Milestone 1 Report

Z. Smoot, D. Fisher, and N. Papas
Rowan University

December 8, 2019

1 Design Overview

This project is a continuation of the skills important to this class. This project focuses on the ability to have a fully functioning closed loop system. A 10 ohm power resistor is used to pull a constant 500mA from the voltage regulator. Since the regulator is linear it dissipates power internally generating heat. A temperature sensor is attached to the regulator and the output is fed directly to the MCU. Based on the output voltage a temperature can be read by performing a simple mathematical calculation. The goal is to input a desired temperature over UART and the system will react accordingly to achieve, and hold that temperature.

1.1 Block Diagram

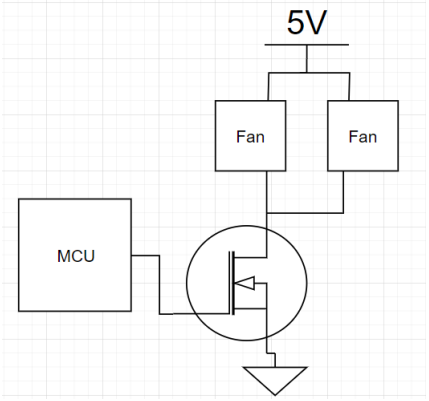

Figure 1: Fan Control Circuit

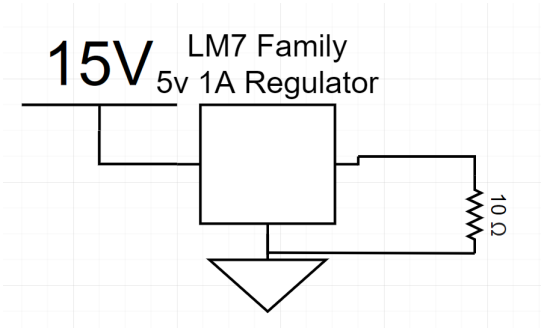

Figure 2: Voltage Regulator Circuit

2 Design Features

There are two subsystems that makeup the entire closed loop. The ADC and the closed loop.

2.1 ADC

This is a very rudimentary system temperature monitoring system. A temperature sensor was selected that varies it's output voltage as temperature rises and falls. Specifically the output voltage rises 10mV per degrees Celsius. A reference voltage is 1.00 V at 50 degrees C. The output voltage reads directly into an ADC port on the MSP430G2553, some simple mathematical calculations are done and with that value to determine the current temperature and report it to the system.

2.2 Closed Loop

The closed loop system in simplest form is the entire system. It must accept the input from the user over UART, and based on the current temperature reading from the sensor it will generate a PWM signal for the fans to reach the desired temperature.

3 Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Communication	UART	The MSP430 will output the temperature sensor reading in Celsius every time the data is ready. You can also send an integer to the processor, and that will become the target temperature it attempts to stabilize the system at.
Temperature Sensor	Range and Operation	The temperature sensor was the TMP36GT9Z and can measure from 125C to -50C. The analog voltage output of the sensor is the temperature reading, where 50C is 1 volt, and every degree is 10mV.
Fans	Operation and Placement	The fans operate on a 5 volt pwm signal, so as the duty cycle increases, the fans spin faster. This fans slowly increase and decrease in speed till the system rests at the desired temperature. These fans should be places either blowing in the same direction on either side of the regulator, or at a 45-90 degree angle with each other facing the regulator.

4 System Description

This system maintains the temperature of a voltage regulator. A temperature sensor is attached to the heat sink plate of a voltage regulator and connected to the MSP430. The MSP430 reads the sensor, and adjusts two PWM fans accordingly to maintain an desired temperature. It does this by applying the PWM signal to the gate of a MOSFET, which when connected grounds the fans. The system also communicates through the USB port using serial communications. The temperature in Celsius is sent out every time the sensor is read, and it receives the desired temperature to keep the voltage regulator at, all through a terminal interface on a computer connected to the MSP430.

