Microcontroller Lab Assignment 03: Road Traffic Management: Update Traffic Light Configuration

Prepared by: Dr. Mosaddek Tushar, Professor
Other Faculty: Redwan Ahmed Rizvee
Computer Science and Engineering, University of Dhaka,
Version 1.0
Demo Due Date: The following weeks as separate parts.
Please report if you find errors or anomalies in the description.

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1 Objectives and Policies

1.1 General Objectives

The objectives of the lab assignment are to understand and have hands-on training in microcontroller (STM32F446RE) I2C and SPI configuration and the operation of I2C and SPI .

1.2 Assessment Policy

The student must complete and demonstrate the assignment by the due date. After completing the assignment student must submit a report and upload the code to the microcontroller lab website or

google classroom. The students must complete the given problem; however, we encourage further assignment extension to replicate a realistic application environment. The student may get bonus marks for demonstrating an innovative extension of the lab assignment. The students submit the code and report on the due date. We will deduct marks for each week late, 5% for the first week, and 10% for the next subsequent weeks (accumulated marks) from the assignment marks.

2 Alert

It would be best if you take care of the microcontroller STM32F446RE; the input power to any GPIO pin must not exceed 3.6V. Do not damage or deform any GPIO pin, and do not use a conducting surface as the operating podium; otherwise, it may damage the microcontroller. Always connect the microcontroller to the computer USB type-A to type-B to power on and program.

3 What to do?

The assignment has two parts: (Later, see the detailed description). The assignment has two parts (i) I2C – master-slave and (ii) SPI master-slave communication. The master device (MCU) sends the configuration command from the control center to the slave device (MCU), which controls the traffic light duration and increases the green light duration for the busy road described in assignments 01 and 02. The assignment must implement two protocols separately. Two groups may collaborate to complete the assignment. Each group must implement (register programming) I2C and SPI to send and set the configuration to the slave device. Upon receiving the configuration slave device must reconfigure the traffic lights.

1. Configure using I2C
    - Master device configuration using I2C
    - Slave I2C configuration
2. Configure using SPI
    - Master device configuration using SPI
    - Slave SPI configuration

4 Assignment Problem Description

To understand the operation and procedure for communication with the traffic control room through I2C and SPI ports, you must develop and solve the following lab assignment.

4.1 Traffic System Monitoring and Customization

The following figure 2 presents traffic at the crossroad. In our country, traffic police usually control road traffic; however, the government has policies to alleviate our country into a digital and gradually smart Bangladesh. Thus it (police hand controlled) is against the policy. Now, the CSE third-year student wants to act positively. They plan to develop an intelligent traffic management system to reach to government's goal and make a usable traffic system for Bangladesh. The students want to emphasize the practical traffic control system (firmware) to control road traffic

now rather than a high-level decision-making system. They plan to develop it first and then take a left turn for the rest of the work for Fourth-year, MS, or Ph.D. students to use the intelligence in the traffic control system. Before going to the field implementation, they try it first in the microcontroller lab as their lab assignment.

Figure 1: Traffic Monitoring and Control Center (left); Expressway (right)

To simplify, they first define some constraints: the traffic can only go forward and left directions. They put three color LED (RYG – Red, Yellow, and Green) for the trafic signal. Traffic cannot flow forward or turn left when the red LED (in front of them) is ON. Traffic can flow straight and turn left only if the green LED is ON. The delay between RED to green is 60 seconds, from green to yellow 5 seconds, and from yellow to RED another 2 seconds. However, the students want to make it more adaptive. Their developed system recognizes the traffic on either side of the road. At the time of detection, if their application finds that the traffic load is less (one or two), they keep the green light glowing for 15 seconds more. However, their application maintains the same timing for an equal number of vehicles. They place three LEDs in each road direction to calculate the traffic load. Three LED ON indicates higher traffic load. Two or one means the traffic load is low. When the green light (LED) is ON, the developed solution moves traffic forward and takes a left turn. Also, the application adds random traffic to each road. It means switching ON a LED (vehicle);

