Digital Assignment

Title of the Mini Project:

MULTI-MODE CLAP & SOUND PATTERN SWITCH

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Course Code & Course Title: BECE206L & Analog Circuits

Academic Year: [2025–2026]

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Abstract:

The Multi-Clap Sound Pattern Switch is an innovative, sound-based automation system that allows users to control multiple electrical devices simply by clapping. The main goal of this project is to create a cost-effective, touch-free, and intelligent control system that can accurately respond to single or multiple clap sequences. In today's world, the demand for touchless operation is growing rapidly—especially in home automation, assistive technology, and environments where hygiene is important. This project meets that need through a simple yet efficient design that combines analog signal processing with digital logic control.

The system uses an electret condenser microphone to capture the sound of claps. This signal is then amplified and filtered using an LM358 operational amplifier, ensuring the claps are reliably detected even from a moderate distance. The amplified signal is sent to an Arduino microcontroller, which processes it using a timing-based detection algorithm. The system can distinguish between different numbers of claps—like one, two, or three—and toggle the corresponding devices. For instance, one clap might switch on LED1 (or Appliance 1), two claps could control LED2 (or Appliance 2), and three claps might operate LED3 (or another device). This logic can be extended to control multiple devices such as fans, buzzers, relays, or even IoT-enabled modules.

What makes this system practical is that it uses simple timing logic for clap recognition instead of complex digital signal processing, making it suitable for low-power microcontrollers and perfect for educational purposes. Overall, this project demonstrates how analog sensing, signal conditioning, and digital control can be combined to create intelligent and interactive automation. The Multi-Clap Sound Pattern Switch provides a practical, user-friendly, and affordable solution

for smart living. Looking ahead, it could be further enhanced with IoT or voice-controlled features, making modern homes and assistive technologies even more convenient and interactive.

Objectives:

The primary goal of the Multi-Clap Sound Pattern Switch project is to design and build a touchless, sound-activated control system that can recognize different clap patterns and use them to control various electrical appliances. This system aims to offer a simple, efficient, and affordable solution for smart automation.

• To develop a sound-based switching system capable of detecting single, double, and triple claps, allowing users to control multiple output devices independently.

• To design a stable amplification circuit using the LM358 operational amplifier, ensuring that even weak signals from the microphone are amplified accurately for reliable detection.

• To achieve a user-friendly, contactless automation setup that can be used in homes, classrooms, or assistive environments where touch-free control is beneficial.

Problem Statement:

In most homes and devices today, we still rely on physical switches to turn things on and off. While this works, it limits convenience and doesn't fit well with the growing trend of smart, automated systems. People now expect more flexible and contactless ways to control their surroundings. To meet this need, the Multi-Clap Sound Pattern Switch is designed to make device control easier and smarter. By using an electret condenser microphone, an LM358 operational amplifier, and an Arduino Uno, the system can recognize different clap patterns—such as one, two, or three claps—to control multiple devices. This approach offers a simple, user-friendly, and scalable way to bring sound-based automation into everyday life.

Literature Survey:

M. A. Kader, R. S. Dhar, M. A. Rahaman, M. R. Islam, and A. Khandakar (2015) developed a *"Single Channel–Multiple Load Hand Clap Controlled Switch Board for Home and Office Application"* at the International Islamic University Chittagong. The system converts clap sounds into electrical signals using a condenser microphone and controls multiple loads through timing-based logic. It demonstrated a simple and low-cost method for contactless control using analog amplification and digital logic. The study effectively showed that a single sound channel can manage several devices, but it lacked detailed performance analysis under noisy conditions and could not differentiate between complex clap patterns. This limitation opens scope for advanced systems that integrate analog signal conditioning (using LM358) with microcontroller-based pattern recognition to improve accuracy and scalability — as proposed in the Multi-Mode Clap and Sound Pattern Switch project.

