EC26105

Electronics Workshop

"Solar Tracker with Rain Detection & Night Light"

Prepared by: Group-1 (A2)

PUSHPENDER BAWARIYA (2402039)
TRIPTI SINGHANIA (2402040)
NEKKANTI MOKSHA SRI RIGDHA (2402041)
AYUSH ARYAN (2402042)
SHALINI SINGH (2402043)

Department: *Electrical Engineering*

Submitted to: *Dr. Sangeeta Singh*
Department: *Electronics & Communication Engineering*

Project Title: *Solar Tracker with Rain Detection & Night Light*

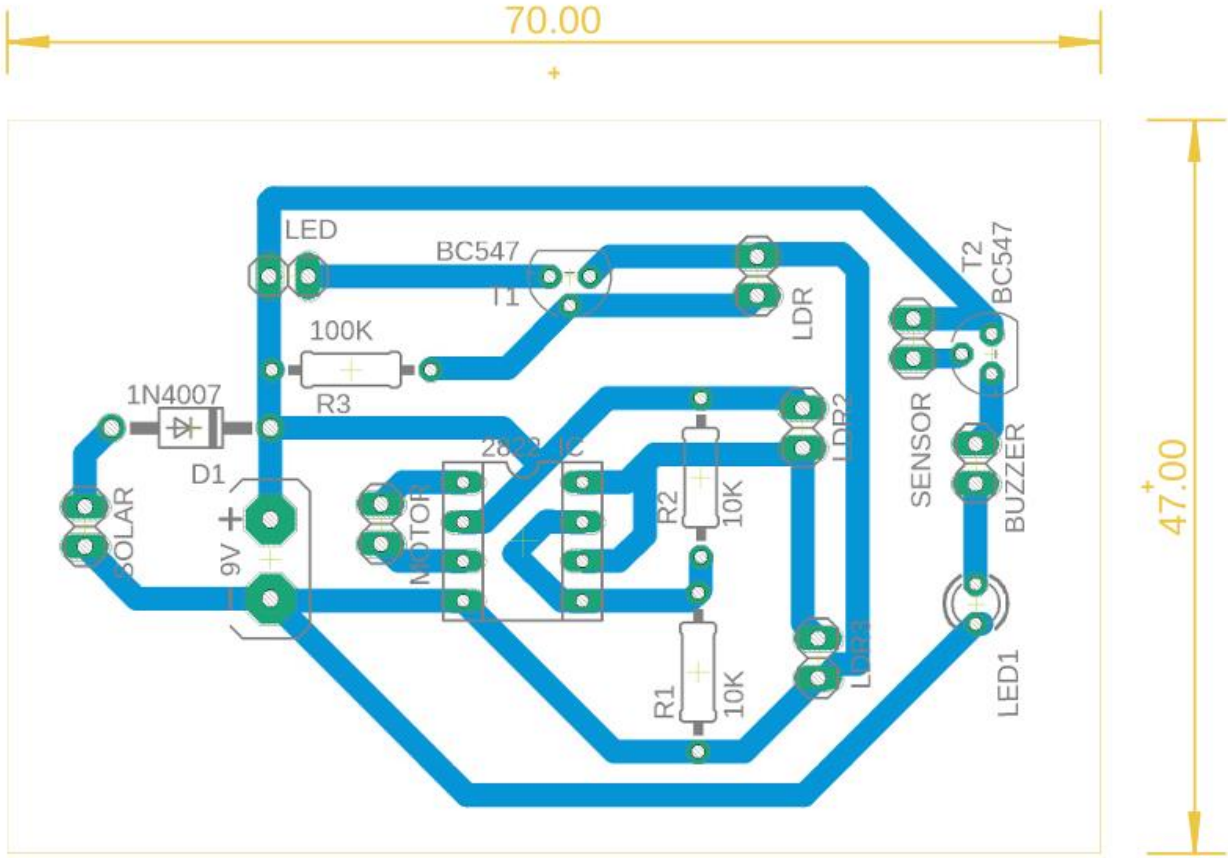

Fig. 1- Initial circuit PCB Layout

1. Brief Introduction

This project combines three functions into a single, self-powered unit:

