A System Approach to Temperature Monitor and Control

DC/AC Circuits

Student Name: ____

Acknowledgements

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Purpose

The purpose of this lab is to apply voltage divider in thermal management system and to observe the relationship between temperature, resistor, and voltage.

Systems Rationale

In a controlled system often times, technicians need to have a sense of feedback to provide appropriate control output. A voltage divider is often used to set up a voltage level from a sensor that signal in conjunction with a control circuit to provide the desired output.

Prerequisite Knowledge & Skills

- Define Ohm's law.
- Create a breadboard circuit.
- Given a digital multimeter (DMM), measure voltage and resistance.
- Calculate a voltage divider.

Student Learning Outcomes

Relevant skill (S) student learning outcomes include:

S1. In the form of a graph, illustrate the relationship between temperature with a resistor and voltage.

S2. Create and install an electronic switch at the system level.

S3. Create and install a comparator circuit at the system level.

S4. Build and test a temperature monitoring and control circuit.

S5. Verify the circuit meets a functional requirement.

S6. Given a system malfunction with causes including connections, and/or component quality, and/or operator error, resolve the problem.

Process Overview

Consider the following temperature monitor and control system block diagram, shown in figure 1 below:

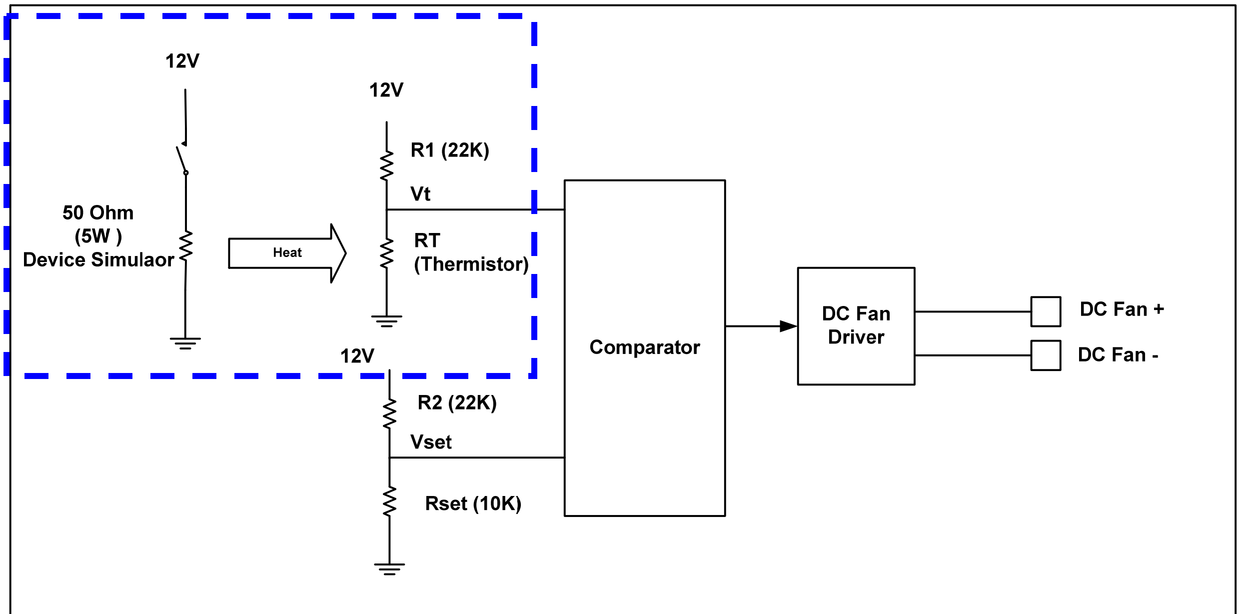


Figure 1: Temperature Monitor & Control System Block Diagram

Assume you just purchased a $200 electronic device (simulated by a 50 Ohm resistor) as shown above. You want to protect your device from burning out. To protect this device, you purchase a Thermistor as a temperature sensor feedback to a comparator circuit. When the device temperature is GREATER than the preset value, the DC fan will turn on. Otherwise, it stays off.

Time Needed

Lab Performance:

It should take you approximately 2-3 hours to work through the entire lab, complete the data sheet, and prepare the presentation, in groups of 2-3 students.

