# Implementation Of an Aircraft Ultrasonic Radar System Using Arduino

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**Abstract.** This paper presents the development of an Aircraft Ultrasonic Radar System using Arduino to enhance aircraft detection, support air traffic management, and improve aviation safety. The system integrates ultrasonic sensors with the Arduino platform to generate and process ultrasonic waves, enabling real-time distance measurement of nearby aircraft. Additional components include RF transmitter and receiver modules for wireless data transfer, reducing wiring needs and improving aircraft flexibility. A DHT11 sensor is incorporated to monitor temperature and humidity, ensuring reliable performance under varying weather conditions. The coordinated interaction between sensors and Arduino forms the core of the system, offering a cost-effective alternative to traditional radar technologies. Supported by a dedicated data processing program, the system facilitates object detection and aircraft guidance across different environments. Through ongoing testing and validation, the project aims to deliver a reliable, efficient radar solution that contributes to enhanced aviation safety.

**Keywords:** Ultrasonic Radar, Aviation Safety, Real-time Distance Measurement, Wireless Data Transmission.

## 1 Introduction

The integration of RF circuits and an Arduino with an ultrasonic sensor for aircraft monitoring demonstrates innovative design with real-world application. The goal of this paper is to develop an affordable and dependable solution for the complex discovery frameworks required for military surveillance and aviation security. The framework for finding planes within a given range is made flexible and easy to use by utilizing Arduino microcontrollers with ultrasonic sensors. Furthermore, by enabling dependable wireless data transfer to external monitoring systems or controllers, RF transceiver (TX) circuits improve the system's communication capabilities. The system's versatility is increased by these remote tracking and feedback features, which make item spotting and tracking more effective.

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The addition of the DHT11 sensor, which measures temperature and provides additional environmental monitoring, is an extension of this work. Although there are countless advantages to such a framework, it is critical to recognize the inherent limitations of airspace monitoring and collision avoidance including range restrictions, environmental conditions, and potential interference. To pave the way for future developments in aviation safety and surveillance systems, we want to investigate the capabilities and constraints of radar technology in the context of plane identification through this research.

## 2 Background

### 2.1 Literature Survey

Investigates an Arduino and ultrasonic sensor-based embedded system-based RADAR system [1]. The low power consumption of Arduino, which interfaces with a microcontroller and servo motor to implement the system, is highlighted in the study. Despite its benefits, the system's detection capabilities are limited by the ultrasonic sensor's limited range and integration issues with other robotic platforms. Furthermore, the efficacy of the system is hampered by its incapacity to offer comprehensive details about the objects it detects. It is advised to add more sensors, such as infrared or laser-based sensors, to address these problems in order to increase detection range, accuracy, and provide more thorough object recognition.

[2] Examine the operational survey plans for cloud scanning radars (SACRs) intended to accomplish scientific goals. The purpose of this paper is to fill in the gaps in cloud scanning radar technology, with an emphasis on the difficulties in differentiating between different kinds of clouds. The study notes that the SACRs' shortcomings—their inability to adequately cover the "cone of silence" and lack of weather measurements—make it difficult to forecast rainfall and develop survey techniques. It is suggested that more SACR devices be deployed in order to improve the system's overall accuracy by decreasing detection gaps and expanding coverage of wider areas.

[3] Examine how weather radars are used in intricate mountainous areas, particularly for real-time rainfall event monitoring and forecasting, which is essential for industries like agriculture and construction. The study does, however, recognize that the high elevation and remote monitoring needed for mountain radar installation present difficulties. Providing electronic displays for radar data is one recommended enhancement that would allow users to visually monitor weather conditions and predict rainfall, which could be useful for industries that rely on weather forecasts.

[4] investigate the use of ultrasonic radar to determine the shape, direction, and distance of moving objects. Due to delayed evaluations of moving objects, the article highlights difficulties in classifying various object types and enhancing object detection accuracy, particularly in real-time analysis. To improve system performance and enable real-time tracking of object movement for path determination, the authors propose connecting ultrasonic radar systems with additional sensors to increase detection accuracy.

### 2.2 Methodology

For the development of an Aircraft Ultrasonic Radar System using Arduino, the V-Model methodology is the most suitable approach due to its emphasis on iterative testing and continuous development, making it ideal for complex systems that require flexibility and detailed testing throughout the paper lifecycle.

