Milestone 2

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1 Design Overview

Through this milestone a temperature control system is built using three main structures a MSP430 micro-controller, fan, and a temperature control sensor. All three of these combined make a functioning closed loop system which is the main objective of this lab. The temperature sensor would be reading a voltage regulator that is solely used to produce heat. The temperature control will read the thermistor values and set the fan at an appropriate speed based off what the temperature reads. The fan will turn off when the value is reached or is less than the target value.

1.1 Design Features

- Able to cool components to a specific temperature such as 30C
- Current temperature in Celsius of the component is displayed through UART
- Bang Bang Control for adjusting the temperature
- Turns off the fan to reduce power consumption

1.2 Featured Applications

Even though the design purpose currently is for cooling a voltage regulator but the application can be applied to other system that need potential cooling.
Featured Application that can take advantage of cooling are:

- PC hardware
- Temperature control in a room
- Server Rooms
- Heaters

1.3 Design Resources

The code for this project can be found at this following GitHub Repository.
Click Here for Repository

1.4 Block Diagram

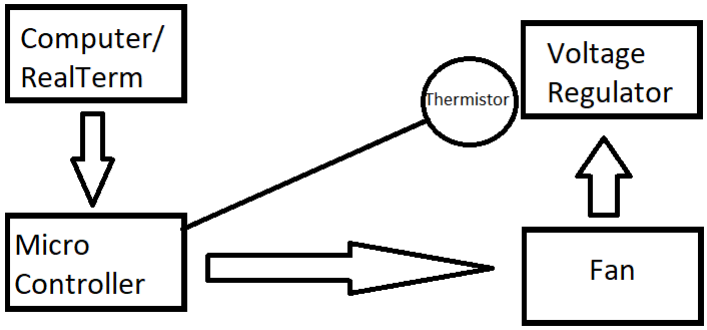

Figure 1: Block Diagram

1.5 Board Image

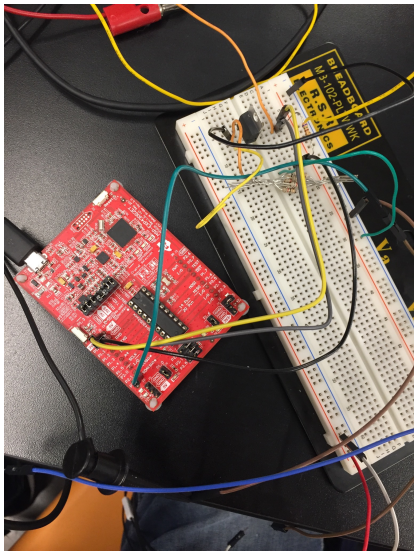

Figure 2: Board Setup

2 Key System Specifications

OBJECT	SPECIFICATION	DETAILS
Micro-Controller	MSP430G2556	Used to process and manage the data
Voltage Regulator	5V 1A	used for the ADC
Cooler Master Fan	12V 2.5A	Cools the voltage Regulator
Temperature	15C - 100C	Temperature range of the program

3 System Description

In this closed loop the goal is to regulate the max temperature by using the fan to reduce the heat on the voltage regulator. The temperature is read by the thermistor which than gives a voltage out that is sent over to the MSP430 to be processed to give a temperature. After calculating the value a signal is sent to the PWM of the fan which varies depending on how big of a difference there is in temperature among the desired and actual value. This information that is processed by the micro-processor is also sent over UART to display the current temperature.

3.1 Detailed Block Diagram

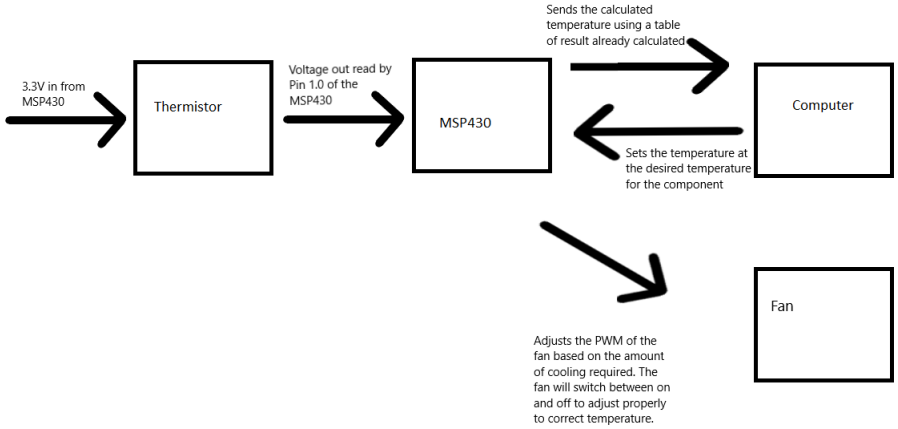

Figure 3: Block Diagram

3.2 Highlighted Devices

1. **MSP430G2556** - This is a micro-controller used mainly for the the processing of the information. An ADC converter isn't needed as it was preemptively calculated and inputted as a table into the code. However the Capture Compare Register (CCR), timer module, and GPIO pins are needed. CCR will perform an

action every time it reaches the value that is stored. UART mode use a receiving line(RX) and a transmitting line (TX) these are used to communicate data with the processor and the computer.

2. **Thermistor** - Used to read the current temperature of the voltage regulator in conjunction with a 6.5k ohm resistor. The voltage out the thermistor is used in the Stein Hart Equation to form an approximation.

3. **Voltage Regulator** - The current heat source was created by applying a 12V signal to the input and using 10 12 ohm resistors in parallel. The thermistor is taped directly to the base of the regulator to get an accurate reading.

