CE323/CE860 Advanced Embedded Systems Design Assignment 2

The assignment is worth 25% of the total mark for this module. This assignment is to design a home alarm system based on the mbed NXP LPC1768 and its virtual board (2 LEDs, 2Switches, 1 LCD, 1 virtual keypad, 1 alarm-LED) or based on the Arduino and virtual board on tinkercad. The home alarm system specification is given below. The sensors mentioned below will be replaced with the switches in the virtual extension board and the alarm is replaced with a LED in your design. Based on the specification, you need to develop a formal specification using a graphical representation (preferably Unified Modeling Language (UML)). The UML specification should include structure diagrams (class diagrams and/or object diagrams), and behaviour diagrams (state machine diagram, sequence diagram). The formal specification should be written in a report. Then you must write a C/C++ program to implement the design of the home alarm system. You also need to make a demonstration in the lab.

The report:

The report should be in PDF and must include a cover page with the module name, student name and ID. The source code should be included in the report. The maximum length of the report is of **5 pages for CE323 Students and 10 pages for CE860 students (without appendix)**.

An important note for CE860 Students:

The program and functionality are similar. However, higher level of technical explanations is expected from CE860 students. Therefore, the length of the report is considered to be 10 pages.

The report should include:

1. Requirement form

2. UML graphical representation of the system

- class diagrams
- state machine diagrams
- sequence diagrams

When necessary, you should provide explanation.

3. Source code

The parts of code you are developing in the labs can be used in your program. You must complete the program and deliver required functionalities. You can also use the program developed in the Assignment 1 (virtual extension board). **Full source code should be provided in the report as an appendix.**

*Online version

Considering the limited access to the labs due to the COVID-19 pandemic. Mbed online simulator or tinkercad online simulator is used for evaluating the code.

Submission:

The report should be submitted through the online coursework submission system (FASER). You should submit a single pdf file called “CE323 Assignment 2 (your name)” for CE323 students and “CE860 Assignment 2 (your name)” for CE860 students and.

Assessment criteria:

- Following the rules mentioned in this document for the submission and preparation of the assignment 10%
- Class diagram 10%
- State machine diagram 10%
- Sequence diagram 10%
- Correctness of program 40%
- Quality of program 10%
- Clarity of program and comments briefly 10%

Late submission and plagiarism

This assignment is to be done individually, i.e. whatever you submit must be your own individual work. Any software or any other materials that you use in this assignment, whether previously published or not, must be referred to and properly acknowledged. Please be aware that the module supervisor may ask students for an interview to explain their submitted work. Please refer to the Undergraduate Students’ Handbook for details of the School policy

regarding late submission and University regulations regarding plagiarism:

http://www.essex.ac.uk/ldev/resources/plagiarism/default.aspx

http://www.essex.ac.uk/about/governance/policies/academic-offences.aspx

Home Alarm System

1. Introduction to alarm systems

A home alarm system is constructed from various separate parts, which all connect to a central control unit (in this link you can find a DIY example of a home alarm system). Your task is to implement a basic control unit and the functionality behind its user interface. To complete this task you must first understand the specification of the external parts provided and the required behaviour of the overall system.

A conventional alarm system normally contains:

- Central control unit
- Keypad entry point / user interface
- Sounder unit
- Sensors such as: magnetic contacts (reed switches), pressure mats, movement sensors like passive infrared sensors (PIRs).

In the case of the sensors, they all contain switches that are “closed” circuit under normal circumstances. This type of switch is known as a Normally Closed (NC) switch, the converse is known as Normally Open (NO). Magnetic contacts are used to detect when doors and windows are opened. When a door is opened a magnet is moved away from the reed switch which causes the switch contacts to open. Likewise, when a movement sensor is triggered or a pressure mat depressed the circuit is broken (the switch is opened), see Figure 1. The opening of a contact can be detected by using one of the microcontroller's parallel port inputs, connected to the top of the switch whose lower end is connected to GND. The top of the switch is also connected through a resistor to 3.3v (V+). When the switch is closed the port, input is connected to 0v (GND), and it will be pulled-up to 3.3v (V+) by the resistor when the sensor's switch opens. Therefore, the microcontroller input is logic low (0v) when a door is closed / there is no movement, and logic high (3.3v) when the sensor is activated. The alarm controller must detect these events and respond as specified later in this document. In this assignment the sensors are emulated using normally closed push to break switches.