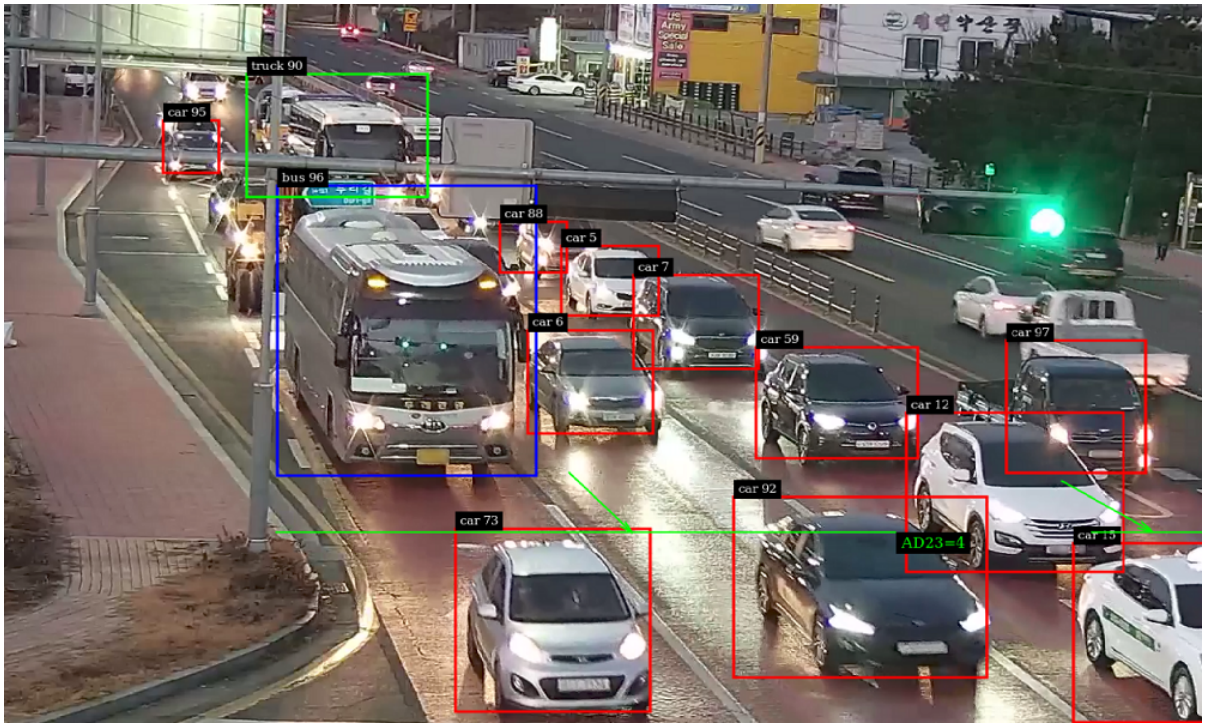

Figure 2: Traffic Monitoring and Control

4.1.1 Technical Specification

These assignment settings facilitate or create opportunities to receive configuration and monitoring commands from the control center and apply them to the traffic lights switching equipment (may contain MCU). A microcontroller receives the control commands and uses SPI or I2C to configure the traffic light switching circuit. The following fig. 3 shows a compact communication between the control center and the detail of the traffic light:

- Enable clocks for the selected ports and peripherals like SPI or I2C
- Select a SPI or I2C port and configure as master
- Select another SPI or I2C port and configure it as a slave system.
- To configure I2C, you need to choose an 8-bit address for the device.
- For SPI – use GPIO pin to enable or disable the device for multiple slaves
- Configure at least 4 LEDs as output and input for traffic signaling connected to the slave
- Develop the process on the slave system to control (i) Traffic lights, (ii) Light duration based on road traffic load – as in assignment 1 or 2
- The master SPI/I2C MCU sends control and configuration commands as given in lab assignment 2.
- Configure a timer to generate a delay.
- Use interrupts for SPI/I2C

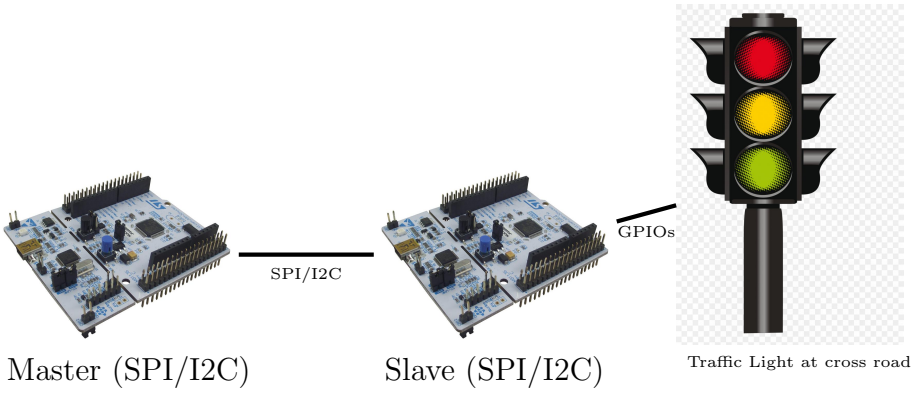

Figure 3: SPI or I2C Master - Slave for configuration and monitoring traffic lights or traffic at the crossroad

- Write test programs (master and slave) to evaluate the configuration.

Note that for I2C, your slave device must have a unique address.

We will provide you update for more clarification. You can post your questions and queries to google classroom. However, we encourage your teamwork and discussion with your classmates. Do not copy others' code.

4.1.2 Boarder Line

Both SPI and I2C must be able to execute the same control and configuration given in assignment 2 for USART. The Master device sends the configuration and control command to the Slave, and the Slave modifies the traffic light configuration and returns monitoring accordingly.

4.1.3 Debugging

You can use Putty, Hercules, or Teraterm for debugging and output to the screen. Use the KEIL debugger for your convenience. It is excellent and helps you to see the inside. KEIL using GDB.

5 Submission

You must demonstrate your solution, submit the code, and report (Latex source files and code) to the lab course website. The submission date is May 05, 2023. On May 05, you must upload your code and demonstrate the solution in the following LAB classes. Each week late (code submission) will reduce 10% from the assignment marks. The submission has two parts: (i) I2C and (ii) SPI. Both SPI and I2C perform accurately and demonstrate the assignment outcome.

Alert: You can discuss with your classmates, however, do not copy code or report from others.