VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY

HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY

EMBEDDED SYSTEM FINAL PROJECT

DESIGNING A THERMOSTAT FOR CARS USING STM32 AND DS18B20 SENSOR

Course: Embedded System Programming (EE3031)

Semester: 251 - **Class:** CC01

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THERMOSTAT V1.0

USER MANUAL

This User Manual provides comprehensive instructions for operating the Thermostat V1.0 system. The device is powered by an STM32F103 microcontroller and DS18B20 temperature sensor. Please read this manual carefully before use to ensure safe and optimal performance.

This is an open-source project. For more information, please visit GitHub Project Link: https://github.com/GHT1305/Embedded-System-Programming-Course-Project/tree/main

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1.1. Introduction

THERMOSTAT V1.0 is a microcontroller-based thermostat designed for automotive cabin temperature management. The system continuously monitors interior temperature using a high-precision DS18B20 sensor and automatically activates a cooling fan when temperature exceeds user-defined setpoint.

1.2. Key Features

- Precision Temperature Control: ±0.5°C accuracy with DS18B20 1-Wire sensor
- User-Friendly Interface: 16x2 LCD display with intuitive 3-button controls
- Automatic Fan Control: ON when temp ≥ setpoint, OFF when temp < setpoint
- Visual Status Indication: Red LED synchronized with fan operation
- Robust Industrial Design: STM32F103C8T6 microcontroller (72MHz operation)
- Configurable Setpoints: 15°C to 35°C range with 1°C increment steps
- Power-On Self-Test: Comprehensive startup diagnostics with LED feedback

CHAPTER 2: HARDWARE SPECIFICATIONS

2.1. Electrical components

- Microcontroller: STM32F103C8T6
- Temperature sensor: DS18B20
- Display: 16x2 Character LCD
- Status LED: 3mm Green LED (20mA) with 220Ω current limiting resistor
- 12VDC fan with NPN transistor and flyback diode
- Control buttons: 6x6mm tactile switches (x3)