1. **Solar Tracking:** A pair of light sensors (LDR) continually detects which side of the panel is brighter. A DC motor then turns the panel to face the sun, maximizing energy capture throughout the day.
2. **Rain Detection:** A self-made rain sensor (cut copper-clad board) senses water by a drop in resistance. When rain is detected, an audible buzzer sounds.
3. **Night Light:** When ambient light levels fall below a set threshold, a dedicated light sensor switches on a low-power LED to provide safe illumination at night.

2. Component Summary

Component	Role
Solar Panel	Converts sunlight into electricity; mounted on a rotating platform for tracking.
7.4 V Battery	Stores energy and powers the system when solar input is low.
1N4007 Diode	Prevents reverse current from the battery back into the panel.
LDRs (×3)	Light-dependent resistors: two for tracking differential light, one for night-light detection.
Resistors (10 kΩ, 100 kΩ)	Form voltage dividers with LDRs, set switching thresholds for tracking and night light.
BC547 Transistors (T_1, T_2)	T_1 for night light; T_2 acts as a switch for the rain buzzer.
Motor-Driver IC	Interfaces the low-power transistor signals to drive the DC motor.
DC Motor	Rotates the solar panel assembly to align with the sun's position.
Cut-CCL Rain Sensor	Cut copper-clad board with interleaved strips; its resistance drops when wet, triggering T_2.
Buzzer	Emits an alarm when rain is detected.
LED Night Light	Automatically turns on in darkness to provide low-level illumination around the setup.

