Mini Project 1: RGB LED State Machine

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Abstract

This project report describes the development and implementation of a simple state machine using the Arduino Nano BLE Sense development board. The state machine comprises four distinct states, namely Dark, Red, Blue, and Green, each represented by a unique color on the inbuilt RGB LED of the board. To facilitate state transitions, a soft switch mechanism is employed, simulating the operation of a physical push button. The primary aim of this project is to create an interactive and visually engaging system that allows users to control and observe state changes through the RGB LED. Despite the absence of a physical switch, this project leverages the board's capabilities to showcase the versatility and utility of the Arduino Nano BLE Sense platform.The report outlines the materials used, explanation of the code, observations, challenges faced, and lessons learnt, details the state machine's functioning, and highlights the implementation process within the Arduino IDE. This project serves as a practical example of using the Arduino Nano BLE Sense for building interactive systems and demonstrates the versatility of this development board for a wide range of applications.

1 Introduction

The Arduino Nano 33 BLE is a versatile and powerful development board that builds upon the well-known Arduino Nano platform while incorporating advanced features that make it suitable for a wide range of applications. It is based on the nRF52840 microcontroller, which offers significant enhancements compared to its predecessor, including a substantial 1MB of CPU Flash Memory. This increased memory capacity provides ample room for more complex and feature-rich projects.

One of the standout features of the Arduino Nano 33 BLE is its integration of a 9-axis inertial measurement unit (IMU), which includes an accelerometer, gyroscope, and magnetometer. This IMU capability opens up opportunities for projects involving motion sensing, orientation tracking, and gesture recognition. Additionally, the board supports Bluetooth Low Energy (BLE) connectivity, enabling seamless communication with other BLE devices and mobile applications. Figure 1 depicts the pinout configuration of Arduino nano 33 BLE.

The central objective of this project is to construct a state machine composed of distinct states, with each state correspondingly associated with a unique color displayed on the inbuilt RGB LED. The novelty here lies in the absence of a physical hardware switch on the Arduino Nano 33 BLE Sense. Instead, a creative solution is employed to create a soft switch mechanism that controls state transitions. In this particular implementation, a soft switch via the keyboard is used to trigger state changes.

2 Implementation

To begin this project, we first familiarized ourselves with the pin configuration of the Arduino Nano 33 BLE Sense development board. This understanding was crucial for effectively utilizing the built-in RGB LED and establishing communication through the Serial monitor.

Next, we installed the Arduino IDE and initiated a simple project to blink lights. This initial step allowed us to grasp the basics of programming the board and gain confidence in working with the Arduino platform. We followed the examples provided in the Arduino IDE and referred to the Arduino example documentation to enhance our understanding of the platform.

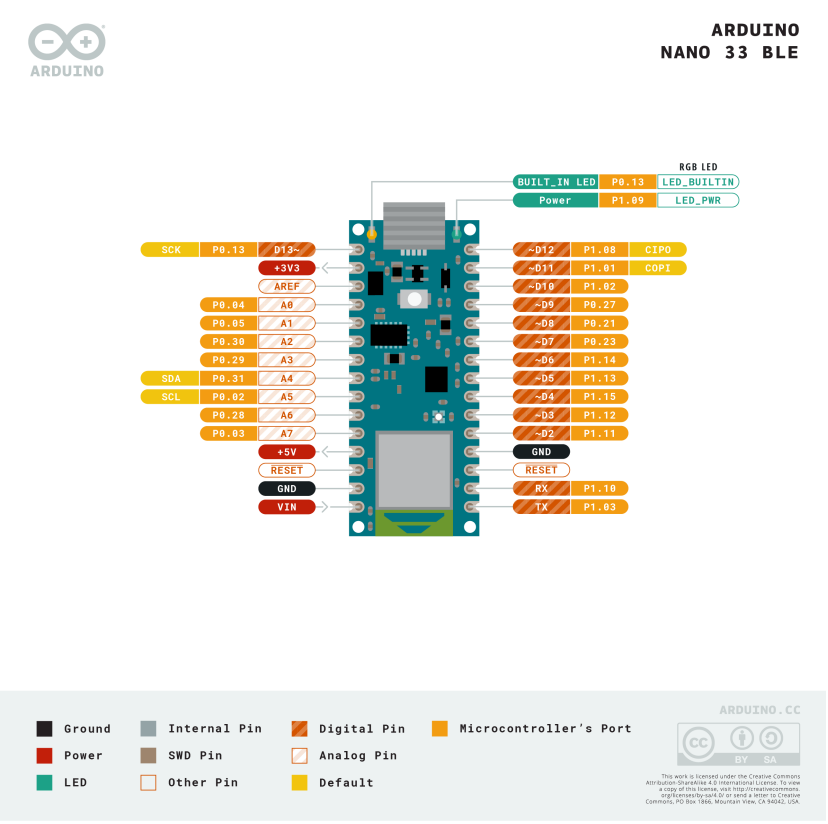

Figure 1: Pinout diagram of Arduino nano 33 BLE

Once we were comfortable with the execution process, we transitioned to the core of our project, which involved receiving input from the keyboard via the Serial monitor. This allowed us to verify that the board was correctly receiving and interpreting data from an external source.

