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"SKY GUARDIAN AND AQUA DEFENDER RADAR IN DEFENSE SYSTEM"

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Abstract-

The advanced airborne radar system designed for long-range detection, tracking, and threat assessment of aerial targets, including aircraft, drones, and ballistic missiles. It operates across multiple frequency bands and incorporates AESA (Active Electronically Scanned Array) technology to provide real-time situational awareness and rapid target acquisition. Conversely, the Aqua Defender radar system is specialized for maritime environments, focusing on surface and sub-surface threat detection, such as ships, submarines, and sea-skimming missiles. Integrated with naval platforms, it ensures all-weather, 180-degree coverage and supports automated target tracking and classification. Both systems enhance battlefield awareness, decision-making, and integrated defense responses through network-centric operation and interoperability with other military assets, their deployment significantly boosts defense capabilities in air and maritime domains, forming a critical part of multi-layered national security infrastructures.

1. Introduction:

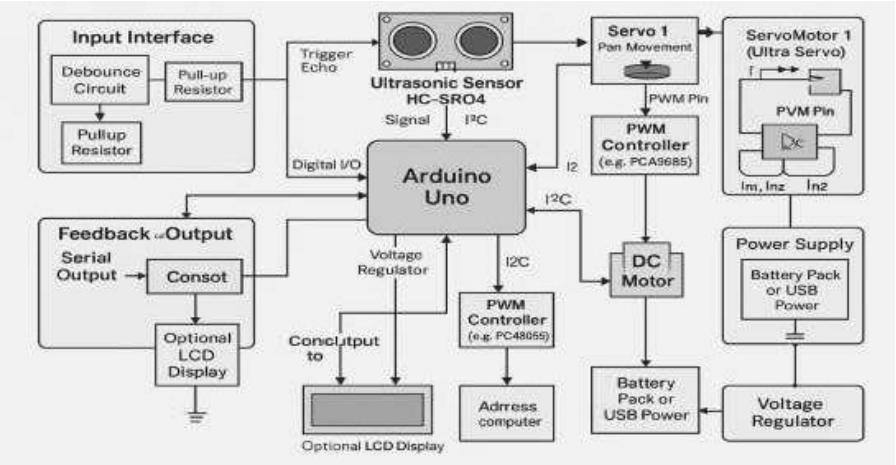
Nowadays most of the military operations have been using innovative radar technology to maintain national security and strategic advantage. The Sky Guardian and Aqua Defender radar systems represent a quantum leap in air-based and sea-based surveillance capacity. Sky Guardian radar is designed to monitor high-altitude airspace with long-range detection of airborne threats, including drones, missiles and stealth aircraft.

The aqua defender radar system, on the other hand, is the world's first and only marine radar system made for the open sea. It delivers accurate tracking of surface and underwater threats, such as high-speed boats and submarines. Designed for the rigors of an at-sea naval environment, the system provides naval operations with greater accuracy and reliability. These radar systems combined mean multi-domain defense is reinforced, threat response synchronized, and modern military operations empowered with state-of-the-art detection and tracking. The word RADAR is an acronym derived from the words Radio Detection and Ranging. In the United Kingdom it was initially referred to as radio direction finding (RDF) in order to preserve the secrecy of its ranging capability, after whom the basic unit of frequency is named, demonstrated in 1886 that radio waves could be reflected, from metallic objects.

2. PROPOSED METHODOLOGY

The working of the proposed system is as follows: after its design, construction, and programming, a few objects are placed in front of the ultrasonic sensor. As the motor started rotating, the monitor displayed the output through the Processing IDE. When the sensor crossed over the object, it showed a red segment with the distance and angle where the object was placed. The first object was placed at a distance of 30.5 cm (measured using a ruler), and the system measured the distance as 32 cm. The second object was placed at a distance of 20 cm, and the system measured it as 21 cm. Hence, the calculated efficiency turned out to be 95%.

