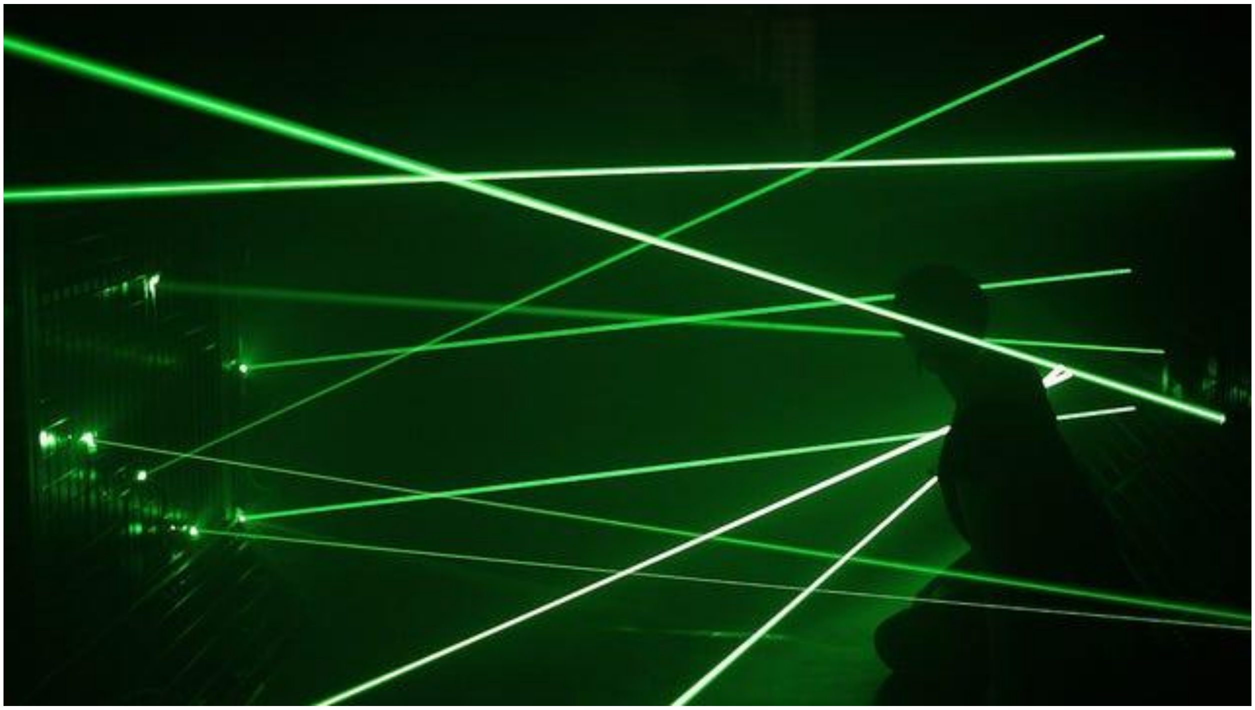
LDR-Based Object Counter Using PIC18F47K42



Abstract

We created a laser-based object detection system utilizing the Microchip PIC18F47K42 microcontroller. The system is representative of those used in industrial applications such as safety fencing and item counting. Information is received as a voltage value from a photoresistor which captures laser light over the analog to digital converter. Lux values are calculated in the microcontroller and monitored for object interference with the light. A count and current lux reading are able to be viewed on an LCD screen. The UART protocol is used to log lux measurement with MATLAB. In order to prevent unauthorized use of a safety critical safety related system a password is required in order to allow access and is communicated over GPIO

Introduction

In industrial automation and safety critical applications, accurate and reliable object detection systems are essential for ensuring both operational efficiency and workplace safety. These systems are commonly used in environments such as manufacturing lines, warehouses, and robotics, where they perform tasks ranging from item counting to the creation of safety fencing that prevents unauthorized access to hazardous areas. This project introduces a laser based object detection system developed around the Microchip PIC18F47K42 microcontroller, a device well suited for embedded control applications due to its robust analog and digital capabilities.

The system operates by directing a continuous laser beam toward a photoresistor that detects light intensity. The analog voltage generated by the photoresistor is read through the microcontroller's analog-to-digital converter (ADC), where it is processed and converted into lux values representing the ambient light level. By monitoring changes in the lux readings, the system is capable of detecting when an object interferes with the laser beam, thereby identifying the presence of an obstruction. This detection method offers a cost effective and scalable solution for a range of sensing applications.

To provide real-time feedback, both the current lux value and a running count of detected objects are displayed on a liquid crystal display (LCD). Additionally, the system incorporates UART communication to transmit lux data to a host computer running MATLAB, allowing for further analysis, visualization, or logging of measurement data. This makes the system not only useful for direct monitoring but also valuable for data driven decision making and diagnostics.

