International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design And Fabrication Of Rover (Rocker Bogie Mechanism)

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ABSTRACT :

The design and fabrication of a rocker bogie mechanism rover represent a significant endeavor aimed at developing a versatile and robust robotic platform for exploration and research purposes. The rover's innovative design incorporates a rocker bogie suspension system, inspired by NASA's Mars rovers, enabling it to traverse challenging terrains with ease and stability. This project focuses on the integration of various components, including motor drivers, microcontrollers, sensors, and communication modules, to create a fully functional rover capable of remote control and autonomous navigation. The fabrication process involves careful selection of materials, precise machining, and assembly techniques to ensure structural integrity and reliability in operation. Throughout the project, emphasis is placed on iterative design refinement, testing, and validation to optimize the rover's performance and functionality. The resulting rover demonstrates promising capabilities for applications such as planetary exploration, environmental monitoring, and educational outreach. Future research directions include enhancing autonomy, integrating advanced sensors, and exploring collaborative multi-robot systems to further expand the rover's capabilities and applicability in diverse domains.

Keywords: Sensors, NASA's Mars rovers, Communication modules

INTRODUCTION: -

The project focuses on creating a remote-controlled rover that integrates the rocker bogie mechanism, a versatile mechanism employed in planetary rovers. The rover's primary goal is to demonstrate the practical application of this mechanism in terrestrial environments, showcasing its adaptability and ability to tackle obstacles. The term “rocker” comes from the rocking aspect of the larger links on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the other goes down. The chassis maintains the average pitch angle of both rockers. One end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie. The term “bogie” refers to the links that have a drive wheel at each end.

To overcome an obstacle, the front wheels are forced against the obstacle by the rear wheels. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle. The middle wheel is pressed against the obstacle by the rear wheel and pulled against the obstacle by the front until it is lifted up and over. Finally, the rear wheel is pulled over the obstacle by the front two wheels. During each wheel's traversal of the obstacle, the forward progress of the vehicle is slowed or completely halted.

The rocker-bogie suspension system was developed in 1988 for NASA's Mars rover Sojourner and has since evolved into the organization's preferred rover design. The rovers from the Mars Science Laboratory (MSL) mission in 2012 and Spirit and Opportunity were part of the Mars Exploration Rover project in 2003. As a result of the larger, body-mounted linkages on each side of the rover, the suspension system includes a "rocker" component. These rockers are connected to the car's chassis and to one another via a differential. The rockers will rotate in opposition to one another with respect to the chassis to provide equal wheel contact. The chassis keeps both rockers' average pitch ngles constant. A rocker has a bogie attached to one end and a drive wheel attached to the other. The "bogie" component of the suspension is the smaller linkage with a drive wheel at each end and a pivot to the rocker in the middle. In order to evenly disperse the load across the terrain, bogies were widely used in the trailers of semi-trailer vehicles and as load wheels on the tracks of army tanks. Both tanks and semitrailers prefer trailing arm suspensions today. The front wheels of the Sojourner rover attach to the bogies, whereas the front wheels of the MER and MSL rovers attach to the rockers.

The Rocker-Bogie suspension system is used in the mechanical robots called Mars rovers that were developed for the Mars Pathfinder mission as well as the Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions. NASA now prefers this design. The suspension system rocks because of the larger links on either side, hence the word "rocker." These rockers are connected to the car's chassis and to one another via a differential. When one rocker moves up concerning the chassis, the other moves down. The average pitch angle of both rockers is maintained by the chassis. A driving wheel is attached to one end of a rocker, and a bogie is attached to the other end. "Bogies" are the linkages that have a driving wheel at either end. Bogies were widely used as load wheels on army tank tracks to spread the burden out over the terrain. Bogies were frequently used on the trailers of semi-trucks.

The Rocker Bogie design, which uses stub axles instead of springs for each wheel, allows the rover to climb over objects like boulders that are up to twice as big as the wheel's diameter while still keeping all six wheels in contact with the ground. As with any suspension system, the tilt stability is determined by the height of the centre of gravity. Systems using spring-based suspensions are more likely to topple as the loaded side yields. Based on its centre of gravity, the mission's rover, Curiosity, can endure a tilt of at least 50 degrees in any direction without suffering any harm from overturning, while automated sensors prohibit it from tilting beyond 30 degrees. The technology is designed to be used at a slow pace of roughly 10 cm/s to minimise dynamic shocks and resultant damage to the vehicle when navigating major obstacles. The rover has six wheels, and each wheel has its own motor. The two front and two rear wheels each have a separate steering motor that allows the vehicle to turn in place. Additionally, each tyre has studs that provide traction for climbing on rocks and in soft sand.