BLOCK DIAGRAM

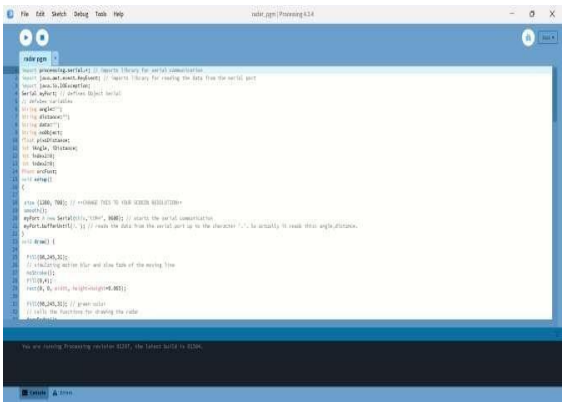


This system utilizes an ultrasonic sensor connected to an Arduino to detect obstacles or measure distance. An input switch triggers the operation, and the Arduino processes the sensor data. Based on the input, the Arduino controls two servo motors— one directly and one via a PWM controller—to move a turret mechanism, likely for targeting or scanning. Additionally, the PWM controller drives a DC motor, which may control turret rotation or another mechanical function. The Arduino also sends serial output to a computer for monitoring or data logging, enabling real-time tracking or further processing.

Software to Operation Plan;

Processing is an open-source computer programming language and integrated development environment (IDE) built for the electronic arts, new media art, and visual design communities to teach the fundamentals of computer programming in a visual context.
The specifications of Processing:

- Free to download and open-source
- Interactive programs with 2D, 3D, or PDF output
- OpenGL integration for accelerated 2D and 3D graphics
- Compatible with GNU/Linux, macOS, and Windows
    - Over 100 libraries extend the core software



3. Components used:

a) **ADAPTOR:** An adapter in a military radar system is a device or module that connects different subsystems or components that may otherwise be incompatible due to differences in signal type, connector type, voltage level, or protocol.

Purpose of an Adapter in Military Radar

1. **Signal Compatibility**

Convert one signal type to another (e.g., analog to digital, or different RF frequencies) to ensure components can communicate.

2. **Connector Conversion**

Match different types of RF connectors or electrical interfaces (e.g., SMA to N-type).

3. **Protocol Bridging**

Convert communication protocols between radar components (e.g., from MIL-STD-1553 to Ethernet).

4. **Integration of Legacy and Modern Systems**

Enable old systems to work with new radar components or upgrades without a complete system redesign.

5. **Testing and Calibration Support**

Allow test equipment to interface with radar systems during maintenance or calibration.

Fig.1

B) IRF520N: The IRF520N is an N-channel power MOSFET made by International Rectifier (now part of Infineon). It's a common low-cost transistor used for switching and amplification in a variety of applications. However, its usage in military radar systems is unlikely or extremely limited.

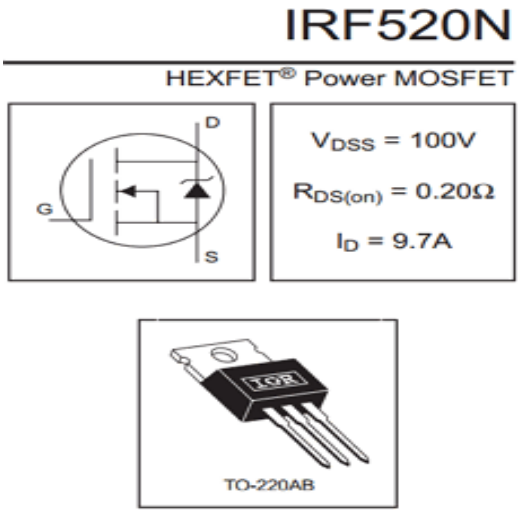


Fig. 2

C. ARDUINO NANO: The Arduino Nano, a compact 8-bit microcontroller board based on the ATmega328P, is generally not used in the core functions of military radar systems due to its limited processing capabilities, lack of ruggedization, and absence of military-grade certifications. However, it may serve auxiliary purposes in non-critical roles such as prototyping, basic control tasks, sensor interfacing, or in test and diagnostic equipment during development phases. Its simplicity, ease of programming, and low cost make it useful for rapid experimentation or internal subsystem testing, but it is unsuitable for real-time radar signal processing, high-speed data handling, or deployment in mission-critical operations.