Recognizing the importance of security in safety critical systems, a password protection mechanism has been implemented. Access to key functionalities of the system is restricted unless the correct password is entered, ensuring that only authorized personnel can interact with or modify the system. This access control feature is handled through general purpose input/output (GPIO) communication, demonstrating a simple yet effective method for enforcing operational security in embedded applications.

Overall, this project demonstrates how fundamental components such as microcontrollers, analog sensors, and serial communication protocols can be integrated to build a practical, secure, and versatile object detection system. Its design reflects principles found in real world industrial solutions and serves as a strong foundation for further development in embedded sensing technologies.

Materials

- PIC18F47K42 Microcontroller
- Light Dependent Resistor
- 4x3 Keypad for password entry
- LCD for display
- FT232RL Mini USB to TTL Serial Converter Adapter Module
- Laptop with MATLAB

Methodology

The development of the laser-based object detection system involved careful integration of analog sensing, digital signal processing, secure user access, and serial communication. The system was implemented using the Microchip PIC18F47K42 microcontroller, which served as the central controller for sensor data acquisition, signal processing, user interaction, and data transmission.

Hardware Design

The core sensing mechanism uses a visible laser module aligned with a photoresistor (light dependent resistor or LDR). Under normal operating conditions, the laser beam shines directly onto the LDR, producing a stable voltage proportional to the light intensity. When an object passes through the beam, it temporarily obstructs the laser light, causing the LDR voltage to drop.

The analog signal from the LDR is connected to an analog input pin on the PIC18F47K42 microcontroller. The microcontroller’s 12-bit analog-to-digital converter (ADC) continuously samples this signal at fixed intervals, converting the analog voltage into a digital value representing the incident light level. Calibration procedures were performed to map ADC values to approximate lux levels, allowing for real-time estimation of ambient light intensity.

Object Detection Algorithm

A thresholding algorithm is implemented in the microcontroller firmware to detect interruptions in the laser beam. When the calculated lux value falls below a predefined threshold, the system identifies an object as having obstructed the beam. To prevent false detections due to noise or momentary dips in light intensity, basic debounce logic is applied. Once a valid interruption is confirmed, the system increments an internal object counter and waits for the lux value to return above the threshold before rearming for the next detection event.

Display System

An LCD screen connected to the microcontroller displays real-time data, including the current lux value and the total count of object interruptions since the last system reset. This provides immediate visual feedback to users in the field. The LCD is updated regularly as new ADC readings are processed.

Serial Communication via UART

To enable logging and analysis of light intensity over time, the system uses the Universal Asynchronous Receiver Transmitter (UART) protocol to transmit data to a host computer. The UART interface is configured to send periodic lux measurements as ASCII formatted strings over a serial connection.

On the host side, MATLAB is used to receive and interpret the data stream. A custom MATLAB script reads incoming serial data, parses the lux values, and displays them in real time using dynamic plotting. This enables users to monitor light fluctuations, detect anomalies, and archive measurement data for further analysis or system evaluation.