4. **CoolerMaster Fan** - Basic CPU fan that has a 4 pin out configuration which is red(12V Power), yellow(RPM Signal Echo), black(Ground), and blue(PWM Signal). For the purpose of this configuration the yellow cable can be ignored.

4 SYSTEM DESIGN THEORY

4.1 Design Requirement 1

The requirement is to make the base circuit for the system which is setting the voltage of the thermistor to 3.3v and voltage out of thermistor to Pin 1.0. As the code that allows you to receive and calculate temperature is provided in the GitHub Repository. Apart from the circuit within the code a Bang Bang controller is implemented which turns off the fan when the temperature is within range and when the temperature moves out of range it turns the fan on. This control still allows the temperature of the ADC to be within 1° C of the set temperature.

5 Getting Started/How to use the device

The following is need for initial setup:

1. RealTerm
2. Code Composer Studio
3. BreadBoard
4. Variable Power Supply
5. DMM Probes
6. Power Resistor
7. Voltage Regulator
8. Thermistor

9. Jumpers
10. MSP430 Micro-Processor

This list contains the software needed to communicate with the micro-processor. RealTerm is used to communicate using the RX and TX line while Code Composer Studio(CCS) is used for loading the program onto the micro-processor. CCS also has features such as debugging the program and Simulink. The rest of equipment is used for setting up the physical systems and testing the system to ensure it is functioning properly. Using a Oscilloscope to test the voltages would be preferable but a multimeter will also give a similar result.

5.1 Communicating with the Device

Using RealTerm is the main way of communicating with the MSP430 as it is possible to send multiple bytes of data at one time. The baud rate should be set to 9600 and the COM port should be connected to the COM port at which you connected the device to the computer. The COM port should be found in device manager under the ports section.

6 Test Setup

To test this setup it is possible to use the debugging tool in CCS to see how the code would run. Realterm can also help show the values of what the micro-processor is receiving. If the physical system is setup it is also possible to measure the voltage out of thermistor to see the oscillation on the voltage which can be viewed through an oscilloscope or a mulit-meter.

6.1 Data for calculation

Below are the tables that are used to determine the temperature and the different ADC values.

Thermister (R)	Temperature (°C)	Voltage (V)	ADC (HEX)
15989.09831	15	0.1478574266	064
15244.38418	16	0.1547418127	069
14539.13781	17	0.1618796319	06E
13871.03297	18	0.1692766855	073
13237.89358	19	0.1769387211	078
12637.68321	20	0.1848714196	07E
12068.49537	21	0.1930803833	083
11528.54456	22	0.2015711218	089
11016.15789	23	0.2103490387	08F
10529.76744	24	0.2194194174	095
10067.9031	25	0.228787407	09C
9629.185965	26	0.2384580071	0A2
9212.32217	27	0.2484360531	0A9
8816.097237	28	0.2587262014	0B0
8439.370777	29	0.269332913	0B7
8081.071585	30	0.2802604391	0BF
7740.193088	31	0.2915128047	0C6
7415.789116	32	0.3030937935	0CE
7106.96996	33	0.3150069318	0D6
6812.898721	34	0.3272554732	0DF
6532.787903	35	0.3398423836	0E7
6265.896245	36	0.3527703252	0F0
6011.525774	37	0.3660416425	0F9
5769.019056	38	0.3796583472	102
5537.75664	39	0.3936221043	10C
5317.154671	40	0.4079342186	116
5106.662668	41	0.4225956215	120
4905.761446	42	0.4376068587	12A
4713.961186	43	0.4529680786	134
4530.799625	44	0.4686790213	13F
4355.84037	45	0.4847390088	14A

4188.671325	46	0.5011469355	155
4028.903215	47	0.5179012607	161
3876.168214	48	0.5350000012	16C
3730.118654	49	0.5524407256	178
3590.425827	50	0.5702205494	184
3456.778857	51	0.5883361317	191
3328.883645	52	0.606783673	19D
3206.461884	53	0.6255589142	1AA
3089.250133	54	0.6446571372	1B7
2976.998956	55	0.664073167	1C4
2869.472106	56	0.6838013743	1D2
2766.445766	57	0.7038356809	1E0
2667.707837	58	0.7241695657	1ED
2573.057268	59	0.7447960719	1FB
2482.303429	60	0.7657078163	20A
2395.26552	61	0.7868969995	218
2311.772019	62	0.808355418	227
2231.660164	63	0.8300744766	236
2154.775461	64	0.8520452038	245
2080.97123	65	0.8742582663	254
2010.10817	66	0.8967039869	263
1942.053952	67	0.9193723617	273
1876.682845	68	0.9422530795	282
1813.87535	69	0.9653355419	292
1753.517863	70	0.9886088837	2A2
1695.502362	71	1.012061995	2B2
1639.726101	72	1.035683545	2C2
1586.091333	73	1.059462002	2D2
1534.505043	74	1.083385658	2E2
1484.878695	75	1.107442657	2F3
1437.127998	76	1.131621012	303

1391.172686	77	1.155908636	314
1346.936303	78	1.180293363	324
1304.346005	79	1.204762972	335
1263.332381	80	1.229305217	346
1223.829264	81	1.253907845	357
1185.773576	82	1.278558624	367
1149.105164	83	1.303245364	378
1113.766651	84	1.327955943	389
1079.7033	85	1.352678327	39A
1046.862878	86	1.377400597	3AB
1015.195529	87	1.402110961	3BC
984.6536599	88	1.426797785	3CD
955.191824	89	1.451449605	3DD
926.7666166	90	1.47605515	3EE