State Machine Implementation:

Our state machine project commenced by defining the necessary pin numbers for controlling the RGB LED, specifically redPin, greenPin, and bluePin. Additionally, we initialized key variables such as count for time tracking and state for keeping track of the current state within the machine.

In the setup() function, we set the pin modes for the LED pins, ensuring they were appropriately configured for output. We also initialized the Serial monitor for communication with the computer, facilitating the input of commands via the keyboard. Initially, the LED was set to the 'Dark' state using the setColor() function.

State Transition Logic:

The state machine's core logic was implemented in the loop() function, continuously monitoring serial input from the computer. The following state transitions and countdown times were implemented:

- Initially, the system begins in the 'Dark' state, where the LED remains off or displays a dark color.
- While in the 'Dark' state, the multicolor LED turns red upon pressing the onboard switch (SW).
- While in the 'Red' state, the LED transitions back to the 'Dark' state after a delay of 5 seconds.
- Additionally, while in the 'Red' state, if you push SW, the LED transitions to the 'Blue' state.
- In the 'Blue' state, the LED switches back to 'Red' after a delay of 4 seconds.
- Similarly, while in the 'Blue' state, if you push SW, the LED transitions to the 'Green' state.
- In the 'Green' state, the LED changes back to 'Blue' after a delay of 3 seconds.

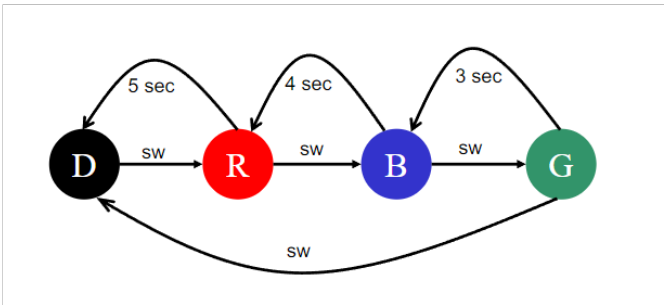

Figure 2: State diagram

- Finally, while in the 'Green' state, pushing SW instantly transitions the LED to the 'Dark' state.

Furthermore, the countdown, monitored by the count variable, triggers the subsequent state transitions based on the allocated time:

- Green → Blue (3 seconds)
- Blue → Red (4 seconds)
- Red → Dark (5 seconds)

This state transition logic, combined with countdown timers, creates a dynamic and interactive state machine that visually represents different states using the RGB LED on the Arduino Nano 33 BLE Sense board.

setColor() Function: The setColor() function takes three arguments for the red, green, and blue components of the LED color. It performs the following operations:

- Adjusts the color values to work with common anode RGB LEDs (values are inverted).
- Sets the LED colors using Pulse-Width Modulation (PWM).

2.1 Observations, Challenges and Lesson Learned

Observations:

Throughout the course of this project, several key observations were made:

- State Visualization: Utilizing the RGB LED on the Arduino Nano 33 BLE Sense allowed for effective visualization of different states, making the project engaging and informative.
- Serial Communication: Implementing serial communication with the computer enabled real-time interaction with the state machine. This feature provided valuable insights into the system's behavior and allowed for control via keyboard input.
- Countdown Timers: The use of countdown timers for state transitions added an element of anticipation and dynamics to the project, making it more interactive and visually appealing.
- Soft Switch Mechanism: Implementing a soft switch mechanism via keyboard input demonstrated the flexibility of the Arduino platform. This approach allowed for state control without the need for physical hardware switches.

Challenges:

While the project was largely successful, it did come with its fair share of challenges:

- Code Complexity: Managing the logic for state transitions, countdowns, and keyboard input required careful code organization. Ensuring that the transitions occurred smoothly and accurately was a challenge.

- Timing Precision: Achieving precise timing for countdowns was challenging due to variations in system performance and clock accuracy. Fine-tuning the delays was necessary to ensure transitions occurred as intended.
- User Interface: While the project was designed to be interactive, it relied on keyboard input, which may not be the most intuitive interface for all users. Integrating a more user-friendly interface, such as a graphical user interface (GUI), could be a future improvement.

Lessons Learned:
This project provided valuable insights and lessons for future endeavors:

- Hardware Exploration: Understanding the capabilities and pin configurations of the Arduino Nano 33 BLE Sense was crucial in utilizing its features effectively.
- State Machine Design: Designing and implementing a state machine offered a practical application of programming concepts and logic. It showcased the power of structured state transitions.
- Serial Communication: Working with serial communication expanded knowledge in establishing connections between microcontrollers and external devices. It demonstrated the potential for remote control and monitoring.
- Time Management: Managing time delays and countdowns required attention to detail and precision. Learning to work with timing elements in code is a valuable skill.
- Creative Problem Solving: Overcoming challenges, such as the absence of a physical switch. It highlighted the importance of adaptability and resourcefulness in project development.

References

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