

# Hybrid HexaRover: Integrating Rocker-Bogie Suspension for Extreme Terrain Navigation

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## ABSTRACT

The development of a high-mobility six-wheeled robot featuring a rocker-bogie suspension system aims to significantly enhance the robot's ability to traverse rough and uneven terrains, making it ideal for applications such as planetary exploration, search and rescue missions, military reconnaissance, and environmental monitoring. Traditional four-wheeled robotic platforms with simpler suspension systems often face limitations such as wheel slippage, tipping, and poor adaptability on rugged terrain. To overcome these challenges, this project proposes a design that maintains continuous wheel contact with the ground using a rocker-bogie mechanism, thereby improving traction, stability, and balance. The robot utilizes six DC motors controlled by two L293D motor driver modules and is operated wirelessly through an HC-05 Bluetooth module connected to an Arduino microcontroller, allowing it to execute basic movement commands forward, backward, left, and right via a mobile device. Additionally, the system includes an ultrasonic sensor to detect and avoid obstacles in its path. This versatile and robust robotic platform is well-suited for deployment in harsh environments such as planetary surfaces, hazardous industrial sites, remote rescue zones, and challenging military terrains, where traditional robots typically struggle.

**Keywords:** 6 - DC Motors, Ultrasonic sensors, Arduino UNO, Battery, L293D motor.

## 1. INTRODUCTION

Over the past decade, research on wheeled robots has grown significantly due to their increasing applications in industries such as defense, space exploration, marine operations, medical fields, and manufacturing. These robots play a crucial role in automating complex tasks, reducing human effort, and enhancing efficiency. Scientists and researchers have been focusing on developing vehicles with high mobility, adaptability, and robustness to withstand extreme environmental conditions. The development of planetary rovers requires interdisciplinary knowledge, integrating mechanical design, control systems, artificial intelligence, and power management to create highly efficient robotic systems. Among various suspension mechanisms, the rocker-bogie system has emerged as a widely adopted design due to its ability to navigate challenging terrains while maintaining continuous wheel contact with the ground. The rocker-bogie suspension system was initially introduced by NASA for its Mars exploration rovers and has proven effective in ensuring smooth traversal over rocky and uneven planetary surfaces. This system allows the robot to overcome obstacles up to 1.5 times the diameter of its wheels, providing superior stability compared to conventional wheeled robots. Besides space exploration, the rocker-bogie suspension mechanism has found applications in terrestrial environments, such as search and rescue operations, hazardous material handling, mining, and military reconnaissance. By combining the rocker-bogie mechanism with modern control technologies such as Bluetooth-based remote operation and voice command capabilities, these robots become more versatile and user-friendly. This project aims to develop a six-wheeled robotic rover with a rocker-bogie suspension system, integrated with Bluetooth-based remote control, ultrasonic obstacle detection, and Arduino-based micro-controller control. The increasing need for robotic exploration in unstructured environments has driven the development of mobile robots with enhanced suspension mechanisms and intelligent navigation systems. One of the major advantages of wheeled robots in planetary exploration

is their ability to operate efficiently with lower energy consumption compared to legged robots. The application of wheeled robotic systems is not limited to exploration; they are also being integrated into industrial automation, agriculture, and transportation. The proposed robotic system will serve as a foundation for future developments in autonomous robotic mobility, contributing to advancements in planetary exploration and beyond.

## 2. LITERATURE SURVEY

**Arunkumar, A. S. Ramabalan, and D. Elayaraja** focused on the optimum design of stair climbing robots using the Taguchi method. Their work aimed to enhance the performance of robots when navigating stairs. The Taguchi method was employed to identify the optimal design parameters that would result in improved stair-climbing capabilities. However, the paper did not specify any drawbacks or limitations associated with their proposed design. [1]

**Gao, Haibo, et al.** investigated a necessary condition for passive all-wheel attachment of a wheeled planetary rover. They explored the mechanical constraints and kinematic conditions required for effective wheel-terrain interactions in challenging planetary environments. The study aimed to improve the mobility and stability of wheeled rovers. However, the paper did not discuss any specific drawbacks or limitations associated with their findings. [2]

