ESET 350 Lab Report:

Clap On & Off Switch Kit

Course Project Report

Section 503 & 508

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Overview

The circuit depicted below in Figure 1 is what is referred to as a Clap On & Off Switch. In more simple terms it is a circuit which takes a sound input (Ex: snap, clap, etc.) and power input (AA batteries) to produce an LED output. When the sound sensor detects a sound within 4 meters it sends a signal to the LED turning it on. The LED will stay on until the sound sensor detects another sound and subsequently sends a signal turning the LED off.

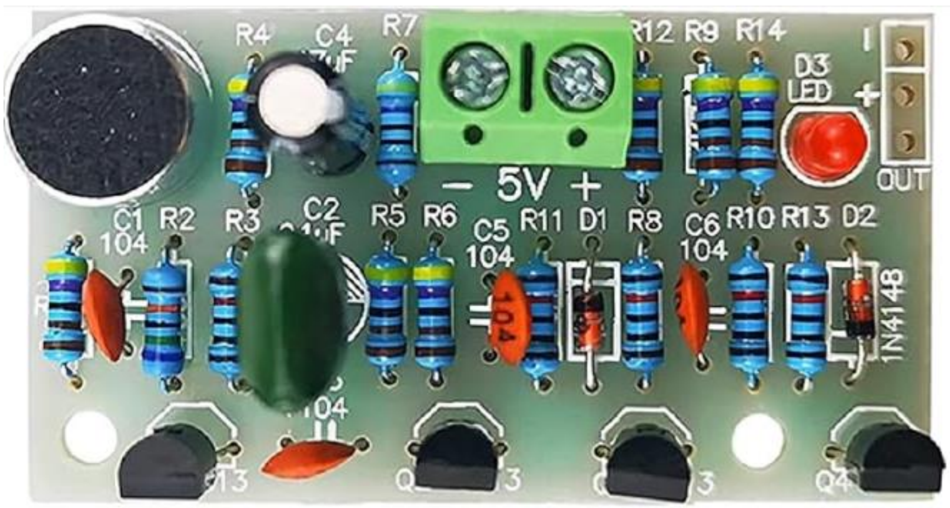

Figure 1 – Top View of Complete Clap On & Off Switch Circuit

Overview - Functional Block Diagram

The Block diagram for the Clap On & Off Switch Circuit is made up of two inputs, three blocks, and one output as shown in Figure 2. The inputs are the Battery and the Microphone Sound Sensor. The main subcircuits are the Audio Amplifier, Bi-Stable Flip Flop Circuit, & Circuit Amplifier. The output is an LED.

Figure 2 – Block Diagram of Complete Clap On & Off Switch Circuit

Theory of Operation - Schematics

The overall schematic for the Clap On & Off Switch Circuit can be seen in Figure 3. It has been broken up into the different circuit sub-components which are as follows: 1- Battery Input, 2- Microphone Sound Sensor Input, 3- Audio Amplifier, 4- Bi-Stable Flip Flop Circuit, 5- Circuit Amplifier, & 6- LED Output. Additionally, a functional simulation of the circuit in Multisim can be seen in Figure 4.

