Automatic Water Detection and Switching using Bipolar Junction Transistor

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Abstract*—This paper presents a design for a water level indicator and automatic switching system for a water pump utilizing Bipolar Junction Transistors (BJTs). The system employs water level probes in conjunction with BJTs to monitor water levels in both an overhead tank and an underground sump. LEDs visually indicate the current water level based on activated probes. An optional automatic switching circuit using an additional BJT and relay can be implemented to control the pump based on the sump water level, ensuring efficient water and electricity usage. The design offers a simple and cost-effective solution for residential or small-scale applications.

Index Terms - Tank, Sump, BJTs, LEDs, Relay, Dc Motor, Dc Power Supply.

I. INTRODUCTION

This template, Water scarcity and energy conservation are pressing issues on a global scale. With nearly two-thirds of the world's population experiencing water scarcity at least one month a year [1], and the energy sector consuming a significant portion of freshwater resources [2], innovative solutions are crucial. This paper proposes a cost-effective and efficient water management system using Bipolar Junction Transistors (BJTs) to address these challenges.

The system integrates water level monitoring and automatic pump control functionalities, promoting judicious water and electricity use. It utilizes water level probes and BJTs to sense water levels in both an overhead tank and an underground sump. Light Emitting Diodes (LEDs) provide a visual indication of the current water level. An optional automatic switching circuit, employing an additional BJT and a relay, can control the pump based on the sump water level. This approach offers a simple and reliable solution for residential or small-scale applications, promoting water conservation and reducing energy consumption associated with unnecessary pump operation

II. SYSTEM DESIGN

A. Hardware Components

The system utilizes the following hardware components:

- Bipolar Junction Transistors (BJTs): NPN type (BC547B) The number depends on the desired functionality, 3 per tank (for water level sensing in overhead and underground tanks) - Total: 7 and another 6 for the Logic gate execution.
- Resistors: 470 Ohms - Same quantity as BJTs (used for current limiting)
- Connecting Wires: To establish electrical connections between components.
- Relay: Coil voltage rating based on chosen pump motor (e.g., 12V in our case). Serves to isolate the low-power sensing circuit from the high-power pump.
- Power Supply: 9V Battery (suitable for demonstration purposes). Consider a wall adapter for long-term use.
- DC Motor (Pump Equivalent): Voltage and current rating based on application needs.
- LEDs: Choose a distinct color for each tank level indication (e.g., red for low, yellow for medium, green for high)

B. Circuit Design

The circuit design comprises two main sections: water level sensing and pump control.

1) Water Level Sensing Transistor Section:

- Each water tank will have a dedicated set of components for water level sensing.
- Transistor Configuration: The BJTs are configured in a common-emitter mode.
- Water Level Detection: Metal probes (not included in the component list) will be positioned at different heights within each tank. As the water level rises and comes into contact with the base terminal of the corresponding BJT, a small current path is established through the water itself. This completes the circuit between the base and the positive power supply (VCC).
- Output: With the circuit complete, current flows through the collector of the transistor and the connected resistor, illuminating the corresponding LED. The resistor limits the current to a safe level for the LED.

2) Relay for Pump Control :

- This section is optional and provides automatic pump control based on the water level in the underground sump.

- Relay Function: The relay acts as a switch, isolating the low-power sensing circuit from the high-power pump motor.
- Pump Activation: When the designated BJT for pump control (optional) is ON (indicating low water level in the sump), the relay coil is energized. This allows current to flow to the pump motor through the relay contacts, activating the pump.

A. Data Sheet

Data sheets of are referred from [3].

BJT RATINGS

Rating	**BJT Characteristics**		
	Symbol	***Value***	***Unit***
Collector - Emitter Voltage BC546 BC547 BC548	Vceo	65 45 30	Vdc
Collector - Base Voltage BC546 BC547 BC548	Vcb0	60 45 30	Vdc
Emitter - Base Voltage	Vebo	6.0	Vdc
Collector Current -Continuous	Ic	100	mAdc
Total Device Dissipation @ Derate above Ta = 25℃	Pd	625 5.0	mW mW/℃
Total Device Dissipation @ Derate above Tc = 25℃	Pd	1.5 1.2	W mW/℃
Operating and Storage Junction Temperature Range	Tj, Tstg	-55 to +150	℃

B. Component Selection

1) Bipolar Junction Transistors (BJTs):

- Model: BC547B (or equivalent NPN general-purpose BJT)
- Current Gain (hFE): Refer to Datasheet for typical value (usually in the range of 100-300)
- Current Rating: 5mA - 100mA (as specified)

2) LEDs:

- Forward Current: 10mA - 30mA (as specified)
- Choose a forward voltage compatible with the 9V power supply (typical LED forward voltage is around 1.8V - 2.2V).