2.2. Electrical wiring diagram

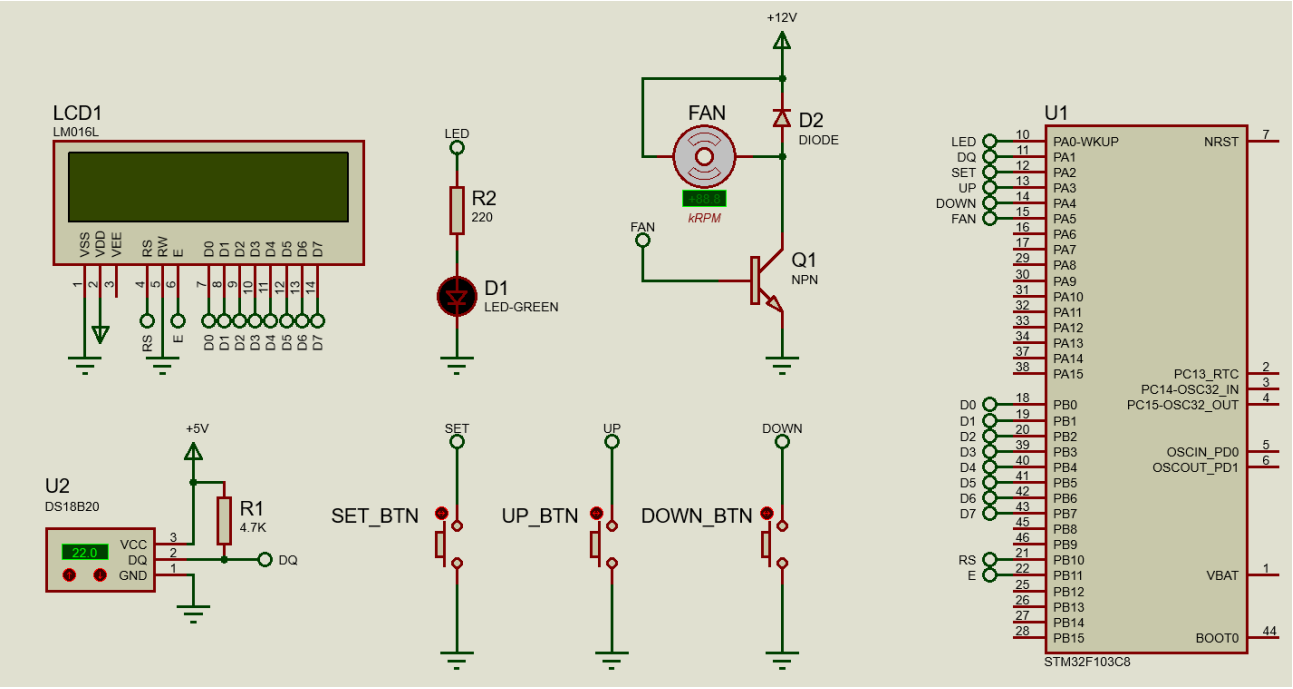

Figure 2.1: Electrical diagram

STM32 connection details:

- DS18B20 data bus: Pin PA1
- Status LED: Pin PA0 (source configuration)
- Fan control: Pin PA5 (source configuration)
- SET, UP, DOWN buttion: Pin PA2 → PA4 (pull-up configuration)
- LCD Reset (RS) Pin: Pin PB10
- LCD Enable (E) Pin: Pin PB11
- LCD Data Pins (D0 → D7): Pin PB0 → PB7

CHAPTER 3: OPERATION INSTRUCTIONS

3.1. During Startup

When turning on the power switch, the LCD screen will display a welcome message. At the same time, the LED will blink rapidly for about 4 seconds. All of those indicate the device has started successfully. The system will then automatically switch to normal temperature display mode.

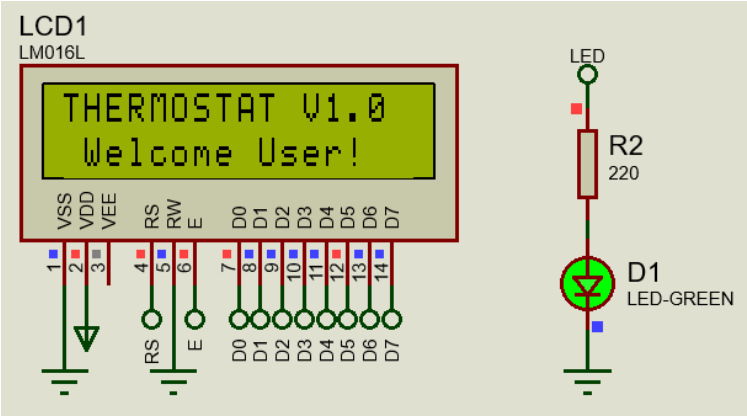

Figure 3.1: LCD Startup display

3.2. During Normal Operation

The LCD screen continuously displays 3 columns: *TEMP*, *SET* and *FAN*.

- *TEMP*: Current ambient temperature (°C)
- *SET*: Set temperature (°C) customized by user to determine the fan *ON* or *OFF* threshold, maintaining desired temperature inside the vehicle. Default on Startup: *20°C*
- *FAN*: Fan status *(ON / OFF)*

The fan will automatically turn *ON* when the temperature reaches or exceeds the set temperature, and turn *OFF* when the temperature drops below the setpoint. The LED lights up in sync with the fan.