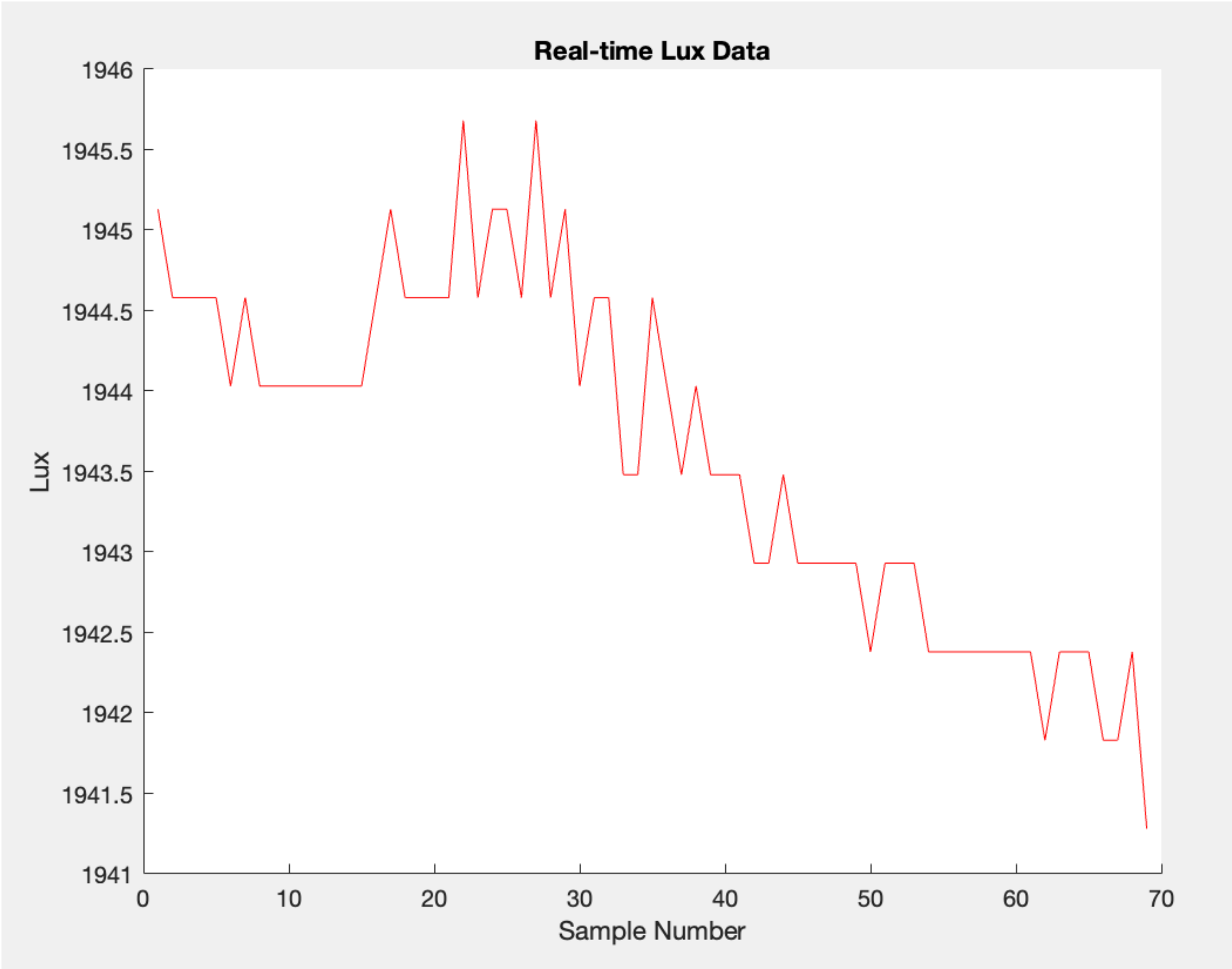
Access Control via GPIO

Given the safety critical nature of similar industrial systems, a password-based access control mechanism is implemented to prevent unauthorized usage. A user must enter a valid password through a GPIO based interface, such as a keypad or DIP switches, before gaining access to system reset or administrative functions. The microcontroller verifies the entered password against a stored value. If the password is correct, access is granted and confirmed via the LCD. If the password is incorrect, the system remains in a locked state.

Results

MATLAB Lux Data Plot:

The microcontroller transmitted lux readings over UART at regular intervals, which were captured and plotted in real time using a custom MATLAB script. The plot clearly visualizes periods when the laser beam was obstructed. These events appear as sharp dips in lux values, corresponding to brief interruptions in the laser signal caused by object movement. Between interruptions, the lux values remained stable, validating the consistency of the sensor and the reliability of the laser alignment.



The Figure above shows the MATLAB plot with multiple drop events spaced in time, demonstrating both the system's sensitivity and its ability to return to a stable baseline after each detection. This confirmed the effectiveness of the thresholding algorithm and the accuracy of the ADC to lux conversion.

Circuit Build

The final hardware was assembled on a breadboard and included the PIC18F47K42 microcontroller, laser module, photoresistor circuit, LCD display, and optional keypad (or DIP switch) for password input. Proper alignment of the laser and LDR was critical to ensuring stable readings, and shielding was added where needed to minimize the effects of ambient light.

Conclusions

Through the development of this laser-based object detection system, valuable hands-on experience was gained in both hardware integration and embedded systems programming. The project reinforced foundational concepts in analog signal processing, particularly in the use of photoresistors and ADCs to interpret real world light intensity changes as digital data. By working with the PIC18F47K42 microcontroller, we

deepened our understanding of microcontroller peripherals, including ADC modules, GPIO, UART communication, and LCD interfacing.

Implementing UART communication and integrating the system with MATLAB provided practical insight into serial data protocols and how embedded systems can interface with higher level software environments for data logging and visualization. This aspect of the project demonstrated the importance of designing systems that not only operate autonomously but also interact effectively with external tools for monitoring and analysis.

Additionally, developing a secure access control mechanism highlighted the importance of safety and authentication in embedded applications, especially those with potential industrial or safety critical use cases. Implementing password-based access through GPIO inputs allowed us to explore simple yet effective methods for enforcing restricted functionality.

Overall, this project provided a comprehensive learning experience across multiple domains of electrical and computer engineering, from sensor interfacing and signal processing to microcontroller programming and system level design. It strengthened both our technical skills and our understanding of how embedded systems are used in real world applications such as automation, safety, and monitoring.