Control & Automation Engineering Department

KON309E Microcontroller Systems – Final Project

Aim: Implementation of a temperature control system.

The aim of the temperature control application is to set the temperature inside the plastic container to the specified reference values using a heating mechanism.

Materials:

- Heat resistant plastic container with a lid
- 2 x 22Ω Ceramic Resistor (11W)
- 2 x BC238 NPN Transistor
- 2 x IRFZ44N MOSFET
- 12 V 2A Adapter and Adapter Connector
- 6 LEDs (2 red,2 green,2 yellow)
- 1 Potentiometer
- USB to TTL Converter
- LM75A Temperature Sensor
- Resistors (470, 10k, 100k)
- Jumper cables
- Current-supporting single core mounting cable
- Breadboard

Preliminaries:

1. Construct the system with the ceramic resistors and the temperature sensor in the container.
   - Ceramic resistors should be connected in parallel **without touching each other**.
   - **Ceramic resistors and their wires must not touch the container.** Plastic covered parts of current-supporting mounting cables can touch the container.
   - For high currents, you must use current-supporting mounting cables. Do **not** use jumper cables for this purpose.
   - Temperature sensor should be in the container.
   - Rest of the circuit should be outside.
2. Block diagram is given in Figure 1. Controller will be implemented on the microcontroller, actuator is ceramic resistors and sensor is the LM75A temperature sensor.

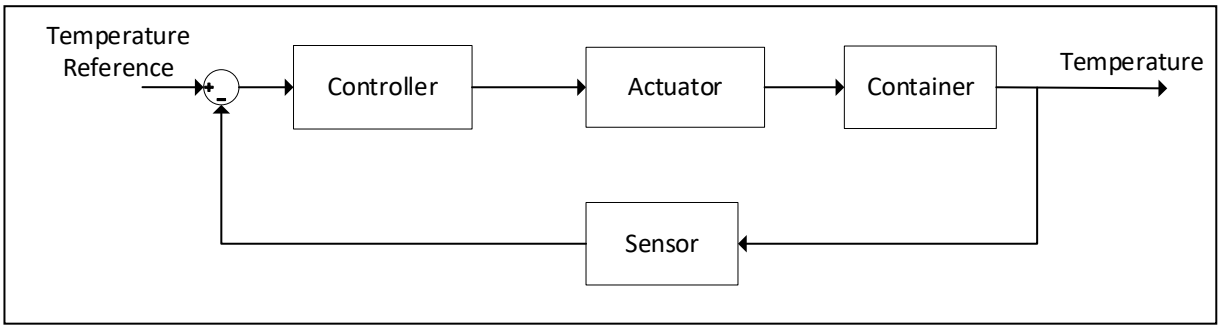

Figure 1: Block diagram of the system

3. You can think of the system as a black box and model it by giving it inputs and observing the output. From the system's step response, you can extract the settling time, %overshoot etc. information and come up with a second order or first order model.
   After obtaining a model, you can design a controller.
   Or you can control the system using conditional statements (if..else) without any model.

   Expectations from the control system:

   - Reaching the reference temperature as soon as possible.
   - Not much exceeding the reference value (overshoot as small as possible).
   - Reaching exactly to the reference temperature value and staying at this temperature as long as the reference is not changed (no steady state error).
   - If there is a disturbance (such as opening the lid of the container), the system output (temperature in the container) will change. In this case, it is necessary to reach the reference temperature value as soon as possible.

- If the reference increases, it is necessary to reach the new reference temperature value as soon as possible.

  Note: Since there is no cooling mechanism, there is nothing you can do if the reference decreases, so do not lower the temperature reference.

4. Circuit diagram for heating mechanism is given in Figure 2.
   - The driver circuit will take its 12V input voltage and ground reference from the socket type adapter. In this sense, the ground reference of the socket type adapter must be shared with the ground references of the microcontroller.