The V-Model is an extension of the traditional Waterfall methodology, where development and testing phases are closely aligned. This model is highly beneficial for papers like radar systems that involve multiple stages of both software and hardware integration. In the V-Model, for each development phase (e.g., design, implementation), there is a corresponding testing phase (e.g., unit testing, integration testing) that ensures the system functions as intended. This structure allows for early detection of defects and errors, facilitating quicker resolutions and preventing costly late-stage modifications.

In the context of the Aircraft Ultrasonic Radar System, the V-Model allows for iterative development, where each component, such as the Arduino board, ultrasonic sensors, RF circuit, and DHT11 sensor, can be developed, tested, and refined in parallel. This ensures that system components are continuously verified for compatibility and performance. For example, the verification phase focuses on the testing of hardware and software components, ensuring that the radar system works accurately and efficiently for obstacle detection and aircraft monitoring.

Moreover, the validation phase ensures that the final system meets the expected performance standards, such as detecting aircraft in a specified area under various environmental conditions. By following this structured approach, the paper team can ensure that the system is both reliable and capable of meeting all defined objectives.

Incorporating the V-Model ensures that each iteration leads to tangible results, making it easier to adapt to any changes in requirements or unexpected challenges. The process of verifying and validating each stage reduces the risk of failure and supports continuous improvement, resulting in a more reliable and accurate radar system. The Aircraft Ultrasonic Radar System using Arduino is extremely user-friendly. The system is simple to use because of its intuitive interface and Arduino microcontroller, which is a well-liked platform for students and enthusiasts. The majority of users may understand and use it because it uses simple components like ultrasonic sensors, RF modules, and DHT11 temperature and humidity sensors. The system has a plug-and-play setup, and the code may be readily updated using the Arduino IDE. The sensors, screen, and alerting components are all simple to connect. Visual indicators such as the TFT display and LCD screen, together with auditory feedback from the buzzer and visual LED indicators, assist users in easily interpreting the system's condition and alerts.

This system's design emphasizes simplicity, making it suitable not only for aviation but also for academic and research purposes. The learning curve is modest, and the system can be installed and utilized by users with limited prior knowledge of electronics or radar systems.

## 3 System design and implementation

The system design phase is discussed, where strategies for structuring the system to achieve reliability and efficiency are explored. This section emphasizes the selection of appropriate hardware components, including the Arduino board, ultrasonic sensors, and RF circuits, and discusses their integration for optimal performance.

### 3.1 System Block Diagram and Flowchart

Figure 1 illustrates the block diagram and flowchart of the Aircraft Ultrasonic Radar System Using Arduino. The system consists of several key components, including an ultrasonic sensor, RF receiver, and DHT11 sensor, which serve as input components. The outputs of the system include a TFT display, LED, buzzer, and LCD. The servo motor is controlled by the microcontroller, Arduino UNO, which processes the inputs and manages the system's functionality [5].

