EE241 Laboratory Exercise
Sound to Light

Instruments
Digital Multimeter
Oscilloscope
Protoboard
Function Generator

Components
Resistors – Standard values
LM741 Operational amplifiers
LM311 Comparators (or LM339 Quad Comparators)
1N4005 Rectifier Diodes
Microphone (Knowles MD9745APZ-F, Digikey part # 423-1023-ND)

In this lab you will create a circuit that will monitor the ambient sound level and produce a light display that is proportional to that sound level. The input is the sound level in the room and the output will be a stack of 3 LEDs. When the room is silent, all LEDs should be off, but as the sound level increases first one LED should light, than two, and then finally all 3 LEDs should light up when the sound level is high. The block diagram for this system is shown in Figure 1. The entire circuit must run off of +/-9V, so that you could power the circuit with 2 9-volt batteries, and the circuit should be responsive to sound frequencies in the range of 100 Hz to 10 kHz.

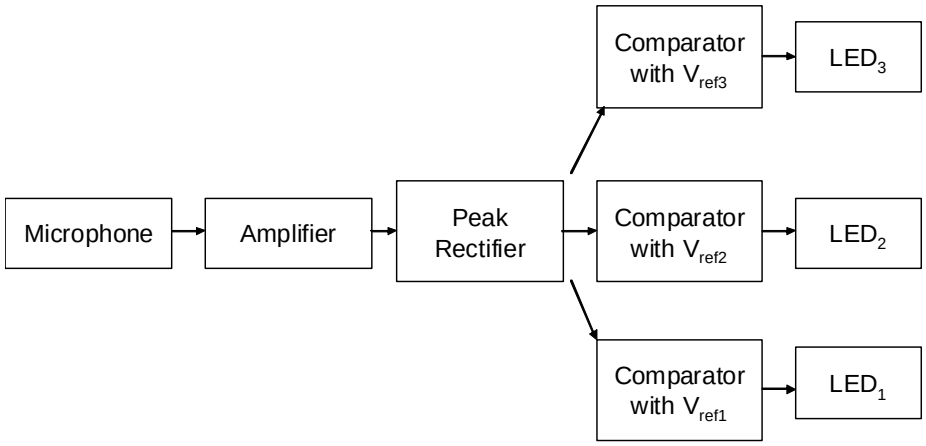

Figure 1: Block diagram for system

Pre-Lab

1. Explain in your own words what each block in this circuit should do. What sort of signal do you expect to see at the output of each block? A sine wave? A steady signal?
2. Now let's consider the contents of each block:
    a. The microphone you will be using is called an "electret condenser" type microphone. Do some web surfing and then explain in your own words what this sensor does and how it works.
    b. Look up the data sheet for the microphone. Notice that the microphone has two terminals, but that it will require 3 connections—one for ground, one for DC power, and one to read off the signal. Determine the circuit that you will need to use with the microphone in order to accomplish this.
    c. Sketch a possible circuit for the amplifier. What are the input resistance, gain and

output resistance for this amplifier as a function of its component values?

d. Sketch a possible circuit for the peak rectifier. What design equations will you use to determine component values?
e. After the signal comes out of the peak rectifier, this system is very similar to that of a Flash Analog to Digital Converter (Flash ADC), except that the comparator outputs are going to drive LEDs rather than going into an encoder. Do some surfing and read up on the Flash ADC converter, and then sketch a circuit that uses a similar structure to accomplish the comparator blocks of the system diagram. What current will the comparators draw from the peak rectifier?
f. Look up the data sheet for the LM311 Comparator. These chips require a pull-up resistor. Explain what that means. Adjust your comparator stage design accordingly.

Lab

Work out component values for your design by considering the interaction between stages and starting with reasonable values. Build and test your design, working each stage alone first and then gradually combining the stages together. Try altering the values of the components in your system to see how each component's value affects the system. Use the LEDs on the protoboard for your output lights. If you get your design to work easily and want a challenge, modify your design to drive more LEDs, or convert your circuit so that it produces a digital signal that could be the input to a microchip with 0 V for '0' and 5V for '1' ('00' for silence, and then '01', '10' and '11' with increasing volume levels)—this may require the addition of some 7400-series logic chips.

Things to consider for your write-up

Describe your entire design process, including your work from the pre-lab. Consider design alternatives.