F. T. Jiwandono (2016) presented "Control of 3-Way Switches Using Clap Sound", describing a simple sound-activated switching system where a microphone detects clap signals to control a three-way electrical switch. The circuit converts sound into voltage signals and uses comparator-based logic to trigger switching operations. The design highlights how basic analog circuitry and timing control can be used for hands-free operation of devices. While the work successfully demonstrates contactless control through acoustic signals, it is limited to single-clap detection and does not handle multiple patterns or noise differentiation. This research provides a foundational concept that the Multi-Mode Clap and Sound Pattern Switch builds upon—enhancing functionality to recognize multiple clap patterns and improving reliability through microcontroller-based processing and analog filtering.

Tools and Technologies Used:

1. Hardware Components

- Electret Condenser Microphone (ECM): The microphone acts as the primary sound sensor, capturing clap sounds and converting them into small electrical signals.
- LM358 Operational Amplifier: Strengthens the weak signals from the microphone so they can be accurately detected by the Arduino.
- Arduino Uno: Serves as the brain of the project, processing signals, identifying clap patterns, and controlling the output devices accordingly.
- 10 kΩ Potentiometer: Allows fine-tuning of the circuit's sensitivity, ensuring the system responds only to intentional claps.
- LEDs and Buzzers: Provide visual and audible feedback, helping users easily identify the system's response to different clap patterns.
- Resistors, Jumper Wires, Breadboard, and USB Cable: Essential supporting components used for safe connections, circuit assembly, and power supply.

2. Software Tools

- Arduino IDE: The programming platform used to write, compile, and upload the clap detection code to the Arduino Uno.
- Serial Monitor: A built-in tool in the Arduino IDE used for observing sensor readings and debugging during testing and calibration.

3. Technologies and Concepts

- Sound Signal Processing: Used to convert acoustic energy (claps) into electrical signals that can be measured and processed.
- Analog Signal Conditioning: Involves amplification and filtering of weak microphone outputs using operational amplifiers (like LM358 or UA741) to produce clean, usable voltage levels for digital processing.

- Embedded Systems Programming: Involves coding the Arduino to recognize timing patterns and differentiate between single, double, or triple claps.
- Digital Control Logic: Enables the system to toggle output devices like LEDs or buzzers based on detected clap patterns.

Proposed System / Methodology:

The Multi-Clap Sound Pattern Switch is designed to offer a smart, contactless, and efficient way to control electrical devices using specific clap patterns. The system integrates sound detection, signal amplification, and microcontroller-based logic to ensure accurate and reliable performance.

1. Sound Detection Stage

The process begins with an Electret Condenser Microphone (ECM), which serves as the system's sound sensor. When the user claps, the microphone detects the sound waves and converts them into small electrical signals. Since these signals are typically very weak, they are passed on to the next stage for amplification.

2. Signal Amplification Stage

The faint signals from the microphone are amplified using an LM358 operational amplifier. This stage strengthens the signal and filters out unwanted noise, producing a clear and stable output that the Arduino can interpret correctly. A 10 kΩ potentiometer is included in this stage to adjust the sensitivity, allowing the system to detect only intentional claps and ignore background noise.

3. Signal Processing Stage (Arduino Uno)

The amplified signal is then sent to the Arduino Uno, which acts as the main controller of the system. The Arduino continuously monitors the signal input and measures the time interval between consecutive claps. Based on this timing, it determines whether the user has produced a single, double, or triple clap.
A simple time-based algorithm ensures that each pattern is detected accurately within a short interval (for example, within two seconds), allowing for reliable differentiation between clap sequences.

4. Output Control Stage

After identifying the specific clap pattern, the Arduino triggers the corresponding output device, such as LEDs or buzzers.

- Single Clap: Toggles the first output (e.g., LED1).
- Double Clap: Toggles the second output (e.g., LED2).
- Triple Clap: Toggles a third output device.

