EE213 ELECTRICAL CIRCUITS LABORATORY
TERM PROJECT
ANALOG AIR CONDIONER SYSTEM

1. INTRODUCTION

Air conditioning can be described as the process of cooling, heating, moisturizing, dehumidification, etc. This process is used to provide more comfortable interior environment. Air conditioners often use a fan to distribute the conditioned air to an occupied space [1].

Air conditioning systems can be modeled by three units, namely, sensing unit, control unit, and temperature or humidity adjustment unit. (See Figure 1.) The sensing unit compares the ambient state, e.g., temperature or humidity, with the desired condition. The control unit, which regulates the desired operation, deduces the action to be taken.

Control units for most air conditioners are digital systems. They have both analog and digital inputs for measurements of the ambient condition and outputs to control the conditioning operations. Digital inputs are dry contacts having only on and off states, and analog inputs are variable voltage or current measurements from a sensing device. Digital outputs are typically relay contacts used to start and stop the equipment, and analog outputs are voltages or currents that control the movement of devices such as valves, dampers, and motors [2].

2. PROJECT DESCRIPTION

In this project, you are required to design an analog air conditioner system. The system acquires heating and cooling functions and consists of three subsystems, namely, the temperature adjustment unit, the sensing unit, and the control unit. The sensing unit provides the ambient temperature to the control unit, and the temperature adjustment unit provides the desired temperature to the control unit. (The desired temperature is set externally by the user.) Then the control unit decides and performs the action to be taken.

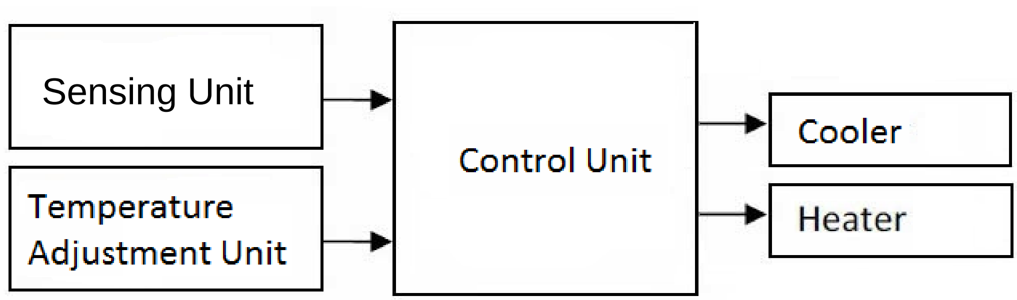

Figure 1: Analog air conditioner system block diagram.

2.1 Sensing Unit

The sensing unit contains an analog temperature sensor in order to sense the ambient temperature. The sensor represents the decrease or increase in temperature by a variable DC voltage level that will be fed to the control unit. (As a temperature sensor LM 35 chip can be used.)

2.2 Temperature Adjustment Unit

The temperature adjustment unit represents the desired temperature by a predefined duty cycle of the rectangular waveform. Buttons, switches, or rotatory encoder like elements can be used to adjust the desired temperature.

2.3 Control Unit

The control unit contains decision and function subunits. The decision subunit compares the ambient and desired temperatures, and informs the function subunit accordingly. The function subunit, then, starts the heater or the cooler and indicates the performing action by using LEDs.

The system continues heating or cooling until the desired temperature is reached. Then, the function subunit stops the operation and enters the idle mode. In this mode, the ambient temperature is continuously checked, and if it deviates 2 degrees from the desired temperature, the required operation starts automatically.

2.3.1.1 Heating Operation

The heating element is an electrical resistor. To achieve high temperature, the current passing through the resistor should be sufficiently high. Since the resistors used in the laboratory cannot endure high current, 5 or 7 Watt stone resistors can be used. The heating element can be placed close to the sensing device for the ease of implementation.

2.3.1.2 Cooling Operation

The cooling element is a DC electric fan. For this purpose you may use 5 or 12 Volt computer case fan or you can make your own fan with a DC motor and a small propeller that fits to your DC motor. The cooling element can be placed close to the sensing device for the ease of implementation.

2.4 Tips & Tricks

The necessary current for a circuit operation (e.g., motor driving, heating, relay switching etc.) may be higher than the current which the available components can endure. For example, the maximum output current for LM358 op-amp is 40mA [3]. In the following sections, there are recommended circuit elements and configurations that can be used to obtain high current in this project.

2.4.1 Using Transistors

Transistors can be used to drive DC electric fans, DC motors, or circuits which require high current. A typical motor drive circuit and motor drive operation with NPN Bipolar Junction Transistors (BJTs) are illustrated in Figure 2. B, C, E, and V_{cc} stand for base, collector, emitter terminals of BJT and supply voltage, respectively.