4.1 Detailed Block Diagram

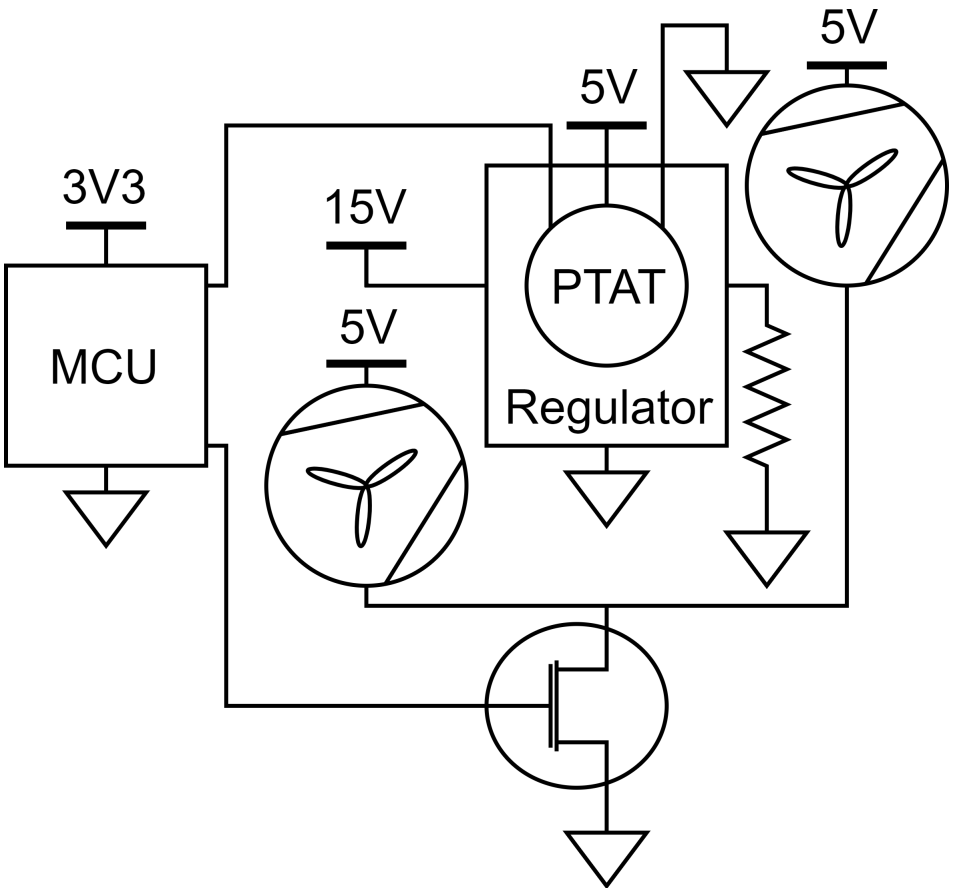

Figure 3: Block Diagram of System

4.2 Highlighted Devices

- MSP430G2553, the microprocessor used to read the temperature sensor and controls the fans
- MSP430G2553 Launchpad, holds microprocessor and provides additional protections and additional input and output elements
- Fans, the PWM fans used to cool the voltage regulator
- TMP36GT9Z, the temperature sensor which outputs an analog voltage that represents the temperature in Celsius

4.3 MSP430G2553 Processor and Launchpad

The MSP430G2553 is a 16-bit low power micro controller. It has an operating voltage of 1.8V-3.6V, 16 I/O ports, and a max clock frequency of 16 MHz. This device was used to read the temperature sensor and control the fans. It was chosen instead of the MSP430FR6989 because the G2 is more simplistic. The FR6989 has many more functionalities adding more delay to the system. The G2 was more than capable for this project and it would be more efficient.

4.4 TMP36GT9Z Temperature Sensor

We used a temperature sensor to monitor the voltage regulator. The sensor outputs an analog voltage based on the temperature, ranging from 125 C to -50 C, where 1 volt is 50 C and every degree is a change of 10mV.

4.5 Fans

There are two 3.3v fans to cool the voltage regulator. They are controlled by a pwm signal to the input voltage. This is controlled with MOSFET whose gate is connected to the microprocessor. The duty cycle is the percent of full power the fan is running at.

5 SYSTEM DESIGN THEORY

5.1 Uart Communications

The MSP430G2553 will output the temperature over USB every half a second. The output is a signed integer in Celsius. The MSP430 also receives a signed integer over USB that is the desired temperature for the voltage regulator. If the regulator goes over the desired temperature, the fans turn on to cool it.

5.2 PWM Fan Control

As the MSP430 family functions at logic 3V3, and the fans require 5V an interface must be designed. An N-channel MOSFET was used as a low side switch where the gate receives the PWM signal directly from the MCU, to allow a 5V system to be controlled with logic 3V3.

6 Getting Started/How to use the device

In order to use the device, the temperature sensor and MOSFET gate must be connected to the launchpad. The output of the temperature sensor sensor goes to P1.0 of the launchpad, and it's Vcc and gnd pins connect to 5V and gnd on the launchpad.The gate of the MOSFET that switches the fans goes to P2.1 of the launchpad.

The system is designed to cool and heat a load comparable to a linear 5V regulator pushing 0.5A; however the cooling capacity can be easily changed by swapping out the fans with no other changes necessary.

7 Getting Started Software/Firmware

Communications with the device are performed over UART via either the USB port or the pins P1.1 (TX) and P1.2 (RX). A simple terminal interface such as PuTTY or RealTerm can be used to communicate with the system. The device transmits the current temperature as a signed 8 bit integer every half second, with a range of -50C to 100C. When the device receives a byte, it will attempt to regulate the system to the desired temperature. By default, when the device is booted, it will have a goal temperature of 0C.

8 Test Setup

The general layout of the test setup can be seen in the detailed block diagram in section 4.1. The fans used were quite small with a diameter of only about an inch. The regulator used was a L7805CV3 and was pushing 0.5A through a 10 ohm power resistor. The NMOS used was a 2N7000, and the temperature sensor was a TMP36GT9Z. See The block diagram in section 1.1 and section 6 for how to setup the circuit. For testing purposes, a breadboard is suficient, however, it requires a seperate method to secure the fans.