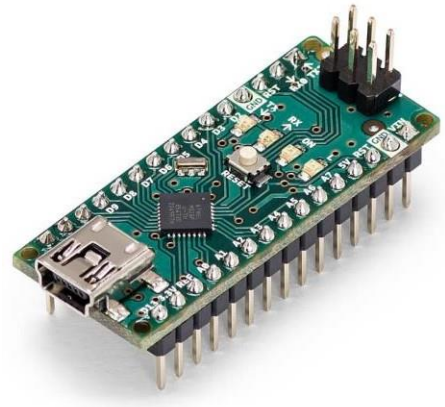


Fig.3

D. MG90 SERVO MOTOR :- The MG90S servo motor, a small, metal-geared hobby servo, is not suitable for core operational roles in military radar systems due to its limited torque, precision, and lack of environmental resilience or military-grade certification. However, it may be used in non-critical applications such as prototyping, educational models, or internal test rigs where precise control of small mechanical components is needed. In such cases, its compact size, ease of control via PWM, and low cost make it a convenient choice for experimental setups or demonstration units, but it is not appropriate for tasks like antenna positioning or long-term field deployment in actual radar operations.

Fig.4

E. ULTRASONIC SENSOR: Ultrasonic sensors, which operate by emitting high-frequency sound waves (typically around 40 kHz) and measuring the echo to determine distance, are not used in the core detection or tracking functions of military radar systems, which operate at much higher electromagnetic frequencies (MHz to GHz) for long-range and high-precision target acquisition. However, ultrasonic sensors may be employed in non-critical support roles, such as proximity detection, equipment positioning, automated maintenance systems, or obstacle avoidance in ground-based radar platforms or transport vehicles. Their simplicity, low power consumption, and effectiveness in short-range applications make them useful for local sensing tasks, but they lack the range, resolution, and robustness required for actual radar surveillance or targeting operations.

Fig.5

F. DC MOTOR: DC motors are commonly used in military radar systems for mechanical movement tasks such as rotating radar antennas, adjusting elevation angles, or positioning subsystems within mobile radar platforms. These motors provide reliable and controllable rotational force, especially when paired with gearboxes, encoders, or feedback control systems to ensure precise motion. In radar systems, DC motors are typically part of the antenna drive mechanism, enabling the radar to scan designated airspace or terrain accurately. For military use, these motors are often ruggedized to withstand harsh environmental conditions, including vibration, temperature extremes, and electromagnetic interference. While not involved in signal processing, DC motors play a critical mechanical role in enabling radar functionality through precise physical orientation and motion.

Fig.6

4. PROGRAMS AND ALGORITHM:

```
import processing.serial.*; // imports library for serial communication

import java.awt.event.KeyEvent; // imports library for reading the data from the serial port  import java.io.IOException;
Serial myPort; // defines Object Serial

// defubes variables  String angle="";  String distance="";  String data="";  String noObject;


float pixsDistance;  int iAngle, iDistance;  int index1=0;
int index2=0;  PFont orcFont;  void setup()
{


size (1200, 700); // *CHANGE THIS TO YOUR SCREEN RESOLUTION*

smooth();

myPort = new Serial(this,"COM4", 9600); // starts the serial communication

myPort.bufferUntil('.'); // reads the data from the serial port up to the character '.'. So actually it reads this: angle,distance.

}

void draw() {


fill(98,245,31);

// simulating motion blur and slow fade of the moving line  noStroke();
fill(0,4);

rect(0, 0, width, height-height*0.065);


fill(98,245,31); // green color

// calls the functions for drawing the radar  drawRadar();
drawLine();  drawObject();  drawText();
```

```
}

void serialEvent (Serial myPort) { // starts reading data from the Serial Port

// reads the data from the Serial Port up to the character '.' and puts it into the String variable "data".  data = myPort.readStringUntil('.');
data = data.substring(0,data.length()-1);
```

5. Results:

Sl no	Target detection	Status of Target
1	<40 cm	Detected
2	>40cm	Not detected

Sl no	Angle in degree	Distance travelled	Weight of missile
Clockwise rotation			
1	30	39 cm	5g
2	60	38 cm	5g
3	90	39 cm	5g
Anti clock wise			
1	30	38 cm	5g
2	60	39 cm	5g
3	90	40 cm	5g

6. Conclusion:

There are several promising avenues for future development of the ultrasonic radar system, ranging from performance and adaptability enhancements to integration, deployment, affordability, and security. Continued research and innovation in these areas will help advance the field and unlock broader applications for ultrasonic radar technology.

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Experimental Model View