EE 213 Electrical Circuits Laboratory Term Project
A Circuit to Measure and Display Sound Level Specifications

In this term project, you are expected to design a circuit which measures the level of environmental sound and display it. According to the pre-design reports you submitted, the specifications of this circuit are determined. Since most of you suggested a similar scheme, the required circuit specifications will be explained under three parts in this document.

1. Input Unit

This unit is the one in which the surrounding sound signals are captured and turned into (meaningful) electrical signals. As most of you suggested, this unit must include an electret (or analog) microphone and the required circuitry enabling the microphone work properly (which is also called as "driving the microphone"). There are some integrated circuits available which include both the microphone and its driver. However, the driver circuit is a simple circuit which does not include any components that you have not used in the laboratory sessions; therefore, using such integrated circuits is NOT allowed. In other words, you must use an analog microphone and implement its driving circuit manually. Note that the output AC signal from the microphone has a small amplitude so this input unit should also provide sufficient amplification of the AC signal.

The output of this unit must be an electrical signal which carries information about the sound level.

2. Decision Unit

This unit transforms the electrical signals coming from the input unit into some electrical signals which will drive the output unit. The transformation will be in the way of carrying the information, not the information itself. That is, this unit is to provide some abstraction between the input and display units. The abstraction it must provide is that the electrical signal coming from the input unit needs to be converted into some other meaningful form. More specifically, you are expected to convert the amplitude of the signal coming from the input unit into a Pulse Width Modulated signal.

In this project, you will display the sound level using a single LED. In this scenario, only a single LED will display the level of sound using the concept of "duty cycle". Duty cycle refers to the fraction of one period when a periodic signal is (said to be) active or high. For example, consider a periodic square wave with a period of 1 second. If the signal is "on" (e.g. at 12 V) for 0.2 seconds and "off" (e.g. at -12 V) for 0.8 seconds each period, then the duty cycle is said to be 20%. Figures

1 and 2 may help you understand what duty cycle and pulse width are. You are welcome to visit the references for further detail.

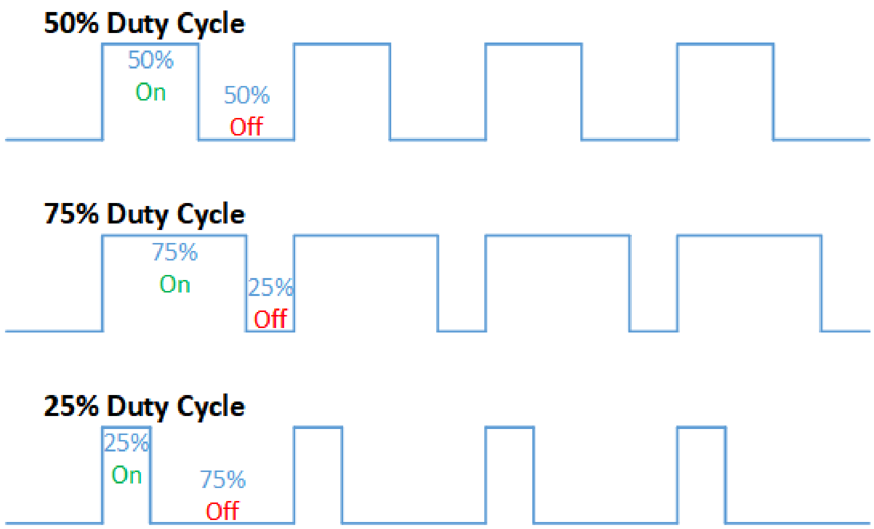

Figure 1: Three periodic waveforms with same frequency having different duty cycles, obtained from http://wikipedia.org/en/Pulse-width_modulation