PCB Fabrication & Assembly Workflow

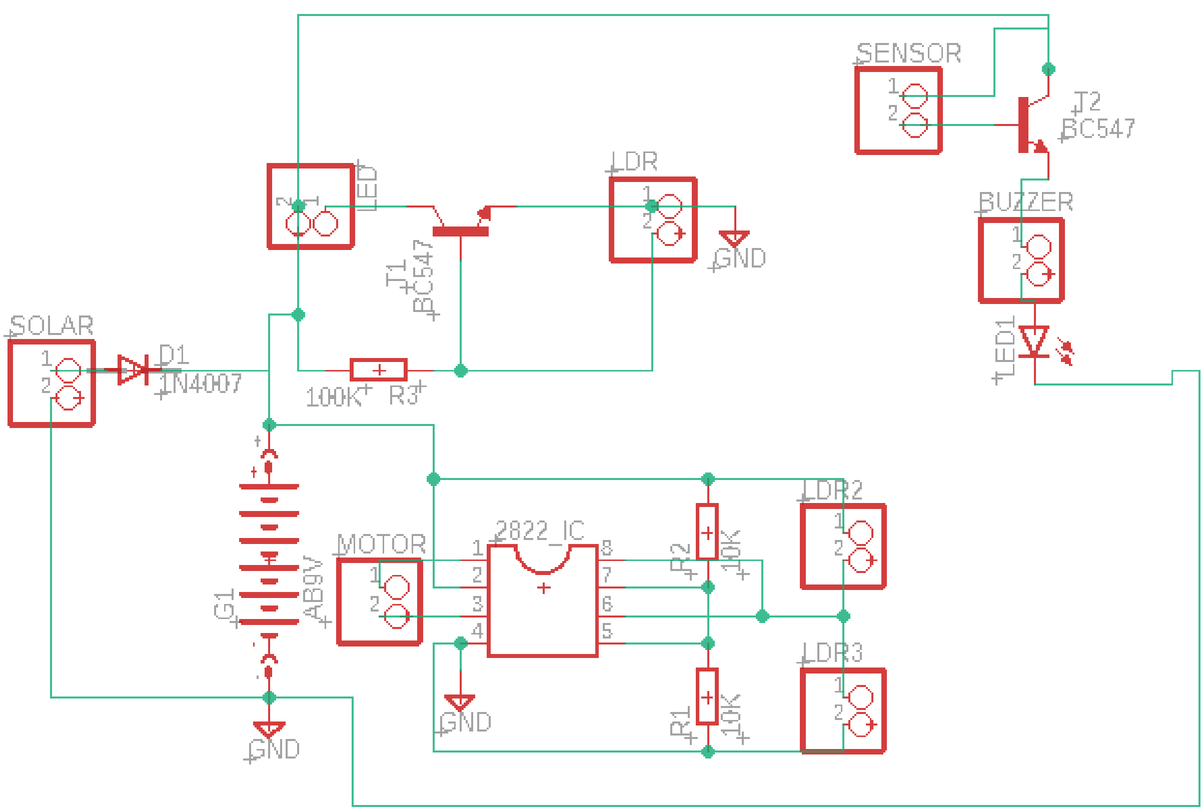

Fig. 2 – Schematic PCB Layout

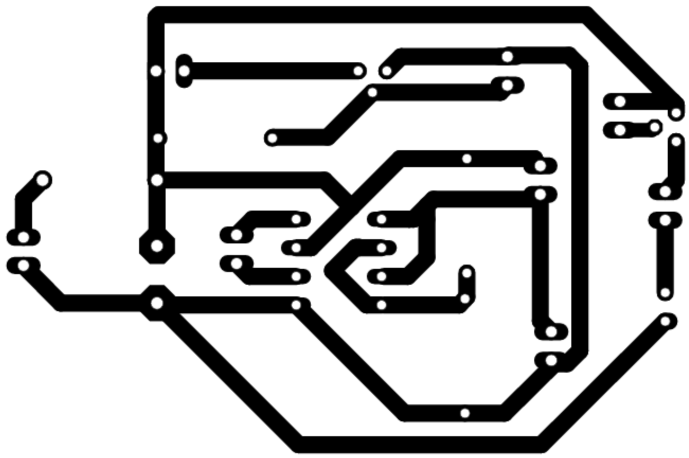

Fig. 3 – final PCB Layout

1. **Schematic Capture & PCB Layout**
   - **EAGLE CAD:** Drew the full circuit schematic (tracking, rain-sense, night light) and then arranged components on a PCB layout.
   - **Routing:** With auto routing optimized track for component placement.
2. **Transfer to CCL Plate**
   - **Printing:** Mirrored the PCB artwork onto A4 paper.
   - **Ironing:** Aligned and heat-pressed the toner-side down onto the clean, degreased copper surface for ~10 minutes at high heat. This transfers the toner as an etch resist.
3. **Wet Etching**
   - **Etchant Solution:** Used **ferric chloride ($FeCl_3$)**.
   - **Process:** Gently agitated the board in the solution for ~30 minutes until all unwanted copper dissolved, revealing the desired tracks protected by the toner.
4. **Cleaning & Drilling**
   - **Toner Removal:** Cleaned board using water to remove excess chemicals and dried the board.
   - **Drilling:** Used a PCB drill bit to make component holes, ensuring best fits for resistor leads, transistor legs, and IC sockets.
5. **Component Insertion & Soldering**
   - **Placement:** Fitted all components—transistors, LDRs, diodes, motor-driver IC, buzzer, LED, resistors—into their respective footprints.
   - **Soldering:** Employed a soldering iron with solder, kept joints shiny.
   - **Inspection & Testing:** Visually checked for shorts/opens, and then powered up gradually to verify each subsystem before final enclosure.

Practical Uses

This integrated system can be deployed anywhere off-grid or in semi-autonomous settings to boost ***solar energy yield, protect equipment from weather, and provide lighting without external power.*** Typical fields include agricultural irrigation, street and pathway lighting, remote environmental monitoring stations, and off-grid residential.