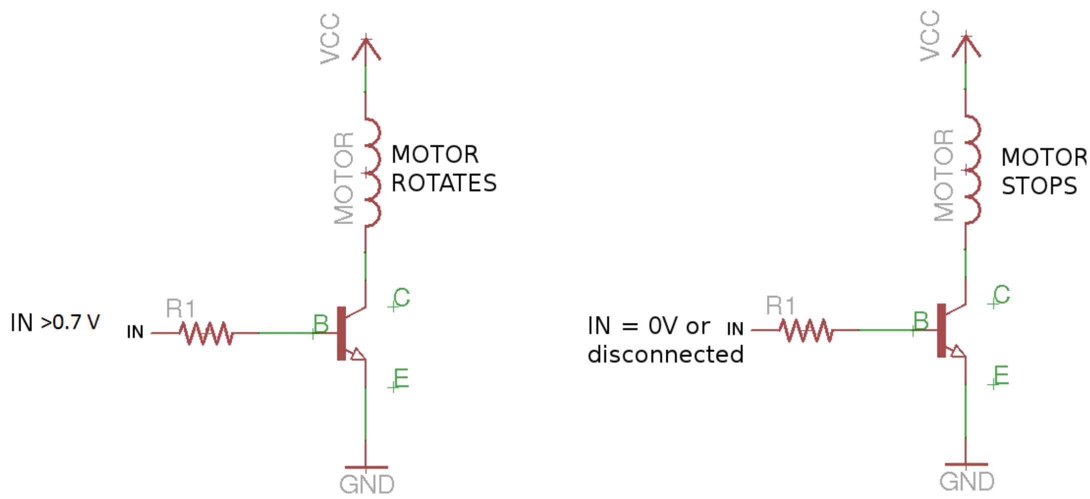

Figure 2: Motor drive circuit and its operation using an NPN Bipolar Junction Transistor [4].

When a certain voltage (e.g., $\cong 0.7V$ for BD135 transistor) is applied between base and emitter, there will be current flowing from collector to emitter. (There are several types of BJTs, however we recommend you to use BD135.)

2.4.2 Using Power Op-Amps

Since the maximum output current for LM358 op-amp is not enough to drive a DC motor or heat a stone resistor, another way to obtain high current is using power op-amps. These are high output current operational amplifiers and can be used instead of LM358 for the high current stages of the project.

2.4.3 Using Motor Drive Chips

The last option is to use motor drive chips. The most popular one is L293D. The required information can be found in its datasheet. Although you are free to choose any option, we do not recommend you to choose this one.

3 RULES AND REGULATIONS

3.1 Allowed Components

You are allowed to use +/-25 V output of DC power supply and you may use any types of resistors, capacitors, inductors, diodes, LEDs, LDRs, op-amps, transistors, DC motor (without encoder), analog temperature sensor.

3.2 Design Specifications

Will be announced later.

3.3 Bonus

Will be announced later.

3.4 Groups

The project will be carried out in groups of two students. The students in the same group should be in the same laboratory session.

3.5 Important Dates

- November 16 : Project Announcement
- November 21 : Announcement of design specifications and evaluation rubric
- December 16 : Deadline for pre-reports (till 17.00)
- December 19-January 6 : Laboratory sessions
- January 5-6 : Submission of demo-videos
- January 7-8 : Demonstrations
- January 11 : Submission of the final report (till 17:00)

3.6 Documentation

You **must** submit two reports and a video for the term project.

3.6.1 Reports

As stated in report guideline, pre-report should include an introduction, pre-design of the project with circuit diagrams, theory, formulations, simulation and experimental results and a conclusion.

Final report should also include all the parts in the pre-report for the overall design. In other words, final report should explain the overall design with an introduction, a block diagram and circuit schematic, operation of each sub-block with theory, formulations, simulation and experimental results. Final report should also include analyses for the cost and power consumption of the project and you should justify the use of each component. Conclusion of the final report is very important since it reflects your understanding of the project and the experiences you gained during the overall process. The objectives, results and the experiences should be clearly presented. This does not necessarily mean a long report, but definitely a well-organized one.

Late submissions for both reports will lower your report grades as:

- %20 off for one-day late submission
- %50 off for two-day late submission
- %90 off for three-day late submission
- Zero credit for more than three-day late submission.

You are referred to the report guideline, which is available on the course website, for further details.

3.6.2 DEMONSTRATION VIDEO

You should prepare a 6-8 minute video where partners of each group present the project in a collaborative manner. The video should include the explanation of main blocks, why they are used and how they are designed. This video should be regarded as a formal presentation to the related assistant. Note that you should always appear in the video together with your presentation material.

3.7 GRADING

- Pre-Report : %15
- Final Report : %20
- Presentation Video : %10
- Design and Performance : %55 (partial credits are possible)
- Bonus : up to %30

3.8 REGULATIONS

- Attending to at least one project session and demonstration is a must for both team members, otherwise, you will **fail the course**.
- Cheating is strongly forbidden and any indication of cheating will cause you to get zero credit from the project. You can collaborate with your friends by exchanging ideas, not copying the design details or the reports. Using the design of another group with slightly modified component values will also be regarded as cheating.
- Both members of the group are responsible for every single detail of their circuit. If you get a credit lower than the pre-score from the design test you will get zero from the overall project grade. Pre-score will be announced later.

REFERENCES

[1] *Daou, K; Wang, Xia (2005).* "Desiccant cooling air conditioning: a review". *Renewable and Sustainable Energy Reviews. 10 (2): 55–77*

[2] *Role on DDC Systems in Building Commissioning. (2012, September 5). Retrieved from http://xinca.com/role-ddc-systems-building-commissioning-386.html*

[3] *LMx58-N Low-Power, Dual-Operational Amplifiers. Retrieved from http://www.ti.com/lit/ds/symlink/lm158-n.pdf*

[4] *DC-Motor Driver Circuits. (2012, May 19). Retrieved from http://playwithrobots.com/dc-motor-driver-circuits/*