SECTION FOUR
Operational Amplifiers: Temperature-Controlled Fan

SECTION OVERVIEW

In this section, you will resume the task of building your power supply. Use your knowledge of operational amplifiers (Op-Amps), to construct a circuit that will control the speed of a cooling fan based on temperature.

Objectives

- Design a circuit with an operational amplifier
- The op amp controls the speed of the fan, based on the temperature inside the power supply case.

Materials

- Your lab kit and power supply.
- Test leads and oscilloscope probes.

Design Constraints

Box 4 lists some of the design constraints for the fan controller. The best source for these constraints is the *Project Specification Document*. Keep these in mind as you complete each section of this lab. Each criterion must be met.

- Safely equipped with a cooling fan that should not normally be running at 70°F, but should still be able to reach rated speed around 95°F.
- Design should use an op-amp, and a BJT (or MOSFET) to control the fan speed.
- Assembled safely and with no electrical hazards.

Box 4: Fan controller design constraints

PRE-LAB

For the Pre-lab for Section Four, complete the following:

1. Using SPICE, design and simulate a circuit that will control the speed of a fan based on temperature. (You can model the fan as a resistor, but choose the resistor value carefully).

Refer to your notes from *Electrical Fundamentals I (*ENGR 201), if you have forgotten how to use an Op-Amp or your own notes from this course. For more information about the thermistor and the fan in your kits, you may want to visit the supplier Web-site and check the datasheets for the components. If this is not sufficient, perform experiments to verify the values of the components.

Hint: Double-check the current needed for the fan, and make sure your circuit can handle it.

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2. Bring a printed copy of the datasheets for the parts used in this lab. These should include the datasheets for the LM/UA 741 (or some other op-amp), the thermistor, and any transistors that you may use in this lab.

LAB

There is only one part/ task for the lab portion in Section Four, which is the **fan controller**. In order to design and build a circuit that automatically varies the cooling fan speed, based on the input from a thermistor, follow these steps:

1. **Build your design** on solder-less breadboard.
2. **Test your design**. The fan should turn slowly, or not at all, when the temperature sensor is cool (about 70-75°F).

The thermistor you will be using is of type "NTC" (Negative Temperature Coefficient). This means that the resistance of the thermistor lowers as the temperature rises.

3. **About the voltage:** The voltage on the fan is about 11-12V when the sensor is warm, (i.e. at about 90 - 95°F).

Do not forget that the fan represents a load, and therefore needs to be included while designing.

4. **Verify the operation:** Verify these operating points, by comparing the fan speed at room temperature, and while the sensor is being pinched between warm fingers.
5. **Add the controller** to your power supply. Carefully consider the sensor and fan placements in order to obtain the best cooling and most accurate measurement of temperature.
6. **Demonstrate your working design** to the TA.

Power supplies can be cooled passively, (i.e. without a fan). This type of design would require you to mount the TIP29/ TIP30 transistors to the case.

Another consideration with this design is that the part of the case to which you mount your transistor, must have numerous cooling fins.

TURN-IN

The following need to be turned in, **at the beginning of the next lab (Section Five).**

Student Name: _____ Lab Section Time: _____

Test (from Project Specification)	Measurements	TA Signature
7.1.15 - THERMAL PROTECTION BLOCK - FUNCTIONAL COOLING FAN		✓ _____
7.1.16 THERMAL PROTECTION BLOCK - DESIGN SHOULD USE AN OPAMP AND A BJT OR MOSFET TO CONTROL THE FAN		✓ _____
7.1.17 - THERMAL PROTECTION BLOCK - THE FAN AND ITS CONTROL CIRCUIT ARE ASSEMBLED SAFELY AND WITH NO ELECTRICAL HAZARDS		✓ _____

The **written project specification** to be turned in next week includes:

☐ Project Specification Sections for this lab's circuits:

- Block Diagram
- Interface Definition
- Schematic and theory of operations
- Parts List Changes and Testing Results

The **prelab** to be completed (before lab begins next week), includes:

☐ Prelab for Section Five.

Lastly, turn in your **answers to the study questions** below.

1. Write a description of the type of circuit that you have built. Include a discussion of whether it has positive or negative feedback, is inverting or non-inverting, and about the gain. Explain why you chose this design and how it works.

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2. Does the current flowing through your thermistor cause it to heat up? How much power are you dissipating in the thermistor? Explain why you do or do not consider this power dissipation to be a problem.

CHALLENGES

1. Modify the fan controller to have hysteresis, thereby causing the fan to continue running until the temperature has fallen below that value, (which caused the fan to turn on). For this design, your fan should actually turn off when cool, rather than just slowing down.
2. Mount your fan in a way that either increases performance, reduces noise, looks cool, or all of the above. Make sure that your fan modification is safe and does not expose any blades.

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