Working of individual circuits

Solar Tracker

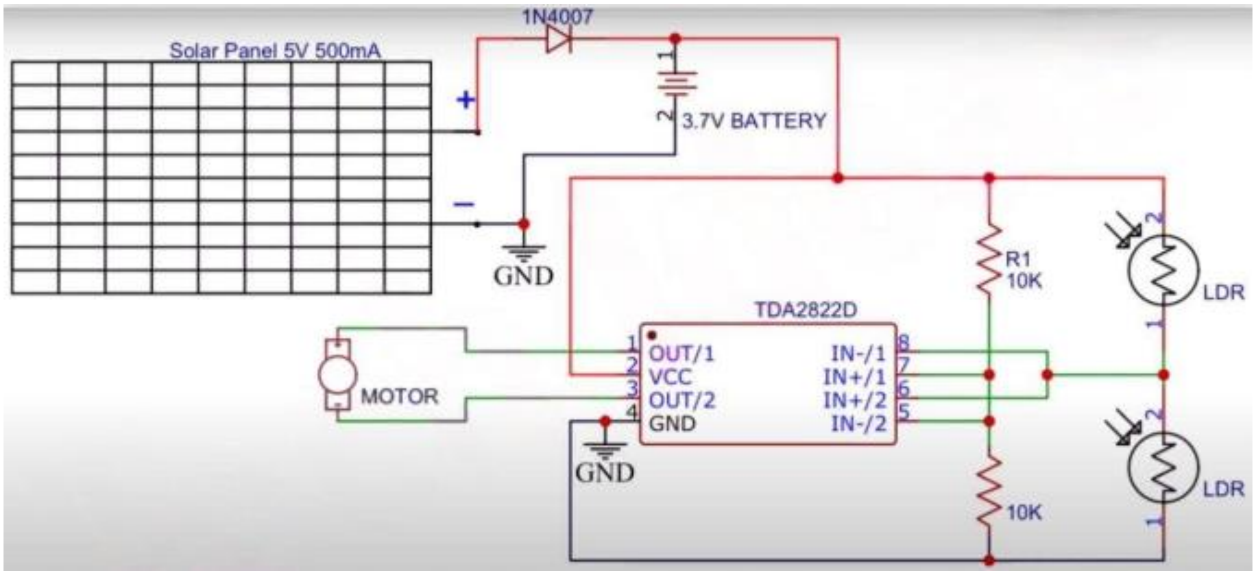

Fig. 4 – Circuit diagram for Solar Tracker

1. Main Purpose of the Circuit

1. **Harvest Solar Energy:**
   A 7.**5 V solar panel** provides power. The energy goes through a **diode (1N4007)**
   to charge a **7.4 V rechargeable battery.**
   - **Why the diode:** It prevents current from flowing *backwards* from the battery into the solar panel when there's no sunlight.
2. **Drive a Motor Based on Light Conditions:**
   The TDA2822 (usually an audio amplifier) is repurposed here as a **motor driver.** It takes input signals from two LDR-based voltage dividers. By comparing the brightness on each LDR, it decides how to spin the motor.
   - If the light on LDRI is different from LDR2, the motor turns to correct this difference.
   - This can be used to **track the sun** or simply respond to changing light levels.

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2. Key Components and Their Roles

1. **Solar Panel (7.5 V)**
   - **Function:** Converts sunlight into electrical energy.

- **Note:** The voltage can fluctuate depending on sunlight intensity, but it's typically around 7.5 V in full sun.

2. **Diode (1N4007)**
   - **Function:** Allows current to flow **from** the solar panel **to** the battery but **blocks** any reverse flow from the battery back into the panel at night or in low light.
3. **Rechargeable Battery (3.7*2 V)**
   - **Function:** Stores the solar energy for later use, powering the circuit.
4. **TDA2822 (Audio Amplifier IC)**
   - **Typical Use:** Stereo audio amplifier for small speakers.
   - **In this Circuit:** It's used as a **motor driver** for DC motor. The two outputs of the TDA2822 can drive the motor in either direction depending on the difference between the two inputs.
5. **Light Dependent Resistors (LDRs)**
   - **Function:** Their resistance changes with light.