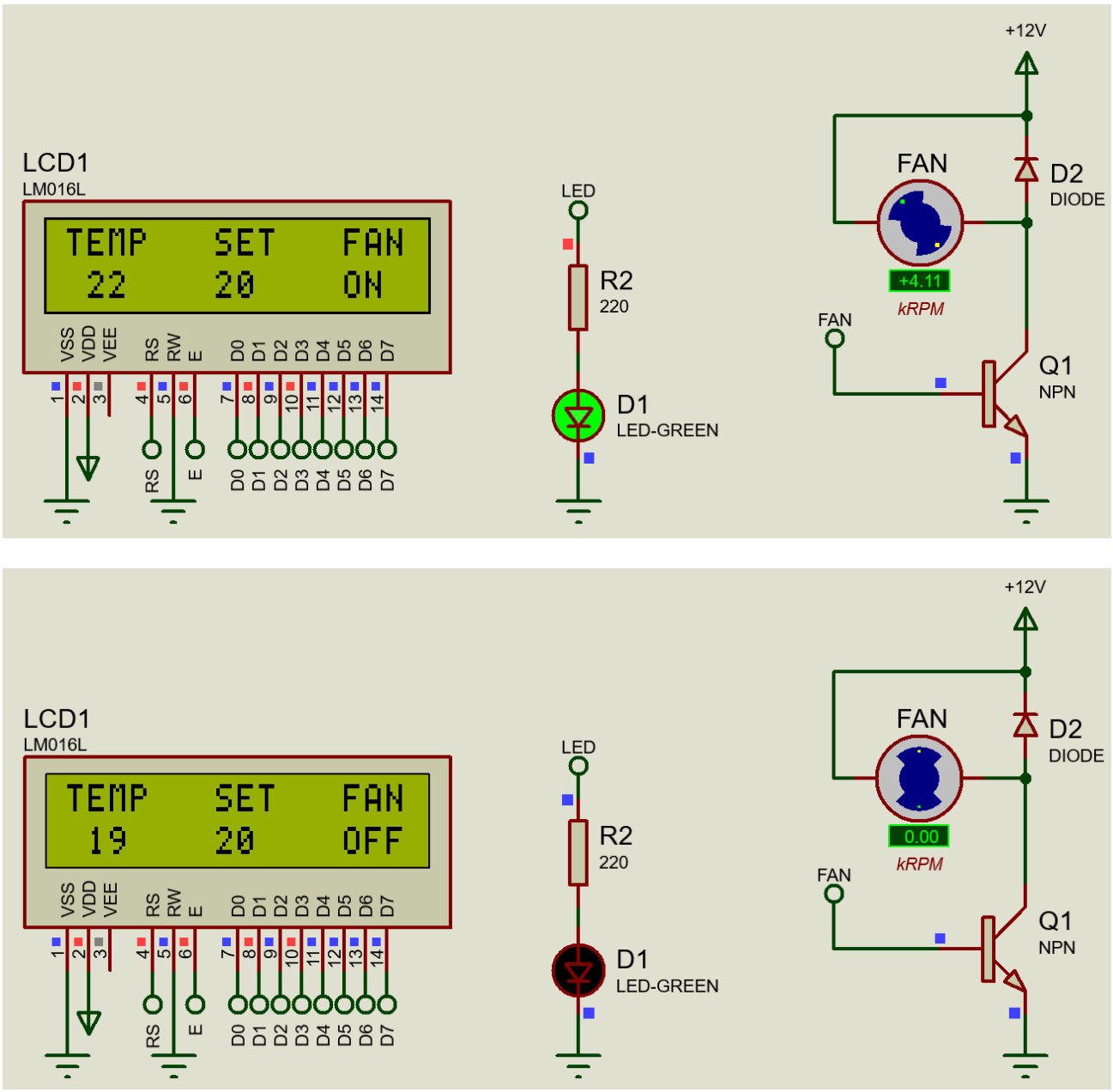

Figure 3.2: Fan status when current temperature changes

3.3. Set temperature adjustment

To adjust the set temperature, press the *SET* button to enter setup mode. The LCD will display *"SET TEMP MODE"*. At this time, the LED and fan will temporarily turn *OFF* while waiting for user adjustment.

- Press UP button to increase the set temperature (+1°C, maximum 35°C)

- Press DOWN button to decrease the set temperature (-1°C, maximum 35°C)

Press *SET* again to exit and save the new setting.