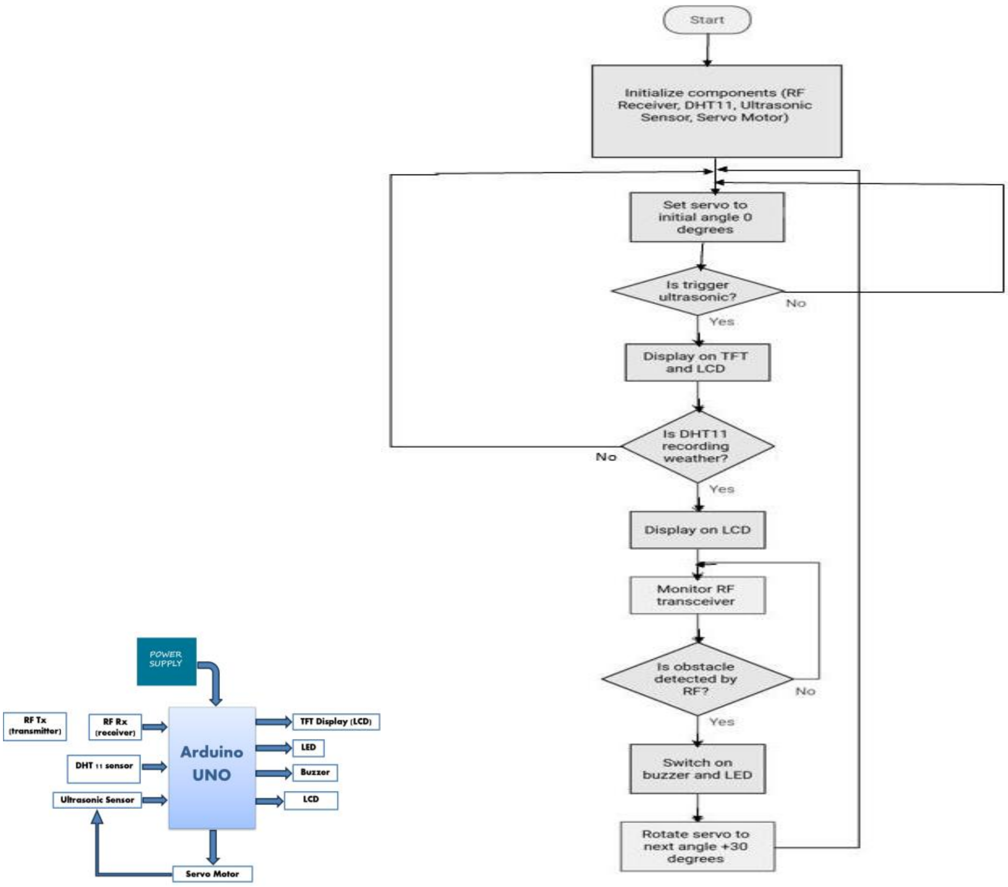


**Fig. 1.** System Block Diagram and Flowchart.

The flowchart for the Aircraft Ultrasonic Radar System Using Arduino, detailing the sequential process for its operation. The flowchart begins with the Start block, marking the initiation of the system. In the next step, initialize components, the system powers up and initializes the essential hardware, including the servo motor, DHT11 sensor, RF receiver [7] and ultrasonic sensor, ensuring they are ready for operation. The system then proceeds to Set servo to beginning angle of 0 degrees, positioning the servo motor at the starting point for scanning.

The Is trigger ultrasonic block checks whether the ultrasonic sensor has been activated to detect the movement of aircraft or objects. If activated, the system displays the information on the TFT and LCD. If not, the servo returns to its initial position and continues to observe.

Next, the flowchart checks whether the DHT11 sensor is recording weather data. If the sensor is recording temperature and humidity correctly, the data is recorded and displayed on the LCD. If not, the system returns the servo to its initial angle and continues monitoring.

The Monitor RF transceiver block ensures the system is constantly checking for obstacles via the RF receiver. If an obstacle is detected, the system triggers a warning by activating the LED and buzzer. If no obstacle is detected, the system continues to monitor the RF transceiver for any signals.

Following this, the Rotate servo to the next angle +30 degrees block rotates the servo to the next scanning position, increasing by 30 degrees for continued detection. Finally, the system resets the servo to the initial 0-degree angle after a full rotation, ensuring continuous scanning and monitoring of the surrounding environment. This flowchart provides a clear and structured approach for the operation of the Aircraft Ultrasonic Radar System, enabling it to detect objects, monitor weather conditions, and ensure constant scanning for aircraft safety.

### 3.2 Implementation

The distance to an object in the Aircraft Ultrasonic Radar System is calculated by measuring the pulse travel time (t) and using the speed of sound in air, which is 343 m/s [8, 9]. The formula for determining the distance is $d=t\times0.01715$. For example, if the pulse travel time is 1000 microseconds, the distance is 17.15 cm. The system provides visual feedback via a Buzzer, LED, TFT display, and LCD, which display the detected distance and temperature. When an obstacle is detected by the ultrasonic sensor, the LED lights up, and the buzzer sounds to alert the user. The servo motor, responsible for scanning the environment, rotates at 60° per second, completing a 180° scan in 3 seconds. Alternatively, with a rotation speed of 30° per second, the full scan takes 6 seconds. The power consumption of the system is essential for its smooth operation. The ultrasonic sensor [5] requires 15mA, the servo motor consumes between 200 and 300mA, the Arduino UNO draws 50mA, and the display and other components require 100mA. The total current required is 465mA, resulting in a power consumption of 2.325W when powered by a 5V supply. This ensures that the system operates efficiently, providing the necessary functionality for object detection and display. Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Test Cases for Hardware and Software Validation:

- **T1:** Test the output voltage of the RF receiver using both a multi-metre and software, comparing the sent and received data to verify the accuracy of the signal reception.