3) Resistor - 470 Ohms

Justification:

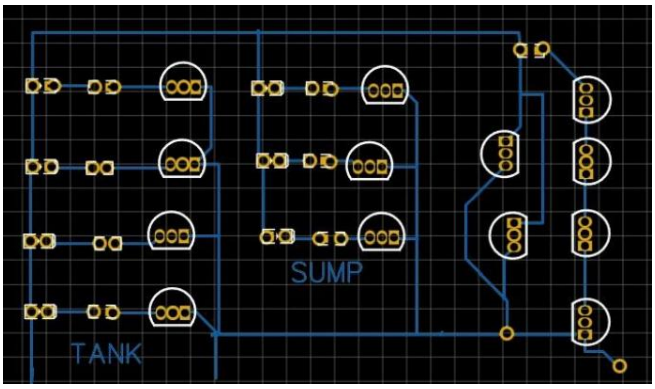
The chosen resistor value (470 Ohms) limits the current flowing through the LED to a safe level within its specified range (10mA - 30mA). By applying Ohm's Law (I = V/R) with VCC = 9V and R = 470 Ohms, the calculated current (I) is approximately 19.14mA, which falls well within both the BJT and LED's current limitations. This ensures proper LED illumination without exceeding component ratings.

C. Budget Plan

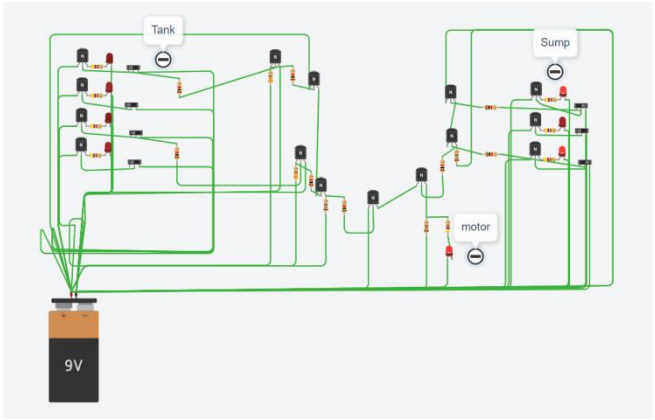
- Resistor (470 Ohms) : 10 units : Rs. 10/-
- NPN Bipolar Junction Transistor (BC547) : 13 units : Rs. 39/-
- LED Bulb : 7 units : Rs. 14/-
- Wire Single Stranded : 1 pack : Rs. 30/-
- Soldering Board : 1 unit : Rs. 40/-
- Soldering Paste : 1 unit : Rs. 20/-
- Soldering Lead : 1 unit : Rs. 10/-
- Battery 9V : 1 unit : Rs. 20/-

III. SCHEMATIC DIAGRAM

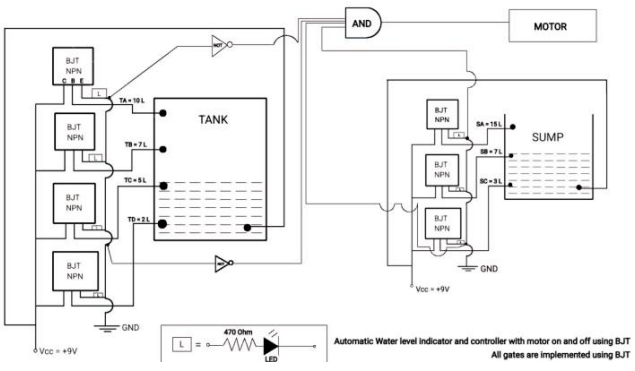
A. 2D PCB Design Layout



B. Simulation Schematics Diagram



C. Logic Design



D. Logic

- The input to AND gate is inverted using NOT gate from tank input first.
- Then the input from sump is passed on to the AND gate.
- The resultant from the sump and tank is later passed through the AND gate and the output is fed to a relay.

IV. RESULT

The designed automatic water level control system utilizes Bipolar Junction Transistors (BJTs) for water level sensing and integrates digital logic for intelligent pump operation.