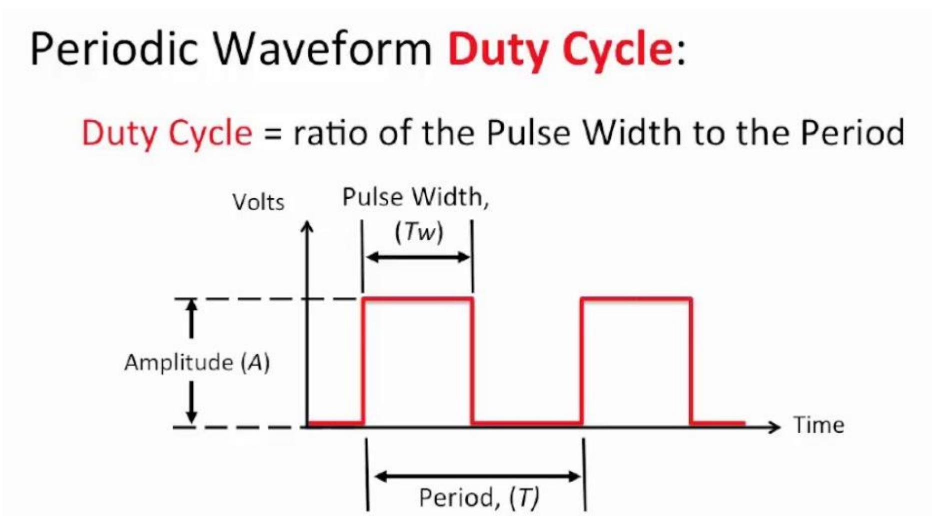

Figure 2: Definitions of pulse width and duty cycle of a periodic waveform, obtained from https://www.youtube.com/watch?v=ERMAPLVG8Z8

Electrical signals can be used to carry information via their different properties such as amplitude, frequency, phase, etc. Making a signal carry information in a specified way via a specified property of it is called "modulating" the signal. For example, suppose that one bit of information (either zero or one) is needed to be carried in the amplitude of the signal. Then, one can choose to make the amplitude of the signal 5V for the information "1" and 0V for the information "0". Then, this kind of modulation is called "amplitude modulation". Similarly, suppose that the same information is needed to be carried in the frequency of the signal. Then, one can choose to make the frequency of the signal 1kHz for the information "1" and 2kHz for the information "0". Obviously, this is called "frequency modulation".

In this project, you must use "Pulse Width Modulation (PWM)" in order to transmit the input information about the sound level to the output of the circuit, which is an LED. Similar to the examples given above, in PWM, you are required to carry the sound level information in the pulse width of a periodic waveform.

You must use a 1 Hz waveform to drive the LED circuitry. The selection of the amplitude of the waveform is to be determined by yourselves. You should consider your amplitude selection as fine provided that the LED is clearly visible to be on and off with a 1 second period.

Your circuit must differentiate between 4 distinct sound levels. The lowest level should be the casual noise level in the laboratory (be aware of the extra noise in the labs during the project demonstrations). In this level, the LED must be completely off (0% duty cycle). Except the "OFF" level, there must be "low", "medium" and "high" sound levels with low, medium and high duty cycles, respectively. You are advised to set the medium level to have a 50% duty cycle waveform for visual distinguishability from other levels. The low and high levels' duty cycles can be any ratio as long as they are distinguishable from the medium level.

To achieve the variable duty cycle, you are expected to use the circuits you learnt in the laboratory sessions. No integrated circuits are allowed except op-amps. You are advised to investigate the functionality of circuits you have studied in experiments 5 to 8, which should mostly get you covered for this project.

3. Output Unit

As mentioned in the previous section, the output unit of your designs must include an LED. Be sure that whether the LED is on or off is clearly distinguishable by eye. The output unit may also include any necessary circuit components to drive the LED.

4. Regulations

4.1. Allowed Components

Be sure that your circuit works well only using the components given below:

- Passive elements (resistors, capacitors, inductors, diodes)
- LEDs
- Analog Microphone
- Op-Amps
- DC Power Supply in the laboratory

4.2. 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.

4.3. Project Phases and Important Dates

The project consists of three phases, namely the pre-design, preparation and implementation phases. Each phase will be concluded by a report.

4.3.1. Pre-Design

In this phase, each group is required to provide their solution ideas for the project in a formal report. This report should include your own solution methods to the design project. Your methods should clearly lead to a solution (any kind of "how will … be done?" questions should have an answer). The specifications will not have been determined when you write this report, so do not try to include the details like circuit schematics, resistance values, number of capacitors used etc. (a general system description is sufficient). The deadline for submitting this report is the 8th of November. Late submissions will lower your grades significantly. Moreover, you will not be allowed to continue the next phase unless this report is submitted.

4.3.2. Preparation

In this phase, each group is required to present a solution design for the project in a formal report (pre-report). This report MUST also include simulation results illustrating the operation of the circuit used in the design. The necessary calculations (for example, resistor and capacitor values) MUST be given in the report clearly. The deadline for submitting the pre-report is the 9th of December. **Note that** this date was initially announced as December, 2nd, and you are expected to come to the laboratory with a design at hand. This deadline extension is allowed because of the initial one for your pre-design reports. **If you do not come to the laboratory with your design, you will lose the opportunity to build and debug your circuit that week.** Late submission penalties will be the same as the late laboratory report submission penalties. Moreover, you will not be allowed to continue next phase unless a pre-report is submitted.

