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**American International University- Bangladesh (AIUB)**

**Department of Electrical and Electronic Engineering**

**EEE4103: Microprocessor and Embedded Systems Laboratory**

***Guidelines for students: Students can design an embedded system that will sense some parameters from their surroundings and using those parameters their system will provide security to human life/ treasury. Students will be completing their lab experiment by verifying the program for their experiment using a relevant software development tool and then implementing their experiment in the trainer board as hardware to observe their results. The time duration for this whole lab experiment will be 60 minutes per group. This overall lab experiment will be done group-wise including 5 or 8 members per group. All the groupmates will be responsible to complete the OEL lab report. The OEL lab report (one report in each group) must be submitted on the final lab exam week (softcopy + hardcopy) before starting the class. Late submission will be accounted for heavy penalty. If a student or group is found to not follow the guidelines, then deductions can be made or zero can be expected. In total, 10 marks are allocated for OEL lab report and student’s individual performance within the group.***

***For OEL report submissions, the following topics must be included:***

***Title:*** Students will provide an appropriate title for a microcontroller-based self-designed laboratory experiment based on ideas and knowledge they acquired from their previous laboratory experiments.

***Objective:*** Students will be implementing this experiment based on one or more objective/objectives.

***Theory and Methodology:*** Students will be explaining their experiment methodology in this section which will be brief. They may produce a circuit diagram by pen to explain the overall system of their lab experiment and label the circuit diagram. **They must use knowledge of SPI, USART, I2C, PWM, etc.**

***Apparatus:*** The students can select apparatus from the table below but are not limited to create their experiment according to their requirements. However, they must purchase or collect it before the experiment, if any particular components, sensors, or display devices are not available in the laboratory.

|  |  |  |
| --- | --- | --- |
| * Arduino UNO * Arduino Mega * Resistors * LED indicators * LCD device | * Ultrasonic sensor * OLED display * Pressure sensor * Breadboard | * Master-Slave Device * Potentiometer * DC motor * H-bridge motor driver * Push button switches |

***Experimental Setup:*** Students will be adding pictures of their implemented hardware circuit connection in this section.

***Codes of the Program:*** Students will be adding the program they wrote for hardware implementation in this section.

***Data collection table/comparison table based on results:*** The students will be including their collected results and make a data table for analysis.

***Discussions:*** Students will be writing reasonable conclusions here related to their experiment.

***References:*** Use appropriate references where necessary in IEEE format.

***Appendix:*** Include **‘individual’s contribution’** in a tabular form.

***Course Outcome Mapping with the OEL:***

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CO/**  **CLO Number** | **CO/CLO Statement** | **K** | **P** | **A** | **Assessed Program Outcome Indicator** | **BNQF Indicator** | **Teaching-Learning Strategy** | **Assessment Strategy** |
| **1** | Simulate laboratory experiments using microcontrollers, sensors, actuators switches, display devices, etc., and a suitable simulator related to the fields of electrical and electronic engineering. |  | P1,  P4,  P5 |  | P.e.2.P4 | FS.6 | Practical Demonstration | OEL Report |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Course Name:** | Microprocessor and Embedded System | **Course Code:** | | EEE 4103 |
| **Semester:** | Spring 2023-2024 | **Section:** | | F |
| **Faculty Member:** | Md Sajid Hossain | **Group:** | 06 | |
|  |  |  | |  |
| **OEL Title:** | Revolutionizing Detection: A cutting edge Arduino Rader System. | | | |
| **Submission Link:** | [**https://forms.microsoft.com/r/H2qfsUXZat**](https://forms.microsoft.com/r/H2qfsUXZat) | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SL** | **Student ID** | **Student Name** | **Contribution** | **Obtained Marks** |
| **1.** | 22-46588-1 | AZMINUR RAHMAN |  |  |
| **2.** | 22-46444-1 | TRIDIB SARKAR |  |  |
| **3.** | 21-45397-3 | SOWRABH CHANDRA DAS |  |  |
| **4.** | 21-45489-3 | AVISHEK CHANDA PRATYAY |  |  |
| **5.** | 21-45408-3 | KOWSHIK HALDER |  |  |
| **6.** | 19-41203-2 | MD. IMTIAZ HOSSAIN |  |  |
| **7.** | 19-40315-1 | S.M. FAYSAL MAHMUD |  |  |

***Assessment Materials and Marks Allocation:***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **COs** | **CO Statement** | **Assessment Materials** | **POIs** | **Marks** |
| CO1 | *Simulate laboratory experiments using microcontrollers, sensors, actuators switches, display devices, etc., and a suitable simulator related to the fields of electrical and electronic engineering.* | Open Ended Laboratory Report | P.e.2.P4 | 10 |

