

“ADVANCED MILITARY SPY AND BOMB DISPOSAL ROBOT”

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ABSTRACT

Modern warfare requires precise surveillance, rapid threat detection, and safe handling of explosive devices. Human involvement in such high-risk environments leads to significant casualties. To address this, the Advanced Military Spy and Bomb Disposal Robot is designed as a multifunctional robotic platform capable of remote surveillance, explosive ordnance disposal (EOD), hazardous material handling, and terrain-adaptive mobility. The system integrates sensors, a robotic arm, wireless communication, vision systems, and autonomous navigation to enhance mission safety and efficiency. This paper presents the design, components, working principle, and advantages of the proposed robotics solution.

Keyword: Advanced military spy, Bomb disposal robot

1. INTRODUCTION

2. Metal detector The increasing global threat of terrorism, insurgency, and unconventional warfare has created a strong need for advanced robotic systems capable of performing reconnaissance and explosive ordnance disposal without risking human lives. Modern soldiers are repeatedly exposed to highly dangerous situations, especially when inspecting improvised explosive devices (IEDs), landmines, booby traps, and suspicious packages in urban and battlefield environments. To address these challenges, the Advanced Military Spy and Bomb Disposal Robot is

designed as an intelligent, remotely controlled machine capable of entering hazardous zones, gathering real-time surveillance information, detecting explosive materials, and safely neutralizing or relocating bombs. This robotic system minimizes direct human involvement in dangerous missions, improving operational safety and reducing casualties.

The mechanical design of this robot focuses on durability, stability, and enhanced mobility across uneven terrains. It typically uses a rugged chassis built from aluminium alloy or carbon fiber, supported by tracked wheels or high-torque motors that enable it to climb debris, stairs, stony surfaces, and rough landscapes. The body is shock-resistant and weather-proof, allowing the robot to function under rain, dust, chemical exposure, or harsh battlefield environments. A robotic arm, often with multiple degrees of freedom, is mounted on the chassis to manipulate objects. This arm can rotate, extend, lift, grip, cut wires, and carefully move explosive devices. With precision motors and servo-controlled joints, the robot ensures steady and controlled movements, even when handling delicate bombs. To support its mission, the robot is equipped with a wide range of sensors that enhance awareness and safety. Ultrasonic sensors provide obstacle detection, helping the robot navigate narrow or cluttered environments. Gas sensors detect explosive gases or chemical leaks, while metal detectors help the robot identify buried landmines or hidden metallic objects that may indicate bombs. Infrared and thermal sensors allow the robot to detect heat signatures, trapped people, or devices concealed in darkness. These sensors together create an intelligent perception system, giving the operator vital data needed to analyze the situation.

1.1 Components :

1. Lead acid battery 12v -8Ah
2. Metal detector
3. Ultra sonic sensor
4. Robotic arm
5. Servo motor
6. Micro servo motor
7. ESP 32 processor
8. ESP 32 Cam module

1.2 Methodology :

The methodology for developing the Advanced Military Spy and Bomb Disposal Robot follows a comprehensive, multi-stage engineering approach that combines mechanical construction, embedded electronics, artificial intelligence, and system integration to create a reliable, mission-ready robotic platform. The process begins with a thorough analysis of military operational needs, including the types of terrains encountered, the nature of explosive devices, the communication range required, and the limitations of human involvement in dangerous environments. Based on this analysis, design specifications are created to define the robot's dimensions, weight, payload capacity, speed, arm

