Temperature Maintenance

Description: The Temperature Maintenance system is composed of two subsystems: Temperature Monitoring and Heating. Overall, these two subsystems work together to maintain the temperature of the liquid at 26.5 ℃ with a variable range of ± 1.0 ℃

Specifications:

Using the following components:

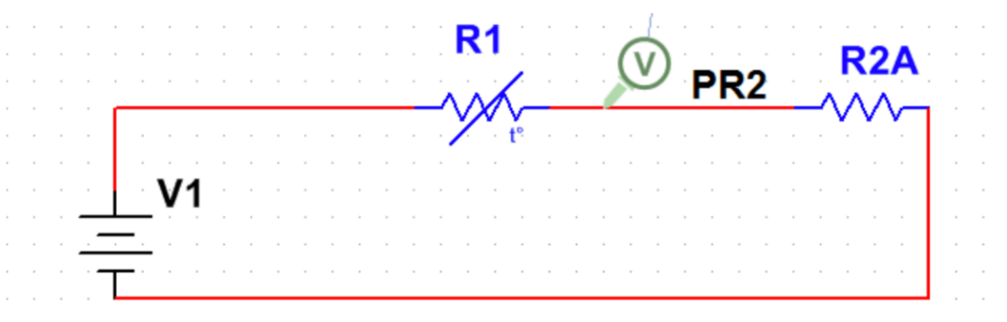
- MSP430G2 + USB Connector Cable
- Energia ver. 0101E0017
- 12V external power supply
- 3Ω 30W immersion heater element
- 10kΩ NTC Thermistor (Farnell #ND06P00103K)

System specifications:

1. Temperature must be read accurately within ± 0.5 ℃
2. Heating element must turn on after the MSP430G2 reads a temperature of less than 26.5. Similarly, the heating element must turn off after reading a temperature of greater than 26.5
3. Liquid temperature must be maintained at ideal temperature ± 1.0 ℃

Temperature Monitoring Subsystem

Circuit The temperature monitoring subsystem reads the temperature using a 10k NTC thermistor. First, the MSP sends 3.3V through a voltage divider composed of a 10k resistor and a 10k NTC Thermistor. The subsequent voltage drop is converted to an ADC Value between 0 and 1024, where ADC corresponds to a value between 0V (0) and 3.3V (1024).

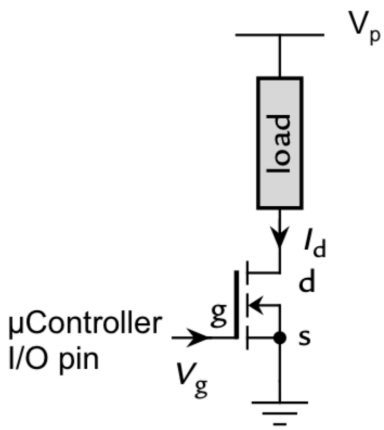


Code The program code (Appendix 4.8) reads in the ADC value and uses the Steinhart-Hart equation (Appendix 4.9), to convert ADC to temperature in Kelvin. The final Celsius temperature is the Kelvin temperature minus 273.15.

As per calibration in the code (Appendix 4.8), the actual ADC ranges from approximately [0, 824] so the raw ADC value is subtracted by 200. After running the new ADC values through the Steinhart-Hart equation and converting to Celsius, there was a steady constant discrepancy of ~17.5℃ below the actual temperature. Therefore, 17.5 is added to the calculated temperature to produce the final, accurate temperature within ± 0.6 ℃.

Heating Subsystem

Circuit The heating subsystem turns the heater element on or off depending on whether the temperature calculated from the thermistor is lower or higher than the ideal temperature. Since the MSP only outputs a maximum of 3.3V, a 12V external power supply is used to power the heater. The 12V must run past a MOSFAT gate, whose resistance is set to either infinite (blocking the 12V power supply to the heater) or zero (allowing the heater to receive power and turn on) depending on the program code (Appendix 4.10)



Code If the sensed temperature is less than the ideal temperature, the MSP program (Appendix 4.9) writes a digital HIGH to the MOSFAT, lowering its resistance to ~0 and turning the heater element on. Conversely, if the sensed temperature is greater than the ideal temperature, the MSP writes a digital LOW to the MOSFAT, raising its resistance to an infinite value and turning the heater element off.

Results

Both subsystems worked well together to read and maintain the liquid temperature to within ± 1.0 ℃ Though there were some initial difficulties with calibration for temperature, the end program reads temperature to within ± 0.5 ℃of accuracy. Similarly, the heater element turns on if the temperature is below ideal and off when the temperature is above ideal.