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<tr><td>Class:</td><td colspan="2">EE320L</td><td>Semester:</td><td>Spring 2018</td></tr>
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<tr><td>Document topic:</td><td colspan="2">Final Project (temperature control diode circuit)</td></tr>
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1. Introduction / Theory of Operation

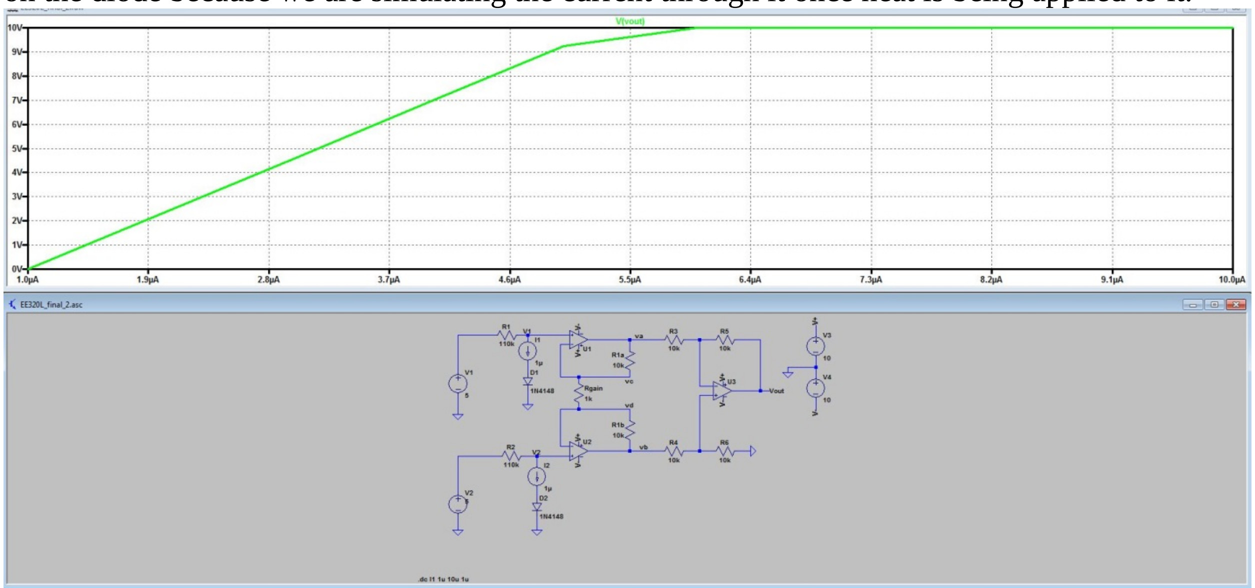
The application of op-amps in relation to testing and measurement equipment has become more common in today's electronic industry. One very useful testing circuit using op-amps is the instrumentation amplifier, which allows different input voltages to be compared and tested. This project introduces a circuit with that same idea except adding diodes in order to obtain voltages in response to diode temperature, which in many cases, could just be the ambient temperature.

The goal of this circuit is to be able to apply it in real world scenarios to help maintain equipment and avoid disastrous outcomes. One application of this circuit is, to attach it or put it on top of computers. If the computer reaches a certain temperature (depending on temperature set up and voltage gain), the circuit will create a major voltage gain and turn on an external fan to aid the internal fan of the computer. Another application of this type of circuit could be on homes. Thermostat on homes turns on and off depending on the average of room's temperature. So, an AC unit on a house would not turn on or off if only one room is hotter or colder than the set temperature of the thermostat. This disregards the temperature of that room, which could mean a malfunction in the system or perhaps could just mean that there is an opened window. However the case may be, there is something to be fixed, which the thermostat could not have been able to detect. And that is where this diode based temperature circuit can provide a solution to those problems. The circuit would detect a difference in temperatures between rooms and notify with an LED or with an alarm system of the problem found.