     Bright light - Lower resistance

     Dim light - Higher resistance
   - **In This Circuit:** Each LDR forms a voltage divider with a 10 k ohm resistor (R1,R2). The resulting voltages go to the TDA2822 inputs. The difference in these voltages tells the TDA2822 which direction to drive the motor.
6. **Resistors (R1 and R2, each 10 k ohm)**
   - **Function:** Along with each LDR, they form **voltage dividers** that feed the TDA2822 inputs.
   - **Purpose:** Control the sensitivity and provide stable, predictable voltage levels to the amplifier IC.
7. **Motor**
   - **Function:** Rotates (e.g., moves a solar panel or some mechanism) based on the signals from the TDA2822 outputs.

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3. Step-by-Step Operation

1. **Sunlight Charges the Battery**
   - When the solar panel is illuminated, it provides around 7.5 V.
   - The diode allows current to flow into the 7.4V battery, charging it.
   - If sunlight is low or absent, the diode prevents the battery from discharging backward into the panel.
2. **Circuit Power-Up**
   - The TDA2822 and the LDR, resistor pairs all get power from the battery.
   - Both LDRs sense the amount of light they receive. Each LDR's resistance changes, creating a unique voltage at each TDA2822 input.
3. **Comparing Light on Each LDR**
   - Suppose **LDRl** is in brighter light than **LDR2.** That means **LDRl** has lower resistance, so the voltage on that input is higher.
   - The TDA2822 sees this difference and drives the motor in a direction that aims to *balance* the inputs.

   - **If LDR2** is brighter, the motor spins the other way.
   - When both LDRs are equally illuminated (i.e., the panel is directly facing the light

source), the inputs become balanced, and the motor **stops.**

4. **Motor Rotation**
   - The motor is powered by the TDA2822 outputs, so it can move the mechanism (often the solar panel itself) to track the light.
   - This is how many simple solar trackers keep a panel aligned with the sun, maximizing the light on both LDRs.
5. **Stable or Idle State**
   - When the motor has moved the panel (or whatever it's rotating) to the point where both LDRs receive similar light levels, the difference in their voltages is minimal.
   - The TDA2822 outputs balance out, so the motor does not run. It waits until a change in light again triggers a difference.

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4. Why the TDA2822

- The **TDA2822** is normally a small **stereo audio amplifier.** However, because it has **two outputs** that can be driven out of phase (one goes high while the other goes low), it can be used as a **motor driver.**
- Each LDR, resistor pair feeds one of the amplifier's input channels. The TDA2822 then **amplifies the difference** between the two inputs to drive the motor accordingly.

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5. Summary

- **Solar Panel** charges the **7.4 V battery** through the **diode.**
- **TDA2822** is powered by the battery and receives **two light-sensing signals** from two LDR, resistor voltage dividers.
- **Differences** in light on the LDRs cause the TDA2822 to **drive the motor.** The motor moves until both LDRs see equal light, at which point the motor **stops.**
- This setup is often used to **track sunlight** or any other directional light source, ensuring maximum alignment.