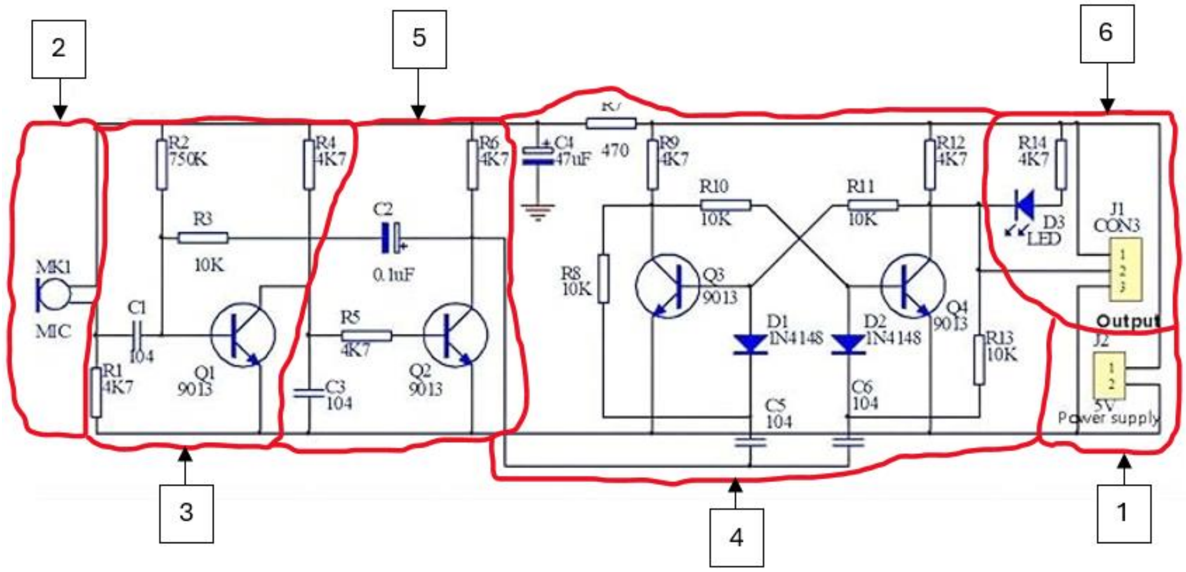

Figure 3 – Overall Schematic of Complete Clap On & Off Switch Circuit Referencing Block Diagram

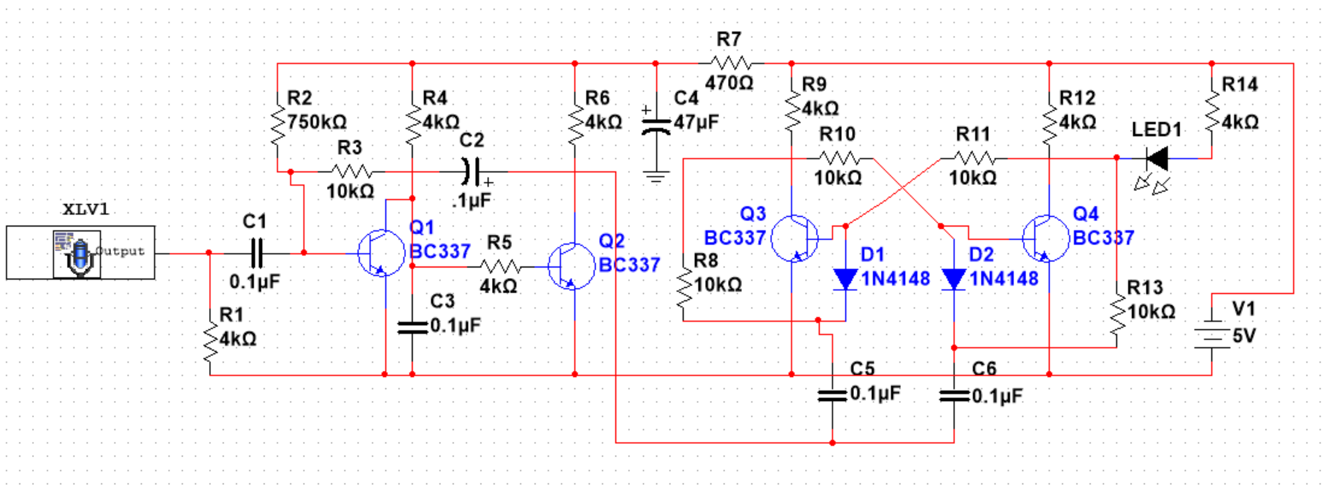

Figure 4 – Overall Schematic of Complete Clap On & Off Simulated in Multisim

Theory of Operation - Explanation

The Clap On & Off Switch Circuit is a simple circuit made up of a combination of Capacitors, Resistors, Diodes, Transistors, and additional parts listed in Figure 6. These parts make up distinct components instrumental to the operation of this circuit as shown in Figure 2, Figure 3, and Figure 4. In this circuit the resistors serve to control the voltages and currents throughout the circuit. The capacitors serve to eliminate any noise variation. The transistors serve to amplify and switch the electric signals and power.