flexibility, and sensor accuracy. Once these specifications are established, the mechanical structure is designed using 3D modeling tools such as SolidWorks or AutoCAD, ensuring that the chassis is strong enough to withstand shock and vibration while remaining lightweight for mobility. A tracked-wheel or four-wheel-drive mechanism is selected to allow the robot to navigate rugged landscapes, debris-covered surfaces, and narrow pathways. The robotic manipulator arm is designed with multiple degrees of freedom to allow precise movement required for bomb disposal, gripping, lifting objects, and cutting wires without damaging the explosive device. The mechanical design is finalized, the next step involves selecting and integrating the electronic components. High-torque motors, servo motors, and drivers are installed to control the wheels and arm movements. Sensors are carefully positioned around the robot to maximize coverage and accuracy. These include ultrasonic sensors for collision avoidance, metal detectors for identifying hidden mines, gas sensors for detecting explosive vapors, thermal sensors for locating heat signatures, and IR sensors for low-light vision. A high-definition camera system with pan-tilt capability is mounted to capture a 360-degree view of the environment. The Raspberry Pi or Arduino microcontroller is chosen as the core processing unit, responsible for motor control, sensor data processing, and communication handling. All electronic components are wired through a stable power distribution module connected to a rechargeable lithium-ion battery pack designed to support long-duration missions. The hardware integration, the methodology advances into the software development phase. Programming is done using Embedded C for Arduino and Python for Raspberry Pi, implementing algorithms for obstacle detection, path control, robotic arm positioning, and data transmission. For communication, secure RF modules, Wi-Fi connectivity, or 4G/5G networks are configured, depending on mission range requirements. Encryption techniques such as AES are applied to secure the command signals and video streams from external interference or hacking attempts. Real-time image processing modules using OpenCV may also be added to enable automatic detection of suspicious objects or unusual heat patterns. The robot's control interface is developed using a mobile app or a laptop-based GUI, allowing the operator to monitor live video, read sensor outputs, and control robot movements remotely. Sensor calibration is done to ensure accurate detection of metals, gases, heat signatures, or obstacles. Communication range tests verify that the robot remains responsive and secure even at long distances. After initial testing, any mechanical or software flaws are corrected, and performance is optimized to reduce delays, improve motor accuracy, and minimize power consumption.

2. BLOCK DIAGRAM

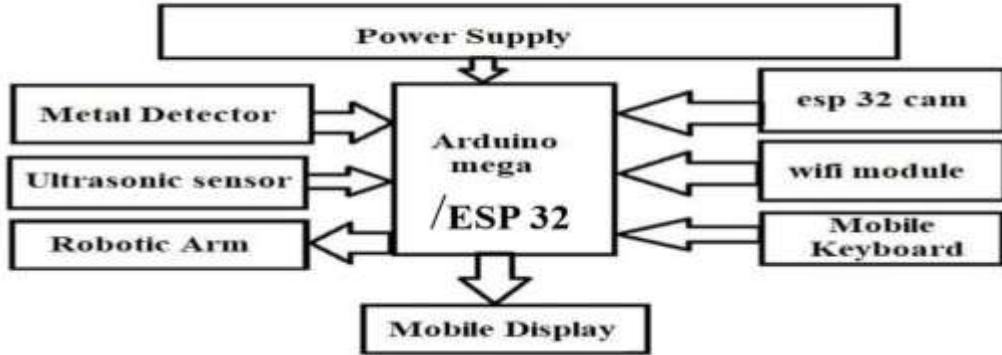


Fig-1: Block diagram of disposal robot

The block diagram illustrates the complete functional architecture of the Advanced Military Spy and Bomb Disposal Robot, showing how each subsystem interacts with the central controller to perform surveillance, navigation, and explosive-handling tasks. At the core of the system lies the microcontroller unit, represented as Arduino Mega / ESP32, which acts as the brain of the robot. All input and output modules are connected to this controller, enabling real-time data processing and remote operation. The entire robot is powered through a regulated **power supply unit**, which distributes stable voltage to all sensors, actuators, communication modules, and the controller to ensure uninterrupted operation during field missions.

On the left side of the block diagram, the Metal Detector, Ultrasonic Sensor, and Robotic Arm are connected as primary input and control components. The metal detector continuously scans the ground for metallic objects or buried mines and sends detection signals to the controller.

The ultrasonic sensor acts as an obstacle-detection module that measures the distance to nearby objects, helping the robot avoid collisions during navigation. The robotic arm is connected to the controller through servo or motor drivers, enabling the ESP32/Arduino to control its movements for lifting suspicious objects, cutting wires, or manipulating explosive devices with precision.

On the right side of the diagram, the ESP32-CAM, Wi-Fi Module, and Mobile Keyboard represent the communication and surveillance units. The ESP32-CAM provides a live video stream of the environment, sending real-time footage back to the operator through wireless communication. The Wi-Fi module enables the robot to transmit sensor data, camera feed, and system status to a remote device, such as a smartphone or laptop. The mobile keyboard or remote controller sends user commands to the robot, which the microcontroller interprets and converts into navigation or arm-movement actions.