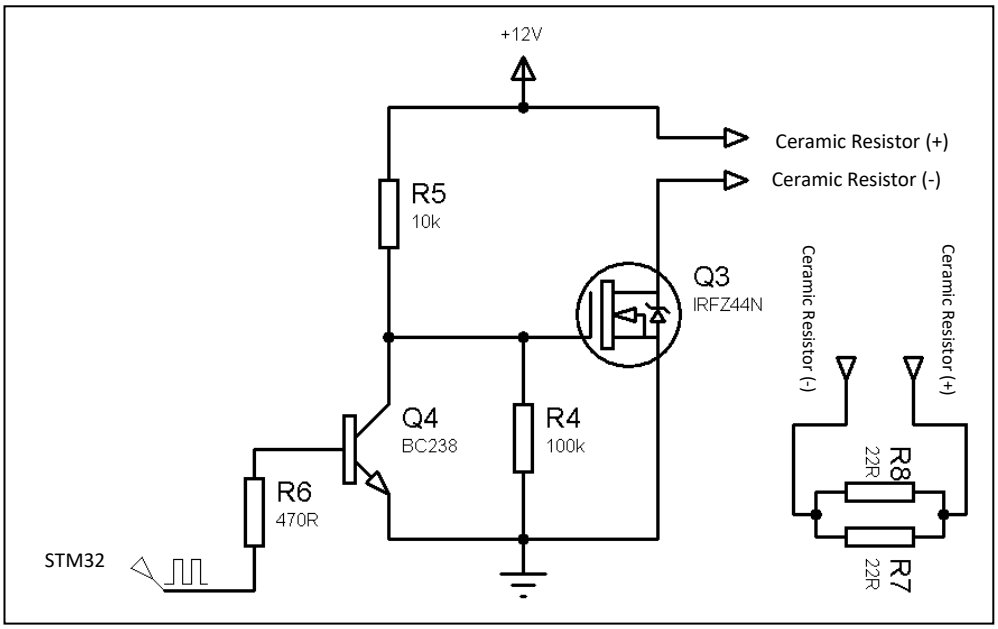

Figure 2: Circuit diagram of heating mechanism

Experimental Procedure:

In this project, participants are expected to achieve tasks given below.

1. Find the limits of your system. Experiment on your system and observe how many degrees you can heat the container without damaging your system.
2. Give the system 3 reference temperatures low, medium and high (low temperature should be higher than room temperature) according to the limits of your system.
   - Give the reference values to your system using a potentiometer.
   - Do not change the reference until the steady state is reached.
   - Once the steady state is reached, give the system some disturbance (e.g. open the lid) and wait for the system output to reach the steady state before changing the reference.

- When low temperature reference is given, green LED will be ON to indicate it. Similarly, when medium and high references are given, yellow and red LEDs will be ON respectively.
- Please keep in mind that these LEDs are different than the overshoot indicating LEDs. You will use these to indicate that the reference you are trying to adjust with the potentiometer is set to the values you determined in your code as low, medium and high temperature references.
- Give the reference temperatures to the system in the order of: $\boldsymbol{low} \rightarrow \boldsymbol{medium} \rightarrow \boldsymbol{high}$.

3. Give the control signal to the system using PWM.
   - Since the circuit has negative gain, the PWM pulse should be set to 0 when the maximum power is to be applied, and the PWM pulse should be set to maximum when zero power is desired.
4. Read the output (temperature in the container) with $0.5°C$ resolution.
5. Use red, yellow and green LEDs to indicate the overshoot of the system output.
   - As long as the output of the system has an overshoot more than 10%, red LED will be ON.
   - As long as the output of the system has an overshoot between 2% to 10%, yellow LED will be ON.
   - As long as the system does not have an overshoot more than 2%, green LED will be ON.
6. Send the output of the system to MATLAB via UART and visualize the data using the code given previously.

Important Note on Safety:

! The circuit you are asked to implement is not in the risky category. **However**, due to the fact that the ceramic resistors **will get hot**, be careful to install them so that **they do not touch the plastic container**.

! The **wires** of the ceramic resistors should **not touch the plastic container**. Only the **plastic covered parts** of current-supporting mounting cable can touch the plastic container.

! Leave enough space between the resistors and the container so that container does not melt. Otherwise, it may burn your hand, cause fire and injuries.

! Ceramic resistors **should not touch each other**. Leave enough space between them when installing the resistors.

! Measures should be taken against electrical shocks in the circuit (such as the use of quality adapters and cables).

! All risks that may occur during the experiment are at your own risk.

Please consider the following steps when preparing your reports.

1. Describe the project **in your own words** and explain what you learned.
2. Add your codes as screen shots.
   - Don't forget to comment your codes **in your own words** explaining how each line of code works.
3. Explain how you implemented the temperature control system.
4. Explain your model and control solution.
5. Include the MATLAB graphics (use plot() function of MATLAB to plot all data).
6. Add a photo of your whole system.
7. Take a video of your system while running, upload it on YouTube, Drive, etc. and include the link on your report.