2023 Session 1 ELEC3042 Major Project

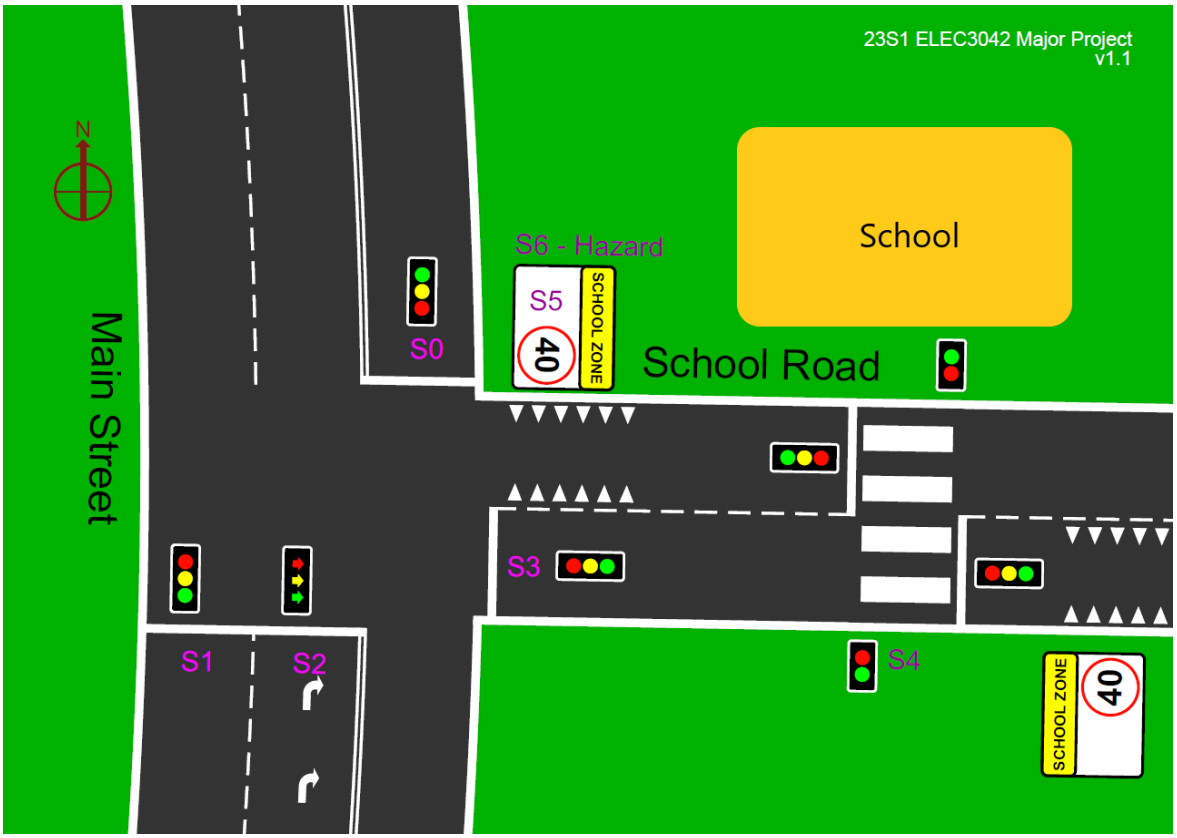
Introduction

Your task is to design and implement the traffic control system for the intersection of Main Street and School Road, and along School Road (shown below). The minimum requirements listed for this assessment task are designed to enable you to demonstrate that you have achieved the learning outcomes of the unit. The extensions are for students who want to demonstrate that they have excelled in understanding the unit material.

This document summarises the specifications and requirements. You should read the entire document carefully before starting. If you feel any part of the specifications are ambiguous, please post your question to the General Discussion Forum on iLearn. Do not make assumptions.

This is an individual project. Your C code and answers to the defence questions must be your own work. You must not share your files with anybody else. Only xc.h, avr/io.h, avr/interrupt.h, and avr/sleep.h header files are allowed. You may write your own header files. For any other libraries, you must first obtain permission before using them.