At the bottom of the block diagram, the Mobile Display acts as the visual feedback device, where the operator receives real-time camera footage and sensor readings. This allows the user to make informed decisions about the robot's movement and bomb-handling procedures. Through the seamless integration shown in the block diagram, each component works together to create a fully functional, remotely controlled, intelligent robot capable of performing surveillance, detecting explosives, navigating hazardous terrain, and safely assisting in bomb disposal operations. The LED emits a bright red glow, indicating that the circuit is correctly powered and functioning. The breadboard provides a clean platform where components are neatly arranged in rows, making it easy to test and modify connections without soldering. The jumper wires link the battery to the breadboard's positive and negative rails, while the resistor limits current to protect the LED from damage.

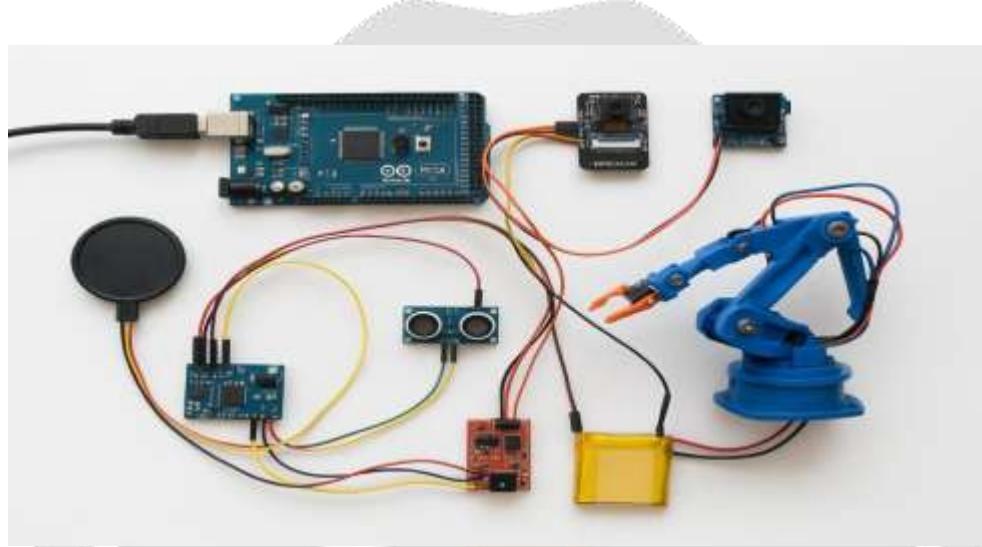


Fig-2: Making military spy connection using hardware components

The image illustrates a basic electronic circuit constructed on a breadboard, commonly used in electronics labs and student projects for quick and flexible experimentation. The circuit features a red LED connected through a 220- ohm resistor, which ensures that the LED receives a safe amount of current from the 9-volt battery. The jumper wires establish connections between the power supply and the circuit components, with the breadboard's internal metal strips distributing power across its rows. The bright illumination of the LED indicates that the polarity is correct and that the circuit loop is properly completed. This type of setup is often used to teach beginners the fundamentals of circuitry, such as current flow, resistance, voltage, and component placement. The clean arrangement on the breadboard also makes troubleshooting easier, allowing learners to observe how simple electrical components interact. Such prototype circuits serve as the foundation for more advanced electronic designs, helping students build confidence before moving on to sensors, microcontrollers, and more complex systems.

2.1 Objective :

The objective of this basic LED circuit setup extends beyond simply lighting an LED; it is designed to build a strong foundational understanding of how electronic components work together in a functional circuit. Through this activity, learners explore essential principles such as voltage supply, controlled current flow, and the role of resistance in preventing component damage. By using a solderless breadboard, the project familiarizes students with a widely used prototyping tool that allows circuits to be assembled, tested, and modified easily without permanent connections. The inclusion of a current-limiting resistor highlights an important safety practice in electronics, teaching students how to calculate and select proper resistor values using Ohm's Law to protect delicate components like LEDs. Jumper wires help illustrate how power rails and signal paths are established, making it easier to understand circuit layout and wiring discipline. As the LED lights up successfully, learners visually confirm the correctness of their connections, gaining confidence in handling electronic components. This simple circuit also encourages logical thinking and systematic troubleshooting, as students learn to identify common issues such as incorrect polarity, loose wires, or faulty components. Overall, the objective of this activity is to provide a thorough, hands-on introduction to electronics, equipping beginners with the practical skills and conceptual knowledge needed to progress toward more advanced projects involving sensors, microcontrollers, communication modules, and robotics.

