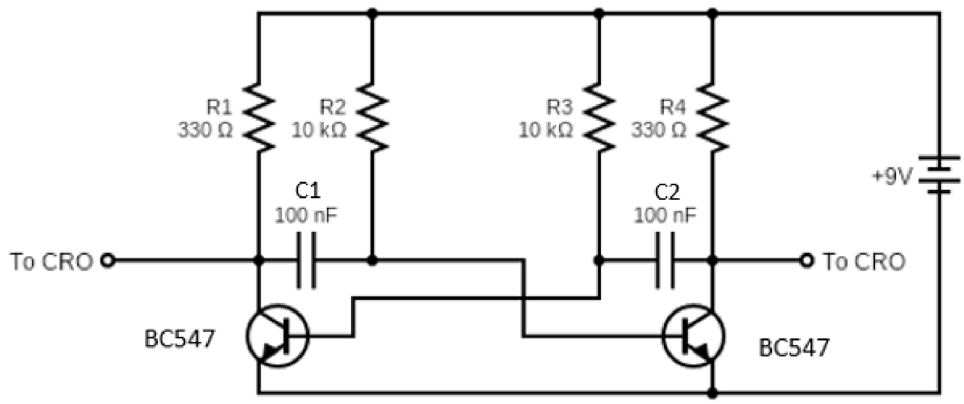

Fig. 1. A standard Astable Multivibrator circuit.

2.1. Modifications —

2.1.1. Capacitor replacements — From the discussions above, we see that the ON time (and 'OFF time' also) of each transistor is 0.693 RC. We want to attach one LED to each transistor and expect them to light up during the ON time of each transistor. The ON time calculated from the above circuit is 0.693 milliseconds and if we attach LEDs, each LED will blink for this time. Since the time interval is too small, the blinking cannot be detected by bare eyes, instead it will appear that the LEDs are glowing continuously (Persistance of vision). This means, in order to see the blinking, we should increase the ON time of the transistors. How?

We know that the ON time depends on the resistors R2,R3 and the capacitors C1,C2. We need to manipulate these values. As a first try, let's fix the values of the resistors to be 10kΩ each and change the capacitor values to say 47μF. The ON time of the transistors now becomes:

T_{ON} = 0.693 R C
= 0.693 x 10 x 10^3 x 47 x 10^6
= 0.325 s

This ON time is long enough so that it can be perceived as blinking by human eyes.

2.1.2. Attaching LEDs — In the old experiment , outpus to the CRO were taken from the collector terminals of the transistors. Following the clue, we attach LEDs to the collector terminals.

2.1.3. Varying the Blinkinig Time – the Variable Resistance — As discussed earlier, the flash time of LEDs could be changed by varying the resistor values (R2 and R3) and/or varying the capacitor values (C1 and C2). Practically, it is difficult to change the capacitor values; so we'll try to change the value of the resistors. For this purpose, we use a 50kΩ variable resisstor, one end of which is connected to the positive terminal of the battery and the other end to both 10kΩ resisors. The modified circuit then appears as in Fig. 2.

By adjusting the variable resistor, the T_{ON} timing can be increased (the frequency of flashes decreased).