***Assessment Rubrics:***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **COs-POIs** | Excellent  [9-10] | Proficient  [7-8] | Good  [5-6] | Acceptable  [3-4] | Unacceptable  [1-2] | No Response  [0] | Secured Marks |
| **CO1**  **P.e.2.P4** | The OEL developed as a process for complex engineering problems considering microcontrollers, sensors, switches, display devices, etc. The simulation and implementation processes are clearly demonstrated combining all input patterns with several outcomes. | The OEL developed as a process for complex engineering problems considering microcontrollers, sensors, switches, display devices, etc. The simulation and implementation processes are clearly demonstrated with some outcomes and limited input patterns. | The OEL developed as a process for complex engineering problems considering microcontrollers, sensors, switches, display devices, etc. The simulation and implementation processes are not clearly demonstrated with some outcomes and input patterns. | The OEL developed as a process for complex engineering problems considering microcontrollers, sensors, switches, display devices, etc. The simulation and implementation processes are not clearly demonstrated with a few outcomes for a few patterns. | The OEL developed as a process for complex engineering problems considering microcontrollers, sensors, switches, display devices, etc. are not appropriate. The simulation and implementation processes are not demonstrated with any outcomes and not for any pattern. | No responses at all |  |
| **Comments** |  | | | | **Total marks (10)** |  | |

**Title:** Revolutionizing Detection: A cutting edge Arduino Rader System.

**Objective:**

The experiment involved exploring the practical application of an Arduino microcontroller along with an ultrasonic sensor and servo motor to construct a radar-like system for the detection and tracking of objects. Students engaged in the fields of electronics, programming and sensor integration, cultivating their creativity and problem-solving abilities. The primary goal was to design, construct and test a fully operational radar system capable of precisely detecting objects within a specified range and conveying their positions in real-time.

**Introduction:**

The experiment commenced with an introduction to the fundamental principles of ultrasonic distance measurement and servo motor control. An understanding was gained by participants on how ultrasonic waves were emitted and received by the sensor to determine object distances. Following this, the Arduino microcontroller was programmed by us to interpret sensor data and control the rotation of the servo motor, thereby creating a scanning mechanism resembling that of a radar.

After mastering the foundational skills, the design of radar systems was undertaken by us considering factors such as sensor placement, scanning angles and data interpretation. Through a process of iterative testing and troubleshooting, designs were refined by us to optimize accuracy and responsiveness. The experiment's adaptability allowed for diverse creative enhancements including the incorporation of visual or auditory alerts upon object detection, the integration of multiple sensors for broader coverage or the implementation of wireless communication to transmit data to external devices.

Throughout the experiment, we were prompted to engage in critical thinking regarding sensor limitations, noise reduction and data smoothing techniques to enhance the radar's performance. Moreover, they were encouraged to explore advanced programming concepts, such as data fusion, to elevate object tracking and recognition capabilities.

The objectives of this experiment are as follows:

1. To design and implement an Arduino-based radar system using an ultrasonic sensor and a servo motor to accurately detect the presence of objects within a specified range and demonstrate their positional tracking capability.

**Theory and Methodology:**

**Ultrasonic Distance Measurement:** Short pulses of high-frequency sound waves or ultrasonic waves, were emitted by an ultrasonic sensor [1]. The time taken for these waves to reflect off an object and return to the sensor was measured. The distance to the object could be calculated using the formula:

Distance = (Time taken by the signal to return \* Speed of Sound) / 2

By measuring the time interval between the emission and reception of the signal, the distance between the sensor and the detected object was accurately determined.

**Servo Motor Control**: A rotary actuator, known as a servo motor, was utilized to precisely control its angular position [2]. It comprised a small DC motor, a gear system, and a feedback control loop. The shaft of the servo motor could be rotated to specific angles, making it suitable for generating a scanning motion. The position of the servo motor was controlled by the Arduino through the transmission of pulse-width modulation (PWM) signals, which specified the desired angle of rotation.

**System Operation:** In this experiment, the ultrasonic sensor is mounted on the servo motor's shaft. By rotating the servo motor in small increments, the sensor's field of view can be scanned in a sweeping motion, simulating the behavior of a radar antenna. As the sensor scans the area, it emits ultrasonic waves and records the time taken for the waves to bounce back. By using this time data, the Arduino calculates the distance to any detected object in the sensor's path.

