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| UMass-Lowell-logo.png (295×358) | **Course Project** | **Electronic Birthday Candle(s)** | |
|  |  | |
| Yolmorakatpanhcharong Lim Lab Partner: N/A | | |
| Bench #424-08 | | |
| EECE.3110 – Electronics 1 Section 802 | | |
| Date submitted: 12/06/2021 | | |
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I. SUMMARY

This report showcases the circuit construction and functionality of the electronic birthday candle course project. The schematic for this report uses three major circuits that amplifies voltages, controls voltages, and uses two smaller circuits to make an AC/DC battery backup circuit. The first circuit amplifies the output voltage of the microphone and multiplies it by some factor which will result if a larger output voltage. The second circuit stores the voltage in the capacitor C1 which then charges the capacitor. Voltage stored in the capacitor will make the MOSFET settle in its saturation mode and the BJT in its active mode. More will be explained in the Circuit Description of this report. The last and third circuit is the battery back up circuit and the AC to DC converter. The AC will supply the DC voltage to the LED when it is turned on and when it is turned off, the DC battery backup will supply the voltage to the LED.

II. EQUIPMENT

Table 1 shows the list of equipment used in the Course Project.

**Table 1. Equipment Used**

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Details** | |
| Breadboard | *Make:* | R.S.R Board |
| *Model:* | *MB-104 WWK* |
| *Serial Number:* | N/A |
| DMM Bench-Top | *Make:* | Keithley – A Tektronix Company |
| *Model:* | 2110 5 ½ Digital Multimeter |
| *Serial Number:* | 8008078 |
| DMM Hand-Held | *Make:* | Tenma |
| *Model:* | 72-9385 |
| *Serial Number:* | H200299550 |
| Analog Discovery 2 | *Make:* | Digilent |
| *Model:* | Analog Discovery 2 |
| *Serial Number:* | SN:210321AD1587 |
| Bench Shoebox | *Make:* | UMASS Lowell |
| *Model:* | N/A |
| *Serial Number:* | N/A |
| Dual Power Supply (+12V and -12V) | *Make:* | Digilent |
| *Model:* | PowerBRICK 12V |
| *Serial Number:* | 410-293-A |
| Function Generator | *Make:* | Tektronix |
| *Model:* | AFG1022 Arbitrary Function Generator |
| *Serial Number:* | 1731189 |
| Oscilloscope Bench-Top | *Make:* | Tektronix |
| *Model:* | MDO3014 |
| *Serial Number:* | C044990 |

Table 2 lists all the components used within the Course Project, showings its quantity and details.

**Table 2. Components Used**

|  |  |
| --- | --- |
| **Component Type** | **Details** |
| Resistor | 1. 100 Ω |
| Resistor | 1. 330 Ω |
| Resistor | 1. 2.2k Ω |
| Resistor | 1. 1k Ω |
| Resistor | 1. 10k Ω |
| Capacitor | 1. 100 µF |
| Capacitor | 1. 0.1 µF |
| Capacitor | 1. 1 µF |
| 1N4001G Rectifier Diode | 1 |
| 1N914 Diode | 2 |
| 1N3064 Diode | 1 |
| 2N3904 npn Transistor | 1 |
| 2N7000 MSOFET | 1 |
| Red LED | 1 |
| LM741CN OP AMP | 2 |
| Microphone (NEWARK SKU: 25R0622) | 1 |

III. CIRCUIT DESCRIPTION  
Note: Refer to the APPENDIX of this report to view videos and other screenshots.

Diagram, schematic

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Figure 1. Multisim Schematic

First Major Circuit: 2 Amplifiers, amplifies the output voltage of the microphone

This circuit schematic has three major parts that are incorporated together to make the LED light up and turn off as a sound is play through the microphone specifically blowing on the microphone. The first circuit uses a non-inverting amplifier that has a 0.4V supply going into pin 3 of the op amp. This 0.4V source is a replication of a microphone in multisim. In the real construction of the circuit, the microphone positive leg uses a 1 µF capacitor connected to pin 3 of the first op amp and it is in series with a 10k Ω resistor that is going to a voltage source. This voltage source comes from the DC supply on the ADK2. This DC supply is a 3V source that is being supplied to the positive leg of the microphone (the leg in which is connected to the 10k Ω resistor). Pin 2 of the non-inverting amplifier is connected to the output which is then connected to the pin 3 of the second op amp (comparator). Both op amps have rail voltages of -6.25 and +6.25 volts with both having a 0.1 µF to reduce the noise coming out of the outputs. Pin two of the second op amp (comparator) has a 0.1V source to change the output voltage to be either negative or positive. The 0.1V source basically checks which input is greater, if the - is greater, the output is -5 and if the + is greater the output is +5. Positive output voltage of the op amp means the LED should not turn on while if measured to be negative, the circuit should work, and the LED should turn on. The output of the second op amp is connected to a 1N3064 diode, the diode is an open circuit when the output voltage of the op amp is negative and short circuit when the output voltage is positive. The diode is also connected to a switch that controls when the capacitor at the end of the switch is charging.