Automatic Night light

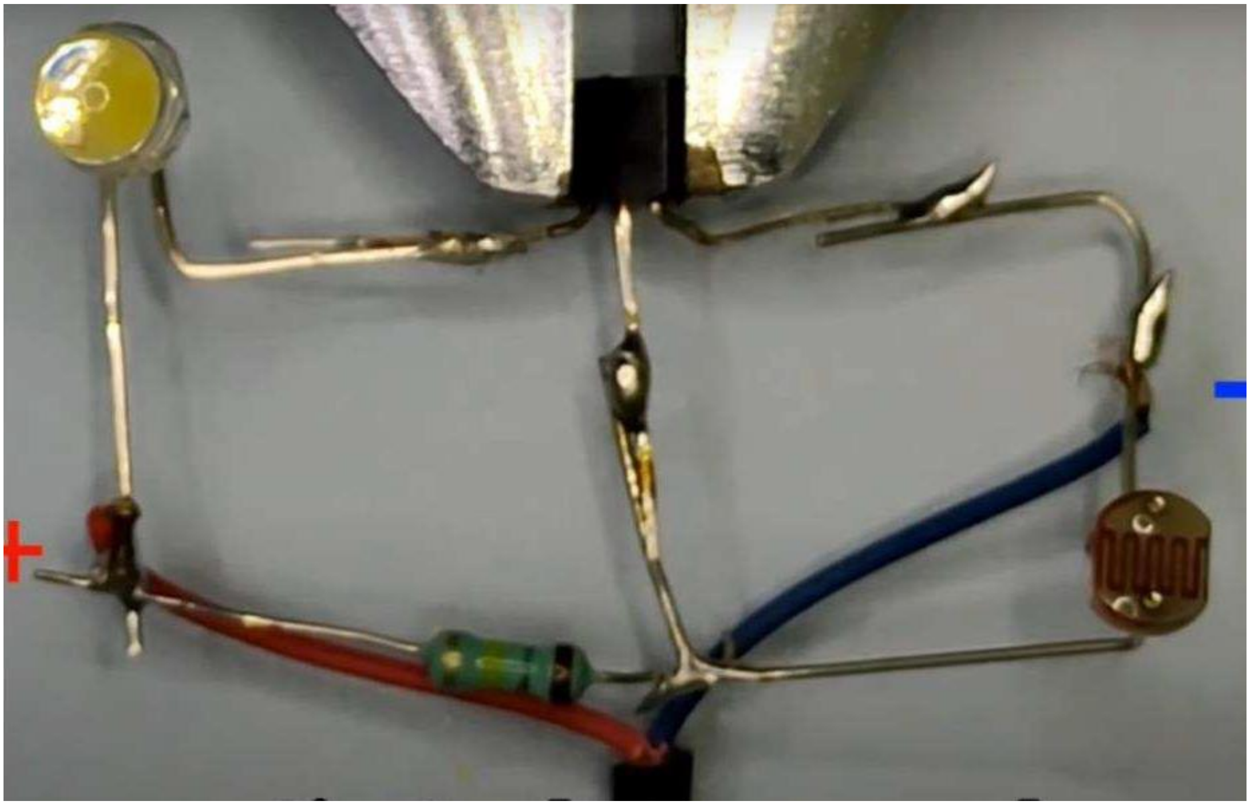

Fig. 5 – Circuit diagram for Night light

1. Components and Their Roles

1. **Power Supply (7.4 V):**
   This is the source of electrical energy for the circuit. We use a regulated 7.4 V supply to power everything.
2. **Light Dependent Resistor (LDR):**
   The LDR's resistance changes with light:
   - In bright light: its resistance is **low.**
   - In darkness: its resistance is **high.**
3. **Fixed Resistor:**
   This resistor has a constant resistance value. It helps set the correct current/voltage levels for the transistor's base and prevents excessive current from flowing.
4. **Transistor(NPN):**
   This is the heart of the switching action. It has three leads:
   - **Base (B)** - the control input.
   - **Collector (C)** - the transistor's "input" from the load side.
   - **Emitter (E)** - the transistor's "output" to ground or negative terminal.

*"When a small current flows into the base, it allows a larger current to flow from collector to emitter. Essentially, the transistor can act like an **electronically-controlled switch.**"*

5. **LED:**
   This Light Emitting Diode glows when current passes through it. It has two leads:
   - **Anode(+)** : connected toward the positive side.
   - **Cathode(-)** : connected toward the negative.

