Heater Control System using Arduino with Timer Interrupt

1. Introduction

This project implements a heater control system using Arduino, a DS18B20 temperature sensor, and a relay module to control a simulated heater. In this prototype, an LED is used to represent the heater, providing a visual indication of when the heater is on or off in a real system. It uses a state machine to track and manage system behavior across five states: Idle, Heating, Stabilizing, Target Reached, and Overheat. A TimerOne interrupt triggers periodic temperature sampling every 500 ms, making the system responsive without using blocking delays.

2. Sensors and Actuators

2.1Sensors

1. **DS18B20 Temperature Sensor:**
    - **Protocol:** OneWire.
    - **Purpose:** Reads temperature for state transitions.

2.2Actuators

- **Relay Module:** Controls heater ON/OFF.
- **LED Indicator:** Provides visual feedback.
- **Buzzer:** Gives an audible signal when the target temperature is reached.

3. Communication Protocols

- **One Wire Protocol -** For interfacing the DS18B20 temperature sensor. This single-wire protocol reduces wiring complexity and supports multiple sensors on the same bus.

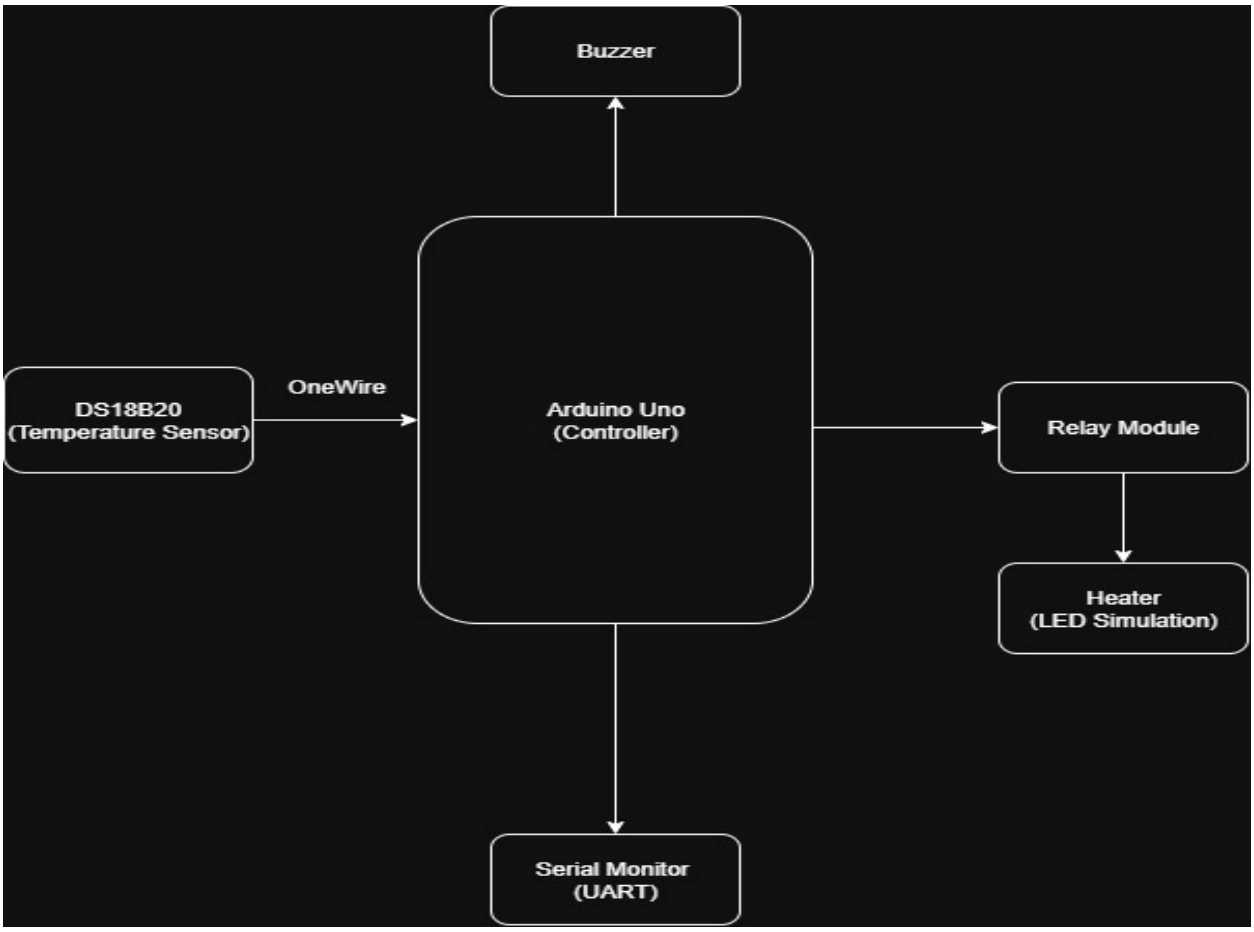
- **UART Protocol** - For logging temperature and state transitions to the Arduino Serial Monitor. This aids in debugging and monitoring.

4. Timer Interrupt

The project uses the TimerOne library to set up a hardware timer interrupt:

- **Interval:** 500 ms
- **Purpose:** Periodically sets a flag (Flag) for non-blocking temperature reading and state updates.
- **Advantage:** Ensures consistent periodic execution without using delay(), improving system responsiveness.

5. Block Diagram



6. System States

State Descriptions

1. **Idle State:**
    - Temperature < 30 °C.
    - Heater OFF.
2. **Heating State:**
    - Temperature between 30 °C and 90 °C.
    - Heater ON.
3. **Stabilizing State:**
    - Temperature between 90 °C and 98 °C.
    - Heater OFF to avoid overshooting.
4. **Target Reached State:**
    - Temperature between 98 °C and 100 °C.
    - Heater OFF, buzzer beeps periodically.
5. **Overheat State:**
    - Temperature > 100 °C.
    - Heater OFF for safety.

7. Features

- **Non-blocking design:** Uses timer interrupt instead of delay().
- **Real-time logging:** Outputs temperature and system state over Serial.
- **State machine:** Clear modular handling of different temperature ranges.
- **Visual & auditory alerts:** LED & buzzer for state indication.

8. Roadmap for Future Enhancements

- **BLE/Wi-Fi + MQTT Integration:** Enable sending temperature and state data to a mobile app or web dashboard using MQTT or REST API for remote monitoring.
- **FreeRTOS Tasks:** Split temperature reading, control logic, and logging into separate tasks for scalability.
- **Multiple Heating Profiles:** Allow dynamic thresholds for different applications.

9. Wokwi Simulation

The system was successfully simulated on Wokwi to validate its behavior, including state transitions and relay/buzzer actions.

Simulation Link: View Simulation here

Output Video Link: View Output here

10. GitHub Repository

The complete project, including Arduino code, diagrams, documentation, and Wokwi simulation files, is available on GitHub:

GitHub Repository – Heater Control System

(https://github.com/Balaji7010/HeaterControlSystem)

11. Conclusion

This project demonstrates a modular, interrupt-driven heater control system using Arduino and DS18B20. The use of a hardware timer enables non-blocking periodic temperature sampling, making the system more responsive and reliable for real-world use.