This approach can easily be expanded to recognize additional clap patterns or control more appliances simply by modifying the program logic.

5. Calibration and Testing

To ensure smooth and accurate operation, the 10 kΩ potentiometer is adjusted so that only deliberate claps generate a response. The system is then tested in different environments and distances to verify its performance, ensuring reliable detection even under varying sound conditions.

Implementation:

The Multi-Clap Sound Pattern Switch circuit integrates an electret condenser microphone, LM358 operational amplifier, Arduino Uno, and output devices such as LEDs and buzzers. The connections are carefully designed to ensure proper signal flow from sound detection to output control.

1. Microphone Connections

- The electret condenser microphone has two pins positive (+) and negative (–).
- The positive terminal of the microphone is connected to the non-inverting input (pin 3) of the LM358 op-amp through a 10 kΩ resistor.
- The negative terminal of the microphone is connected to ground (GND).
- A bias resistor (10 kΩ) is connected between the op-amp's non-inverting input (pin 3) and Vcc (5V) to provide proper biasing for the microphone.

2. LM358 Op-Amp Connections

- The LM358 has two op-amps inside; only one is used here.
- Pin 8 → Connected to +5V supply from Arduino.
- Pin 4 → Connected to GND.
- Pin 3 (Non-inverting input) → Connected to the microphone's output (as mentioned above).
- Pin 2 (Inverting input) → Connected to the middle pin of the 10 kΩ potentiometer, which is used to set the reference voltage (sensitivity).
- Pin 1 (Output) → Connected to Arduino digital input pin 2 (D2).
  This pin outputs a HIGH signal whenever a clap sound is detected and amplified.

3. Potentiometer Connections

- The middle pin (wiper) of the 10 kΩ potentiometer connects to pin 2 of LM358.

- One side pin of the potentiometer connects to GND, and the other side connects to Vcc (5V).
- Rotating the potentiometer adjusts the voltage threshold and helps fine-tune sensitivity for accurate clap detection.

4. Arduino Uno Connections

    - Digital Pin 2 → Connected to LM358 output (pin 1) to receive the amplified sound signal.
    - Digital Pin 8 → Connected to LED1 (through a 220 Ω resistor).
    - Digital Pin 9 → Connected to LED2 (through a 220 Ω resistor).
    - Digital Pin 10 → Connected to buzzer.
    - 5V Pin → Supplies power to the op-amp, potentiometer, and microphone.
    - GND Pin → Common ground for the entire circuit.

5. Output Device Connections

- Each LED or buzzer has its positive terminal connected to the respective Arduino output pin (8, 9, 10).
- The negative terminal of each device is connected to GND through a 220 Ω resistor (for LEDs) or directly (for a buzzer).

Software code:

```
const int micPin = A0;

const int led1 = 9;

const int led2 = 10;

const int buzzer = 11;

int threshold = 550;
```

```
int clapCount = 0;
unsigned long firstClapTime = 0;
unsigned long lastClapTime = 0;
// States for toggling
bool led1State = false;
bool led2State = false;
bool buzzerState = false;
void setup() {
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(buzzer, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  int sound = analogRead(micPin);
  if (sound > threshold && (millis() - lastClapTime) > 200) {
    clapCount++;
    lastClapTime = millis();
    if (clapCount == 1) firstClapTime = millis();
    Serial.print("Clap detected! Count: ");
    Serial.println(clapCount);
  }
  if (clapCount > 0 && (millis() - firstClapTime) > 2000) {
```

```
    if (clapCount == 1) {
      led1State = !led1State;
      digitalWrite(led1, led1State);
      Serial.println("LED1 toggled");
    }
    else if (clapCount == 2) {
      led2State = !led2State;
      digitalWrite(led2, led2State);
      Serial.println("LED2 toggled");
    }
    else if (clapCount == 3) {
      buzzerState = !buzzerState;
      digitalWrite(buzzer, buzzerState);
      Serial.println("Buzzer toggled");
    }
    clapCount = 0;
  }
}
```

Results and Analysis:

The Multi-Clap Sound Pattern Switch worked effectively, detecting and responding to different clap patterns:

- Single Clap: The first output device LED1 toggled ON or OFF reliably.
- Double Clap: The second device LED2 responded correctly when two claps occurred within 2 seconds.
- Triple Clap: Three quick claps successfully toggled a third device Buzzer.
- Extended Patterns: Additional clap sequences could be recognized by modifying the Arduino code.

