**MA2012 Introduction to Mechatronics System Design**

**Assessment 1**

**Assessment Instructions:**

* You have received this assessment lab document at least 24 hours prior to the assessment lab session.
* On 03 October 2022, you will commence at 4:30 pm and will end at 6:15 pm. Admission to the lab is at 4:20pm.
* This hands-on assessment has a total of 20 marks.
  + 16 marks will be allocated to the tasks described in this document.
  + 4 marks will be allocated to new tasks stated on the grading sheet given to you at the start of the assessment lab session.
* This assessment will make up 20% of the final result.
* Write the names of all group members on the provided assessment grading sheet. Please leave the grading sheet on the lab bench upon completion.
* You need to submit the source code by email to [wtang@ntu.edu.sg](mailto:wtang@ntu.edu.sg) before 5pm on 04 Oct 2022.

**Assessment Description:**

* You are going to design a control system of a vending machine using two Arduino UNO MCUs.
* The vending machine has 2 pigeonholes, ‘1’ and ‘2’ to place the items to be sold. A X-Y robotic manipulator moves the Gripper to the centroid of pigeonhole to grasp the selected item and then move and drop the object at the collection window. This is illustrated in Figure 1.
* The basic components and circuitry have been provided to you. The schematic diagram is shown in Figures 2A & 2B.
* The operation of the vending machine is as follow:

MCU1:

* + The toggle switch is the master ON-OFF switch of the vending machine.
    - When the toggle switch is turned ON/OFF, the on board LED is turned ON/OFF.
    - When the master switch is ON, the vending machine goes into Standby mode.
    - When the master switch is OFF, both MCUs are not operational and the LCD has no display.
  + In Standby mode,
    - The LCD displays:

[Line 0] Select 1 / 2

[Line 1] *Blank*

* + - Only Keys ‘1’ and ‘2’ on the Hexadecimal Keypad are valid keys, pressing all other keys has no effect at this point.
  + If Key ‘1’ or ‘2’ on the Hexadecimal Keypad is pressed,
    - Display the selection (i.e. character ‘1’ or ‘2’) on LCD Line 1;
    - If a new selection is made, the LCD shall overwrite and display the new selected number.
  + If Key ‘C’ is pressed after a selection is made, MCU1 sends the selected character ‘1’ or ‘2’ to MCU2 via the serial link.
  + When MCU1 receives a ‘0’ from MCU2 via the serial link,
    - The LCD displays 5 cycles of flashing message:

[Line 1] Collect Item

1 cycle of display is to show the message for 1 second and then a blank line for 0.5 s.

* + - It goes back to the Standby mode.

MCU2:

* + The X and Y manipulators are controlled by a DC Motor and Stepper Motor respectively.
    - One CCW revolution of the DC motor output shafts moves the X manipulator linearly in the +X direction by 1 cm.
    - One CCW revolution of the Stepper motor output shafts moves the Y manipulator linearly in the +Y direction by 5 cm.
  + The Gripper is controlled by a Servomotor, it is closed and opened when the flange is at 45° and 135° respectively.
  + The centroid of pigeonholes ‘1’ and ‘2’ are at coordinates (-10, 5) cm and (-5, 5) cm respectively. The centroid of the Collection Window is at (5, 0) cm.
  + The LED1 & LED2 will be turned ON when the vending machine is in operation.
  + When MCU2 receives a ‘1’ or ‘2’ from MCU1 via the serial link,
    - The corresponding LED shall blink at 1 Hz for 2 s and then remain ON.
    - The X-manipulator moves the required displacement in the X-direction.
      * The DC Motor rotates with a speed profile of 50%-100%-50% duty cycle, in (approximately) 20%-60%-20% proportions of the path, e.g. to move 10 cm, the first ~2.0 cm is at 50% duty cycle, the next ~6.0 cm is at 100% duty cycle and the last ~2.0 cm is at 50% duty cycle. (*Note: Only final positioning accuracy is important, an error of ± 1.0 cm is permissible. Positioning accuracy along the path will not be assessed.*)
    - After the X-manipulator stops, the Y-manipulator moves to the required displacement in the Y-direction.
      * The Stepper Motor rotates at a speed of 0.5 revolution per second.
    - After the X-Y robotic manipulator moves the Gripper (default position: Open) to the centroid of the selected pigeonhole, the gripper closes to grasp an item in the pigeonhole.
    - Then the X-Y manipulator moves the Gripper to the centroid of the Collection Window.
      * X-manipulator moves first, followed by Y-manipulator, using the same motion profiles as previously described.
      * The Gripper opens to drop the item.
      * The buzzer sounds 2 times.
    - The X-Y robotic manipulator moves back to coordinates (0,0) in any sequence and motion profiles of your choice.
    - MCU2 sends a ‘0’ back to MCU1 via the serial link when the operation has completed.
* You are to write a C++ language program to perform these tasks.

Pigeonholes

1

2

y

Collection Window

Gripper

x

Figure 1 Vending Machine X-Y Robot Manipulator (Not to scale)

Diagram, schematic

Description automatically generated

Diagram, schematic

Description automatically generated

**MA2012 Introduction to Mechatronics System Design**

Hands-on Assessment Grading Sheet

Student Names:

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| Assessment Items | Marks |
| 1. Turning the vending machine ON and OFF.  - Turn ON onboard LED when Toggle Switch is HIGH  - All operations are halted when Toggle Switch is LOW  (2 marks) |  |
| 2. Keypad operation  - Detection of keys ‘1’, ‘2’, & ‘C’  (1 marks) |  |
| 3. LCD operation  - Display of Line 0: Select 1 / 2  - Display of Line 1: blank and selection  - Display of Line 1: Collect Item (flashing)  (3 marks) |  |
| 4. Serial Communications  - Tx & Rx of MCU1 & MCU2  (1 marks) |  |
| 5. X-manipulator operation  - Speed control of DC Motor  - Displacement control of DC Motor  (4 marks) |  |
| 6. Y-manipulator & Gripper operation  - Displacement control of Stepper Motor  - Position control of Servomotor  (3 marks) |  |
| 7. LEDs & Buzzer  - Blinking LED at pigeonhole when selection is made  - Sound buzzer 2 times when item is dropped at Collection Window  (2 marks) |  |
| 7. Additional Tasks  (4 marks) |  |
|  | /20 |

Figure 2