1. Reason for adding a capacitor and a resistor in the positive leg of Microphone:

So, the microphone was given a voltage source of 3V from ADK2 power supply. The capacitor and resistor measure the change in voltage. Blowing on microphone generates voltage. That voltage is a rate of change, only the change in voltage will be let through. Any DC voltage will be stored in the capacitor and stops it from moving forward.

1. Microphone Voltage Amplification equation for the two op amps:
2. Reason for 2 Op Amps:

The reason for two op amps in this circuit is to amplify the voltages coming out of the microphone and also the 0.1 V by a factor of the result using the equation above. This will make the microphone process the sounds going into it more accurately.

Second Major Circuit: 1 MOSFET and 1 BJT, controls when the LED receives voltage and if it’s on or off

The second major circuit component of this schematic is a voltage controller circuit. When the capacitor at the gate of the MOSFET is charged (stores voltage) with voltage (when the switch is pressed and then released), the MOSFET should be in saturation which then makes the BJT in active mode. The MOSFET biases the base of the BJT and controls whether or not the BJT is in active or cut off mode. This affects the LED and controls when it turns on or off. Both the BJT and MOSFET are short circuit which also short the LED meaning that the LED is off (when the microphone is blown on). When the microphone isn’t being blown on, the BJT and MOSFET are in cut off. This means that both are open circuit which also makes the LED an open circuit, thus turning on the LED (with a charged capacitor). A simpler way to put it is that the AC and DC signal in the third circuit (will be explained in the next paragraph) will light up the LED with their voltages when the two transistors (MOSFET and BJT) are open circuit (cut off). If the AC supply (AC to DC) is turned off, the DC battery back-up will supply the led and vice versa if the DC is turned off.

This circuit is almost like a Darlington transistor configuration except the first transistor is replaced by a MOSFET in which its source is connected to the base of the 2N3904 BJT. This now becomes similar to a IGBT configuration or an Insulated Gate Bipolar Transistor. In short, it is a BJT with an insulated gate terminal, it has a control input MOSFET and a BJT that acts as an output switch which then determines the on and off of the LED [12].

Third Major Circuit: AC to DC Converter and Battery Backup

The third major circuit component incorporates a half-wave rectifier circuit connected to a 1N914 diode supplied with a 3V source to replicate a battery back up circuit. The half-wave rectifier circuit was taken from Electronics I Lab 4 of this semester. The rectifier circuit converts AC voltage to DC voltage which then “fights” to leave the circuit section to supply the voltage. The higher voltage within this major circuit will “beat” the lower voltage supply to then supply the LED with voltage and turn it on. This battery back up works the way the course project had outlined it, “The candle will automatically switch to battery when the a.c. signal source converted to d.c.is removed and will automatically return to the a.c. signal source converted to d.c. once it is available [4].”

Note: To view results of the physical working circuit, see the videos in the APPENDIX section of this report.   
As a summary, the LED lights up and blows out when only the AC voltage is supplied, it also works when only the DC is supplied, and finally when both the AC and DC are supplied the LED functions the same way [12].

Bread Board-setup Legend:  
Blue Box – Circuit 1 Microphone

Red Box – Circuit 2 Voltage Controller (LED)

Green Box – Circuit 3 AC to DC Converter and DC Battery Back up

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Figure 2. Bread Board Setup

Note: There is another rectifier diode in parallel with the original at the Green Box, which is circuit 3 in the legend at the top of this image. This diode was placed in to test what will happen with to the converter if a second diode was placed. The original circuit set up for that specific part should only have 1 rectifier diode in series with the parallel connection of the capacitor and resistor. This was a small mistake that was left behind and was forgotten about, this mistake did not affect the circuit functionality in any way.

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APPENDIX

**Laboratory Results Videos**:

1. Course Project Circuit setup
   1. <https://youtu.be/yykWttB-Pns>
2. Course Project DC Supply ON
   1. <https://youtu.be/KCj5jcs0Dz4>
3. Course Project AC Supply ON
   1. <https://youtu.be/6VioM58zlBU>
4. Course Project AC/DC Supply ON (Both ON)
   1. <https://youtu.be/G1EpVoLYQOc>

**Laboratory Pictures**:

1. Course Project Circuit setup

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