# Astable Multivibrator Using Transistors

***Abstract*—Astable Multivibrators are free running oscillators which oscillate between two states continually producing two square wave output waveforms.**

## I. Introduction

An **astable multivibrator** is a type of oscillator circuit that continuously switches between two states without needing any external trigger. It is commonly used to generate square waves for applications such as clock pulses, tone generation, and timing circuits. In the context of a **transistor-based astable multivibrator**, it uses transistors (either **NPN** or **PNP**) to produce a continuous oscillation, making it a simple and effective way to generate waveforms.

## II. THEORY

The circuit of an astable multivibrator typically consists of two **transistors**, resistors, capacitors, and sometimes diodes. These components form a feedback loop that causes the circuit to alternate between two unstable states. Here's how it works:

### A. Operating States

1) **Initial State**: When the circuit is powered up, one transistor (say, Q1) is turned on and the other transistor (Q2) is off.
   - Q1 is connected to a capacitor (C1), which starts charging.
   - As C1 charges, the voltage across it increases, eventually making the base of Q2 more positive, which turns Q2 on.
2) **State Transition**: Once Q2 is turned on, it forces Q1 to turn off. This sudden change causes the capacitor (C1) to discharge quickly.
3) **Oscillation**: This cycle repeats, with the capacitors constantly charging and discharging, alternately switching the transistors on and off. The frequency of oscillation depends on the values of the resistors and capacitors in the circuit.

### B. Frequency Calculation

The oscillation frequency $f$ is determined by the values of the resistors and capacitors in the circuit. For a basic configuration, the frequency is approximately:

$$f = \frac{1}{T} = \frac{1}{\ln(2) \cdot (R1 + R2) \cdot C1}$$

where:

- $R1$ and $R2$ are the resistors connected to each transistor,
- $C1$ is the timing capacitor.

### C. Applications

- **Clock Generators**: Used in digital circuits for generating clock signals.
- **Tone Generators**: In sound-producing circuits, such as alarms and beepers.
- **PWM (Pulse Width Modulation)**: Useful in controlling motor speed or light dimming in power electronics.
- **Flashing Lights**: Commonly used in flashers or indicator lights.

## III. Methodology

An astable multivibrator, or free-running multivibrator, is a type of multivibrator with no stable states. Its output oscillates continuously between two unstable states without the aid of external triggering. The time period of each state is determined by the resistor-capacitor (RC) time constant.

### A. Components Used

- LED x2
- Screw terminal
- Wires
- Perfboard
- 330$\mu$F capacitor x2
- 47k$\Omega$ resistor x2
- BC547 NPN transistor x2

### B. Circuit Diagram

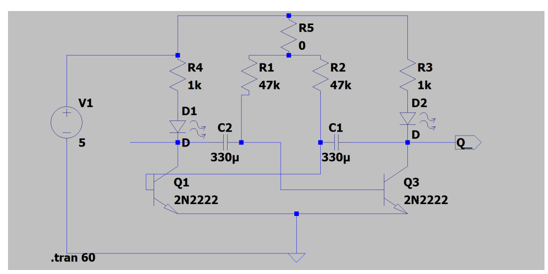


Fig. 1. Circuit model in LTSICE

### C. Procedure

#### 1) Step 1: Circuit Design and SPICE Simulation:

- **Objective**: Design the BJT oscillator circuit (e.g., Colpitts or Hartley oscillator) to meet the desired frequency specifications.
- **Simulation**: Use a SPICE simulation tool to verify the circuit design.
- **Analysis**: Check the waveform, frequency, and stability in the simulation. Adjust component values as needed to achieve the target performance.