Equipment & Supplies

Item	Quantity
Thermistor	1
10K Resistors	5
Prototype breadboard	1
LM393 comparator	1
50 Ω resistors (5 W)	1
IRF510 Power MosFET	1
12 volt Power supply	1
12 volt DC Fan	1
Precut wires (22 gauge)	1
Timer (watch)	1
Digital thermometer	1
Computer with presentation software	1

Special Safety Requirements

No serious hazards are involved in this laboratory experiment, but be careful to connect the components with the proper polarity to avoid equipment damage.

Lab Preparation

- Review a Voltage Divider, shown in figure 2 below. Calculate voltage based on given resistors values.

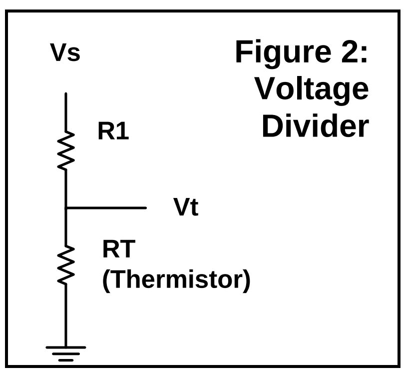


Figure 2: Voltage Divider

Sample calculation:
Given: Vs = 12 V, R1 = 22 K Ohm, RT = 10 K Ohm, what is the voltage at Vt?

- Learn how a comparator interface works at system level, shown in figure 3 below.

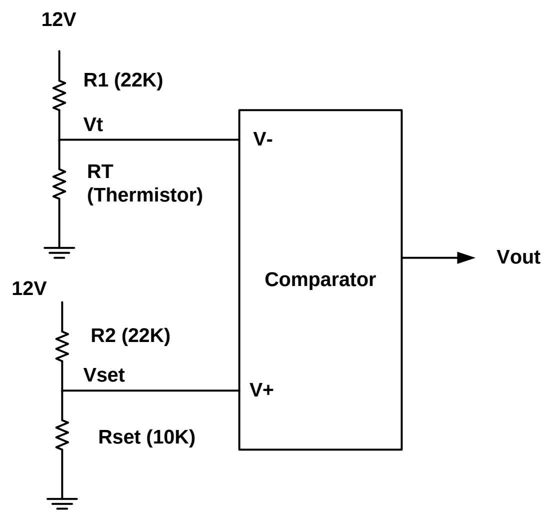


Figure 3: Comparator Interface

A comparator is a device that provides the following function:

a) When the V- input voltage is less than V+ input voltage, the output voltage Vout = 12 V

b) When the V- input voltage is greater than V+ input voltage, the output voltage Vout = 0 V

- Learn how DC Fan Driver works at system interface level, shown in figure 4 below.

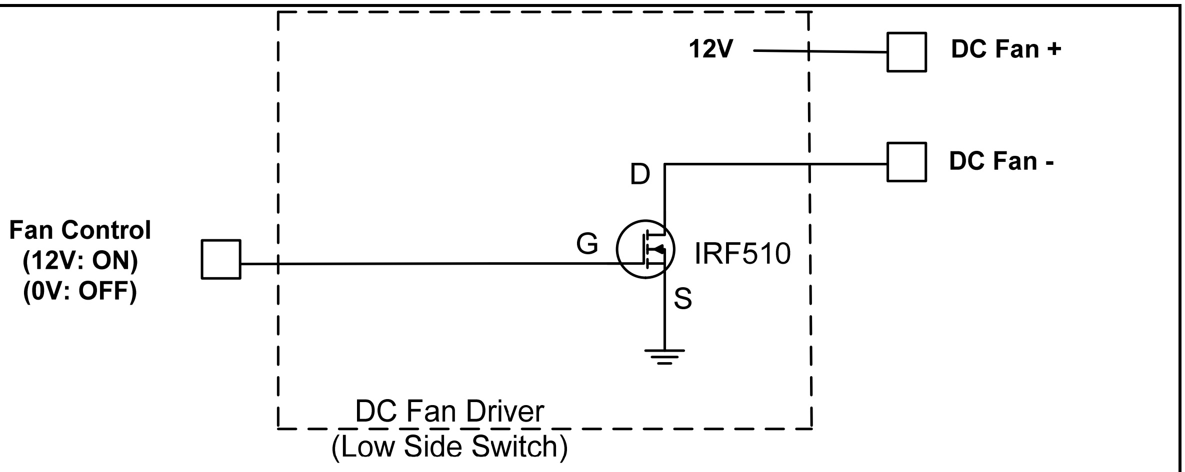


Figure 4: DC Fan Driver

A DC fan driver is an Electronic Switch that provides the following function:

a) When the Fan Control input voltage is 12 V, the electronic switch closes D to ground, the result is the DC Fan is ON.

b) When the Fan Control input voltage is 0 V, the electronic switch is open, the result is the DC Fan is OFF.