- **T2:** Test the signal transmission from the RF transmitter to the receiver to ensure the correct data is transmitted without interference.
- **T3:** Measure the output voltage of the DHT11 sensor with a multi-metre and software. The sensor should be tested by placing a heating source nearby to check if the temperature rises. The readings should be compared with those from a calibrated instrument, such as a mobile phone, within a range of 0 to 50°C.
- **T4:** Test the output voltage of the ultrasonic sensors with both hardware and software, verifying that the measured distances between 2 and 40 cm are accurate and match actual distances.
- **T5:** Test the servo motor's rotational movement to ensure it travels smoothly and precisely across the required range (0 to 180 degrees) through both hardware and software testing.
- **T6:** Test the TFT display to ensure that it shows accurate graphical output by displaying data and confirming the graphics are clear and updates are correct.
- **T7:** Test the LED activation for visual warnings, ensuring it responds effectively and is visible when required.
- **T8:** Test the buzzer's audio alerts by programming it to sound in various scenarios and ensuring that the tone and volume are appropriate for the intended alerts.
- **T9:** Test the output voltage of the LCD screen with a multi-metre and software, confirming that the temperature and distance display update correctly in real-time, ensuring all components are properly connected and functioning

**Table 1.** Test Plans.

| Test Point (Sensor) | Design Value | Simulation Value | Implemented Value |
|---|---|---|---|
| T3 (DHT11 Sensor) | 5V | 4.8V | 4.77V |
| T4 (Ultrasonic Sensor) | 5V | 4.7V | 4.68V |
| T6 (TFT Display) | 5V | 5V | 4.89V |
| T9 (LCD) | 5V | 4.8V | 4.68V |

Table 1 shows the testing values for several components, including the LCD, TFT display, DHT11 sensor, and ultrasonic sensor. Even while the simulated and implemented values differ slightly, they are still rather close to the anticipated 5V, suggesting effective power management and design parameter adherence.

This section highlights the process of verifying the functionality and reliability of the radar system. Using the Arduino IDE, each component of the system was tested during the evaluation phase to ensure the design objectives were met.

After confirming the operation of individual components, the system was tested with varying inputs and outputs to simulate real-world conditions. For instance, when the ultrasonic sensor detects an aircraft within its range, the servo motor rotates to scan the area, and the LCD and TFT displays show the distance information. The LCD provided real-time data, while the LED and buzzer served as alerts to notify the pilot when objects were dangerously close to the aircraft.
To ensure accuracy, the input and output readings were tested, and the error percentage for certain components was calculated using the formula:

$$Percentage\ Error = \left(\frac{|Implemented\ Voltage - Design\ Voltage|}{Design\ Voltage}\right) \times 100 \quad (1)$$

**Table 2.** Percentage of Error and Accuracy.

| Component (Test Point) | Error (%) | Accuracy (%) |
|---|---|---|
| Ultrasonic Sensor | 6.4% | 93.6% |
| DHT11 Sensor | 4.6% | 95.4% |
| TFT Display | 2.2% | 97.8% |
| LCD | 6.4% | 93.6% |

As shown in Table II, the system demonstrates excellent accuracy and reliability, meeting the paper's design requirements. The minor discrepancies in readings can be attributed to testing conditions, and overall, the system performed effectively in accordance with the established design criteria.

## 4 Conclusion

The primary objective of this paper—to develop an ultrasonic radar system using Arduino to enhance aviation safety—was successfully achieved. The system effectively detects obstacles, provides real-time data, and offers a cost-effective solution to improve air traffic control and reduce aviation hazards. By integrating servo motors, ultrasonic sensors, and a graphical TFT interface, the system delivers accurate and reliable distance measurements, fulfilling the critical need for hazard detection. Multiple ultrasonic sensors were strategically positioned, ensuring broad radar coverage. The TFT display provided a graphical representation of radar data, while the LCD panel displayed temperature and distance readings, enabling comprehensive environmental monitoring. Additionally, RF transceiver modules facilitated real-time wireless communication, enabling remote monitoring for timely decision-making. Safety features such as LED indicators and a buzzer further enhanced situational awareness by alerting users to potential hazards.

While the system demonstrated excellent accuracy and reliability, future improvements could include advanced detection methods, energy-efficient components, AI integration for object classification, and scalability for wider coverage. This paper showcases the potential of ultrasonic radar systems in aviation, advancing safety and offering a solid foundation for further technological developments in the field.

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