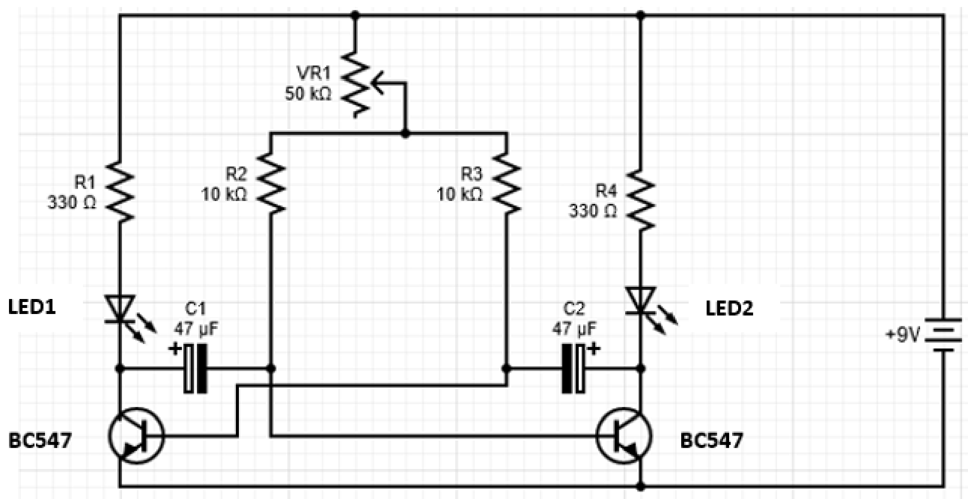

Fig. 2. The LED flasher

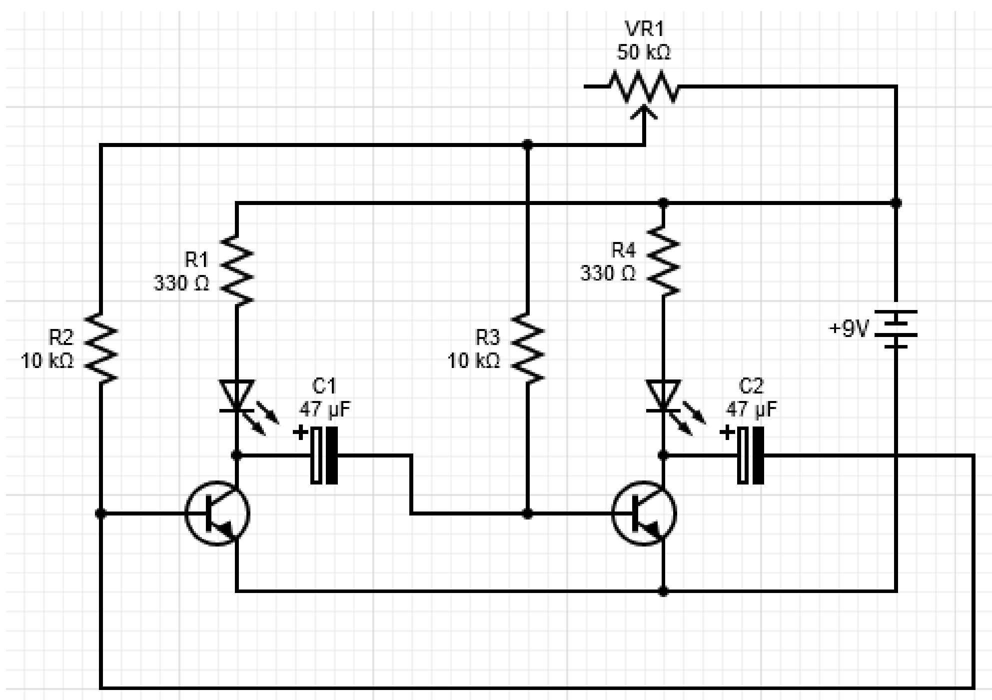

Fig. 3. The LED Flasher *redrawn*

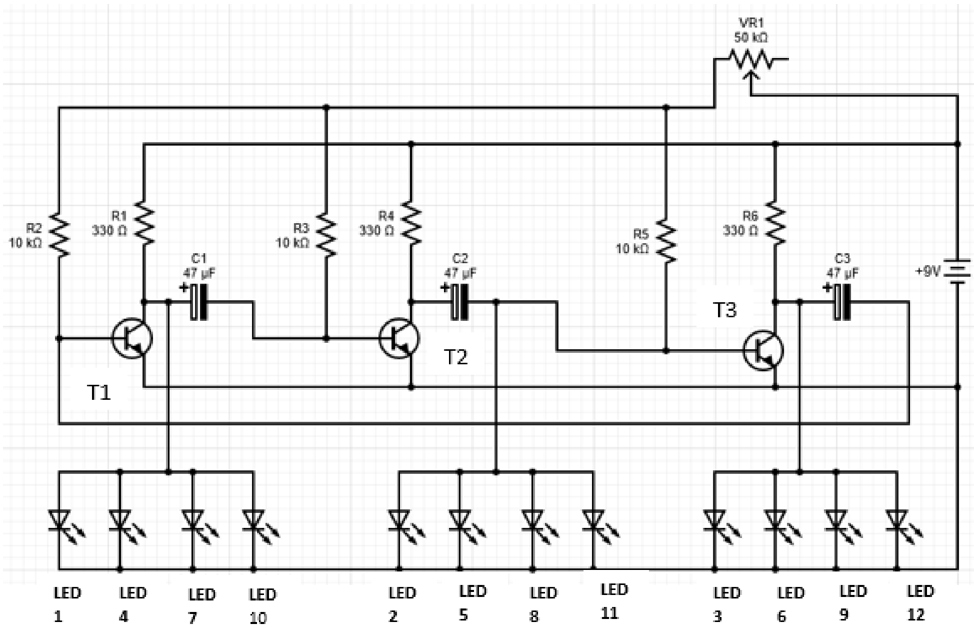

Fig. 4. The Running LED Chaser with three transistors

3. Device 2 – ‘ The Running LED Chaser’

With some more modifications, the LED flasher can be converted into a LED chaser circuit to make the running LED effect.

3.1. Modifications —

3.1.1. Redrawing the circuit — As a first step towards our objective, let’s redraw the LED flasher shown in Fig. 2 to a bit more simpler format as shown in Fig. 3.

3.1.2. Adding one more transistor — The running LED effect is created with the blinking of three sets of LEDs which flash at definite intervals. To drive these three sets of LEDs, we need three transistors, three capacitors, three base resistors and three collector resistors. This means, we are in need to one transistor, one capacitor one base resistor and one collector capacitor in addition to what we already have. Let’s connect these additional elements and draw the circuit again (Fig. 4).

The additional elements added are the resistors R5, R6 the capacitor C3 and the transistor T3. Arrange the LEDs according to their number in a straight line (or in a curve / circle). The LEDs glow one set after the other making a running effect. The running speed can be adjusted by the variable resistor VR1.