EXPERIMENT NO :- 04

Komal Deolekar	Roll: No :- 14
Shreyash Dhekane	Roll: No :- 16
Tejas Gunjal	Roll: No :- 18

Aim : To study Distance Measurement Using Laser Sensor .

Theory :

Distance measurement plays a crucial role in various applications such as robotics, automation, object detection, and security systems. One of the most efficient methods to measure distance is by using a Time-of-Flight (ToF) sensor like the VL53L0X, which works by sending an infrared laser pulse and measuring the time it takes to return. When interfaced with an Arduino Uno, the sensor can provide highly accurate distance measurements and display them on an LCD screen.

The VL53L0X is a laser-based Time-of-Flight (ToF) sensor that accurately measures distances up to 2 meters by emitting a laser pulse and detecting the time taken for it to reflect back from an object. It operates on the principle of ToF, unlike traditional ultrasonic sensors that rely on sound waves.

The Arduino Uno processes the signal from the sensor, computes the distance, and displays the result on an output device such as an LCD or a serial monitor. This setup provides accurate distance measurement over short to medium ranges and is useful in applications like robotics, automation, and obstacle detection.

Components Used in the Experiment

1. VL53L0X Time-of-Flight Sensor

- Measures distance up to **2 meters** with high accuracy.
- Uses **I2C protocol** for communication.
- Works efficiently even in low-light conditions.

2. Arduino Uno R3

- A **microcontroller board** based on the **ATmega328P** processor.
- Reads data from the **VL53L0X sensor** and processes the distance calculation.
- Controls the output on an **LCD screen or serial monitor**.

3. LCD Display (16x2 or OLED Display - Optional)

- Used to display the measured distance in real-time.

- Connected to the Arduino using an **I2C module** (SDA & SCL pins).

4. Jumper Wires & Breadboard

- Used for electrical connections between components.

5. Power Supply

- The **VL53L0X sensor** operates on **3.3V–5V DC**, provided by the **Arduino Uno**.

VL53LOX Sensor :

The VL53L0X is a Time-of-Flight (ToF) laser ranging sensor developed by STMicroelectronics. It is designed for accurate distance measurement by utilizing laser-based infrared technology. The sensor emits a low-power infrared laser pulse and measures the time it takes for the pulse to reflect back from an object. This method enables precise, high-speed distance measurements independent of ambient light and object color.

Unlike traditional ultrasonic sensors (which use sound waves) or infrared sensors (which detect reflected IR intensity), the VL53L0X uses a direct ToF measurement technique, making it more reliable for applications such as robotics, obstacle detection, automation, and IoT-based systems.

Key Features of VL53L0X:

Measurement Range: 30 mm to 2000 mm (2 meters)
Accuracy: ±3 mm in ideal conditions
Operating Voltage: 2.6V - 5V (works with Arduino's 3.3V and 5V logic)
Communication: I2C (Inter-Integrated Circuit) interface
Compact Size: Suitable for embedded applications
Low Power Consumption: Ideal for battery-powered devices
Fast Response Time: Measures distances quickly and efficiently

Working Principle of VL53L0X Sensor

The VL53L0X sensor operates using Time-of-Flight (ToF) technology, which calculates the distance by measuring the travel time of a laser pulse. The complete working process is explained below:

1. Laser Emission

- The sensor emits a narrow, invisible **infrared laser pulse** using a **VCSEL (Vertical-Cavity Surface-Emitting Laser)**.
- This laser pulse travels at the speed of light toward the target object.

2. Reflection from Object

- When the laser pulse **hits an object**, it is **reflected back** toward the sensor.

3. Time of Flight (ToF) Calculation

- The sensor measures the **time taken** for the emitted laser pulse to reach the object and return.

- The total **round-trip time** (T) is recorded.

4. Distance Calculation

- Using the **speed of light ($c = 3 \times 10^8$ m/s)** and the measured round-trip time, the distance (D) is calculated using the formula:

$$D = \frac{c \times T}{2}$$

  - The **division by 2** accounts for the round-trip travel (sensor → object → sensor).

5. Output Data Processing

- The calculated **distance** is processed by the internal **SPAD (Single Photon Avalanche Diode) detector** and **microcontroller unit (MCU)** inside the VL53L0X sensor.
- The data is sent to an **Arduino or any microcontroller** via **I2C communication**.

6. Display and Further Processing

- The Arduino **receives the data** and can display the measured distance on an **LCD screen, Serial Monitor, or an OLED display**.
- The output is given in **millimeters (mm)** or **centimeters (cm)**.

Arduino Uno

The **Arduino Uno R3** is an open-source microcontroller board based on the ATmega328P chip. It features:

- 14 digital input/output pins (6 of which support PWM output)
- 6 analog input pins
- A 16 MHz quartz crystal
- USB connection
- Power jack and ICSP header
- Operating voltage of 5V
- Onboard LED connected to digital pin 13 for easy debugging

The Arduino Uno is programmed using the Arduino IDE, which allows users to write, compile, and upload code using a simple programming language based on C/C++. It supports a vast range of libraries and modules, making it highly adaptable for various applications. The board operates using both external power (7-12V DC adapter or battery) and USB power (5V from a computer or power bank).

Working Procedure with Arduino Uno IDE

Step 1: Install Arduino IDE

- Download and install the Arduino IDE from the official website (https://www.arduino.cc).
- Connect the Arduino Uno to the computer via a USB cable.

Step 2: Set Up the Circuit

- Connect the VCC pin of the HW493 sensor to the 5V pin on the Arduino.
- Connect the GND pin of the sensor to the GND pin of the Arduino.
- Connect the Output Signal Pin of the sensor to a digital pin on the Arduino (e.g., Pin 7).

Step 3: Write and Upload the Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Initialize the LCD (address, columns, rows)
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
  lcd.init();         // Initialize the LCD
  lcd.backlight();    // Turn on the backlight
  lcd.setCursor(0, 0);
  lcd.print("Hello, World!");
  lcd.setCursor(0, 1);
  lcd.print("Arduino!");
}

void loop() {
  // No action needed here
}
```

Step 4: Compile and Upload the Code

- Open the Arduino IDE and paste the above code.
- Select the correct Board (Arduino Uno) and Port under the "Tools" menu.
- Click Upload to compile and transfer the code to the Arduino.

Step 5: View the Output

- Open the Serial Monitor (Ctrl + Shift + M) to view the distance readings in real time.
- If using an LCD, modify the code to display the distance on the LCD.

LCD WILL DISPLAY

Hello, World!
Arduino!

Conclusion :

The VL53L0X Time-of-Flight sensor is a powerful and efficient distance measurement sensor that uses infrared laser technology. It provides fast, accurate, and reliable distance readings without being affected by object color or ambient light conditions. By integrating this sensor with an Arduino Uno, we can create applications for robotics, automation, gesture recognition, and IoT-based projects.