(Note: since this electronic switch is connected to ground, it is often referred as Low Side Switch)

- If printed circuit board is not available, build the circuit on a prototype breadboard, as shown in Appendix A.

Introduction

When an electronic device operates, it generates heat. Most electronic devices have the upper temperature limit at 85 deg C. To keep the device working reliably, you need to keep its temperature at certain limit.

In this lab, you will apply a Thermistor (a resistor with resistance changes as a function of temperature) to monitor a device temperature.

A 50 Ω (10W) resistor is used to simulate heat dissipation of an electronic device, as the device is on, the temperature will rise and the resistance of the Thermistor will change.

You will set up Thermistor in a voltage divider to interface with a Comparator circuit, the output of the comparator will drive an electronic switch to activate a DC Fan. When the device temperature exceeds a preset limit, the DC Fan will be turned ON to keep the device cool; when the device temperature is less than a preset limit, the DC Fan will be turned off to conserve energy.

Task

As you do the lab, record lab data in attached data sheet. **When problem occurs, document nature of the problem and how you solve it.**

You will have three main tasks:

1. Calibrate the temperature sensor (Thermistor). In this task, the DC Fan is NOT connected. You will take temperature and voltage data. This data will be useful later on to set the temperature that you want the DC Fan to turn ON.
2. Verify the temperature control circuit works. In this task, the DC Fan is connected. You will take temperature and voltage data. Review the data to verify if the control circuit works as expected.
3. Apply your voltage divider knowledge to set a desired new temperature limit. In this task, you will use data collected in Task I, apply the voltage divider and your knowledge of how a Comparator works. Review the data to verify if the control circuit works as expected.

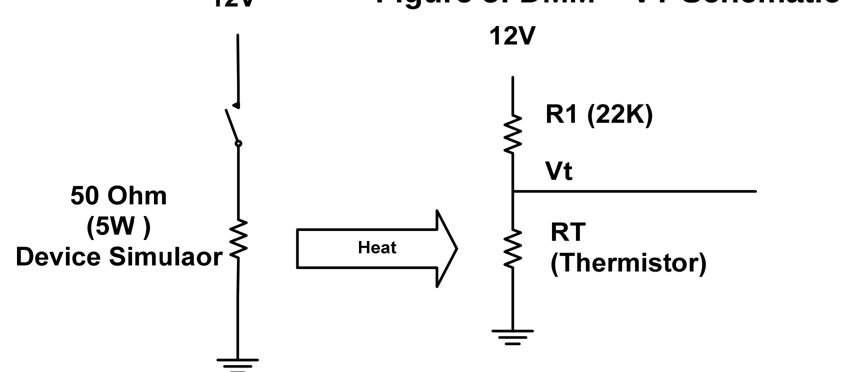
Performance

Note: This procedure is written for a hand build prototype, it will be updated for printed circuit board version when it is available.

Task I: Test the system without the DC fan connected

1. Attach a DMM to the temperature signal (Vt) as shown in the DMM – VT Schematic (figure 5) & DMM – VT Breadboard (figure 6) below:

Figure 5: DMM – VT Schematic



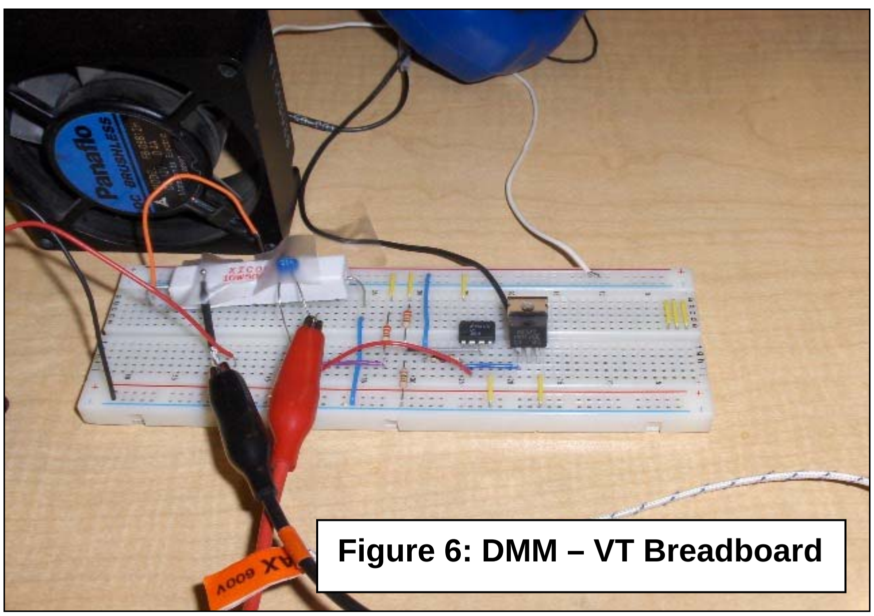


Figure 6: DMM – VT Breadboard

2. Attach the thermal couple of the digital thermometer to the 50 Ω heater, as shown in figure 7 below.

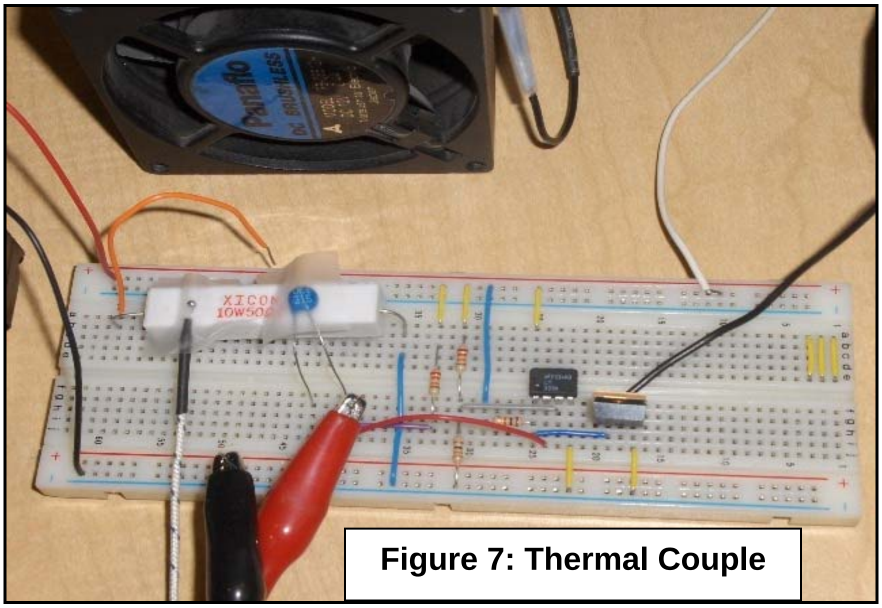


Figure 7: Thermal Couple

3. Attach your power supply or a 12V battery pack, as shown in figure 8.

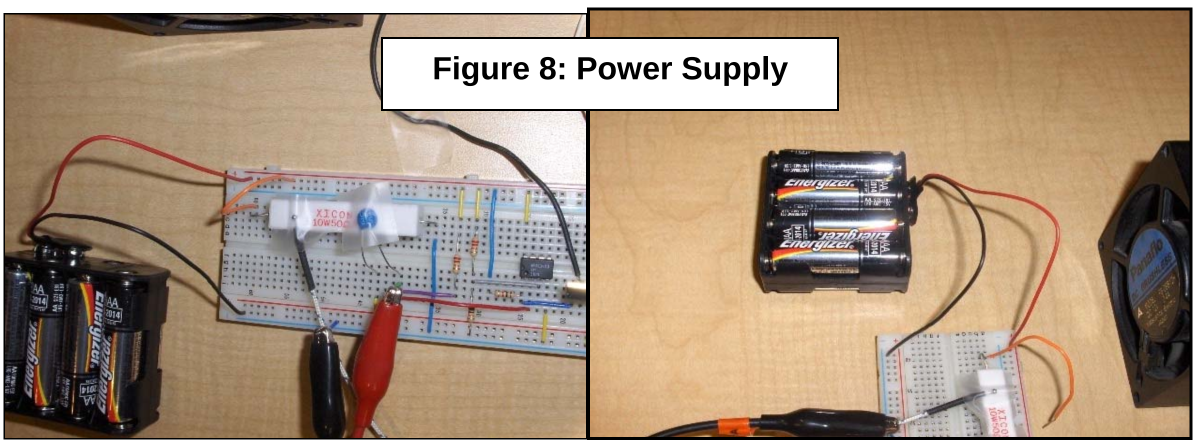
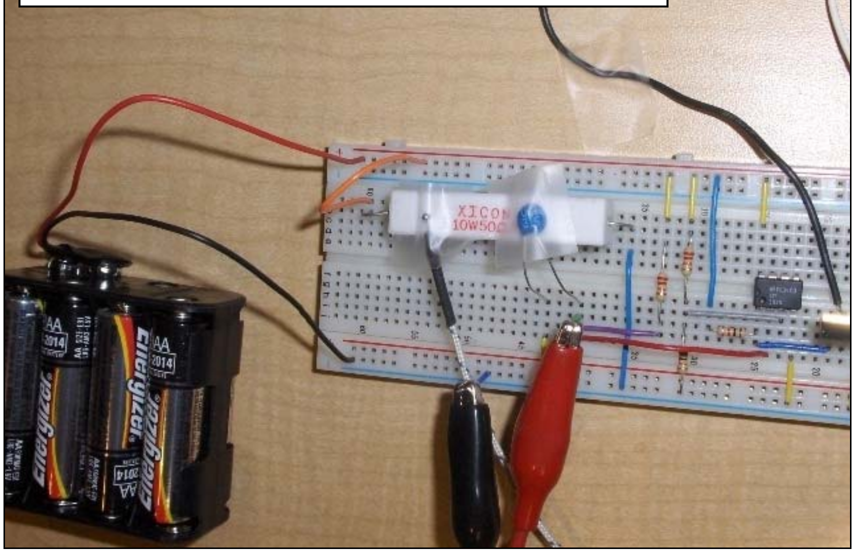


Figure 8: Power Supply

4. Get your stop watch. Be ready to record the temperature and voltage readings at 30 second intervals for 3 minutes.

5. Turn ON the heater by connecting the 12V to 50 Ω resistor with a jumper wire, as shown in figure 9.