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2. Working Principle

1. **In Bright Light:**
   - The LDR's resistance is **low.**
   - Because the LDR is low resistance, the base of the transistor is pulled closer to ground (low voltage).
   - A low voltage on the base means **no significant base current** can flow.
   - With no base current, the transistor stays **off** (like an open switch).
   - The LED receives no current and stays **off.**
2. **In Darkness:**
   - The LDR's resistance becomes **high.**
   - With the LDR now high resistance, the base gets pulled **up** through the fixed resistor to a higher voltage.
   - Once the base voltage is high enough, current flows into the transistor's base.
   - This base current allows a larger current to flow from the collector to the emitter, powering the LED.
   - The LED **turns on** and glows.

Essentially, **the transistor switches ON when it's dark** because the base is driven to a higher voltage through the fixed resistor. When it's bright, the LDR "shorts" the base toward ground, keeping the transistor OFF.

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3. Overall Summary

When there is plenty of light, the LDR's low resistance pulls the transistor's base close to ground, so the transistor is off and the LED does not glow. When it becomes dark, the LDR's resistance goes up, raising the transistor's base voltage through the fixed resistor. This turns the transistor on, allowing current to flow through the LED and lighting it up.

Rain Detection

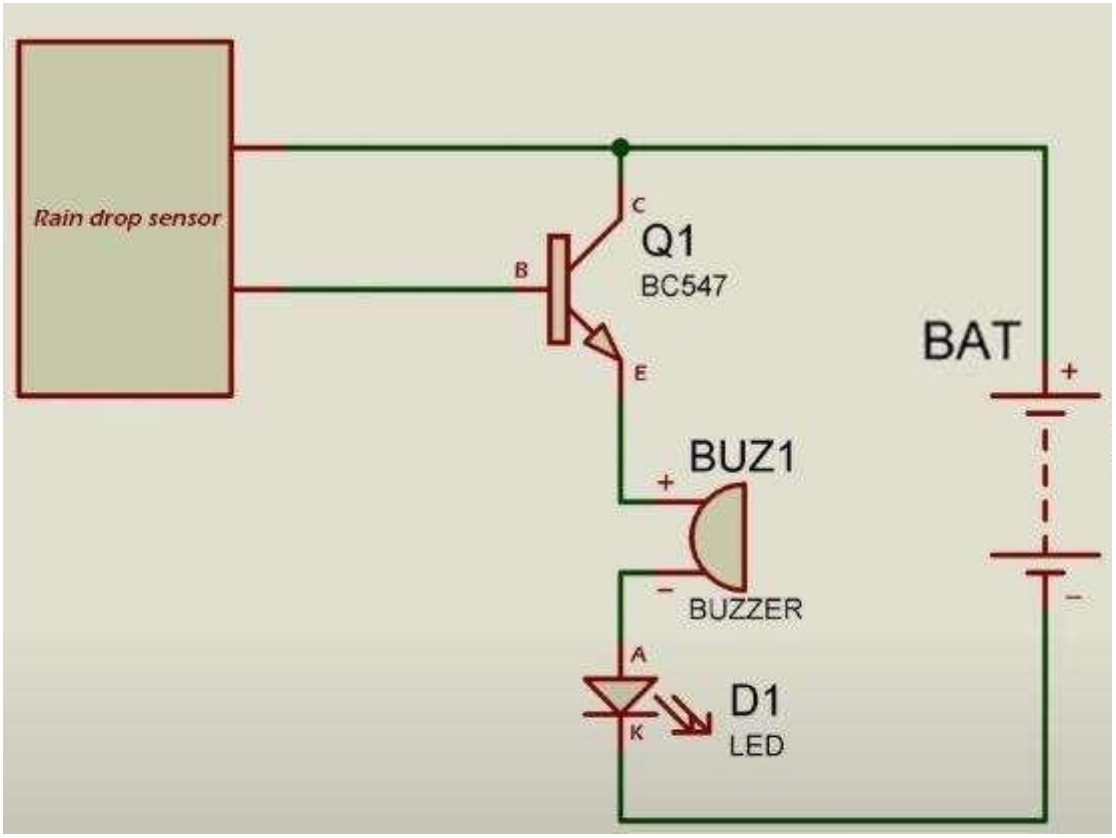

Fig. 6 – Circuit diagram for Rain detection

1. Overview of the Circuit

- **Raindrop Sensor:** This is a special sensor that detects the presence of water. When raindrops fall on it, its resistance changes significantly, allowing a small current to flow.
- **Transistor (BC547):** This is an NPN transistor acting like an electronic switch. When a small current enters its base, it allows a larger current to flow from the collector to the emitter.
- **Buzzer (BUZl):** The buzzer makes a sound whenever it receives enough current. This alerts us that rain has been detected.
- **LED (Dl):** The LED lights up when current passes through it. It provides a visual indication alongside the buzzer's sound.
- **Battery:** This is the power source for the entire circuit.

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2. Role and Working of Each Component

1. **Raindrop Sensor**
    - **Purpose:** Senses moisture (rain).

- **Operation:** When raindrops fall on the sensor, the sensor's surface becomes conductive (due to water's presence), allowing a small current to flow.
- **Effect:** This small current goes into the transistor's base, telling the transistor "it's raining!"

2. **Transistor (BC547)**
   - **Purpose:** Acts like an electronic switch or gate.
   - **Pins:**
     Base (B): Receives a small current from the raindrop sensor when it's wet.
