EE447:INTRODUCTION TO MICROPROCESSORS DESIGNING A TEMPERATURE CONTROLLER USING TM4C123GH6PMI

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1 Introduction

The Temperature Controller System project aims to create a reliable and versatile temperature control system that will utilize the TM4C123G microcontroller. The project involves interpreting the requirements of a complex temperature control task and breaking it down into sub-tasks to ensure efficient implementation. The key objectives of this project are to develop a temperature-sensing mechanism, provide temperature control, and create a user interface for setting temperature limits. To achieve these goals, several utility modules such as a pressure and temperature sensor, a Nokia 5110 LCD screen, the RGB LED on the Tiva board, a resistive heating pad, and a Peltier will be utilized. In addition, the project aims to ensure the compatibility and effective integration of hardware components for seamless cooperation among components. Furthermore, the development of multi-tasking software to control the temperature based on sensor readings and implementing a system that simultaneously handles temperature sensing, control, and user interface interactions is also part of the project. Lastly, serial communication will be introduced and implemented using SPI and I2C protocols for efficient data exchange.

2 Sensing with BMP280

BMP280, a low power digital pressure and temperature sensor, will be utilized for temperature sensing. This sensor should be supplied at most 3.6V. Due to low power requirement, 350μ A on sensing, this sensor can be supplied using 3.3V pin on Tiva launch pad. In addition, it is restricted to use I^2C communication for data receive from the sensor, which requires CSB pin on BMP280 to be connected to VDDIO, or VCC. For commuunication, GPIO A port 0 and 1 will be used for SCL and SDA respectively. In order to achieve proper connection, SDO pin will be connected to VDDIO to get slave adress of 1110111. Figure 1 shows the described connections for BMP280 and the controller.

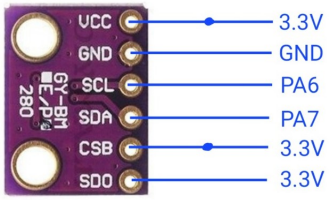

Figure 1: BMP280 Pin connections

3 Temperature Control Mechanism

This unit will control the temperature according to sensor readings and user inputs. Figure 2 shows the flow chart of the algorthm that will realize the temperature control. Initially, after configuration, program starts with demanding user input for high and low tresholds. Based on that tresholds, sensor readings will determine the operation. If the reading is lower than the low treshold, heating pad driving MOSFET gate will be driven to high and heating pad will start to warm up the sensor and RGB LED will turn into red. If the sensor reading is higher than the high treshold, peltier driving MOSFET gate will be driven to high for sensor to start cooling. Otherwise, none of these operations will be done except for turning RGB LED to green. Screen will be updated periodically independent of temperature as well as LED.

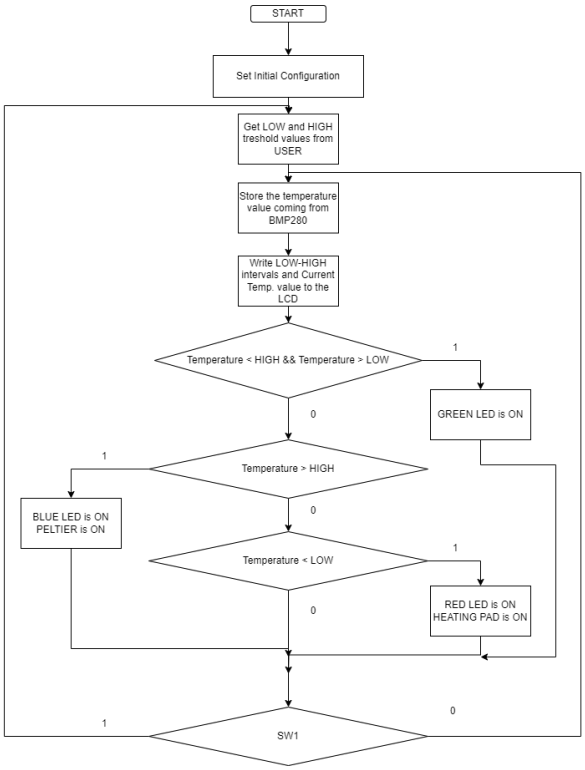

Figure 2: Flowchart

For cooling, a peltier will be used. According to datasheet, it can have 60W power at maximum. Therefore, driving it through Tİva board may cause irreversible damage on board. Therefore, a power MOSFET, exact model is not decided yet, that can pass at least 10A at 20V should be used for safe operation. Its gate trigger signal will be delivered by Tiva board, specifically from PC6 pin. For power supply purpose, a DC supply, if it is not forbidden, or battery will be used.