Major Project Intersection



The road intersection is the junction between a main road and a minor road. The main road is called Main Street and the minor road is called School Road. School Road has two lanes, one for each direction, with cars entering the junction from School Road being able to turn both left and right.

Main Street has three lanes, two in the Northbound direction and one in the Southbound direction. In the Northbound direction, there is a lane to turn right into School Road and one to continue along Main Street. In the Southbound direction, there is one lane that continues along Main Street. When cars are turning right from Main Street Northbound into School Road, Southbound traffic must stop. When traffic is exiting School Road, no traffic should be allowed to enter the intersection from Main Street.

Minimum System Requirements

Operation of the Controller:

The controller must initialise itself in the Hazard phase. In the **Hazard phase**, all lights in the intersection are off except for the nominated lights. These nominated lights flash simultaneously in an alternate on/off fashion. The nominated lights are all on for one second then all off for one second. All non-nominated lights remain off at all times during hazard phase. The nominated lights at the intersection are the car yellow lights on Main Street and the car yellow lights on School Road.

After 10 s in the Hazard phase, it will move to normal operation. During normal operation, one of the following traffic phases of the intersection should occur:

School Road to Main Street (SRM): Traffic is allowed to proceed from School Road into Main Street.

Main Street Right Turn (MSR): The right turn lane on Main Street Northbound is green.

Main Street Straight (MSS): The car lanes that allow traffic on Main Street to go straight can proceed.

The lights in the intersection should change in a predictable order to allow for the phases of traffic described above. You will need to arrange and justify the order you select. Your arrangement of lights should be optimal to maintain traffic flow. As a hint, the phases of traffic and state of the lights in the intersection are not synonymous and should not be considered interchangeable with each other when you are designing your system.

Your controller should only allow a particular phase of traffic to occur when the corresponding sensor(s) has been triggered. There are 4 input sensors at the intersection (indicated by S_0 to S_3 in the diagram), one for each lane of traffic in the intersection. If no sensors are triggered, the default phase of the intersection should be Main Street Straight.

Note: Consecutive occurrences of the same phase are not allowed. If necessary a phase of MSS must be inserted to ensure the same phase does not repeat.

Timing:

Except for the Hazard phase, the duration of the phases of traffic are prescribed in terms of time periods. A time period is by default 1 s. However, you are to add an adjustable input using a 10k linear potentiometer. The potentiometer is to be connected to PORT C, pin 0. When on ‘full’ (5 V), the time period is 1 s. As the voltage is reduced, the time per time period is reduced until it reaches 0 V where it should represent 100 ms per time period.

Each phase of traffic has a minimum time of operation. The timing should be extended to the maximum time as long as the sensor(s) corresponding to that phase is held down. However, when the maximum time is reached, it should move on to the next phase according to your predetermined order (as long as that sensor has been triggered).

The minimum and maximum Green light times are:

Phase	**Minimum Time**	**Maximum Time**
School Road to Main Street	2 Time Periods	4 Time Periods
Main Street Right Turn	2 Time Periods	3 Time Periods
Main Street Straight	4 Time Periods	6 Time Periods / Unlimited if no other traffic

Lights:

The order of the traffic lights should be Red -> Green -> Yellow -> Red. Yellow lights are to be illuminated for 2 time periods (not including the time period for the phase). Between phases, the red light must be illuminated for 2 time periods before the following phase’s green lights are illuminated. If a green light will be illuminated for both the current and next phases, it should not change to yellow, then red, then green.

LCD Display:

There is to be a 16x2 LCD display on the main controller. This display gives status information about the system.

The top row of the LCD display is reserved for indicating the state of the inputs and the system time. The leftmost 7 positions are reserved for displaying the state of the input sensors. When a sensor is triggered, the corresponding character location should display an ‘X’ character (display code 0x58). When the sensor input is cleared, the corresponding character should display an ‘O’ character (display code 0x4F). The rightmost 5 positions on the top row are reserved for displaying a 5-digit time period counter that starts from

00000 and increases once per time period until 99999. When 99999 is reached, it should roll over back to 00000 and restart the count.