1. Battery Input: The battery provides power to the entire circuit and its components. This circuit requires a power supply of 3 to 5 volts. This is achieved through the use of 3 AA batteries in series each providing 1.5 volts bringing the total amount of DC power supplied to around 4.5 volts.

2. Microphone Sound Sensor Input: The condenser microphone (speaker) works as a transducer converting

sound signal into electrical pulsating energy biased by the R1 resistor. The speaker receives close to a consistent supply of 1.5 volts of power going through it. The speaker's output is 0 Volts until a sound is detected which produces a voltage output that, depending on the intensity of the sound, can be anywhere between 1 to 4 volts. The second resistor (R2) controls the sensitivity of the microphone. The larger the resistance value of the second resistor (R2) the higher the sensitivity.

3. Audio Amplifier: The audio amplifier serves as a common emitter circuit which receives a small sound signal from the microphone and converts it into an electrical signal that is then amplified through the use of a transistor. The amplified signal is sent to the Flip Flop Circuit from the collector of the transistor.

4. Bi-Stable Flip Flop Circuit: The flip flop circuit consists of two transistors which are cross connected that produce a single output pulse when triggered making it a triggered pulse producer. Each transistor represents an individual state of the circuit. One transistor is for when the circuit is in the on position and the other is when the circuit is in the off position. Only one transistor conducts at a time, the other is cut off. This configuration is known as a Bi-Stable Multi Vibrator change state or in more simple terms, in the larger context of the entirety of the circuit, a sound operated switch. The output of the transistor is switching between a 1 logic and 0 logic and remains in that state until a trigger pulse from the audio amplifier changes it to the opposite logic state.

5. Circuit Amplifier: The weak electric current from the Flip Flop is unable to directly power the LED so it must be amplified. The circuit amplifier, made up of another transistor, takes the weak electrical signal output from the Flip Flop configuration and amplifies it, making it much stronger to light up the LED.

6. LED Output: The LED produces a light if the circuit is in the on configuration and remains on until the circuit is changed to the off configuration. The LED has close to 5 volts of power going through it when on and 0 volts when off.

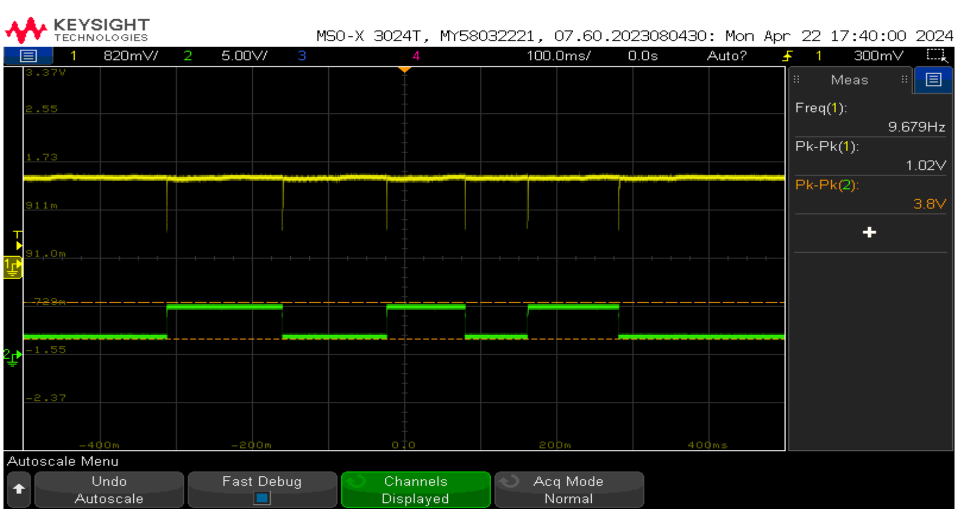

Figure 5 – Voltage Waveform of Pos. & Neg. Terminals of Microphone (Yellow) and LED (Green) Experiencing Sounds

Figure 5 is a perfect example of the overall function of the circuit and the relationship between the LED & the microphone. As the microphone records a sound and pulses the LED turns on or off respectively.