**Bouton, Arthur, and YangGao** presented the MARCEL (Mobile Active Rover Chassis for Enhanced Locomotion), a rover chassis design focused on improving locomotion capabilities. The design incorporated active suspension systems and adaptable wheels to enhance mobility over various terrains. The paper highlighted the advantages of the MARCEL system but did not explicitly mention any drawbacks or limitations. [3]

**Jeon, Haneul, and Donghun Lee** proposed an explicit method for identifying point wise terrain gradients to compensate for speed in four driving tracks of a passively articulated tracked mobile robot. The study aimed to improve the robot's motion control and maneuverability over uneven terrain. However, the paper did not discuss any specific drawbacks or limitations associated with their proposed method. [4]

**Nicolella, Armando, et al.** provided an overview of the kinematic analysis of the rocker-bogie suspension system for six-wheeled rovers when approaching obstacles. The study aimed to analyze the system's performance and identify limitations in obstacle negotiation. However, the paper did not delve into specific drawbacks or limitations associated with the rocker-bogie suspension system. [5]

**Cosenza, Chiara, et al.** presented a spring-loaded rocker-bogie suspension design for six wheeled rovers. Their work focused on improving the mobility and stability of rovers in rough terrains. The paper highlighted the advantages of the proposed suspension system but did not explicitly mention any drawbacks or limitations. [6]

**Cosenza, C.Niola, et al.** conducted theoretical study on a modified rocker-bogie suspension system for robotic rovers. They aimed to enhance the mobility and terrain adaptability of the rovers. The paper provided theoretical analysis and simulations but did not specify any drawbacks or limitations associated with the proposed modification. [7]

**Pandey et al.** introduced a new six-wheeled rocker-bogie robot design aimed at enhancing the performance and stability of the rocker-bogie mechanism for planetary rovers. The study focused on improving the overall functionality and stability of the system for better performance in challenging environments. Their analysis included a detailed examination of the robot's mobility and robustness in

various terrain conditions, ensuring greater adaptability for space exploration missions. Additionally, the design aimed at optimizing the rover's ability to traverse rough and uneven surfaces. [8]

### 3. PROPOSED SYSTEM

A six-wheeled robot equipped with a rocker-bogie suspension system is proposed to enhance stability and mobility on rough terrain. This suspension design ensures that at least two wheels remain in contact with the ground at all times, significantly improving traction and balance, even on uneven surfaces. The independent movement of each wheel allows the robot to adapt more effectively to terrain variations, reducing the risk of tipping and ensuring smoother navigation across obstacles. The suspension system also absorbs shocks and impacts, protecting the robot's components from damage and contributing to a more durable and reliable design.