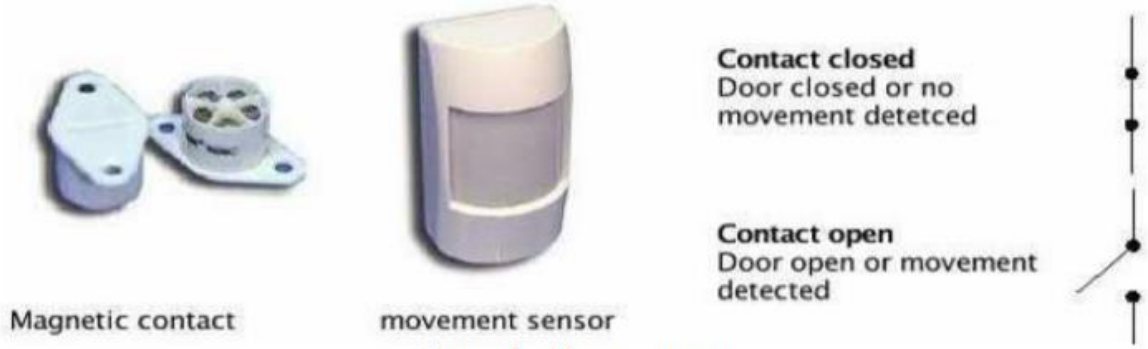

Figure 1: Alarm sensors

Figure 1: Alarm sensors

Normal home alarm systems include multiple sensors located in various locations, each location can have its own circuit which allows identification of the triggered switch, i.e. it lets the user know where the break-in occurred. Each sensor circuit is known as a zone, and zones can have different behaviour.

2. Functional Specification - Zone Behaviour

The virtual extension board (3 LEDs, 2 Switches, 1 LCD, 1 virtual keypad), will be used for demonstration. This alarm has SIX states of operation set, unset, entry, exit, alarm, and report. Initially it is in the unset state.

- Unset state:
  - In the unset state, activation of any of the sensors should not cause the alarm-LED to blink.
  - Entry of the correct four-digit code in the user interface (described later) followed by "B" should cause the system to change to the exit state.
  - If the user enters an invalid code three times, the alarm should change to the alarm state.
- Exit state:
  - When in the exit state, the user has a time interval called the exit period (you can choose any time e. g. 1 minutes) in which to vacate their home.
  - In the exit state, activation of any sensors in a full set zone should cause the alarm to enter the alarm state.
  - Whilst in the exit state the alarm-LED should blink.
  - If the user enters their four-digit code followed by "B" within the period, the exit state should change to the unset state.
  - If an invalid code is entered three times, the exit state should change to the alarm state.
  - If all the zones are inactive when the exit period (e. g. 1 minutes) expires, the exit state should enter the set state.
- Set state:
  - In the set state, activation of any sensors in the set state zone should cause the system to enter the alarm state.
  - Activation of the entry / exit zone should change the state to entry state.
- Entry state:
  - The purpose of the entry state is to allow the user a period of time to gain access to their home so that they can unset the alarm, this duration is known as the entry period (e. g. 2 minutes).
  - Whilst in the entry state, the alarm-LED should sound blink.
  - If the user enters their four-digit code followed by "B" within the period, the state should change to the unset state.
  - If the user fails to enter their correct code within the entry period, the state should change to the alarm state.
  - In the entry state, activation of any sensors in a full set zone should cause the state to enter the alarm state.
- Alarm state
  - When in the alarm state, the alarm-LED should be on all the time.
  - After 2 minutes, the sounder unit should be disabled.
  - If the user enters the correct code followed by "B", the alarm should change to the report state, otherwise stay in the alarm state.

- Report state
  - When in the report state, the LCD should show the zone numbers or code error information in the first line (e. g. ‘code error 1’). In the second line it should show “C key to clear”.
  - When an “C” is entered, the alarm should change to the unset state.