Figure 9: Resistor and Jumper Wire

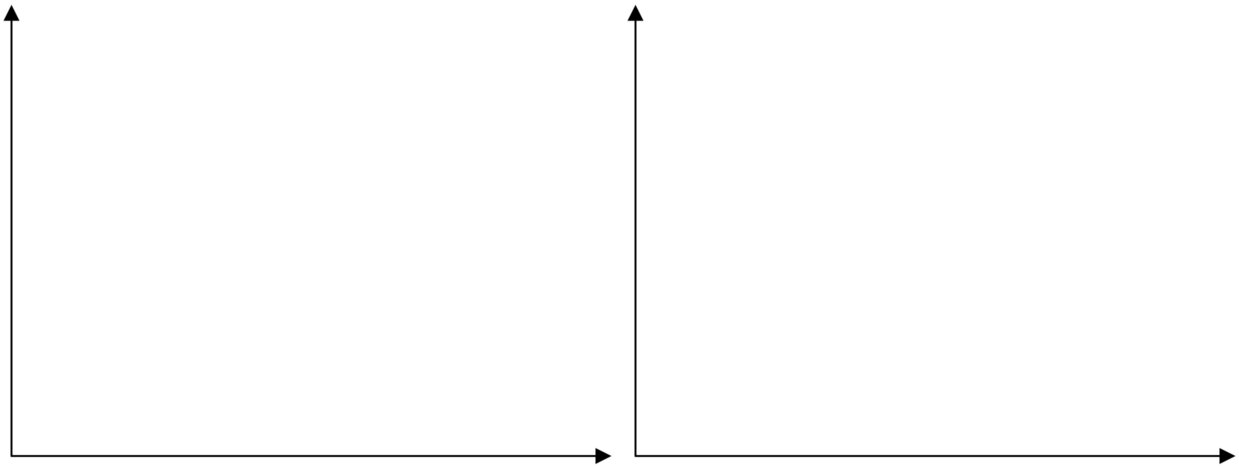


6. Using the table below, record the following (without the DC fan connected) for 0-180 seconds in increments of 30 seconds:
   i) The temperature in degree(s) Fahrenheit (^oF)
   ii) The voltage (Vt)

Time (Sec)	Temperature (^oF)	Voltage (Vt)
0		
30		
60		
90		
120		
150		
180		

7. Turn OFF the heater by disconnecting the jumper wire from the resistor.

8. In the space below, plot the measured **Voltage Vs time** and then **Voltage Vs Temperature**. (2 separate graphs). Make sure you label your axis with the appropriate variables and units.



