Milestone 2

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1 Design Overview

Milestone 2 is a program executable on the MSP430F5529 development board that functions as a temperature regulation system. The design is a closed loop system using the MSP430F5529 to control the speed of the fan. This is accomplished by using hardware PWM (Pulse-Width Modulation). The speed of the fan is controlled by using the ADC12 (12 bit Analog to Digital Converter) after taking in the voltage of through a voltage divider which contains a thermistor and a resistor. The PWM will adjust itself due to the thermistor's characteristic of dropping resistance as the temperature increases. The voltage across the thermistor will correlate to a certain temperature in Celsius as the data is sent into the F5529. The amount of oscillation is controlled through the method of PID control (Proportional, Integral, Derivative).

1.1 Design Features

- Regulates temperature between 24°C and 100°C
- USB controllable
- programmable temperature through Realterm
- Real-time Temperature update
- Accuracy within $\pm$ 3°C

1.2 Featured Applications

- Cooling Systems
- Temperature Regulation

1.3 Design Resources

- GitHub
- Thermistor Datasheet
- MSP430 Family User Guide
- MSP430F5529 Datasheet

1.4 Block Diagram

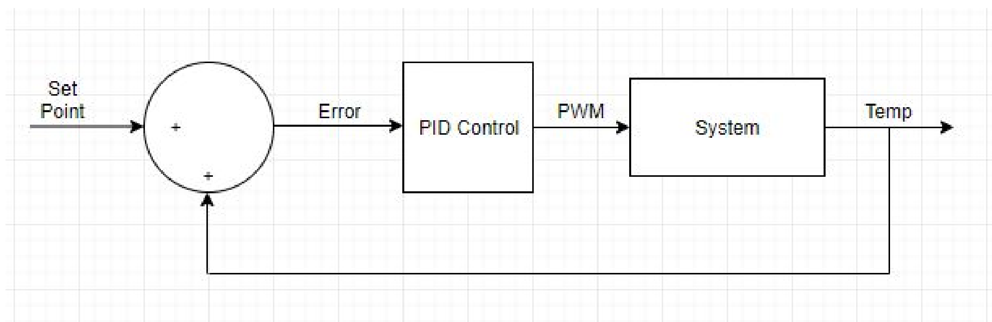

Figure 1: High Level Schematic of System Control Loop

1.5 Board Image

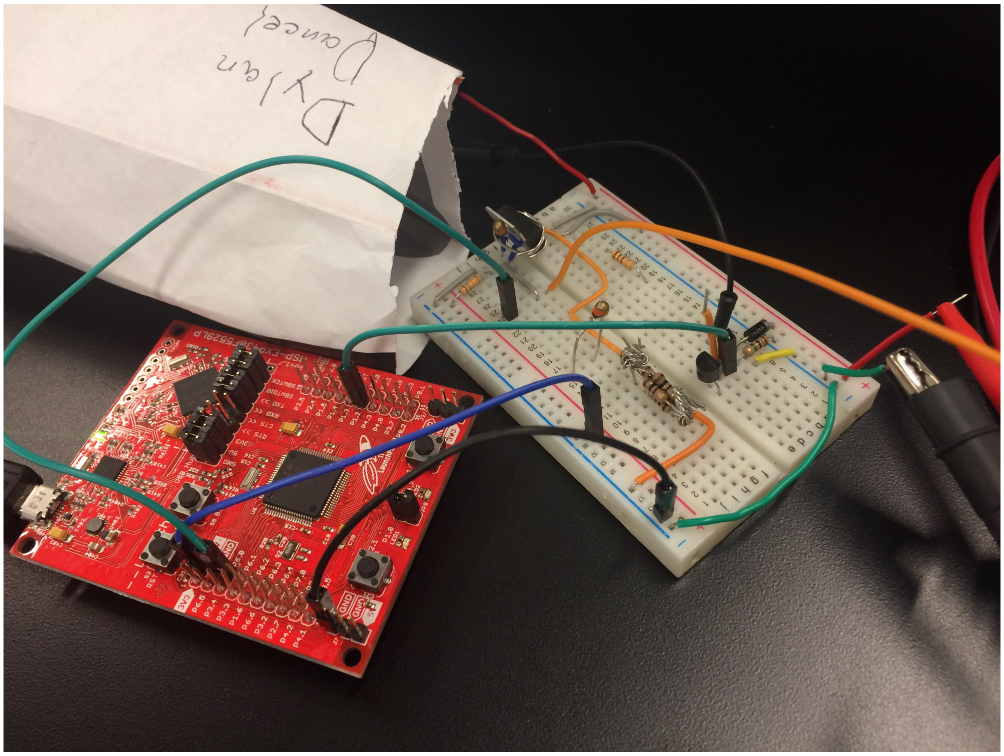

Figure 2: Circuit Setup

2 Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Baud Rate	9600	Baud Rate used to communicate with the MSP430F5529
Timer A0	16 bit	16 bit timer that has 5 capture compare registers
SMCLK	1MHz	1MHz clock that is active in low power mode 0 and 1
ADC12	12-bit	Quantizes analog signal to binary values

3 System Description

The desired outcome of the system is to control the temperature of the LM7805 Voltage regulator by driving a fan with a PWM signal.

