Smart Thermostat System - Requirements Specification

1. Introduction

1.1 Purpose

This document defines the requirements for the Smart Thermostat System built using ESP32. The system reads temperature (LM35), distance (Ultrasonic), and threshold (Potentiometer), communicates through MQTT, and performs LED actions based on thermostat logic.

1.2 System Goal

The system monitors temperature, detects user presence, adjusts threshold values, publishes data to a cloud dashboard, and activates LED indicators according to conditions.

2. System Overview

2.1 System Inputs

- LM35 Temperature Sensor
- Ultrasonic Sensor (Presence Detection)
- Potentiometer (Threshold)
- MQTT Commands

2.2 System Outputs

- LED System Indicator
- MQTT Publish (Sensor Data + Alerts)
- Dashboard Visualization

3. Functional Requirements (FR)

3.1 Temperature Sensor (LM35)

ID	Requirement
FR-TEMP-01	Read temperature periodically.
FR-TEMP-02	Convert ADC reading to Celsius.
FR-TEMP-03	Compare temperature with threshold.
FR-TEMP-04	Publish temperature via MQTT.
FR-TEMP-05	Trigger LED when temperature exceeds threshold.

3.2 Potentiometer (Threshold Control)

ID	Requirement
FR-POT-01	Read Potentiometer value.
FR-POT-02	Map analog value to threshold range.
FR-POT-03	Publish threshold to dashboard.

3.3 Ultrasonic Sensor (Presence Detection)

ID	Requirement
FR-ULT-01	Measure distance using Ultrasonic sensor.
FR-ULT-02	Detect presence if distance < defined range.
FR-ULT-03	Activate thermostat mode when user is present.
FR-ULT-04	Publish distance via MQTT.

3.4 LED Module

ID	Requirement
FR-LED-01	Turn LED ON when temperature exceeds threshold.
FR-LED-02	Blink LED when presence detected.
FR-LED-03	Allow LED control through MQTT commands.
FR-LED-04	Indicate system modes (Cooling / Idle / Alert).

3.5 MQTT Communication

ID	Requirement
FR-MQTT-01	Connect to MQTT broker.
FR-MQTT-02	Publish sensor data periodically.
FR-MQTT-03	Publish alerts and events.
FR-MQTT-04	Subscribe to dashboard commands.
FR-MQTT-05	Auto-reconnect if MQTT disconnects.

3.6 Thermostat Logic

ID	Requirement
FR-TH-01	Temperature > Threshold → Cooling Mode (LED ON).
FR-TH-02	Temperature <= Threshold → Idle Mode (LED OFF).
FR-TH-03	Presence detected → Activate thermostat mode.
FR-TH-04	Publish thermostat state to dashboard.

3.7 Dashboard Requirements

ID	Requirement
FR-DASH-01	Display temperature, distance, and threshold values.
FR-DASH-02	Show alarm indicators.
FR-DASH-03	Allow remote control via MQTT.
FR-DASH-04	Display real-time graphs.

4. Non-Functional Requirements (NFR)

1. NFR-01: Sensor reading frequency shall be ≤ 1 second.
2. NFR-02: MQTT communication must be stable and lightweight.
3. NFR-03: System must auto-recover after network failures.

4. NFR-04: Modular architecture (APP–HAL–MCAL).
5. NFR-05: System response time < 250 ms.

5. Pin Mapping

Component	ESP32 Pin	Function
LM35	GPIO33 (ADC)	Temperature Input
Potentiometer	GPIO33 (ADC)	Threshold Input
Ultrasonic TRIG	GPIO5	Trigger Signal
Ultrasonic ECHO	GPIO18	Echo Signal
LED	GPIO2	System Indicator
MQTT/WiFi	Built-in	Communication