3. Functional Specification - User Interface

The user interface consists of:

- a 4x4 virtual keypad
- a 16 character by 2-line LCD display
- 1 LEDs for entrance door (replaced with 1 switch connected to a LED)
- 1 LEDs for alarm.
- 1 sensor for 1 zone (replaced with 1 switch connected to a LED)

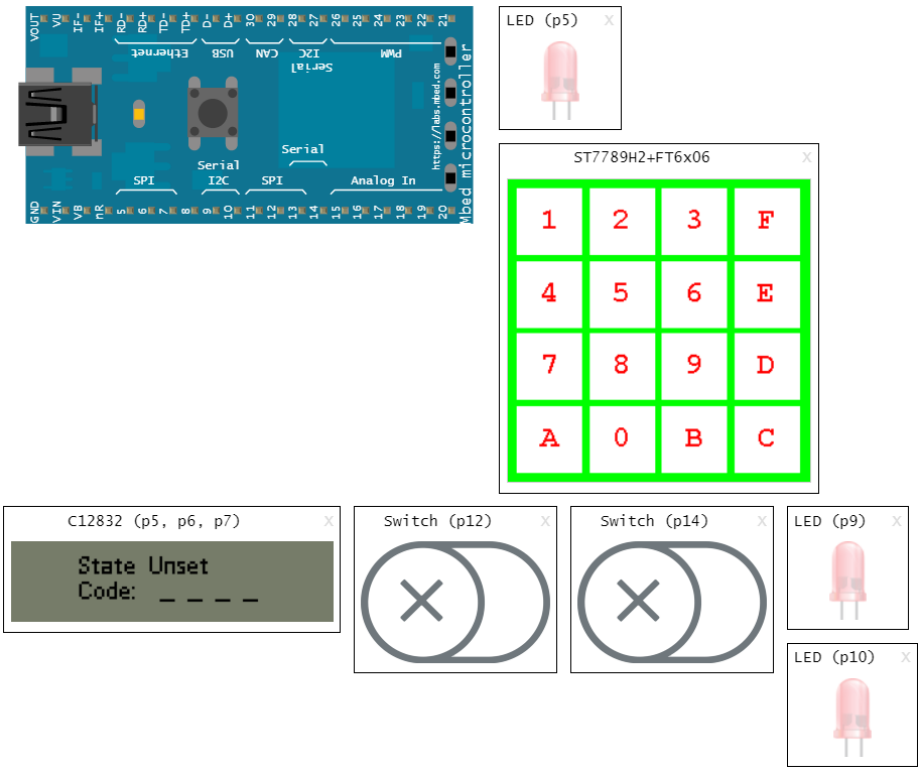

Fig. 2 Mbed online simulator for home alarm system

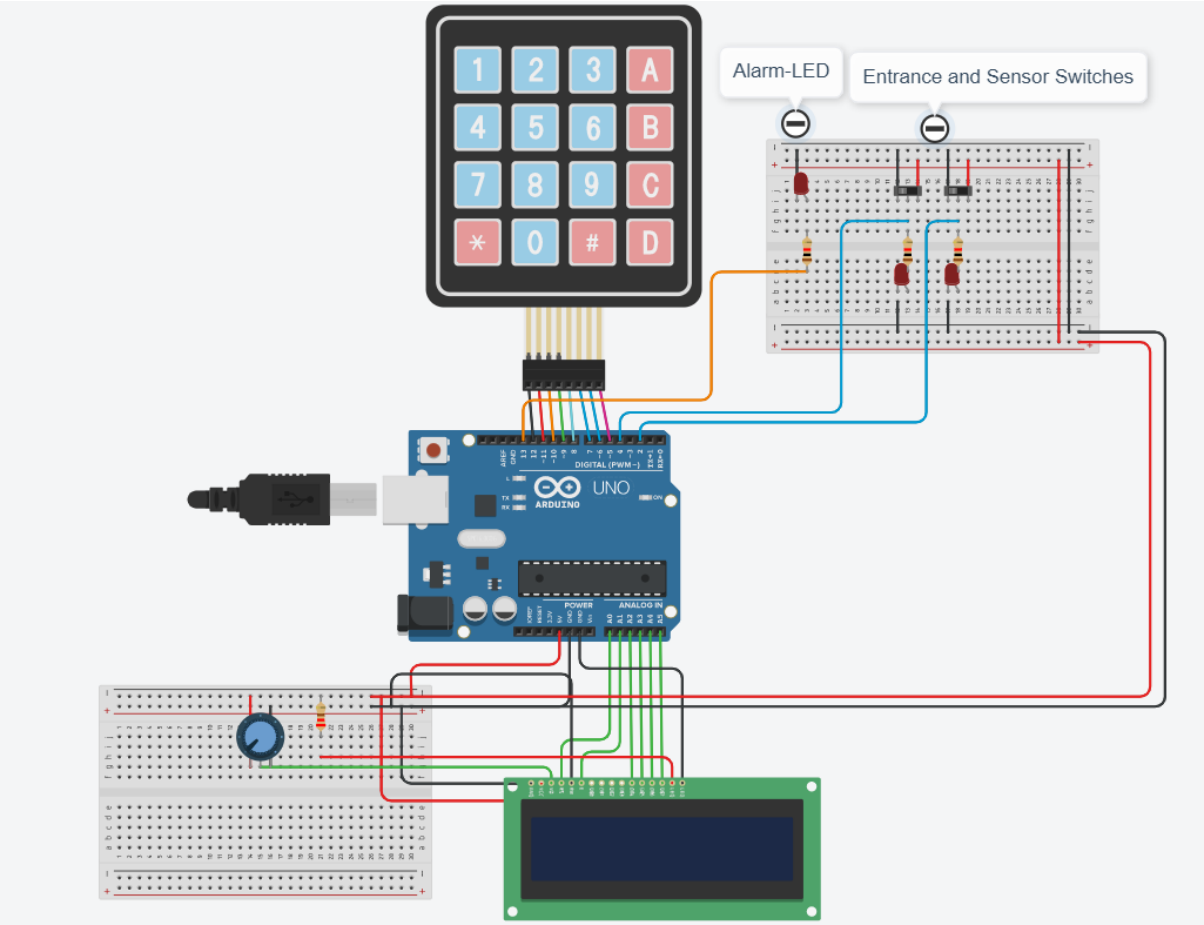

Fig. 3 TinkerCAD online simulator for the home alarm system

When a sensor in a zone is active (circuit broken), the corresponding LED should be illuminated. When the system leaves the alarm state, the alarm-LED should be off.

The LCD should display the state of the system on the first line of the LCD display.

- When the user enters the first digit of their code in the unset state, the second line of the display should additionally show left aligned “Code: * _ _ _” with the “_” characters being replaced with each successive digit entered.
- If the user presses the “C” key, then the last entered character should be deleted and replaced with “_” unless there are no characters left, in which case the display should only display the state, i.e. be the same as when none of the code had been entered.
- When all four digits of the code have been entered, the second line of the display should display “Press B to set”.
- Any other key should cause the code entry procedure to abort without checking the user code.

Alternative Design Assignment 2

For the students with Experience/Interest in embedded system programming an alternative/complementary assignment is available. If you feel you are interested in doing more and tasks in the current assignment you can volunteer for this assignment. This alternative work is on the design and development of an embedded system for the microrobotics system we are currently developing in the University of Essex (Fig. 1).

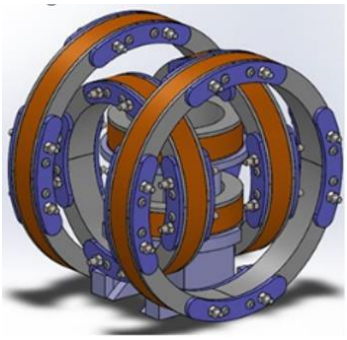

Fig. 2 Magnetic actuation system for Microrobotics studies

The following system is controlled by Mega Arduino. We have developed a MATLAB connection and we want to monitor the system in real time using cameras. The system controls a 3D magnetic field. Please kindly note that the requirement and the quality of the work is higher for this design and you should discuss during the lab sessions with the module supervisor.