3.1 Detailed Block Diagram

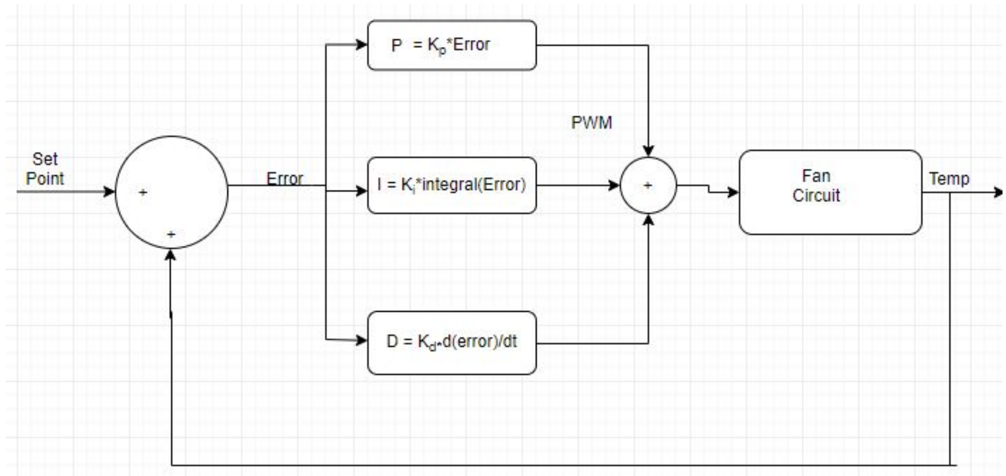

Figure 3: Detailed Schematic of System Control Loop

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3.2 Highlighted Devices

- MSP430F5529
- 12 V, 500 mA brushless Fan
- LM7805 5 V, 1 A voltage regulator
- 10 kΩ Thermistor

3.3 MSP430F5529

The MSP430F5529 is a Texas Instrument processor with a TimerA0 that contains 5 capture compare registers and an analog-to-digital converter. Out of the 5 registers that could be used only two of the registers were needed. These capture compare registers were used as PWM to drive a fan.

4 SYSTEM DESIGN THEORY

4.1 Design Requirement 1

The first design requirement is to control the temperature of the LM7805 within $\pm$ 3°C by driving a fan. The desired temperature is sent to the MSP430 by the user through

UART. The temperature of the thermistor is calculated, and using the temperature difference and the previous temperature difference, the MSP430 calculates a PWM to drive the fan.

4.2 Design Requirement 2

The second design requirement is to regulate temperature with disturbances applied to it. The disturbance tested was lowering 12 V fan supply voltage down to 9 V. The system still works at the lowered voltage.

5 Getting Started/How to use the device

To power the device, a USB-to-micro-USB must connect the MSP430F5529 development board to a computer with the ”Realterm” application. All other connections use MSP430F5529 pins. Figure 5 shows the detailed connections for the off-board circuit needed to operate, where V_{cc} is 12V.

6 Getting Started Software/Firmware

The user must be aware of the information they send into the MSP430F5529 through RealTerm. Only values between 30°C and 80°C are values the system can support. Values lower than 30°C will not be reached, and the fan will run at full power indefinitely. Values above 80°C will not be reached, and the fan will be off indefinitely.

6.1 Device Specific Information

The voltage across the thermistor must connect pin P6.0 for analog-to-digital conversion. The left leg of the LM7805 must be connected the 12 V rail. The right leg must be connected to the the 5 V rail. The center leg must be connected to a resistor network, which connects to ground. The resistor network consists of six 100 Ω resistors in parallel. This network is necessary because it increases the the power dissipation.

7 Test Setup

The test setup is started by executing RealTerm and configuring the display settings to the uint8 and Half Duplex setting. Configuring RealTerm in this way allows the user to see the transmitted and received bytes on the screen that represent the target temperature and the current temperature. Next the COM port must be identified and adjusted accordingly in the port settings. The COM port is unique to each device and computer. The Windows Device Manager shows the particular COM port of the MSP430 on the users computer. Navigate to ports (COM LPT), then to MSP Application UART1 (COMn). Finally, the Baud Rate must be set to 9600.