Marker	Component	Component name	Specification	Qty
C1, C3, C5, C6		Ceramic chip ca	104	4
C4		Electrolytic Capacitors	47uF	1
C2		Polyester Capacitor	104	1
R1, R4~R6, R9, R12, R14		Resistors	4K7	7
R2		Resistors	750K	1
R3, R8, R10, R11, R13		Resistors	10K	5
D1, D2		Diodes	1N4148	2
D3		Light-emitting diodes	Red	1
Q1~Q4		Triode	9013	4
MK1		Microphone	5MM	1
J2		Wiring Terminal	2P	1

Figure 6 – Parts List for Complete Clap On & Off Switch Circuit

Testing - Testing and Measurement

Testing for Clap On & Off Switch Circuit included the use of an oscilloscope and cables to capture voltage waveforms of different components of the circuit. Each type of component in an important position was measured in the on and off states and recorded in Figures 7 through 15. All waveforms were as expected.

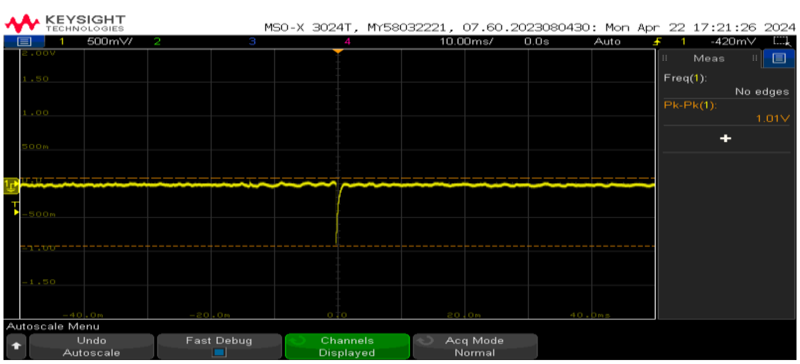

Figure 7 – Voltage Waveform of Pos. & Neg. Terminals of Microphone Experiencing a Distant Sound (Very Small Sound)

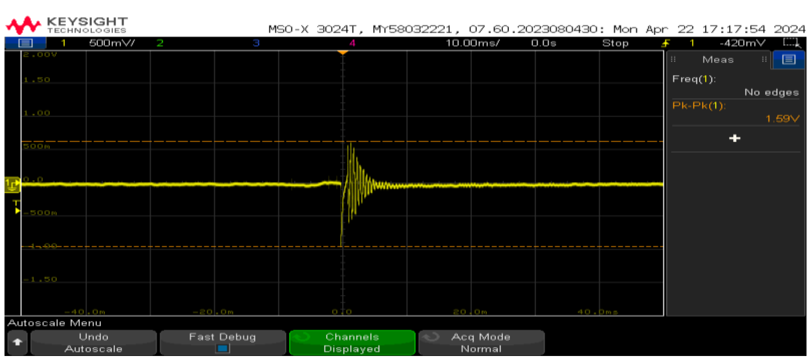

Figure 8 – Voltage Waveform of Pos. & Neg. Terminals of Microphone Experiencing a Snap (Smaller Sound)

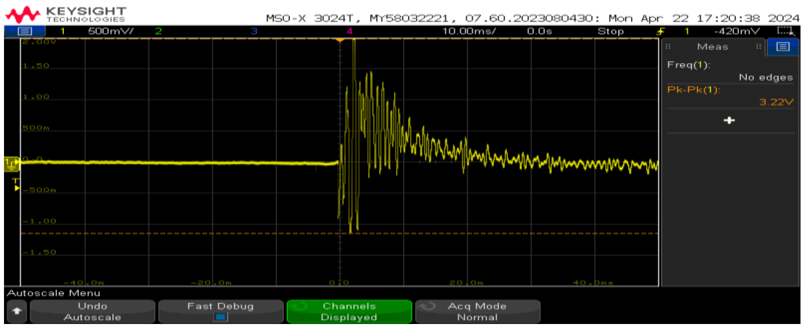

Figure 9 – Voltage Waveform of Pos. & Neg. Terminals of Microphone Experiencing a Clap (Larger Sound)