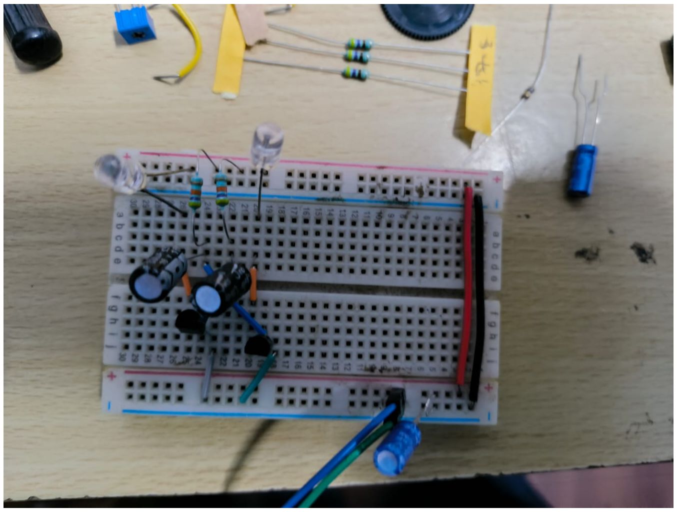

Fig. 2. Assembled circuit on a bread- board

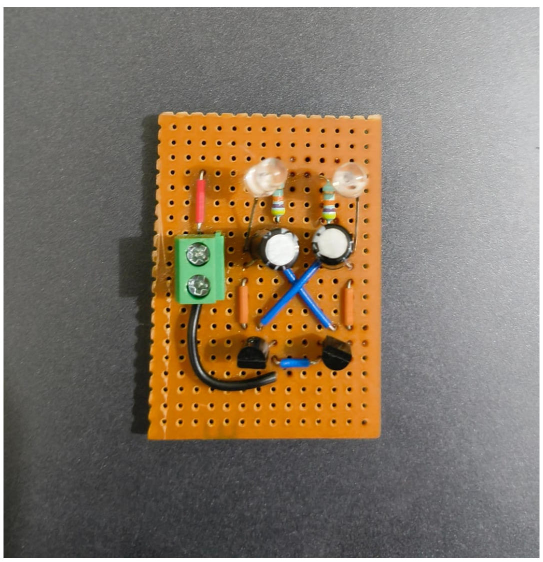

Fig. 3. Assembeld circuit on prefboard

*2) Step 2: Breadboard Assembly and Testing:*

- **Component Placement**: Assemble the circuit on a breadboard according to the schematic from the SPICE simulation.
- **Testing**: Power up the circuit and observe the output waveform using an oscilloscope.
- **Troubleshooting**: If the oscillator does not perform as expected, adjust connections or component values as necessary until the desired oscillations are observed.

*3) Step 3: Perfboard Soldering:*

- **Perfboard Preparation**: Once the circuit works reliably on the breadboard, transfer the design to a perfboard.
- **Component Placement**: Arrange the components on the perfboard, following the layout you tested on the breadboard.
- **Soldering**: Carefully solder each component in place, ensuring secure connections and minimal short circuits.
- **Final Testing**: After soldering, perform a final test with an oscilloscope to verify the output waveform and ensure the oscillator functions correctly.

## IV. Results

This section presents the results from both the SPICE simulation and the hardware implementation of the BJT oscillator circuit. The results are documented with images and waveforms to compare simulated performance with actual hardware behavior.

### *A. SPICE Simulation Results*

The SPICE simulation was used to observe the output waveform and the voltage across the capacitor, validating the design before moving to hardware.