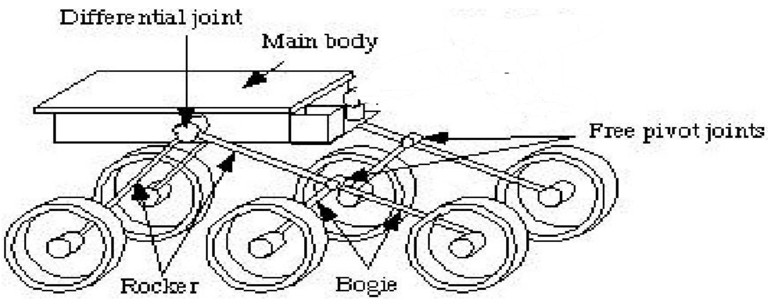


FIG 1.1 Rocker Bogie Mechanism

PROBLEM STATEMENT

To design and develop a remote-controlled rover utilizing the rocker bogie mechanism. The rover aims to offer users an interactive experience while remotely controlling its movements "Having stair climbing capabilities and efficient navigation over challenging terrains."

REVIEW OF RESEARCH AND DEVELOPMENT

The rocker bogie mechanism originated from the need for robust mobility in space exploration vehicles, enabling them to traverse challenging terrain while maintaining stability

It incorporates rocker arms and bogie assemblies to distribute weight and maintain multiple contact points with the ground, allowing for efficient navigation over uneven surfaces.

Current research focuses on improving efficiency, reducing weight, and enhancing adaptability to different terrains, with future directions including the integration of advanced materials, optimization of control algorithms, and exploration of autonomous navigation capabilities.

OBJECTIVES

To design and construct a rover for:

- Climbing staircase having rise of 10-15cm.
- Load carrying capacity of 1.5 kg.
- Overcoming the rolling and pitching.
- Transporting household and industrial goods

ORGANIZATION OF THE PROJECT

The organization of the project can be explained by path followed as the methodology. This section of the report provides the arrangements and decisions about the realization and the process of the project.

METHODOLOGY

The following are the steps to be taken into consideration for accomplishing the project:

- Project Planning: Search for the project topics and finalizing the best one
- Literature Review: Research on the mechanism and reviewing and studying different research paper regarding project.
- Conceptual and detailed design: Design calculation and CAD model.
- Material Procurement: Selection of appropriate materials that will give optimal performance for low cost.
- Fabrication Assembly: of electrical components, machining operations on the metal used, coding on the Arduino board.
- Testing: Final testing using the model for different stairs and obstacles.

INTRODUCTION

This section of the report provides an overview and summary of a literature use. This is survey of scholarly sources on DESIGN AND FABRICATION OF ROVER (Rocker Bogie Mechanism) topic. It provides an overview of current knowledge, allowing us to identify relevant theories, methods,and gaps in the existing research.

DESIGN CALCULATIONS

DIAMETER OF WHEEL:

Assumed speed = 10 cm/s =100 mm/s V= (3.14*D*N)/60

100= (3.14*D*N)/60

D*N= 1909.86

Velocity	8cm/s		Velocity	10cm/s		Velocity	12cm/s	
RPM	Diameter		RPM	Diameter		RPM	Diameter	
	M	cm		m	cm		M	cm
10	0.153	15.277	10	0.191	19.096	10	0.229	22.915
20	0.076	7.638	20	0.095	9.548	20	0.115	11.458
30	0.051	5.092	30	0.064	6.365	30	0.076	7.638
40	0.038	3.819	40	0.048	4.774	40	0.057	5.729
50	0.031	3.055	50	0.038	3.819	50	0.046	4.583
60	0.025	2.546	60	0.032	3.183	60	0.038	3.819
70	0.022	2.182	70	0.027	2.728	70	0.033	3.274
80	0.019	1.910	80	0.024	2.387	80	0.029	2.864
90	0.017	1.697	90	0.021	2.122	90	0.025	2.546
100	0.015	1.528	100	0.019	1.910	100	0.023	2.292
110	0.014	1.389	110	0.017	1.736	110	0.021	2.083
120	0.013	1.273	120	0.016	1.591	120	0.019	1.910
130	0.012	1.175	130	0.015	1.469	130	0.018	1.763
140	0.011	1.091	140	0.014	1.364	140	0.016	1.637

Table 3.1.1 Velocity and Wheel Diameter Design of Rocker Bogie Mechanism

Hence from above table we select the values for D = 9.36 cm = 10 cm (approx.) N = 30 RPM

CALCULATION OF WHEEL BASE :