Figure 10 – Voltage Waveform of Backside of D2 Diode Relative to Ground Experiencing Sounds

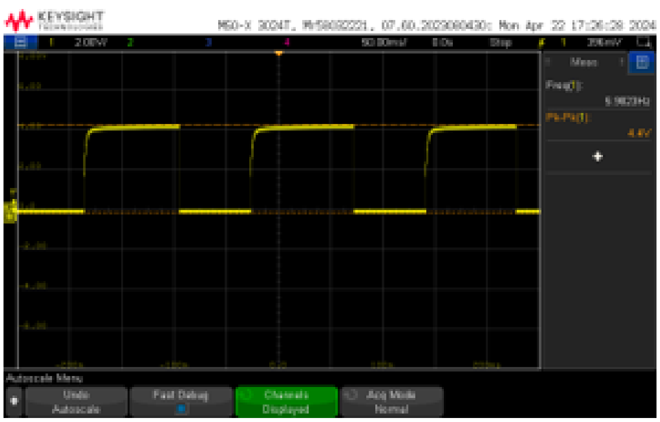

Figure 11 – Voltage Waveform of C6 Capacitor Relative to Ground Experiencing Sounds

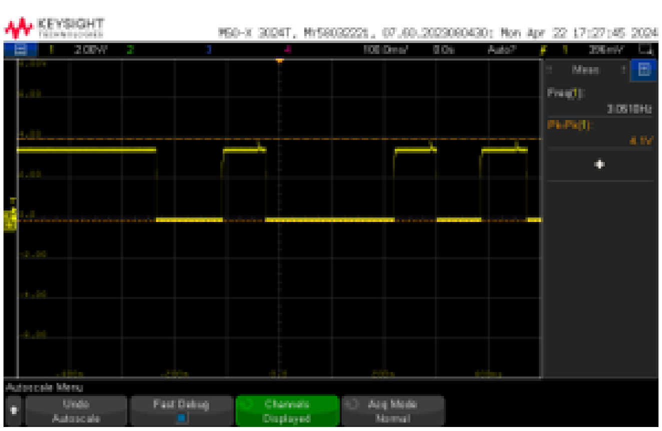

Figure 12 – Voltage Waveform of Q4 Transistor Emitter Leg Relative to Ground Experiencing Sounds

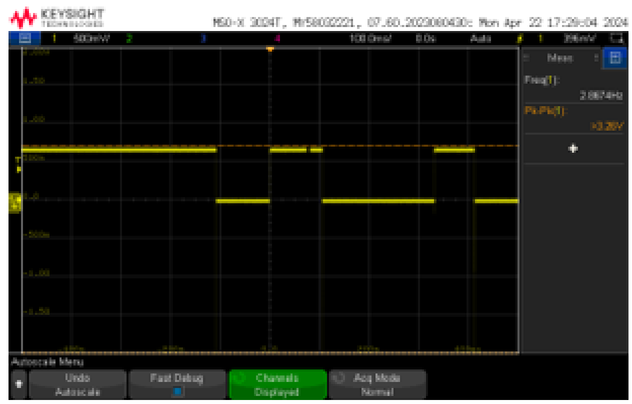

Figure 13 – Voltage Waveform of R11 Resistor Relative to Ground Experiencing Sounds