Task II: Test the system with the DC fan connected

You will repeat the same setup process as before, except this time you'll connect a DC fan.

1. Follow steps 1-3 (pages 7-8), found in Task **I**.
2. Attach the DC fan (Positive lead to 12V, and Negative to **Pin D** of the power driver), as shown in figure 10.

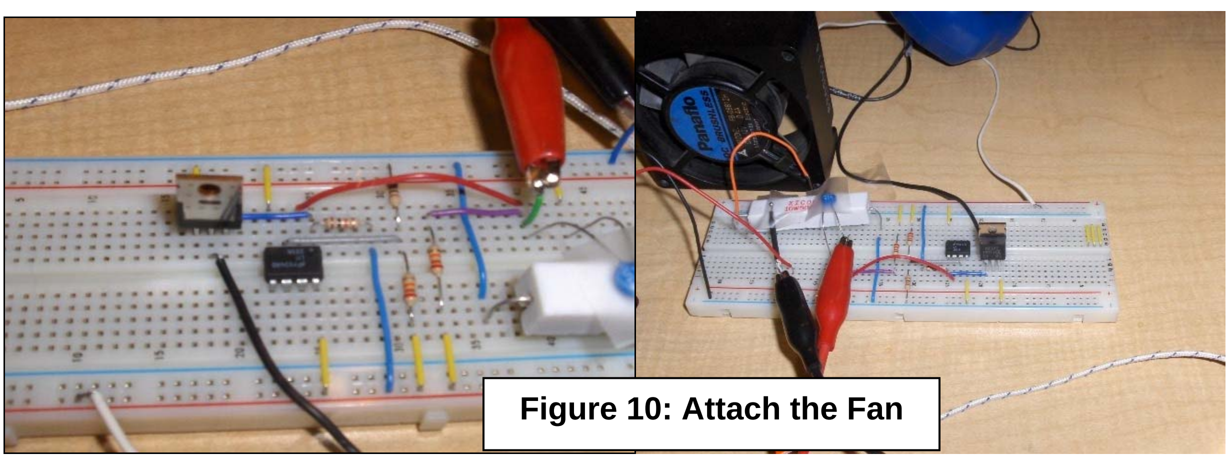


Figure 10: Attach the Fan

3. Reconnect your power supply or a 12V battery pack
4. Get your stop watch. Be ready to record the temperature, voltage readings, and observe the fan as it turns on or off, at 30 second intervals for 3 minutes.

5. Turn ON the heater by connecting the 12V to 50 Ω resistor with a jumper wire.
6. Using the table below, record the following (with the DC fan connected) for 0-180 seconds in increments of 30 seconds:
   i) The temperature in degree(s) Fahrenheit (^oF)
   ii) The voltage (Vt)
   iii) The fan's behavior (On or Off)

Time (Sec)	Temperature (^oF)	Voltage (Vt)	Fan (ON/OFF)
0			
30			
60			
90			
120			
150			
180			

7. Turn OFF the heater by disconnecting the jumper wire from the resistor.

Task III

Based on the data that you came up with in part I and II, select Rset such that the fan is turn on at 104 degree F using the following voltage divider formula:

$$Vt = \frac{Rset}{Rset + 22K} \times Vs$$

Remember, Vs = 12 V.

1. Set your system up and observe its behavior.

2. Did the DC fan turn ON at the expected temperature? Explain why or why not below.

3. Make sure to put everything you used back, in the same condition and location where you found it.

Record all findings in your final report write up and prepare your presentation deliverable.