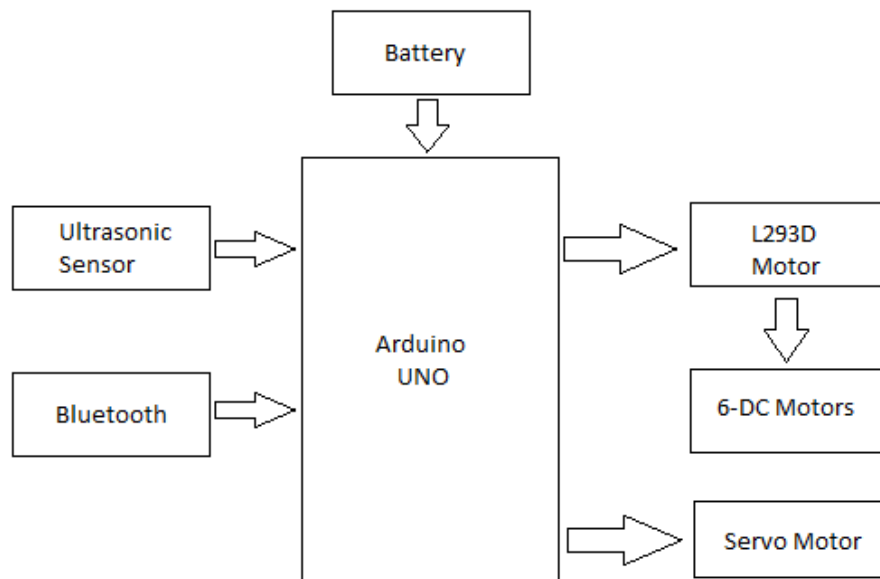


Fig. 1: Block diagram of 6 wheeled rocker-bogie

There are five modules - Controller, RPS, Input, Software and Output module. The power is supplied to the RPS module through an adapter. The adaptor converts 230 volts AC to 12 volts DC and this 12 volts DC is given to the RPS module. The RPS module consists of voltage regulator 7805 which converts the 12 volts DC into 5 volts DC, the capacitor is used to reduce noise and LED is used which indicates whether the power is supplied or not. This 5 volts DC power supply goes to each and every module.

The HC-05 Bluetooth module is a popular wireless communication module used for serial data transmission between micro-controllers and other devices. It supports both master and slave modes, allowing flexible connectivity. The Ultrasonic sensor is used for obstacle detection. This sensor consists of four pins. It detects if any obstacle occurs front and back of the vehicle. The driver is alerted by the beep or the dashboard display.

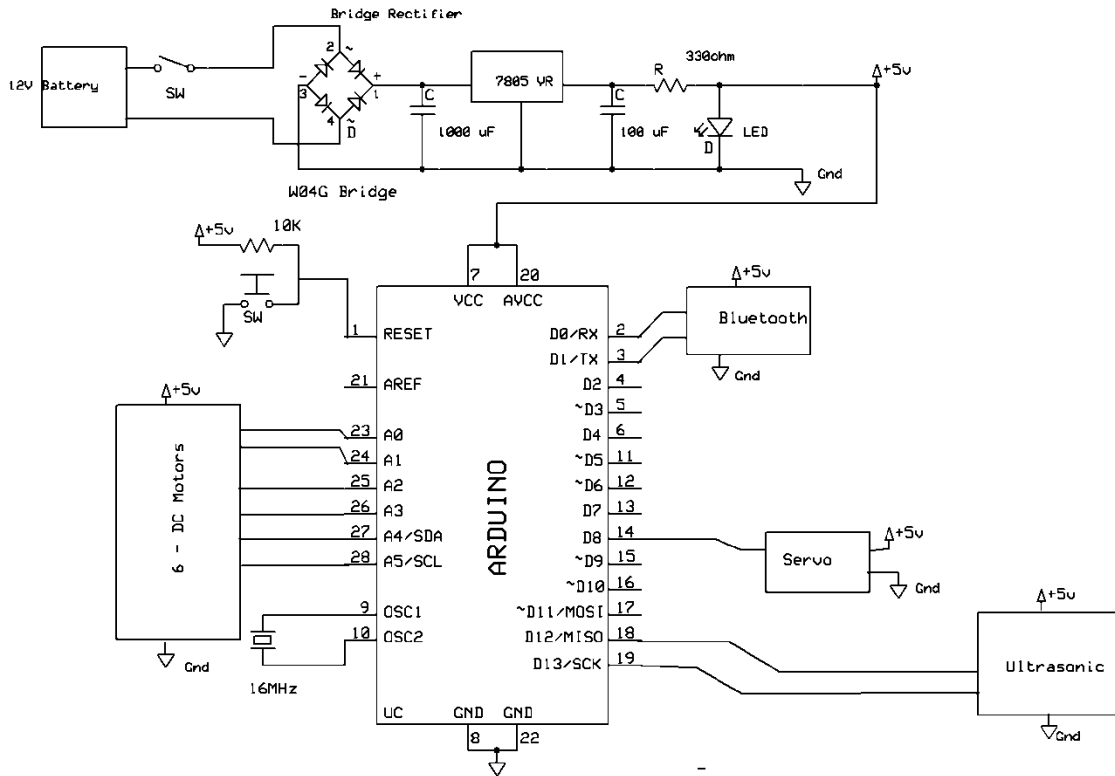


Fig. 2: Schematic diagram

This is the pin diagram where all the hardware components are been connected components. This ARDUINO microcontroller having 28 pins. In which 14 GPIO pins as digital pins and 6 GPIO pins. 16MHz crystal oscillator connected internally. The step down transformer, Bridge rectifier capacitor with 1000f Resistors and led are connected in Regulated power supply which provide the 5v to the Arduino and all input/output modules. Based on the circuit diagram, the Arduino microcontroller is connected to multiple components.