7.1 Test Data

The target temperature data is sent from the user to the processor is represented by the green decimal values. If the first value sent is 45 then the fan will remain off until the achieved temperature of 45. Once 45 is reached the PWM signal coming from pin 1.2 will turn on the fan and try to keep the fan at a consistent 45 at all times. Then if a new target temperature is set the fan will turn off or turn accordingly to reach the desired temperature. A temperature cooler than 45 will tell the fan to put a stronger PWM signal to cool the LM7805 and a hotter temperature will send a 0 PWM signal to let the LM7805 heat up.

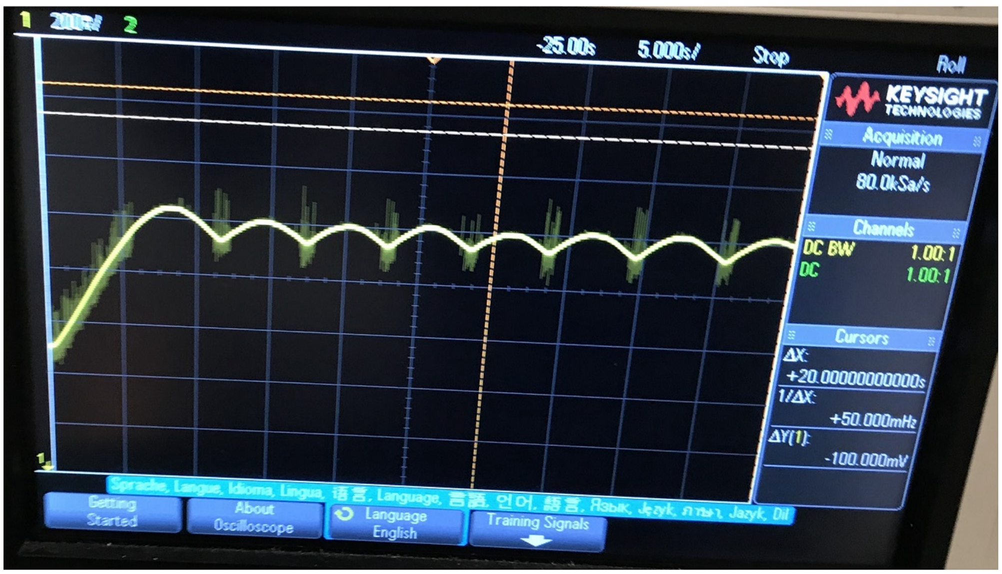

Figure 4: Transition of PWM signal from 45° to 60°.

8 Design Files

8.1 Schematics

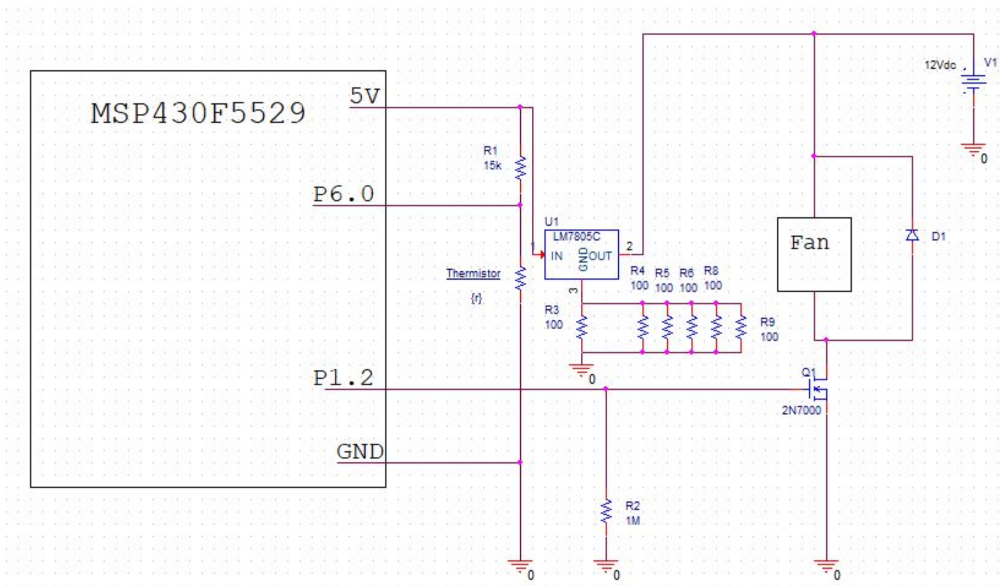

Figure 5: Circuit of Closed Loop System