EE313 ANALOG ELECTRONICS LABORATORY
TERM PROJECT

PROPOSAL REPORT

Design of a Micro-Air Conditioner

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To design an air conditioning system, we need to have a sensing unit, display unit, control unit, and an operation unit. In this document, we will explain our approach to implement those functioning units one by one.

Sensing Unit

Sensing unit is a simple unit consisting of a temperature sensor and its amplifier. For the actual sensor we are going to use LM35. It will give a voltage output which has a linear relation with the temperature in the specified range. Some of the other features of this sensor are, 4-30 V operation range and 0.5°C accuracy. Amplifier at the output of the temperature sensor will enable us to isolate the different parts of the circuit which ensure its reliability and it will help us to scale the reading to a more useful range. We will place the sensor close enough to the heating and cooling elements so that we can change the temperature at the desired rate.

Display Unit

Display unit consists of two sets of RGB LEDs (red-green-blue light emitting diodes) in common anode configuration - one for displaying the set value, and the other for displaying the measured room temperature. We wanted to separate the LEDs to better visualize the operation of the system. As described in the project, we have a color bar indicating the temperatures. To achieve the same output we need to create three different signals for each LED. Required signal for each color is shown in Figure 1. Series of operational amplifier structures will be used to generate the aforementioned signal. When it comes to driving the LEDs we will utilize bipolar junction transistors (BJTs). These semiconductor devices enable us to control the current of the individual LEDs which corresponds to their brightness. The selected topology is a common emitter amplifier. This structure is also named as transconductance amplifier, which means that an input voltage produces an output current.

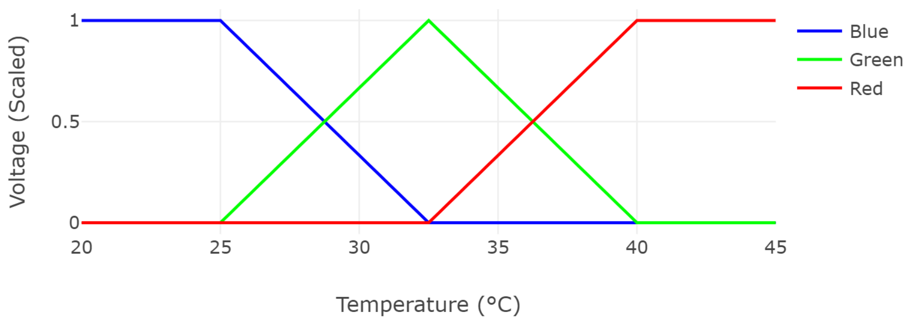

Figure 1. LED driving signals for each color.

Control Unit

Control unit has the highest complexity among others. It will have several parts for handling various tasks. First of all, it will take input from two different sources. First one will be the amplified output voltage of the temperature sensor. Second one will be the reading from the potentiometer. This unit will generate outputs for two different elements, heating and cooling respectively. We decided to implement a PID (proportional integral derivative) controller for this task, which is a controller with feedback. This way we can control the elements in an analogous fashion. We will take the input from the potentiometer as the set point and the amplified LM35 output as the process variable. The PID implementation will be done with operational amplifier configurations as shown in Figure 2. For op-amp selection, we will go with LM358 dual channel op-amps. They are cheap, reliable and suitable for the control unit. Also a dead-band is constructed at the end of this stage.

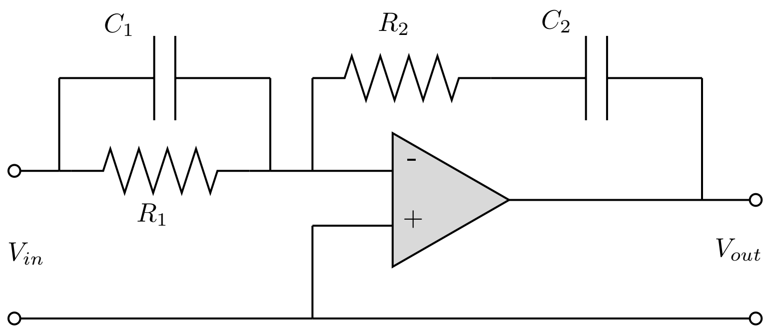

Figure 2. PID controller implemented with single operational amplifier.

Operation Unit

Operation unit is sort of a driver unit. In this section, output of the control unit is picked up and converted into pulse width modulation (PWM) signals so that our elements can be controlled more accurately. An oscillator will be implemented in this section to generate the PWM clock for the elements. This single clock will be utilized by both of the comparator blocks, which means that their frequency will be the same. Basically the triangle oscillator is compared with control signals to generate desired PWM signals for each output. Later these signals are fed onto mosfet bridges to adjust the power given to each element. The heating element is selected as a piece of nickel-chromium wire. The heating wire will be wrapped around our temperature sensor without touching to ensure more of the power is transferred onto the sensor. The resistance value for the wire will be chosen such that at most it will dissipate 10 watts of power. For cooling we will use a 12 V computer fan, which takes direct current voltage for an input. The power consumption of the selected fan is around 2 watts. Preliminary experiments showed that these power ratings will be fairly enough.

Mechanical Design

Mechanical construction of the system is decided to be built upon the fan. The mounting holes of the fan will be used to carry the circuit and the sensor will be placed on the circuit and directed towards the fan and it will be surrounded by the heating wire. For this design our circuit will be carried over the printed circuit board (PCB) with surface mount components. KiCad is selected for the PCB drawing program since it is open source and easy to use . This approach not only shrinks the size of the circuit but also helps us to reduce the electromagnetic interference. In the end we hope this rigid construction will be aesthetically pleasing (see Figure 3).

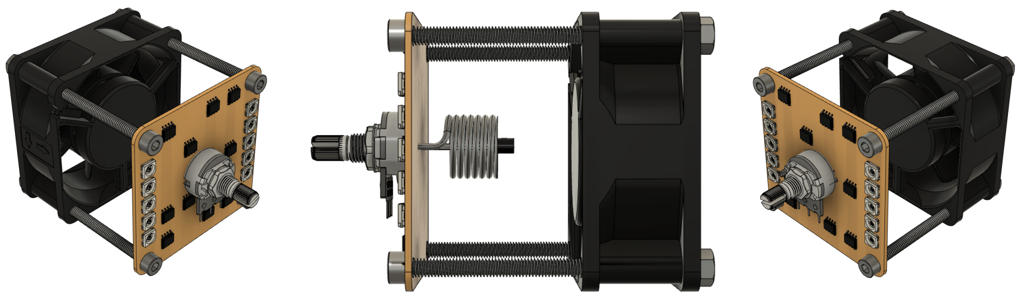

Figure 3. Computer aided drawing of the planned construct.

As we work on this project, we will first precisely choose the components we use (with their values) and simulate our designs in LTspice by simulating each unit separately and simulating some of them together (if applicable). If we get the results we expected, we will move on to the prototyping stage where we build each unit on a breadboard and test them. After all these stages, the circuit is reconstructed on a PCB and mounted on the fan.