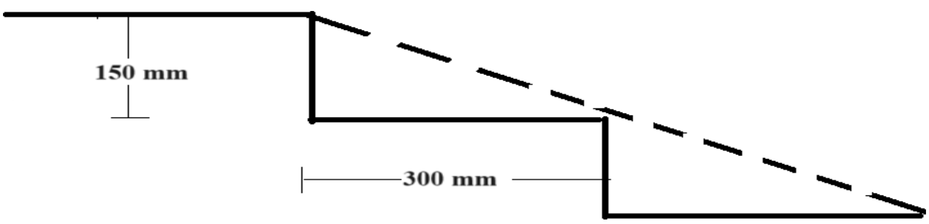


FIG 3.1.2 Stair Dimensions

Now the width of stair is 300 mm so the max length of rover can be 300 mm

To deduce the wheel base =Total length- (radius of front wheel + radius of rear wheel)

= 300-(50+50)

= 200 mm

3.1.3FORCE ACTING ON ROVER

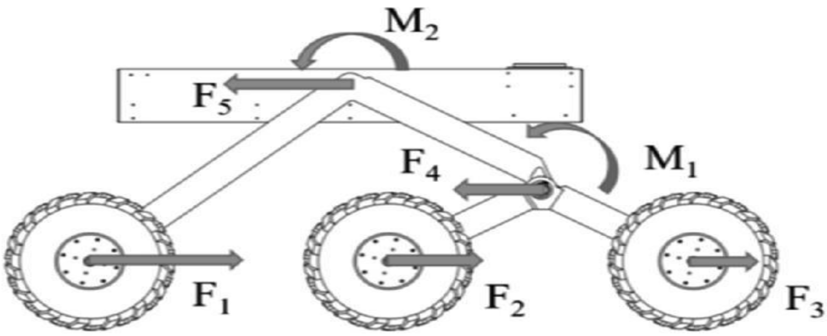


FIG 3.1.3 FBD of Rover

- W = total weight of rover
- F = Frictional force acting on wheels (F1,F2,F3)
- N = Normal force acting on wheels
- For tiles, μ = 0.42
- For rough surface μ = 1

FORCE ACTING ON THE ROVER ON SLOPE AT AN ANGLE OF 25^0

CASE 1: For tiles

Total force required to move = Weight acting downwards + frictional force
= mg. sin (25) + μ.mg cos (25)
= 16.58 + 14.93
= 31.51 N

CASE 2: For rough Ground

Total force required to move = Weight acting downwards + frictional force
= mg. sin (25) + μ.mg cos (25)
= 16.58 + 35.56
= 52.14 N

MOMENT AT JOINTS

At Pivot Joint,
Taking moment about pt 4 the moment at that point becomes zero Therefore,

$$M_1 = (F_2 + F_3) * r1$$

$$= (32.96) *$$

At Differential Joint,
Taking moment about pt 5 the moment at that point becomes zero $M_2 = (F_1 * r2) + M_1$

MOTOR TORQUE CALCULATIONS

Torque required by each wheel,

F = (m.g.r)/4 Where,
F = traction force in N
m = mass of the rover in kg r = radius of shaft in meter

F = 4*9.81*0.0033/4
= 0.3237 N
Torque = Force* Radius of wheel
= 0.3237* 0.05
= 0.0161865 Nm

Torque produced by each motor

Torque of motor is 5kg-cm So it is equal to the 0.49 Nm
At wheel radius 0.05 m the torque produced by motor/ wheel is T_2

$T_1 r = T_2 R$

Where,

T_1= Torque at shaft of motor r = Radius of shaft

T_2 = Torque at wheel radius R = radius of wheel

0.49*0.003= T_2* 0.05

T_2 = 0.0294 Nm

Motor selected is right because Torque Produced > Torque required

TRACTION AND SLIP

The rover must maintain good wheel traction in challenging rough terrains. If traction is too high, the vehicle consumes a lot of power in order to overcome the force and move. If traction is too low, the rover is not able to climb over obstacles or inclined surfaces. Slip occurs when the traction force at a wheel-terrain contact point is larger than the product of the normal force at the same wheel and the friction coefficient. Hence, no slip occurs if the condition

$$T \le \mu N_i$$

VEHICLE STATIC STABILITY FACTOR

A vehicle's SSF is calculated using the formula SSF=T/2H, where T is the "track width" of the vehicle, and H is the "height of the centre of gravity" of the vehicle. The track width is the distance between the centres of the right and left tires along the axle. The location of the center of gravity is measured in a laboratory to determine the height above the ground of the vehicle's mass. The lower the SSF number, the more likely the vehicle is to roll over in a single-vehicle crash.

What is a good SSF?

A higher SSF value equates to a more stable, less top-heavy vehicle. SSF values across all vehicle types can range from around 1.00 to 1.50. Most passenger cars have values in the 1.30 – 1.50 range. Higher-riding SUVs, pick-up trucks, and vans usually have values in the 1.00 – 1.30 range.

