VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY

HO CHI MINH UNIVERSITY OF TECHNOLOGY

FACULTY OF COMPUTER SCIENCE AND ENGINEERING

MICROPROCESSORS - MICROCONTROLLERS

Assignment

STM32 Multi-Mode Traffic Lights

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Ho Chi Minh City, 12/2025

Acknowledgement

We would like to express our sincere gratitude to our instructor, **Dr. Le Trong Nhan**, for his dedicated guidance and for providing the fundamental knowledge of Microprocessors and Microcontrollers that made this project possible. His lectures and course materials were instrumental in helping us understand the complex concepts of STM32 programming and controlling systems.

We also wish to thank the Faculty of Computer Science and Engineering at Ho Chi Minh City University of Technology (HCMUT) for providing an excellent academic environment that encourages research and practical application. And lastly, we appreciate the constructive feedback and support from our peers during the development of this project.

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1 Design objectives and Requirements

Traffic congestion is a critical issue in many areas. Effective traffic light control is essential for managing vehicle flow, reducing bottlenecks, and enhancing road safety. This project focuses on simulating a flexible four-way traffic light control system that allows for manual intervention and clear status display via an LCD screen.

The main goal is to design and simulate a microcontroller-based traffic light system. The system must meet the following technical requirements:

- **Microcontroller:** Utilize 32-bit microcontroller in STM32F103xx medium-density performance line family, specifically STM32F103RBT6.
- **Display:** Two sets of traffic lights for two directions. A 16x2 LCD module must display the current mode and the countdown timer.
- **Control Interface:** Four buttons are used to control the system with two modes, each has a distinct set of functionalities. In `AUTO` mode:
  - `MODE` Button: Cycle through operating modes (Automatic ↔ Manual).
  - `CONFIG` Button: Entering configuration mode.
  - `UP` Buttons: Increase the Red/Green/Yellow duration.
  - `DOWN` Buttons: Decrease the Red/Green/Yellow duration.

  In `MANUAL` mode:
  - `MODE` Button: Cycle through operating modes (Automatic ↔ Manual).
  - `SWITCH` Button: Changing light signals on each direction.
  - `FLASH` Buttons: Flashing Yellow light (Warning signal).
  - `RED` Buttons: Red light on both directions (Emergency stop).
- **Safety Logic:** Adherence to traffic regulations must be ensured by satisfying the time constraint:

$$T_{Red} = T_{Green} + T_{Yellow} \tag{1}$$

  The system must automatically calculate the Red light duration based on the user-set Green and Yellow times.

2 Physical Components

2.1 The Microcontroller Unit (MCU)

2.2 Interfacing with LCD 16x2

The LCD 16x2 module based on the HD44780 controller is used for information display. In this assignment, our display use an I2C shield in order to communicate with the MCU.

2.3 LED module for traffic lights

2.4 Buttons and Debouncing

The system uses four pull-up configured pushbuttons. Software debouncing (typically 20ms delay) with timer interrupt rather than using `HAL_Delay()` is implemented to ensure reliable signal readings from the mechanical switches.

3 Finite State Machine (FSM) Logic

4 System Block Diagram

The system is logically divided into three main blocks as shown below:

Figure 1: System Block Diagram

5 Conclusion and Future Improvements

Conclusion: The final project successfully met all design requirements for a flexible four-way traffic light controller. The group gained practical experience in applying microcontroller programming techniques, including Timer/Interrupt handling, and interfacing with key peripherals like LCDs and buttons.

Future Work: To enhance the system for real-world application, future developments could include:

1. Implementing sensor input (e.g., inductive loops or cameras) to dynamically adjust T_{Green} based on real-time traffic flow (Smart Traffic Light).

2. Integrating a communication module (e.g., UART or ESP8266 Wi-Fi) for remote monitoring and centralized control.