Key objectives include:

- To understand the fundamental principles of electrical circuits, including current flow, voltage, resistance, and polarity through a simple LED-resistor circuit.
- To learn the practical use of a solderless breadboard for building and testing circuits without soldering, enabling quick assembly and troubleshooting.

- To demonstrate the importance of current-limiting resistors in protecting components like LEDs from high current that can cause overheating or permanent damage.
- To develop hands-on skills in connecting electronic components, such as LEDs, resistors, jumper wires, and power sources, in a safe and organized manner.
- To visualize and verify circuit functionality by observing the LED illumination when the circuit is correctly connected and powered.
- To introduce beginners to prototype-level circuit design, forming the foundation for more advanced electronics projects involving sensors, microcontrollers, and robotics.
- To enhance problem-solving and analytical skills by identifying correct component orientation and troubleshooting common issues like loose connections or reverse polarity.

2.2 Importance and Motivation :

The importance of this basic LED circuit project lies in its ability to introduce learners to the fundamental building blocks of electronics in a simple, visual, and highly engaging manner. Even though the circuit appears basic, it represents the essential principles that govern all electronic systems, such as power distribution, resistance control, and proper component orientation.

Importance

- Introduces learners to the fundamental concepts of electronics such as voltage, current, and resistance.
- Helps students understand the practical use of a breadboard for assembling and testing circuits without soldering.
- Demonstrates the importance of using a current-limiting resistor to protect sensitive components like LEDs.
- Provides a visual confirmation of circuit functionality, making learning easier and more engaging.
- Builds a strong foundation for understanding more advanced electronics, including sensors, controllers, and robotics.
- Encourages safe handling of components and awareness of correct polarity and wiring.
- Strengthens troubleshooting and analytical skills through hands-on practice with real components.

Motivation

- Encourages beginners to overcome fear of electronics by offering a simple, achievable project.
- Provides immediate positive feedback when the LED glows, increasing confidence and interest.
- Inspires curiosity about how electronic devices work in daily life.
- Motivates learners to explore more advanced projects such as Arduino, IoT, and automation systems.
- Helps develop practical skills that are essential in engineering, technology, and STEM fields.
- Promotes logical thinking and problem-solving through real-time experimentation.

- Acts as a stepping stone for students interested in careers related to electronics, embedded systems, and robotics.

This simple experiment motivates them to explore more complex topics like Arduino programming, embedded systems, and smart technologies. Moreover, this project enhances problem-solving skills, encourages logical thinking, and fosters curiosity about how everyday electronic devices function. The combination of simplicity, visual feedback, and educational value makes this activity an essential starting point for anyone entering the world of electronics.

3. WORKING :



Fig 3 Working of military SPY and bomb disposal robot

The basic LED circuit works on the principle of completing an electrical path that allows current to flow from a power source, through electronic components, and back to the source. In this setup, a 9-volt battery provides the necessary voltage to energize the circuit. The positive terminal of the battery is connected to the breadboard's positive rail using jumper wires, while the negative terminal is connected to the ground rail. These rails distribute power to various points on the breadboard, making it easy to connect components without direct wiring to the battery. When the LED and resistor are placed in series between the positive and negative rails, the current flows through the resistor first and then through the LED, causing it to emit light.

The resistor plays a crucial role in the working of the circuit by limiting the amount of current flowing through the LED. LEDs are sensitive components that can burn out if exposed to high current. The resistor reduces the current to a safe level according to Ohm's Law, ensuring the LED operates within its rated specifications. When the circuit is complete and the battery is connected, electrons move from the battery's negative terminal through the components and toward the positive terminal. As electrons pass through the LED, energy is released in the form of visible light, demonstrating the conversion of electrical energy into electromagnetic energy.

The breadboard itself helps in the functioning of the circuit by providing internal metal strips that connect rows and columns together. These internal connections allow components to be placed without soldering, making the circuit easy to assemble, modify, or troubleshoot. When the LED lights up, it confirms that all connections—power supply, resistor, component placement, and polarity—are correct. If the LED does not glow, it indicates common issues

such as reversed LED orientation, loose connections, or incorrect wiring. This simple visual feedback mechanism helps users understand how electrical continuity and component arrangement affect circuit performance.