Deliverable(s)

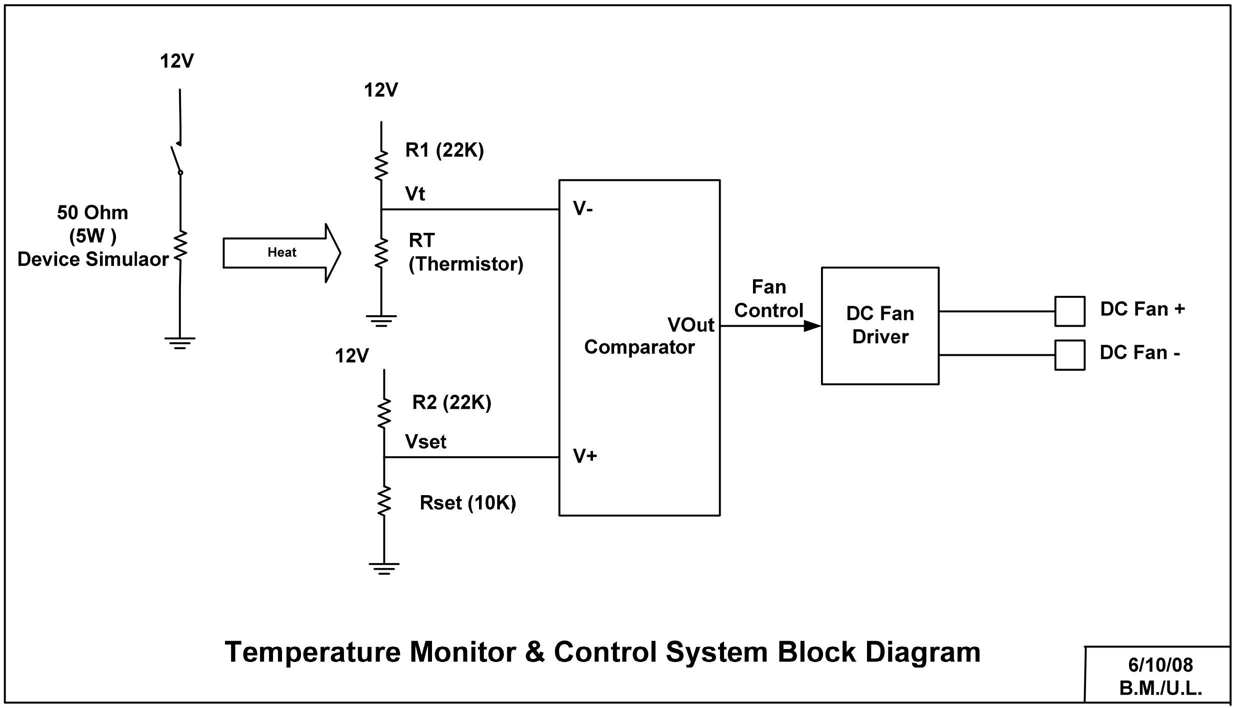
Summarize your lab results in a power point presentation with the following content:

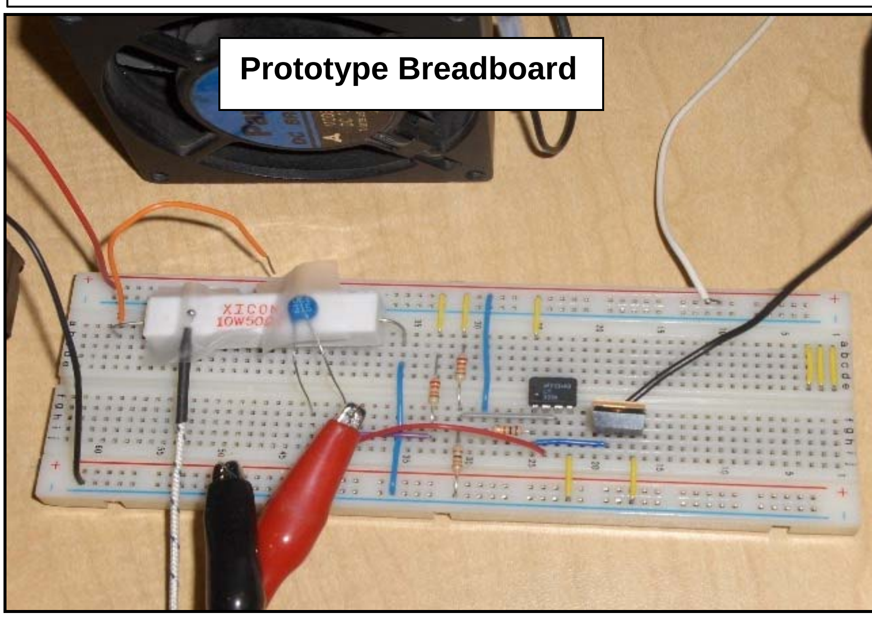
- Project title / date & team members' names
- System block diagram (you may use the temperature and system control block diagram found on page 13)
- Functional requirement
- Lab data
- Problems encountered and associated solutions
- Summary: Did your control circuit do the job? Any recommendation to improve the lab activity?