For heating, a heating pad will be used. According to datasheet, it draws approximately 750mA at 5V. This power, almost for sure, can not be delivered by Tiva board. Therefore, a MOSFET will also be required for heating pad. Similar to peltier, the power will be delivered by power supply and it will be controlled by the board, specifically from PC7 pin.

4 Displaying Outputs

LCD 5110 is a 48 x 84 Dot LCD Graphic display that comes with an internal controller/driver "PCD8544" for easy display and operation control. To power the device, the VCC Pin will be connected to the VBUS pin of the microcontroller, and the GND to the GND pin of the microcontroller. The SCE pin will be used to control the operation of Pin Controllers, while the RESET pin will reset the LCD. The D/C Pin will configure the data formats between Data and Command. For the serial

data line, SDIN pin will be used. For the serial clock line, the SCLK pin will be used. Lastly, we'll use the LED Pin to control the LED (Back Light). Figure 3. shows pin positions of the LCD.

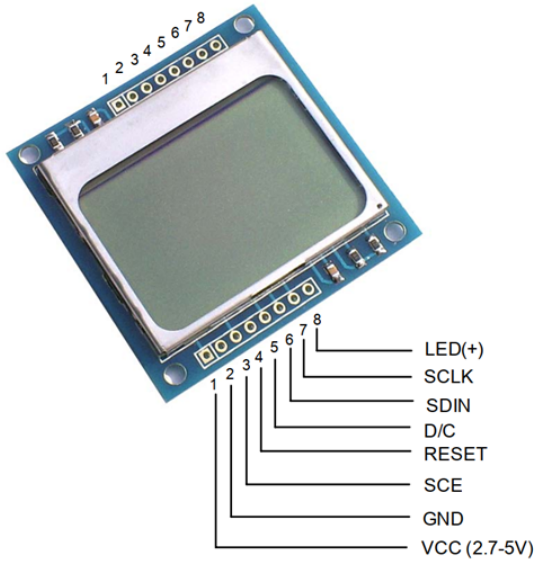

Figure 3: Pin positions of LCD

To initialize the Nokia 5110 LCD screen, the display must first be reset by holding the Reset pin low for 100ms and then setting it high. This action resets the display, preparing it for initialization. The next step is to send initialization commands which involves entering Extended Command Mode and setting H=1 for Extended Command Mode. Then, set V=0 for Horizontal Addressing and configure display parameters such as setting VOP (Operating Voltage). It is needed to determine the value of VLCD at 5 volts. To do this, the following formula will be used taken from the datasheet.

$$5 = 3.06 + (\text{VOP6 to VOP0}) * 0.06$$

$$\text{VOP6 to VOP0} = \frac{5 - 3.06}{0.06} \approx 32$$

this value can be represented as 32 (20H) or 0100000B. Finally, to send the command to the LCD to set the value of VOP, the command 11000000B or C0H will be used. After completing the previous steps, the temperature control value must be set by trying out values between 0x04 and 0x07 to ensure proper operation. Then, the voltage bias value must be set to 0x13. Now, the Extended Command Mode may be exited and returned to the Basic Command Mode by setting H=0. Next,the display should be configured for Normal Mode and ensured that it is set to display data normally. the starting address for displaying data will be determined by setting the cursor start address. Once everything is initialized, the data to be displayed on the LCD screen can be send.

5 Conclusion

In conclusion, the stages of the Temperature Controller System project successfully set the stage for the development of a sophisticated temperature control system. The project, centered around the TM4C123G microcontroller, incorporates key utility modules such as the BMP280 sensor and Nokia 5110 LCD. The outlined objectives, including hardware cooperation and multi-task software development, provide a clear roadmap for the upcoming implementation phase. Considerations such as I2C usage for BMP280 and careful initialization of the Nokia 5110 LCD underscore the importance of adhering to project restrictions. As we move forward, the focus will be on translating these insights into a robust codebase, rigorous testing, and comprehensive documentation, to deliver a reliable and innovative Temperature Controller System capable of maintaining precise temperature control within defined parameters.