Electrical Engineering 2
Lab 6 Report

Astable Multivibrator

Study program: Electrical Engineering

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Abstract

The report contains 1 exercise that is related to the topic “Astable Multivibrator”.

The goal of Exercise 1 is to build an astable multivibrator circuit with varying switching speed. This is done on a breadboard with a DC voltage source, variable resistor, resistors, capacitors, transistors, and LEDs. The LEDs are observed. The observed results matched the expected results.

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1. Introduction

An astable multivibrator is a circuit that generates a continuous output of oscillating waveforms without requiring any external triggering. It continuously switches between its two unstable states, thereby producing a square wave output. It is constructed using transistors, resistors, and capacitors, and it can also be implemented using integrated circuits like the 555 timer IC.

The basic operation of an astable multivibrator involves the charging and discharging of capacitors through resistors, which causes the circuit to oscillate between two states. When a capacitor charges through a resistor, the voltage across the capacitor increases until it reaches a threshold. When the threshold voltage is reached, the circuit switches states, causing the capacitor to discharge. The capacitor discharges through another resistor until it reaches a lower threshold, at which point the circuit switches back, and the cycle repeats. This continuous cycle of charging and discharging results in a square wave output.

Astable multivibrators are important because they provide a simple and reliable means of generating periodic waveforms.

- They provide clock pulses for digital circuits, such as counters and shift registers.
- They are also used in applications requiring PWM signals, such as motor speed control and dimming LEDs.
- Used for creating time delays and producing accurate time intervals.
- Serve as basic building blocks for more complex oscillators and waveform generators.

Astable multivibrators find applications in various fields due to their ability to generate consistent and reliable square wave signals:

- Used in digital watches, clocks, and timing circuits.
- Control the flashing rate of LEDs in applications like indicator lights and decorative lighting.
- Generate audio tones in devices like alarms, sirens, and simple music synthesizers.
- Provide pulses for digital circuits, including microcontrollers and logic circuits.
- Used in communication equipment to generate carrier frequencies.

2. Exercise 1: Variable Astable Multivibrator

2.1. Description

The goal of this exercise is to build an astable multivibrator circuit with variable switching speed.

2.2. Approach

A DC voltage source is connected to a 50kΩ variable resistor, two 1kΩ resistors, two 220kΩ resistors, two 470nF capacitors, two BJT transistors, and two green LEDs, as shown in Figure 1.

The DC voltage source is set to 12V and the LEDs are observed to check if they are alternately switching between themselves.

The variable resistor is changed to check if the switching speed of the two green LEDs changes.

2.3. Measurement Circuit

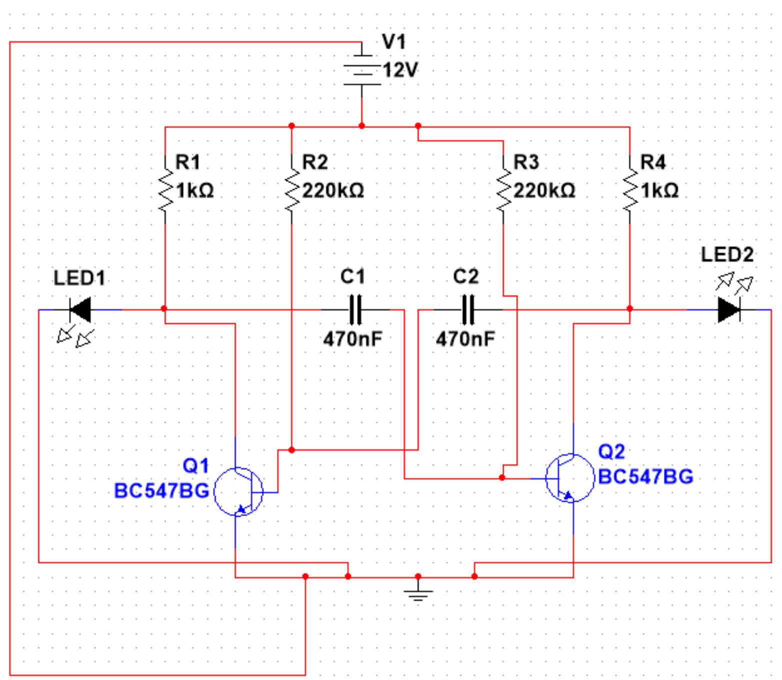

Figure 1: Astable multivibrator circuit

2.4. Used Equipment.

The following list shows the used components and equipment:

- Resistors x2 (1kΩ)
- Resistors x2 (220kΩ)
- Variable resistor (50kΩ)
- Breadboard (E.I.C. E-CALL EIC-406)
- DC power supply (GW Instek GPP-3323)
- Tinned jump wires, clamps, stackable banana plug wires
- Capacitors x2 (470nF)
- Transistors x2 (BC547B)
- LEDs x2 (green)

2.5. Measurement Results

The LEDs switch on alternately.

When the variable resistor's resistance is increased, the LEDs take longer to switch, and vice versa.

2.6. Discussion

When a 12V DC supply is connected, one of the transistors, Tr_1, switches off (cut-off) and its collector voltage rises towards 12V, meanwhile the other transistor, Tr_2, turns on. Plate A of capacitor C_1 rises towards the 12V supply as it is connected to the collector of Tr_1 which is now cut-off. Since Tr_1 is in cut-off, it conducts no current so there is no volt drop across load resistor R_1.

The other side of capacitor, C_1, plate B, is connected to the base terminal of transistor Tr_2 and at 0.6V, because transistor Tr_2 is conducting (saturation). Therefore, capacitor C_1 has a potential difference of +5.4V across its plates, (6.0V – 0.6V) from plate A to plate B.

Since Tr_2 is fully-on, capacitor C_2 starts to charge up through resistor R_2 towards 12V. When the voltage across capacitor C_2 rises to more than 0.6V, it biases transistor Tr_1 into conduction and into saturation.

The instant that transistor, Tr_1 switches on, plate A of the capacitor, which was originally at 12V, immediately falls to 0.6V. This rapid fall of voltage on plate A causes an equal and instantaneous fall in voltage on plate B, therefore plate B of C_1 is pulled down to -5.4V (a reverse charge) and this negative voltage swing is applied to the base of Tr_2 turning it off. This is one of the unstable states.

Transistor Tr_2 is driven into cut-off so capacitor C_1 now begins to charge in the opposite direction via resistor R_3 which is also connected to the 12V supply. Thus, the base of transistor Tr_2 moves upwards in a positive direction towards 12V.

However, it never reaches 12V because as soon as it gets to +0.6V, transistor Tr_2 turns fully on into saturation. This action starts the whole process over again but now with capacitor C_2 taking the base of transistor Tr_1 to -5.4V while charging up via resistor R_2 and entering the second unstable state.

Thus, we can see that the circuit alternates between one unstable state in which transistor Tr_1 is off and transistor Tr_2 is on, and a second unstable state in which Tr_1 is on and Tr_2 is off at a rate determined by the RC values. This process will repeat itself as long as the supply voltage is present.

The amplitude of the output waveform is approximately the same as the supply voltage with the period of each switching state determined by the time constant of the RC networks connected across the base terminals of the transistors. As the transistors are switching both on and off, the output at either collector will be a square wave with slightly rounded corners because of the current which charges the capacitors.

If the two time constants produced by $C_2 \times R_2$ and $C_1 \times R_3$ in the base circuits are the same, the mark-to-space ratio ($^{t_1}/_{t_2}$) will be one-to-one, making the output waveform symmetrical in shape. By varying the capacitors, C_1 and C_2, or the resistors, R_2 and R_3, the mark-to-space ratio, and therefore the frequency, can be altered.

Adding a variable resistor changes the equivalent resistance of both base circuits in equal amounts, meaning the frequency can be altered while also keeping the mark-to-space ratio one-to-one so the output waveform is still symmetrical.