**Object Detection and Tracking:** If the measured distance fell below a specific threshold, it signaled the presence of an object within the sensor's range. The Arduino tracked the position of the detected object over time by continuously scanning and recording distance measurements generating a real-time display resembling a radar illustrating the object's movement within the scanning area.

**Apparatus:**



1. Arduino IDE (1.8.19 from Microsoft Store)

2. Arduino Uno Board.

3. Ultrasonic Sensor.

4. Servo Motor.

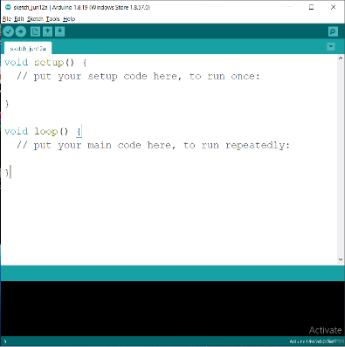
5. Breadboard and Jump Wires.

**Precautions:**

1. Safety precautions were observed during the experiment, including the proper handling of electronic components and materials to prevent accidents or damage.
2. Wiring and connections were carefully attended to prevent short circuits or incorrect wiring.
3. Simulations were run in Proteus software to validate the circuits and code before physical implementation to reduce the risk of errors.
4. Power sources were disconnected when changes were made to the circuit.

**Experimental Procedure:**

1. On the PC, the Arduino IDE was launched, displaying an interface that looked like the following:



**FIG 1:** Arduino IDE initial Window**.**

2. Code was written to facilitate the rotation of the motor within a specific angle range and the detection of objects by the ultrasonic sensor.

3. A circuit was constructed in accordance with the specified requirements.

4. Following the code composition, the sketch (the file containing the code) was saved.

5. The sketch was then compiled by navigating to Sketch → Verify/Compile.

6. After the compilation was completed, the code needed to be uploaded onto the Arduino Uno board. The Arduino Uno R3 board was connected to the PC using a USB cable for the program to be uploaded. Before uploading the code, the board type and port were selected within the Arduino IDE, involving the following steps: - Tools → Board: "Arduino Uno" → Arduino Uno. - Tools -> Ports -> COMx.

7. Once the board and port were selected, the code was uploaded by choosing the upload option within the Arduino IDE.

8. With the assistance of processing.org, a visual representation of the detected objects was obtained through a demonstration.

**Experimental set up:**

**Code of the Program:**

**Data collection table/Comparison table based on results:**

|  |  |  |
| --- | --- | --- |
| **Angle (degrees)** | **Distance (cm)** | **Detected Object** |
| … | … | … |
| 55 | 14 | Minimal Range |
| 56 | 15 | Minimal Range |
| 57 | 14 | Minimal Range |
| 58 | 19 | Minimal Range |
| 59 | 18 | Minimal Range |
| 60 | 22 | No |
| 61 | 21 | No |
| 62 | 21 | No |
| 63 | 24 | No |
| 64 | 24 | No |
| 65 | 23 | No |
| 66 | 23 | No |
| 67 | 23 | No |
| 68 | 22 | No |
| 69 | 24 | No |
| 70 | 24 | No |
| 71 | 27 | No |
| 72 | 27 | No |
| 73 | 45 | No |
| 74 | 45 | No |
| 75 | 87 | No |
| 76 | 88 | No |
| 77 | 106 | No |
| 78 | 159 | No |
| 79 | 197 | No |
| 80 | 236 | No |
| 81 | 313 | Highest Range |
| 82 | 307 | Highest Range |
| 83 | 313 | Highest Range |
| 84 | 310 | Highest Range |
| 85 | 308 | Highest Range |
| 86 | 301 | Highest Range |
| 87 | 315 | Highest Range |
| 88 | 317 | Highest Range |
| 89 | 321 | Highest Range |
| 90 | 322 | Highest Range |
| 91 | 315 | Highest Range |
| 92 | 299 | No |
| 93 | 285 | No |
| 94 | 273 | No |
| 95 | 273 | No |
| 96 | 273 | No |
|  | Table 1: Analysis of data |  |

**Discussion:**

The Radar System utilized an ultrasonic sensor for precise object distance determination, addressing its coverage limitation by integrating a servo motor for controlled scanning. Visual representations were generated using processing.org, with the Arduino microcontroller monitoring real-time object movement and the simulation aligned with experimental results, confirming the radar system's accuracy and validity.

**Conclusion:**

The integration of an ultrasonic sensor for distance measurement and precise control through a servo motor in an Arduino-based radar system enabled object detection and tracking, offering practical insights into sensor integration, signal processing and motor control principles for emulating radar functionality in a laboratory experiment.

**Reference:**