A. Water Level Sensing with BJTs:

- Circuit Completion: Upon reaching the designated probe in a tank, rising water completes a circuit. Current flows through the BJT, activating its collector and permitting current flow to the connected LED.
- LED Indication : A chosen 470ohm resistor limits current to a safe level for the LED. Distinct coloured LEDs can provide visual water level indications (e.g., red for low, yellow for medium, green for high).

B. Digital Logic Control:

This section leverages the output from the BJT sensing circuit:

- Input to Digital Logic Board: The signal from the BJT sensing circuit serves as an input to the digital logic board containing logic gates made using BJT.
- Logic Processing: The digital logic board, with specific logic (AND and NOT), processes the input signals from the tank and sump to determine pump activation.
- Relay Control: The processed output from the digital logic board controls the relay.

C. Pump Operation:

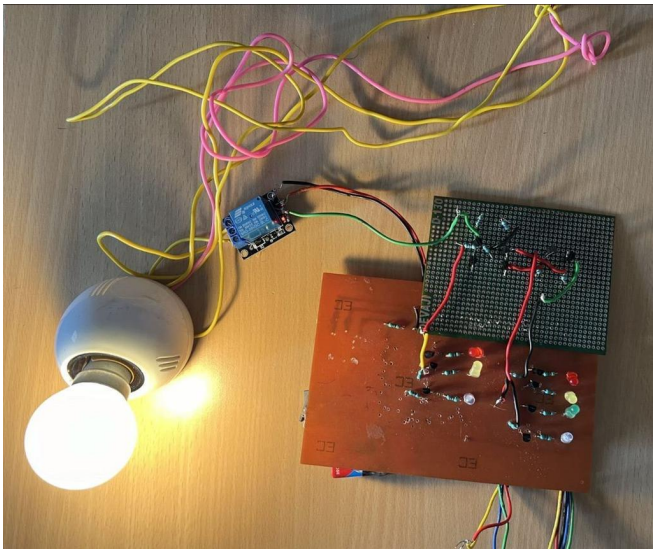
Based on the processed logic output:

- Test Case 1 : Motor On (Sump Low & Tank Empty): When the sump water level is low and the tank is empty (or below a threshold), the relay activates, allowing current to flow to the pump motor, turning it on to refill the sump.
- Test Case 2 : Motor On (Sump Full & Tank Empty): If the sump is full (reaching a designated level) and the tank is empty, the pump turns on momentarily to prevent overflow before deactivating.
- Test Case 3 : Motor Off (Sufficient Levels): When both the tank and sump have sufficient water levels based on the programmed logic, the relay remains inactive, keeping the pump off.

D. Overall Performance:

The BJT and digital logic system offers a versatile and automated approach to water level control. It effectively monitors water levels and manages pump operation based on pre-defined logic, promoting efficient water usage.

E. Pictorial Representation of the Output



V. CONCLUSION

1) Key Features:

- Water Level Sensing: The system employs water level probes and BJTs in a common-emitter configuration to detect water levels in each tank. LEDs provide a visual indication of the current water level
- Automatic Pump Control (Optional): An additional BJT and relay can be implemented to automate pump operation based on the sump water level.
- Cost-Effectiveness: The system utilizes readily available and inexpensive components (BJTs, resistors, LEDs), making it a cost-effective solution for residential or small-scale applications.

2) Future Enhancements:

- Micro controller Integration: The design can be further enhanced by incorporating a micro controller. This would enable functionalities like displaying precise water level readings, setting pump operation timers, and implementing more complex control logic.
- Alternative Sensing Techniques: Exploring alternative water level sensing techniques, such as ultrasonic sensors or pressure sensors, could potentially improve accuracy and reliability.

ACKNOWLEDGEMENTS

The project was started from the curiosity of our guide Dr. Salila Hegde, Associate Professor, Department of ECE, NIE Mysuru and is aimed to reduce Water Wastage caused by

Excess water flowing from sump to the tank when the motor Is operated manually in an affordable way.

REFERENCES

[1] UNICEF. (n.d.). Water scarcity. https://www.unicef.org/press-releases/1-3-children-exposed-severe-water-scarcity-unicefI.

[2] International Energy Agency. (n.d.). Energy and water. https://www.iea.org/topics/energy-and-water

[3] BC547 Transistor Datasheet. [You need to replace this with the actual Datasheet used for BC547 or equivalent] (Specific Datasheet example)