Module-01: A basic touchless dustbin

Obstacle detection using sensors is an essential technology in various automation and smart systems, ranging from robotics to household appliances. Ultrasonic sensors are commonly used for detecting the presence and position of objects due to their reliability and ease of use. In modern smart homes and public places, hygiene and convenience can be greatly improved by using touchless dustbins that automatically open their lids when someone approaches to dispose of waste. In this module, a basic touchless dustbin is designed using an ultrasonic sensor and a servo motor to open and close the dustbin lid. An ON-OFF controller is implemented to control the movement of the dustbin lid based on the distance detected by the ultrasonic sensor.
The objectives of this module are as follows:

Objectives: Design an automatic, touchless dustbin lid opening system using an ultrasonic sensor to detect the presence of a hand (or object) near the dustbin and open the lid accordingly.

Video Link of prototype: `https://iitgoffice.sharepoint.com/:v:/r/sites/Grp_Grp_EE351_2025/Shared%20Documents/General/Videos/Module-01.mp4?csf=1&web=1&e=wHt9zU`

Report Guidelines:

1. Objectives of the module.
2. Circuit diagram with proper labelling.
3. Block diagram of the system designed.
4. Flowchart of the algorithm.
5. Observations, if any.
6. Answers to the questions below.

Answer the following:

1. Draw the complete block diagram of your implemented system, clearly labeling each component and its function. Identify and justify whether the system is an open-loop or closed-loop system.

2. (a) Describe the operating principle of the ultrasonic sensor. Support your answer with a timing diagram illustrating the trigger, echo, and response phases.

   (b) Derive and explain the formula used to compute the distance from the echo pulse duration. Mention units and assumptions.

3. (a) Explain how the servo motor is controlled through the microcontroller. Include a labeled PWM timing diagram.

   (b) Is the servo motor itself operating as an open-loop or closed-loop system? Justify your answer based on its internal control mechanism.

4. Provide a detailed signal flow diagram from sensor input to motor output. Explain each processing stage (sensing, computation, decision, actuation) and the type of signals (digital/analog, PWM, etc.) involved.

5. (a) Describe any chattering (unwanted rapid opening/closing) observed during system operation. What conditions caused it? If you did not observe chattering, why was it not observed?

   (b) What modifications (such as hysteresis, delay, threshold buffer, etc.) did you implement to mitigate chattering, if any? Support your answer with experimental evidence or logical justification.

6. If you had the option of using a different control strategy instead of ON-OFF (without changing the hardware set-up), how would you minimize chattering, and why? Demonstrate the same.

OBSERVATION SHEET

`This sheet needs to be attached to the report.`

1. Demonstrate the interfacing of the ultrasonic sensor with the Arduino UNO. You should display the distance to an object, as measured by the ultrasonic sensor, on serial monitor.

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2. Demonstrate that the servo motor has been successfully interfaced with the Arduino UNO. You need to show that the servo motor moves to any angle between 0^o to 180^o based on the command you give.

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3. Demonstrate that all objectives have been fulfilled.

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4. Show that chattering effect has been eliminated in your design. (Question 5 of the report)

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5. Demonstrate a control strategy other than ON-OFF that you have used to minimize chattering. (Question 6 of the report)

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