Grading

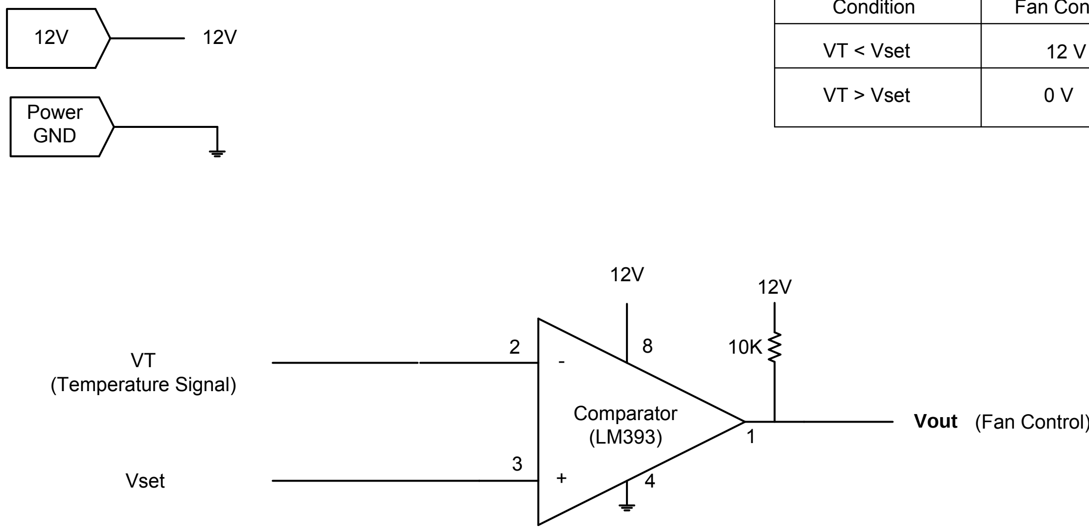
Your instructor will let you know how this lab will be graded.

Appendix A: Drawings for Building Prototype Breadboard



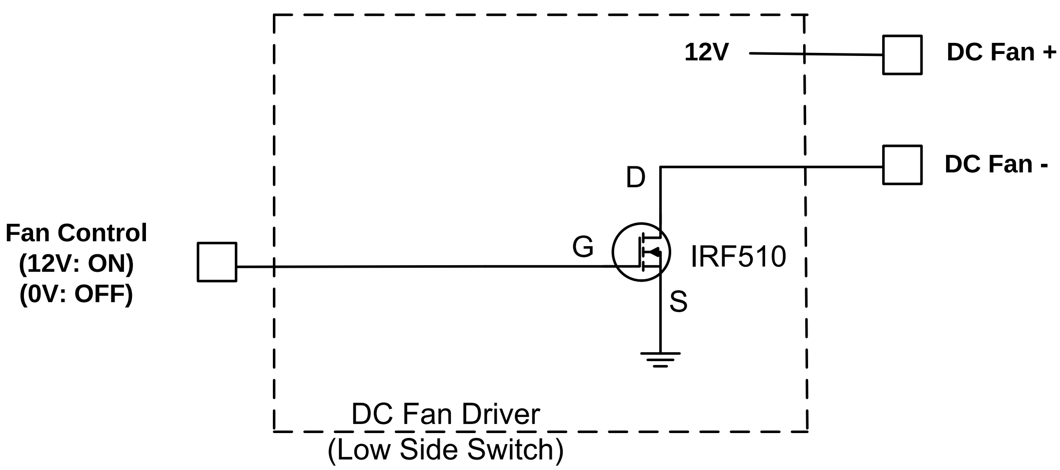


Condition	Fan Control
VT < Vset	12 V
VT > Vset	0 V



Comparator Schematics

eSYST Lab
6/11/08



DC Fan Driver