The bottom row of the display is for showing the current phase of the system. The leftmost 3 positions are reserved for showing the current phase of traffic using the acronyms shown above. The 4th character position should be used to indicate the current colour (R, Y or G) of the light that is illuminated corresponding to the current phase. During the Hazard phase, the acronym HZD should be shown and the colour character should be blank.

The grey character positions are reserved and should not be used. The remaining character locations on the bottom row can be used to display other useful diagnostic information of your choosing.

S_0	S_1	S_2	S_3	S_4	S_5	S_6					0	0	0	0	0
Phase	Phase	Phase	Colour												

Hazard Input:

Port B Pin 0 is the hazard input. When this input is connected to ground, the traffic lights must change to the hazard phase of operation (as described earlier), and must continue in Hazard as long as this pin is grounded. When disconnected from ground, the controller should continue in the hazard phase for an additional 10 seconds before returning to normal operation.

Extension 1 (required for Distinction Grade)

You must meet the above requirements and pass all published tests before attempting this extension. Duplicate the working project from above before starting the extension. You will need to upload both versions for submission.

In addition to the above requirements, your traffic control system must now also control the pedestrian crossing on School Road.

Hazard phase:

At the pedestrian crossing on School road, the nominated lights are the car yellow lights only. The timing pattern of the flashing is identical and in phase with the main intersection.

Normal operation:

There are two modes of traffic at the pedestrian crossing, Non-School Zone time and School Zone time. By default the pedestrian crossing is in Non-School Zone time.

Mode	**Non-School Zone Time**	**School Zone Time**
Pedestrian Phase	3 Time Periods	6 Time Periods
School Road Cars Phase	min 5 Time Periods	min 6 Time Periods

By default the pedestrian crossing is in the School Road cars phase. The lights at the pedestrian crossing should only transition to the pedestrian phase after the button S4 is pressed. Button presses of S4 during the green light of the pedestrian phase should be ignored. When pedestrians are crossing School Road, the cars travelling along School Road must stop.

The timings for the pedestrian phase and the School Road phase are dependent on whether there is a school zone currently in operation.

The pedestrian lights should be solid green for the specified time period. Then it should flash red once every time period for 3 time periods in a 50% duty cycle, then change to solid red. Between phases the red light must be illuminated for 2 time periods before the following phase's green lights are illuminated. When button S4 is pressed outside of a pedestrian green phase the car green phase will illuminate the car green light and run for a minimum of the specified time periods before cycling to the pedestrian phase. If the car green light has been illuminated for the minimum time periods then the phase change can commence immediately.

A speaker is to be attached to the system for pedestrians with visual impairment. The speaker should issue a sharp chirp once every 2 time periods when the pedestrian lights are red. When the pedestrian lights change to green, the speaker should issue a descending tone and then a quick chatter tone whilst the pedestrian light remains a solid green. The speaker should revert to the chirp mode when the pedestrian lights change to flashing green. Note, the pitch of your speaker sounds must not be affected by the setting of the POT.

School Zone Input:

PORT D Pin 6 is the School Zone input. When this input is connected to ground, the pedestrian crossing on School Road enters School Zone operation. During this period, the School Zone LED (connected to PORT D Pin 7) should flash once every time period in a 50% duty cycle. The duration of the pedestrian and School Road phases change to the school zone time periods.

LCD Display:

					Phase	Colour	SZ								

The character positions above are to be used to indicate the phase of the pedestrian crossing (P – for Pedestrians, C – for cars), the current colour of the light (R, Y, or G) that is illuminated corresponding to the current phase, and whether the School Zone (SZ) is active (1) or not (0).

Extension 2 (required for High Distinction Grade)

You must meet the above requirements and pass all published tests before attempting this extension. Duplicate the working project from above before starting this extension. You will need to upload a separate submission for this extension.

There are three parts to this extension. You should fully complete a part before attempting another. Which part you complete first is up to you. You will need to complete all parts to score full marks.