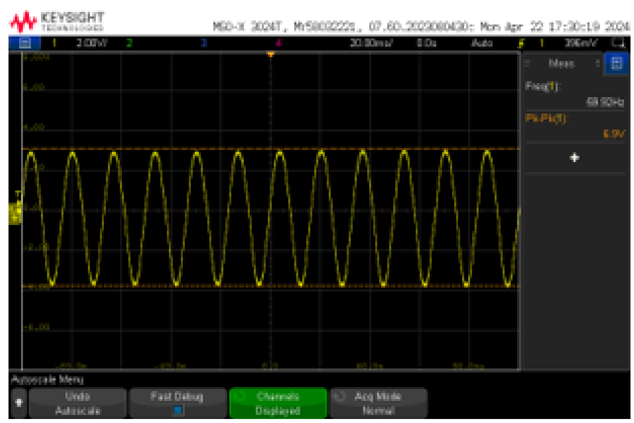

Figure 14 – Voltage Waveform of C2 Polyester Capacitor Relative to Ground Experiencing Sounds

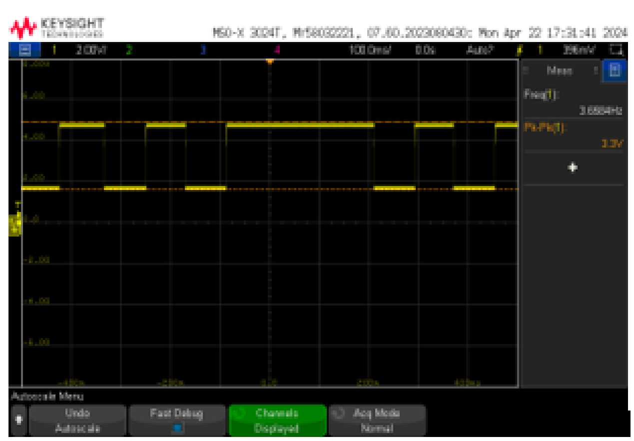

Figure 15 – Voltage Waveform of Pos. & Neg. Terminals of D3 LED Experiencing Sounds

Testing - Analysis

For testing the microphone, a voltage waveform was captured using an oscilloscope across the positive and negative terminals of the microphone while the circuit was off as shown in Figure 7. The voltage waveform was relatively flat with only minor fluctuations of a small 1V output voltage due to this having no filtration. Next, the speaker was subjected to low changing sound inputs (snapping and not snapping) and was recorded across the same terminals as shown in Figure 8. The voltage waveform exhibited fluctuations in response to the noisy environment due to receiving an analog input signal with no filtration, but it has a clear distinction of when sound is and isn't being generated. Finally, the speaker received high-changing sound input (clapping and not clapping), which created a much more prominent voltage spike due to the increased sound intensity of a clap.

Once the waveform passes through the filtration circuit, and subsequently the ADC circuit, diodes D1 and D2 act as a rectifier by only allowing the pulsing voltage to pass when positive for D1 and Negative for D2 which changes the output voltage depending on the input noise. This output, as shown in Figure 10, got converted to a constant on or off voltage depending on whether a clap was heard or not.

As previously stated, the op-amps output a changing high-low signal that gets fed into the capacitors as shown in Figure 11. The capacitor smooths the voltage from the diode and creates a clean output signal back to transistors Q1 and Q2. This was achieved by probing both ends of the capacitor to see the flow of electrons through it. Capacitors are also essential prior to the DC conversion as capacitors are used to make bandpass filters and provide a smooth sinewave output as shown in Figure 14 after performing the same probe. As for resistors, they are essential to the filtration process by filtering current such as resistor R11 which provides biasing current to the transistor base effectively controlling current through the transistor as shown in Figure 13. This is measured by observing the voltage across both sides of the resistor.

The transistors are essential to the flip-flop circuit to turn the circuit on and off. This was done by measuring the transistor at the emitter and ground to view the output waveform as shown in Figure 12. This shows the circuit flipflops on and off as the transistor controls the output voltage.

In conclusion, based on all the testing this circuit effectively functions as both an ADC (Turning the analog signal into a digital, steady voltage) and a flip flop (fluctuates between on and off as the circuit powers on and off). One disadvantage to this simple circuit setup is that without sound control devices the microphone picks up outside noise it shouldn’t be. This is a major problem in loud environments with this circuit as clappers are commonly made with 555 timers or ICs to offer tighter filtration, but this implementation doesn't fully remove interference from affecting these components, which for an ADC circuit can cause miscues to the output state.

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