4.3.3. Implementation and Demonstration

In this phase, you will physically construct your circuit. Each group has to attend their laboratory sessions in the two weeks, December 2-6 and 16-20, for testing their circuits. Note that in the week of December 2-6, you will have a short laboratory session followed by your implementations. You are not allowed to attend other laboratory sessions other than your own. Attending at least one test session is a MUST for both team members (you will fail the course otherwise) and your attendance will be taken. You are required to attend the third session in the week of 23rd and 27th of December. The demonstrations will be held at the weekend 28th-29th of December. Both team members MUST attend demonstrations (you will fail the course otherwise).

Early demonstration is possible if you complete your circuit during the test sessions. A successful implementation requires extensive test-modify-test cycle. Since you are allotted a limited time for testing your circuits in the laboratory, you should make use of your time effectively. You must provide your own circuit components (op-amps, resistors, capacitors, pots, etc.) and bread-board.

You will submit your final reports after the demonstrations. The deadline for submitting the final report is the 27th of December. The final report will include all details about your design project. You are also expected to submit a video of the presentation of your project (lasting 6 to 8 minutes), both members participating equally to the explanation of your design.

4.3.4. Important Dates

- October 25: Project Announcement
- November 11: Deadline for Pre-Design Reports (till 17:30) ~~Previously November 8~~
- November 20: Announcement of specifications (except bonuses) ~~Previously November 14~~
- December 9: Deadline for pre-reports (till 8:40) ~~Previously December 2~~
- December 2-6: First Laboratory session (following a short demo of experiment 9)
- December 16-20: Second Laboratory session
- December 23-27: Third Laboratory session (mandatory to attend)
- December 28-29: Demonstrations (Demo videos should be submitted to the lab assistant a day before the demo)
- ~~December 23-27: Demonstrations (Demo videos should be submitted to the lab assistant a day before the demo)~~
- December 27: Deadline for final reports (till 17:40)

4.4. Documentation

4.4.1. Pre-Design Report

Pre-Design report must include your own solution ideas about the design project. It must consist of the following parts:

- Introduction
- A general system description
- Brief explanations of sub-blocks (if any)

4.4.2. Pre-Report

Pre-Report must include the basic idea about how to implement the project. It must consist of the following parts.

- Introduction
- Overall circuit block diagram and explanation of sub-blocks (if any)
- Basic formulations (if any)
- Simulation results
- Conclusion

4.4.3. Test Procedure Checklist

You are required to submit a printed document during your final demonstrations detailing the procedure to test the functionality of your circuits. More details will be added to this part of the document guiding you through the preparation of this process.

4.4.4. Final Report

The final report should include the final design, results, a simple cost analysis, and a summary of the experiences gained during the project. The reports should be properly formatted. The objectives, results and the experiences should be clearly presented. This does not necessarily mean a long report, but definitely a well-organized one. The final report should contain the following sections:

- Abstract (a brief summary of the report)
- Introduction (motivation behind)
- Design formulation
- Selection of equipment
- Cost analysis
- Power analysis
- Description of circuit operation and tests required to check the functionality of your design
- Comparison of computer simulation results (MATLAB Simulink, LTspice, etc.) and results from your setup
- Comments and conclusions

4.4.5. Demonstration Video

You should prepare a 6-8 minutes 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. Video submission deadline as well as submission procedure will be provided at a later stage.

5. Checklist

In this section, a list of your responsibilities and some regulations about this design project is provided.

1. Be sure that you use no other component other than the allowed ones.
2. Prepare a report including your design and simulation results. You can use LTSpice or other circuit simulation programs (e.g. Multisim). The deadline for this report is December 9th, Sunday at 23:59.
3. Be sure that the frequency of the on-off cycle of the LED is 1 Hz.
4. Be sure that 4 different sound levels are clearly distinguishable by your circuit.
5. Continuously changing the duty cycle according to the sound level is not allowed, distinction between the sound levels must be clear.
6. Be sure to use the laboratory hours efficiently. All of you have limited time in the labs, so do not miss your chance to use it (let us know any extreme situations so that we can arrange the laboratories for you) and do not ask for more time than the other students have.
7. You can use the components in the labs, as long as you put them back after you leave the lab. It is not allowed for you to take the components in the lab with you. Therefore, it is strongly recommended that you have your own components. This will also enable you to construct your circuits outside the lab, providing you with the valuable time in the lab to debug your circuit.
8. Feel free to ask anything about the design process (preferably on ODTUClass so that the information is beneficial to anyone).