Extension 2A

Implement an internal system clock to keep track of time of the time of day. Each day is to consist of a total 240 time periods. Every time period simulates 1 minute of real-world time, and there are 60 time periods per hour. The 5 character positions on the LCD display should show HH:MM to represent this. School Zone operation should occur between 07:30 and 09:30, and 14:30 and 16:00, every day. In addition, the School Zone input should also be able to be used to enable School Zone Operation outside of these times. The POT must remain functional to speed up and slow down the duration of a time period.

Extension 2B

The section of road between the intersection of School Road and Main Street, and the pedestrian crossing takes 2 time periods for a car to traverse after having stopped at a red light. Study the timing periods prescribed for the intersection and pedestrian crossing, and optimise your controller to maximise traffic flow. During the oral defence, you will need to explain why your design is optimal.

Extension 2C

Having an energy efficient embedded system is important. Ensure the implementation of your system is as efficient as possible.

Assessment

Your major work will be assessed in three parts. Read the submission and assessment details carefully because failure to adhere to these instructions may result in loss of marks.

1. Major Project Design Review (15%)

This will be a 10-minute oral assessment over Zoom. You will have 5 minutes to present a state diagram that describes how your controller moves through the phases of normal operation as well as the hazard phase for the minimum system requirements. You must explain and justify how your system will keep time, and which parts of your system will be interrupt driven. You should also show any code that you have already written to demonstrate your progress. Your presentation will be followed by 5 minutes of clarification questions, and/or feedback. A document will be provided for you to fill in to assist with the review.

Your design review will be graded according to the following rubric:

Mark	Description
0-2	Unsatisfactory progress
3-7	Some progress but errors noted or unable to explain design choices
8-12	Satisfactory progress towards achieving minimum requirements. Able to explain system design
13-15	Excellent progress so far. System design is well explained and justified.

2. Product Demonstration (20%)

You need to submit a working program written in the C programming language on iLearn. It must not use any Arduino libraries. Your program must be uploaded to iLearn as a zip file created using the MPLAB-X IDE. To do this, right-click on the project name in the left Projects pane of the IDE and choose Package. Once the build is complete, you will see the location of the packaged project shown in the Build, Load output console. Upload this zip file to iLearn before the physical demonstration.

During the physical demonstration, you will first need to show that your code compiles without errors or warnings. This will be followed by a demonstration showing your system meets specifications by passing a checklist of tests. Demonstration should be on your own hardware. You will be provided a list of tests at least one week before the product demonstration. However, there will also be some hidden tests that will not be revealed until

the day of demonstration. You must have submitted your code to iLearn on time in order to be awarded these marks.

There are three separate submission places for the Product Demonstration. The first is for the code to implement the minimum system requirements. The second is for code that completes Extension 1, and the third is for code that completes Extension 2. Code will only be examined in an extension if the previous levels are fully functional and pass all published tests. Hence, it is important to ensure one set of code passes all the published tests before moving onto an extension.

3. Major Project Defence (25%) - Hurdle

For this component, you will need to submit written answers to a set of questions, along with a block diagram showing the major components of your system and their associated state diagram(s). This document will then be used as a starting basis of your oral defence. You should include as much detail as you can to help you explain your system and design choices during your oral defence.

Document History:

Date	Revision	Author	Change
2/2/22	1.0	Alan	Initial version. Entered description of project and assessment criteria
3/2/23	1.1	Rex	Updated some criteria, in particular state changes.
10/2/23	1.2	Alan	Added instructions for creating zip file, restrictions on libraries, and additional clarifications to extensions
24/3/23	1.3	Alan	Added additional clarifications for Major Project Design Review and extensions
19/4/23	1.4	Rex	Added clarification that MSS must occur between consecutive phases of MSR or SRM
20/4/23	1.5	Rex	Changed pedestrian timings, and changed flashing from green to red for pedestrian lights
25/4/23	1.6	Rex	Updated and clarified the Extension 1 section. Updated and Clarified pedestrian mode of operation. Changed Hazard mode specified lights to only yellow lights.