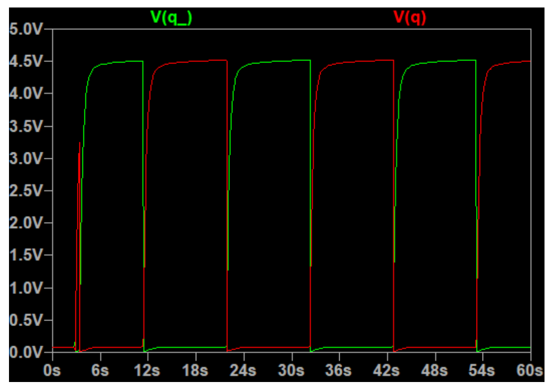


Fig. 4. SPICE simulation output waveform of the BJT oscillator

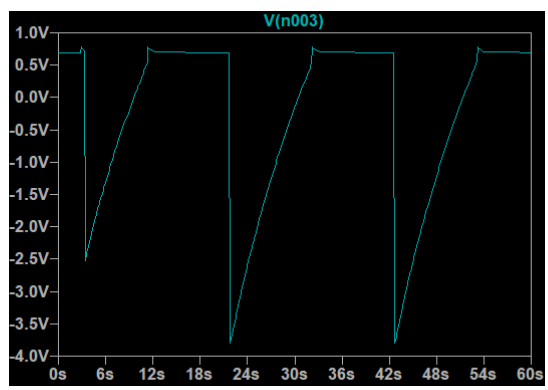


Fig. 5. Voltage across capacitor in SPICE simulation

In Figure 4, the output waveform of the oscillator shows continuous oscillations, as expected in a stable astable multivibrator. Figure 5 shows the voltage across the capacitor, with characteristic charging and discharging cycles.

### *B. Hardware Results*

The hardware implementation was tested on a breadboard and later soldered on a perfboard. The observed waveforms confirm the oscillator's functionality, showing alternating states. The hardware results are documented with two images showing the oscillator in each of its two states.

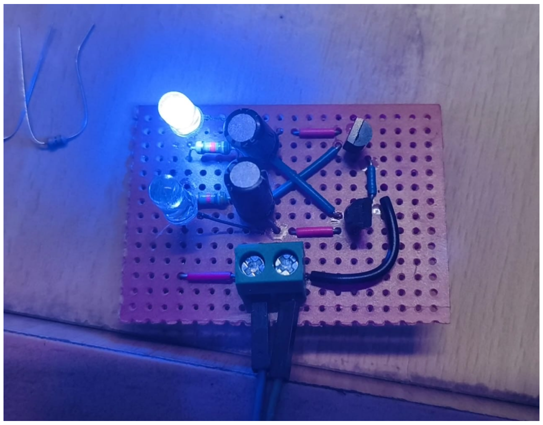

Fig. 6. Hardware result: Oscillator in State 1

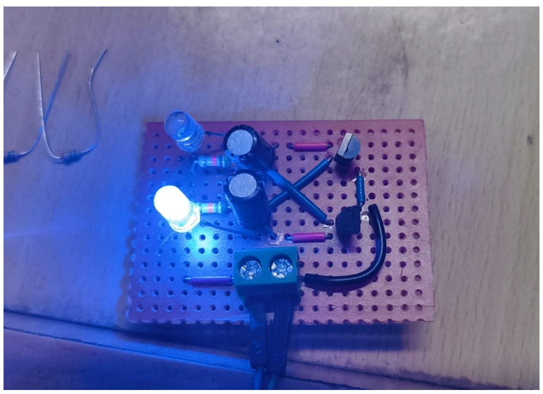

Fig. 7. Hardware result: Oscillator in State 2

Figure 6 and Figure 7 show the two distinct states of the oscillator on the hardware setup, corresponding to the charging and discharging of the capacitors in the circuit. These images validate the circuit's behavior, with the LEDs alternately lighting up in synchronization with the oscillating states.

## V. Conclusion

The Astable Multivibrator was thus designed and implemented using BJTs. Circuit completion revealed that the circuit was good at producing square waves of continually dictated frequency and duty cycle, at the joints of the values of resistors and capacitors.

The experimental results were virtually coincident with the theoretical calculations, which proved that the design principles as well as the accuracy of the used component was correct. The circuit appeared to be robust with stable oscillations over a wide range of operating conditions.

This project will provide great practical and hands-on experience related to understanding the operating principles of astable multivibrators, their possible applications in any electronic systems, especially timing circuits, pulse generators, and frequency dividers.

## Acknowledgment

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