The system responded almost instantly, and false triggers were minimal after adjusting the 10 kΩ potentiometer for sensitivity. LEDs and buzzers provided clear visual and audible feedback for each detected pattern. This experiment shows that a timing-based approach using a microphone and op-amp is very effective for detecting multiple clap patterns. The system proved to be:

- Accurate: It reliably distinguished between single, double, and triple claps.
- Scalable: More clap patterns and devices can be added easily with minor code adjustments.
- Simple and Cost-Effective: The design uses readily available components without the need for complex signal processing.

Conclusion:

The Multi-Clap Sound Pattern Switch demonstrates a practical and contactless sound-activated control system capable of recognizing single, double, and triple claps to toggle devices such as LEDs, buzzers, or small appliances. It integrates an electret condenser microphone for sound sensing, an LM358 op-amp for signal amplification, and an Arduino Uno for timing-based pattern analysis. The system proved accurate and responsive, with adjustable sensitivity minimizing false triggers. Its design is simple, cost-effective, and easily scalable through software modifications. Beyond educational use, it offers real-world applications in home automation and assistive technology.

Future Enhancement:

The Multi-Clap Sound Pattern Switch lays a strong foundation for touchless, sound-activated control systems, and there are several exciting opportunities to expand and enhance its capabilities:

1. IoT Integration:
    - The system could be connected to Wi-Fi or Bluetooth modules, enabling remote monitoring and control via smartphones or web apps.
    - Users would be able to switch appliances on or off and check their status from anywhere, making it ideal for modern smart homes.
2. Control of Higher-Power Devices:
    - By adding relays or solid-state switches, the system could safely operate AC appliances like fans, lights, or home entertainment systems.
    - This would extend its functionality from small devices like LEDs and buzzers to full-scale home automation.
3. Enhanced Pattern Recognition:

- The Arduino code could be upgraded to recognize more complex sound patterns, such as combinations of claps and snaps or different sound frequencies.
- This would allow more devices to be controlled and make the system more flexible and responsive.

4. Integration with Voice or Gesture Control:
   - Combining clap detection with voice commands or gesture sensors could create a hybrid control system, offering a more intuitive and user-friendly experience.
   - This would be particularly useful in assistive technology, helping people with mobility or accessibility challenges.
5. Energy Efficiency and Low-Power Design:
   - Optimizing the circuit for low-power operation could make it suitable for battery-powered or portable setups.
   - Integration with solar panels or energy-harvesting modules could make the system even more sustainable and eco-friendly.
6. Educational and Research Applications:
   - The project can serve as a learning platform for studying sound detection, signal amplification, timing-based algorithms, and microcontroller programming.
   - It can also be adapted for research in smart home automation, sensor networks, and IoT-enabled systems.

In summary, the Multi-Clap Sound Pattern Switch has immense potential to evolve into a more sophisticated, connected, and versatile automation system, offering convenience, accessibility, and smart technology in a simple yet practical design.

References:

F. T. Jiwandono, "Control of 3-way switches using clap sound," *Academia.edu*, 2016.

M. A. Kader, R. S. Dhar, M. A. Rahaman, M. R. Islam, and A. Khandakar, "Single channel–multiple load hand clap controlled switch board for home and office application," *Dept. of Electrical and Electronic Engineering, International Islamic University Chittagong (IIUC)*, Chittagong, Bangladesh, 2015.