Overall, the working of this LED circuit demonstrates several basic but important electrical concepts. It shows how current travels through a closed loop, how resistors regulate current, and how LEDs respond to controlled electrical energy. It also highlights the importance of correct polarity, since the LED will not light if the anode and cathode are reversed. Additionally, the circuit shows how even a simple setup can help learners verify the behavior of components and understand real-world electronics. This solid foundation prepares students to work with more complex circuits involving sensors, microcontrollers, communication modules, and automation systems.

The demonstrating basic circuit principles, this LED setup also highlights how simple prototype circuits help learners understand the behavior of components under real operating conditions. For example, the LED's brightness directly reflects the current flowing through the circuit, showing how resistance and voltage influence light intensity. This allows students to experiment by changing resistor values, observing how the LED becomes brighter or dimmer, and thereby gaining hands-on experience with circuit tuning and component selection. Moreover, the circuit reinforces the concept of a closed electrical path, as the LED will only light when every connection is correctly placed and there are no breaks in the circuit. This practical feedback teaches users the importance of attention to detail and reinforces core troubleshooting strategies that are essential when working with more complicated electronic systems. Overall, this simple circuit serves as a practical, interactive learning platform that strengthens fundamental concepts while preparing learners for advanced electronics work.

3.1 Application and Public Impact :

APPLICATION

- Used in schools and labs to teach basic electronics concepts like current, voltage, and resistance.
- Helps beginners learn breadboard prototyping and safe circuit assembly.
- Forms the foundation for advanced circuits involving sensors, microcontrollers, and robotics.
- Used as an indicator light in many electronic devices to show power status or warnings.
- Helps test power supplies, connections, and components before building larger projects.
- Commonly used in DIY electronics, hobby projects, and small automation systems.
- Acts as a starting point for learning Ohm's Law and component selection.

PUBLIC IMPACT

- Promotes basic technical knowledge among students and the general public.
- Encourages interest in STEM fields, leading to future innovation and technology development.
- Helps people understand simple electronics, enabling small repairs and DIY solutions.
- Builds confidence for beginners to explore advanced technologies like IoT and robotics.
- Contributes to creating a more tech-literate society capable of solving everyday problems.

- Inspires creativity and curiosity, motivating youth toward engineering careers.
- Supports national technological growth by building foundational skills at an early stage.

TECHNICAL HIGHLIGHTS

- Uses a basic LED-resistor-breadboard configuration to demonstrate essential circuit principles.
- Incorporates a 9V DC power supply, providing stable and consistent voltage for the experiment.
- Utilizes a 220-ohm current-limiting resistor to protect the LED from excessive current flow.
- Demonstrates correct LED polarity orientation, teaching users the importance of anode and cathode placement.
- Employs a solderless breadboard, enabling fast, clean, and flexible prototyping without permanent connections.
- Includes standard jumper wires for power and signal routing, improving understanding of circuit layout.
- Showcases how series connection works, with components connected in a single continuous path.
- Highlights the concept of voltage drop across components, especially the LED and resistor.
- Enables measurement of current flow and voltage using a multimeter, supporting hands-on instrument training.
- Demonstrates the conversion of electrical energy into light energy when current passes through the LED.

4. CONCLUSIONS

The development of this basic electronic LED circuit represents an essential foundation for understanding modern electronics and practical circuit implementation. Through the simple arrangement of a power supply, resistor, breadboard, and LED, learners gain hands-on experience in the core principles of electrical engineering, including current flow, voltage distribution, circuit continuity, and component protection. This small-scale setup not only demonstrates how electrical energy is converted into light but also teaches the importance of correct polarity, resistance calculation, and safe wiring practices. By experimenting with different resistor values, voltage levels, and LED types, users develop practical troubleshooting skills and a deeper understanding of real-world circuit behavior. Beyond serving as a beginner-level experiment, this circuit acts as a stepping stone toward more complex projects involving sensors, microcontrollers, automation systems, and embedded technologies. Mastery of this fundamental circuit enables learners to confidently progress to advanced applications such as IoT devices, robotics, security systems, and programmable LED controllers. As technology continues to advance rapidly, the ability to understand and construct basic circuits remains a critical technical competency. This simple yet powerful experiment cultivates analytical thinking, problem-solving abilities, and creative design skills that are essential for future engineers and innovators. Overall, the project highlights the importance of foundational electronics education and showcases how even the simplest circuits can provide meaningful insights into the functioning of larger and more sophisticated systems. It reinforces the idea that technological innovation begins with understanding the basics, making this LED circuit a valuable and impactful learning tool for students, hobbyists, and educators alike.

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