**National Textile University, Faisalabad**



**Department of Computer Science**

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**DOCUMENTATION TASK A**

**Introduction**

This project demonstrates how to control multiple LEDs using two buttons on an ESP32 microcontroller. The first button cycles through different lighting modes such as OFF, Alternate Blinking, All LEDs ON, and PWM Fade. The second button acts as a reset button that immediately turns everything OFF and returns the system to the initial mode. An OLED display is used to show the mode currently active.

This assignment teaches the concepts of non-blocking programming, software-based PWM, button debouncing, and real-time user interaction in embedded systems.

## **2. Objectives**

* To implement multiple LED behaviors controlled through a single button.
* To use a second button as a master reset.
* To display active modes on an OLED screen.
* To use non-blocking timing instead of delay() for better performance.
* To simulate PWM using software logic for environments where analogWrite() is unavailable.

## **3. Hardware Components**

|  |  |  |
| --- | --- | --- |
| **Component** |  | **Description** |
| ESP32 |  | Main microcontroller |
| 3 LEDs |  | Output indicators |
| 2 Push Buttons |  | Mode selection and reset |
| OLED Display (I2C) |  | To show active mode |
| Jumper wires |  | Connections |

## **4. Pin Configuration**

|  |  |  |
| --- | --- | --- |
| **Component** |  | **ESP32 Pin** |
| LED 1 |  | GPIO 16 |
| LED 2 |  | GPIO 17 |
| LED 3 |  | GPIO 18 |
| Mode Button |  | GPIO 32 |
| Reset Button |  | GPIO 33 |
| OLED SDA |  | GPIO 21 |
| OLED SCL |  | GPIO 22 |

## **5. Operating Modes**

|  |  |  |
| --- | --- | --- |
| **Mode Number** | **Mode Name** | **Behavior Description** |
| 0 | All OFF | All LEDs are OFF |
| 1 | Alternate Blink | LEDs turn ON one-by-one in sequence |
| 2 | All ON | All LEDs remain ON continuously |
| 3 | PWM Fade | LEDs gradually fade in and out using software PWM |

The OLED screen displays the current mode name for user clarity.

## **6. Key Concepts Used**

### **6.1 Non-blocking Timing**

Uses millis() instead of delay() to allow multiple tasks to run smoothly without freezing the system.

### **6.2 Debouncing**

Ensures only one valid button press is detected, preventing multiple triggers due to contact noise.

### **6.3 PWM (Pulse Width Modulation)**

Brightness of LEDs is controlled by rapidly turning them ON and OFF. In this project, PWM is simulated using software logic.

### **6.4 Mode Cycling**

Each press of the mode button increases the mode counter. When it reaches the last mode, it resets to zero.

### **6.5 Reset Function**

The reset button clears all LEDs, resets brightness and blink counters, and returns to Mode 0.

## **7. Workflow**

1. System starts in Mode 0 (All LEDs OFF).
2. Mode button pressed once → moves to next mode.
3. Modes cycle in the following order:  
    OFF → Alternate Blink → All ON → PWM Fade → Back to OFF.
4. At any time, pressing the reset button immediately turns everything OFF and resets the mode to 0.
5. OLED displays the active mode in real-time.

## **8. Software Logic Summary**

* Button press is detected using INPUT\_PULLUP.
* Timers monitor elapsed time without blocking program flow.
* Software PWM controls LED brightness.
* OLED display is updated each time the mode changes.
* Reset has the highest priority and executes immediately.

## **9. Applications**

* Smart lighting systems
* IoT-based control panels
* Home automation prototypes
* Embedded system learning modules
* User interface design for microcontrollers

## **10. Conclusion**

This project successfully demonstrates the use of multiple control modes using two buttons on an ESP32 board. It introduces essential embedded concepts like non-blocking programming, PWM generation, and user feedback using an OLED display. The system is efficient, responsive, and can be extended to real-world applications.