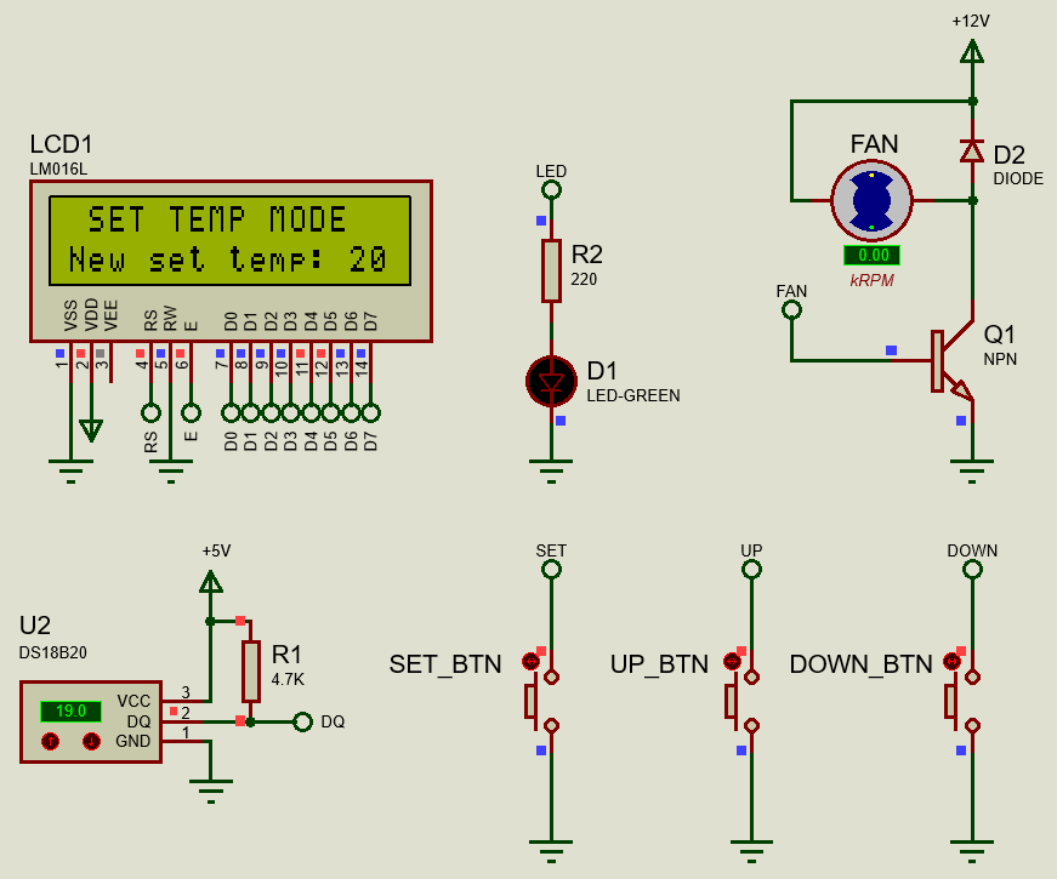

Figure 3.3: Setting mode

3.4. Troubleshooting

If you encounter issues, turn off power and wait 10 seconds before turning it back on. If problems persist:

- LCD screen is blank but the microcontroller or LED is still lit, check all LCD connections including power (VSS to GND, VDD to 5V) and data lines.
- If the fan does not turn ON/OFF correctly as shown on the display, verify the fan control circuit. Check PA5 pin voltage (should toggle between 0V and 3.3V), transistor wiring, flyback diode installation, and 12V power supply to the fan.

- If temperature readings are incorrect or erratic, inspect the DS18B20 sensor connections. Ensure proper wiring (VCC to 5V, GND to ground, DATA to PA1) and verify the 4.7kΩ pull-up resistor is correctly installed between PA1 and 5V.
- If any component becomes excessively hot, immediately check your power supplies. Measure 5V logic supply (should be 4.9-5.1V) and 12V fan supply. Look for short circuits, insufficient power supply capacity, or inadequate cooling.

For any problems that cannot be resolved using the above steps, please contact our support team for professional diagnosis and repair service. Do not attempt to modify internal circuitry or firmware.

REFERENCES

[1] STMicroelectronics, “STM32F103C8T6 Reference Manual”, https://www.st.com/resource/en/reference_manual/rm0008-stm32f101xx-stm32f102xx-stm32f103xx-stm32f105xx-and-stm32f107xx-advanced-armbased-32bit-mcus-stmicroelectronics.pdf

[2] STM32-base, “STM32F103C8T6 Blue Pill Datasheet”, https://stm32-base.org/boards/STM32F103C8T6-Blue-Pill.html

[3] Hitachi, “LCD 16x2 LM016L Datasheet”, https://digsys.upc.edu/csd/chips/classic/LM016L_Hitachi.pdf

[4] Maxim Intergrated, “DS18B20 Datasheet”, https://www.analog.com/media/en/technical-documentation/data-sheets/ds18b20.pdf