#### 4. RESULTS AND DISCUSSION

The development of a high-mobility six-wheeled robot with a rocker-bogie suspension system enhances terrain adaptability and stability, making it suitable for rough and uneven surfaces.



Fig. 3: Six-wheeled robot with a Rocker-bogie suspension system

The design also optimizes power consumption, ensuring efficient energy use while maintaining high mobility. The robot is equipped with sensors, including an ultrasonic sensor for obstacle detection. Additionally, motor driver modules regulate the power supply to the DC motors that control wheel movement. If the robot is manually controlled, it receives user input through a remote control, Bluetooth module. On the output side, the robot exhibits wheel movement, where six motors drive the wheels for navigation over different terrains. The rocker-bogie suspension mechanism adapts to uneven surfaces, enhancing mobility.

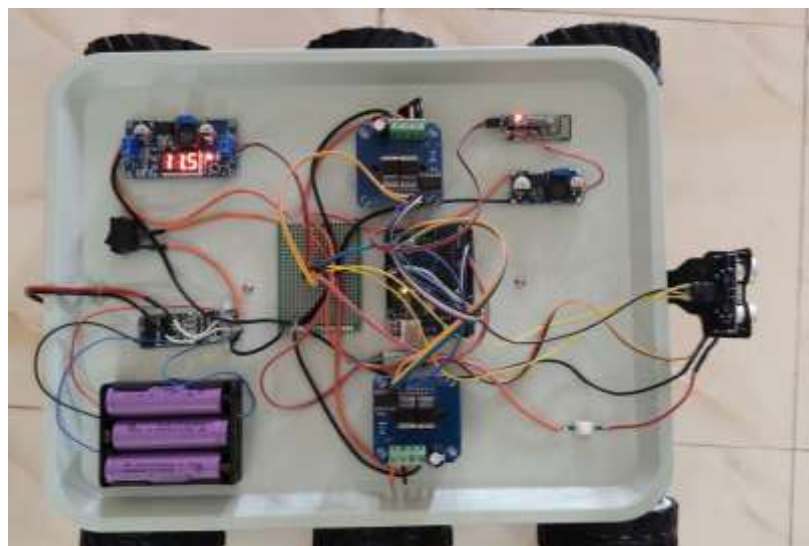


Fig. 4: Circuit System

Through successful implementation and testing, this project validates the effectiveness of the rocker-bogie mechanism for real-world applications, demonstrating its potential for use in various industries requiring robust and adaptable robotic solutions.



Fig. 5: Rolling over obstacle

This Image shows a Six-wheeled robotic vehicle with a suspension system having ultrasonic sensor at the front, which is used for obstacle detection, and it contains the servo motor, allowing it to rotate and scan the surroundings which helps to detect obstacles in multiple directions rather than just in a fixed straight path.

## 5. CONCLUSION

We designed and Implemented the “Development of High mobility Six wheeled robot with Rocker Bogie Suspension system”. The aim of this project was to develop a high-mobility six-wheeled robot with a rocker-bogie suspension system to enhance terrain adaptability, obstacle-climbing capability, and overall stability. The system successfully improves traction and weight distribution, allowing the robot to navigate rough and uneven surfaces efficiently without requiring complex active control mechanisms. The system ensures continuous ground contact, reducing the risk of tipping and improving operational reliability. The experimental results confirm improved traction and stability, allowing the robot to navigate obstacles with minimal energy consumption. Over all, the rocker-bogie design significantly enhances robotic mobility, making it ideal for applications in space exploration, defense, agriculture, and disaster response.

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