     Collector (C): Connects to the sensor (and thus the battery's positive through the sensor).
     Emitter (E): Goes to the negative side of the battery (ground).
   - **Operation:**
     When **no rain** is detected, no current flows into the base, so the transistor remains OFF. No current flows from collector to emitter, so the buzzer and LED stay off.
     When **rain** is detected, a small current flows into the base. This "turns on" the transistor, letting a larger current flow from the collector to the emitter. This larger current powers the buzzer and the LED.
3. **Buzzer (BUZl)**
   - **Purpose:** Emits an audible alert when it receives current.
   - **Operation:**
     It is connected from the positive battery terminal through to the transistor's emitter (once the transistor is on). When the transistor switches ON, current passes through the buzzer, causing it to vibrate and produce sound.
4. **LED (Dl)**
   - **Purpose:** Provides a visual indicator that rain is detected.
   - **Operation:** Like the buzzer, the LED is powered once the transistor is ON. Current flows through the LED, making it glow.
5. **Battery**
   - **Purpose:** Supplies the necessary voltage and current to power the circuit.
   - **Operation:** The positive terminal feeds both the buzzer and LED. The negative terminal connects to the transistor's emitter.

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3. Step-by-Step Operation

1. **No Rain Condition**
   - The sensor is dry, so almost no current flows into the transistor's base.
   - The transistor remains OFF (like a gate that's closed).
   - The buzzer and LED remain off because there is no current path for them.
2. **Raindrops Detected**
   - Water on the sensor's surface lowers its resistance, allowing a small current to flow from the sensor into the transistor's base.
   - This small base current "opens the gate" inside the transistor.

- **Transistor Amplification:** The transistor amplifies the small current from the sensor, so even if the sensor only allows a tiny current when wet, the buzzer and LED can still get enough power.
- Now a larger current can flow from the collector to the emitter, effectively completing the circuit for the buzzer and LED.
- **Result:** The buzzer sounds, and the LED lights up, indicating rain is present.

3. **Continued Rain**
    - As long as the sensor stays wet, the transistor remains ON, and the buzzer and LED remain activated.
    - When the sensor dries up, the base current stops, and the transistor switches OFF again.

4. Summary

With this circuit:

- The **raindrop sensor** detects moisture and sends a signal (small current) to the **base** of the **BC547 transistor.**
- The transistor then allows a larger current to flow from **collector to emitter,** powering both the **buzzer** and **LED.**
- You get an **audible** (buzzer) and **visual** (LED) warning as soon as raindrops are detected.

Final Circuit