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CS350

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Project One

Thermostat System Report

The goal of this project was to design and implement a prototype for a smart thermostat system using the TI CC3220S LaunchPad development board. The thermostat incorporates the TMP006 temperature sensor to monitor room temperature via I2C communication, LEDs to indicate the heating status, and two buttons to control the temperature setpoint through GPIO interrupts. In addition, the system uses a UART interface to simulate data transmission to a server, representing cloud connectivity. This project is aimed at fulfilling SysTec’s business requirement for a functional thermostat capable of interacting with remote servers for real-time monitoring and control.

To achieve the required functionality, the project implements several key components. The TMP006 temperature sensor is read periodically through the I2C peripheral, and the data is used to determine whether the heating system should be active. The buttons allow the user to increase or decrease the temperature setpoint, and this action is captured by GPIO interrupts for immediate processing. The system also outputs temperature data and setpoint values through the UART peripheral to simulate server communication. This is done in a non-blocking manner using a task scheduler, ensuring that temperature readings, button checks, and data transmission occur periodically without interference.

A critical part of the system design is the implementation of a task scheduler, which is driven by a timer. The task scheduler ensures that the system reads the temperature every 500ms, checks the button state every 200ms, and sends data to the server every second (1000ms). The timer-based scheduler prevents tasks from blocking each other and ensures that all system operations are performed at the correct intervals. This method of scheduling allows for efficient multitasking while maintaining responsiveness, especially when adjusting the setpoint temperature via the buttons.

The thermostat's peripheral support is extensive. It uses the I2C protocol to read from the TMP006 sensor, GPIO pins to control the LEDs and detect button presses, and UART for communication. The system also uses interrupts to handle button presses immediately, ensuring that the user’s input is captured without waiting for the next task cycle. This enhances user experience by making the thermostat feel responsive, particularly when adjusting the setpoint temperature.

For future scalability, cloud connectivity was considered for the next phase of the project. Three potential architectures were evaluated for their ability to support Wi-Fi and provide enough memory for the thermostat's operation: TI's CC3220S, Microchip’s PIC32MZ, and NXP’s i.MX RT. The TI CC3220S was identified as the best choice for this application due to its integrated Wi-Fi capabilities, low power consumption, and robust security features. With 256KB of RAM and secure boot functionality, the CC3220S is optimized for IoT applications like this thermostat, making it a more cost-effective and efficient solution compared to other options.

The thermostat connects to the cloud via Wi-Fi using the integrated Texas Instruments CC3220S module, which supports 802.11 b/g/n standards for reliable communication. This Wi-Fi module enables the thermostat to send temperature and system data to cloud platforms using protocols such as MQTT and HTTP, providing real-time monitoring and control. Additionally, over-the-air (OTA) firmware updates can be deployed through the cloud, ensuring ongoing system optimization and security.

In conclusion, the CC3220S-based thermostat prototype fulfills the business requirements for temperature monitoring and control. Its efficient use of peripherals, including I2C, GPIO, and UART, combined with the task scheduler for multitasking, ensures that the system operates reliably. With the introduction of cloud connectivity in future iterations, this thermostat can be scaled into a competitive smart device in the growing global market. The prototype serves as a solid foundation for SysTec’s venture into the smart thermostat space, with its architecture capable of supporting future enhancements such as remote control and data analytics.

References

Texas Instruments. (2021). SimpleLink™ Wi-Fi® CC3220S, CC3220SF SimpleLink™ Wi-Fi® and Internet-of-Things Solution, a Single-Chip Wireless MCU. [https://urldefense.com/v3/\_\_https://www.ti.com/lit/ds/symlink/cc3220s.pdf?ts=1729183601364&ref\_url=https\*253A\*252F\*252Fwww.ti.com\*252Fproduct\*252FCC3220S\_\_;JSUlJSU!!BeImMA!6WpAcWxqY\_RanDnYahmWZuaMQ774j8wFbT5awgQP7kfEWvYfd-B3789bmWz7SNP717gDl9mGfwKB1mLXiw$](https://urldefense.com/v3/__https://www.ti.com/lit/ds/symlink/cc3220s.pdf?ts=1729183601364&ref_url=https*253A*252F*252Fwww.ti.com*252Fproduct*252FCC3220S__;JSUlJSU!!BeImMA!6WpAcWxqY_RanDnYahmWZuaMQ774j8wFbT5awgQP7kfEWvYfd-B3789bmWz7SNP717gDl9mGfwKB1mLXiw$)