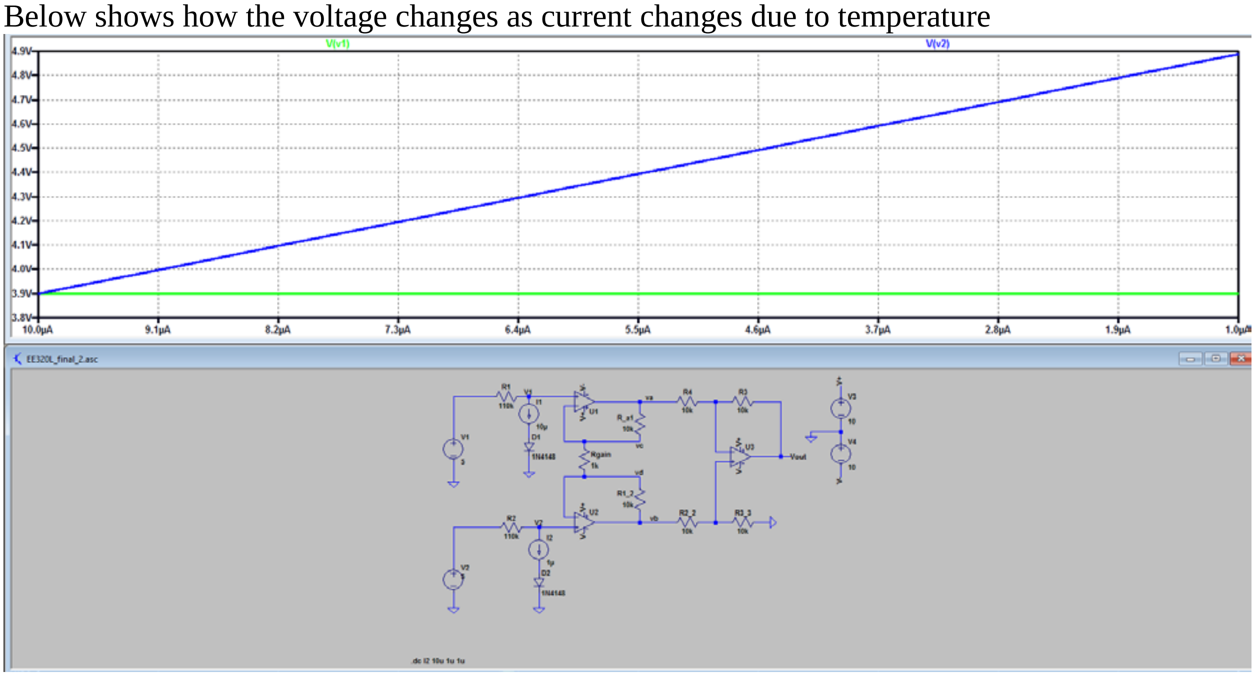
2. Description of Project

This circuit idea came from the application of instrumental amplifiers, which are used to test electrical equipment and took some information from the website "All about Circuits". Instrumental amplifiers used three operational amplifiers with two cascading stages. The first stage includes two parallel and opposite amplifiers with a non-inverting topology and using a resistor between each other's inverting input. The difference in voltage between the inputs will produce a current through the resistor, which will create a gain voltage. That gain voltage then follows through the second stage into another amplifier with an inverting topology. Thus the output will be an inverting voltage of the difference of the two inputs. Adding diodes and resistors in parallel with the input at the begging of the circuit will create a similar output, except, the input voltage changes in respect to the diode current, which changes due to ambient temperature. The output was connected to an LED to show that the voltage increases enough to turn on the LED. When the LED turns on, then the voltage stops increasing, but this LED is simulating a trigger switch or alarm system. The circuit was tested with 5V input and 110KΩ resistor in parallel with a 1N1448 diode. The results are shown below. For the ltspice model a DC sweep was used on the top op-amp in order to show the changes in voltages with respect to the diode current.

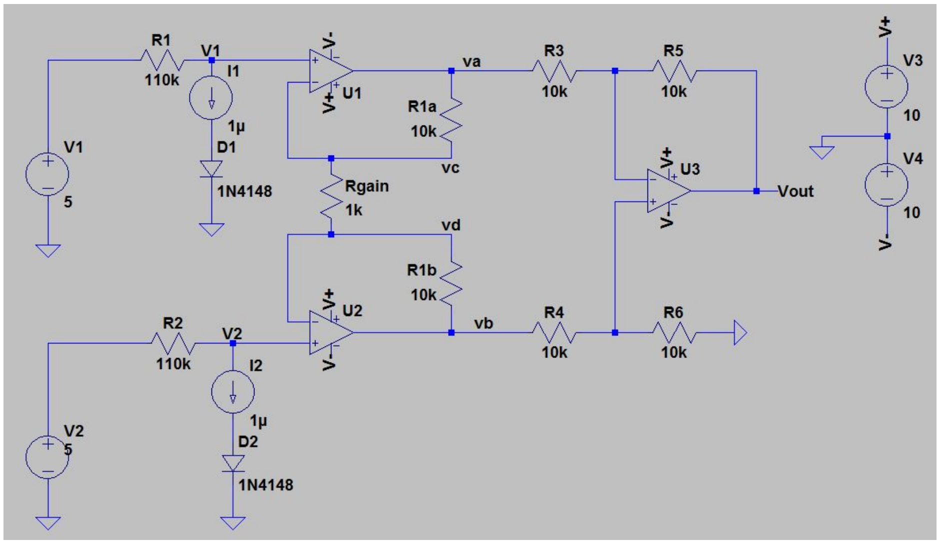
Below shows a DC current sweep to observe output voltage. We are applying a DC sweep on the on the diode because we are simulating the current through it once heat is being applied to it.



Below shows how the voltage changes as current changes due to temperature



Schematic used



Schematic formula

$$V_{va} = (V_{vb} - V_{va})(1 + \frac{2R}{Rgain})$$

Gain $\rightarrow$ $Av = 1 + \frac{2R}{Rgain}$ $\rightarrow$ $1 + \frac{2(10K\Omega)}{1K\Omega} = 21$

Number of times the output voltage was tested with the LED and heat gun.

	C°	F°	Voltage
1	75	167	1.9
2	73	163.4	1.85
3	76	168.8	1.9
4	71	159.8	1.89
5	72	161.6	1.91
6	73	163.4	1.9
7	72	161.6	1.91
8	73	163.4	1.9
9	72	161.6	1.91
10	73	163.4	1.9
Average/mean	73	163.4	1.89

Room temperature shown on multi-meter before testing was about 27 C°

$$73\text{C°} - 27\text{C°} = 46\text{C°} \qquad \frac{1.89}{46} \approx 41mV\ per\ C°$$

3. Encountered Problems

Most of the problems we encountered were ground issues. There were several times we did not connect ground properly, or the ground wire was in the breadboard, but due to discontinuities within the board itself, we had floating points. However, we were able to find slots in the breadboard that work properly and we were able to make changes accordingly to test the circuit.

4. Summary

This project is a circuit combination of diodes and an instrumentation amplifier circuit. Diodes were added in parallel to the inputs in order to create voltage changes in respect to temperatures. This difference in voltage gets increased by the gain value, which results as an increase in output voltage. The voltage increases until it turns on the LED that is connected to the output. When the LED turns on, it means in our case that the temperature is too high and the LED acts as trigger device or switch.

5. Conclusions

In conclusion this project helped us understand different applications of diodes as well as operational amplifiers. Combining diodes and instrumental amplifiers, a temperature circuit based on diodes can be built. Also, we learned much about troubleshooting since there were many troubles with the board and connections with ground.