Milestone 2: Closed Loop Temperature Controlling System

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1 Design Overview

The closed loop system uses three different parts, the MSP430 micro-controller, temperature sensor, and a fan. In order to create heat a voltage regulator was used and the temperature sensor read the heat coming from it. The MSP430 converted the analog reading to digital. The digital values are then converted back to analog in code to adjust the fan speed using PWM to cool the heat sensor. RealTerm was used to set and read values from the temperature sensor. The system created held the value of the input temperature within 3 degrees.

1.1 Design Features

These are the design features:

- MSP430F5529
- UART serial connection operating at 9600 BAUD
- PTAT Temperature Sensing
- PWM Fan Control
- ADC Conversion

1.2 Featured Applications

Possible features include:

- Room temperature control
- Computer Fan
- Temperature Monitoring
- Error Detection for Control Loops

1.3 Design Resources

- Datasheet: http://www.ti.com/product/MSP430F5529
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1.4 Block Diagram

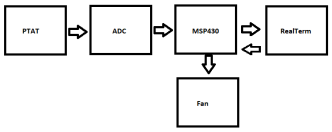

Figure 1: Block Diagram

1.5 Board Image

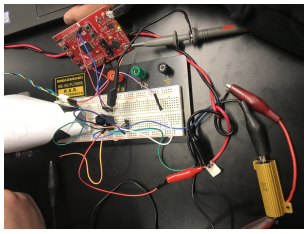

Figure 2: Board Connections

2 Key System Specifications

3 System Description

The closed loop system reads the temperature and adjusts the fan speed to bring the sensor to the temperature that was set. The voltage regulator heats up when voltage is applied while the PTAT (temperature sensor) reads the temperature. The PTAT's voltage is a function of the temperature that is applied. The voltage then passes through the ADC and is converted to a digital value that is stored in a register. The

PARAMETER	SPECIFICATIONS	DETAILS
PTAT	LM60 CIZ 2.7V	Temperature Sensor
Micro-Controller	MSP430F5529	Micro-Conctroller used
Voltage Regulator	5V 1A	Used for ADC
Fan	12V	Cooling down parts

digital value is converted back to analog so that it can find the temperature being read. The equations below were used to find temperature.

$$VoltageADC = \frac{(ADC12MEMO * 3.3)}{4095} \tag{1}$$

$$Temp = -((330000 - (262460 * VoltageADC))/(2729 * VoltageADC)) \tag{2}$$

Constants vary for different temperature ranges in second equation. The temperature value calculated is stored and displayed as the current temperature on the terminal. Two timer capture/compare registers (TAxCCRx) TA0CCR0 and TA0CCR1. TA0CCR0 is used to set the limit to the PWM to 255 and TA0CCR1 is used to control the fan speed.Using the OUTMOD function of Timer A, the GPIO pin controlling fan speed resets and sets. This allows for the micro-controller to control the duty cycle of the pin and the PWM. TA0CCR1 will increase PWM and the fan speed while decrementing CCR1 decreases the fan speed. The fan can correct itself when the temperature goes over the set temperature or below the set temperature.

3.1 Detailed Block Diagram

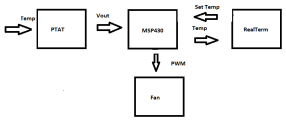

Figure 3: Detailed Block Diagram

3.2 Highlighted Devices

- MSP430F5529- is a micro controller. In this lab the controller's timer module, GPIO pins, ADC conversion, and UART mode were used. CCR registers or capture/compare registers values set or reset the GPIO pins based on Timer A0. The ADC converted analog values to digital values so that they could be used. UART mode transferred data through the RX and TX pins.

- PTAT- is a sensor that reads temperature of the voltage regulator. The PTAT outputs a voltage value that can be changed to a temperature value through formulas in the code. The equation for the PTAT voltage output is

$$Vout = 6.25\frac{mV}{C} * Temp(C) + 424mV \tag{3}$$

- Voltage Regulator- was used as a heat source. A greater voltage was applied to the 5V regulator and it regulated it. 12V were applied which made it heat up.
- Fan- was a simple fan. The fan had 4 wires, 3 of which were used: ground, PWM, and power. The fan needs a 12V source.

4 SYSTEM DESIGN THEORY

4.1 Design Requirement

The closed loop system cools a voltage regulator using different fan speeds. The fan need a voltage of 12V and the voltage regulator needs at least 5V. The draw current cannot be more than 1A since that is the max output of the regulator.

5 Getting Started/How to use the device

The programs needed for the project are Code Composer and Realterm. Code Composer allows for the programming of the MSP430 board. Realterm is a program that reads and writes byted of information to the micro processor. A circuit on and off the board was built. For the off board circuit the following materials were used: breadboard, jumpers, power resistor (6 ohms), DC power supply, DMM probes, PTAT, and voltage regulator. The power is used as a load for the regulator.

6 Getting Started Software/Firmware

Code composer allows to run a program with a micro processor. In CCS the program can be debugged. This programs the micro controller with the code.

In RealTerm the baud rate must be set to 9600 and the port of your computer must be set. Then click open port. To send temperature type in the target temperature in Celsius. The number must be an integer.

6.1 Communicating with the Device

RealTerm communicates with the MSP430F5529 by sending bytes of data. This is done by having the same baud rate and selecting the correct COM port through Device

Manager. In Device Manager a port should include ”UART”. This is the correct COM port.

As discussed before the target temperature can be sent and the current temperature is received constantly.

7 Test Setup

To test the data an oscilloscope was connected. The BNC oscilloscope probes were connected to ground and point of testing which was the PWM. The probes were connected to ground and pin 1.3.