A good SSF would be 1.5, not good would be 1.1. Not good is defined as once the vehicle starts to slide, there is a 28 to 30 percent chance of a rollover.

Length Of Links:

Total Wheel base = 200 mm

Let us assume, θ = 45 In Triangle BNC, Angle BNC = 90° Angle NBC=Angle NCB= 45°

Therefore, NC=NB

$NC^2 + NB^2 = BC^2$ ……… (Pythagoras theorem) $2NC^2 = BC^2$ (1)

$BC^2 = 2*115*115$ BC= 162.63 mm

Rounding off BC= 160 mm Substituting in eqn (1) we get, $160^2 = 2NC^2$

NC=113.13

Also, AN=NC=113.13 mm

In triangle AMN , Ang. AMN= 90o

$AM^2 + MN^2 = AN^2$ (Pythagoras theorem)

$2AM^2 = AN^2$ AM=79.99=80 mm

Due to symmetry, AM=MN=80 mm BM=AB-AM = 160-80 BM=80mm

Height Calculation

$Height^2 = BC^2 - NC^2$

= 1602 - 113.132

= 113.144 mm

Net Height = Height + Radius of wheel

= 113.144 + 35

Net Height = 148.144 mm

CAD MODEL AND SOFTWARE USED

We have used Solidworks software of 2023 version to create a 3D model of rocker bogie mechanism. Solidworks is easy to use, operate and able to appl all mechanical constraints and parts like bearings and nuts.

Solid Modeling: SolidWorks provides robust tools for creating solid 3D models of parts and assemblies.

Parametric Design: It supports parametric modeling, allowing users to easily modify designs by changing parameters or dimensions.

Assembly Modeling: Users can create complex assemblies by assembling individual parts and components together.

Drawing Tools: SolidWorks offers comprehensive drawing tools for creating detailed 2D drawings, including annotations, dimensions, and GD&T symbols.

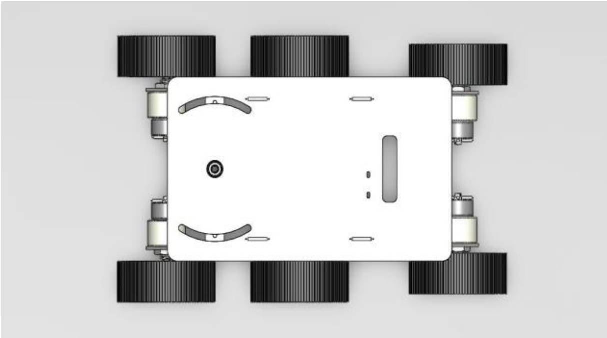


FIG 3.2.1 TOP VIEW

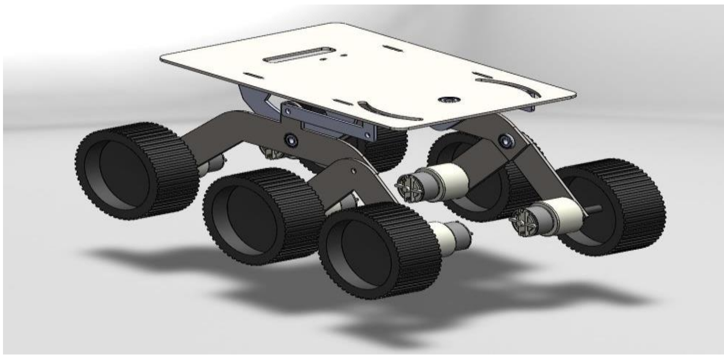


FIG 3.2.3 ISOMETRIC VIEW

MATERIAL SELECTION: -

- Composition: Mild steel, also known as low carbon steel, typically contains iron (Fe) as the primary element with carbon (C) content ranging from 0.05% to 0.25%. Additionally, it may contain small amounts of other elements like manganese (Mn), sulfur (S), and phosphorus (P).

Mechanical Properties:

- ➢ Tensile Strength: Mild steel has a moderate tensile strength ranging from 400 MPa to 600 MPa, depending on the exact composition and processing.
- ➢ Yield Strength: Typically, the yield strength of mild steel ranges from 250 MPa to 450 MPa.
- ➢ Elongation: Mild steel exhibits good ductility, with elongation values ranging from 20% to 25%. This means it can deform significantly before fracturing.
- ➢ Modulus of Elasticity: The modulus of elasticity for mild steel is around 200 GPa, indicating its ability to return to its original shape after deformation when subjected to stress within its elastic limit.
- Machinability: Mild steel is relatively easy to machine, drill, cut, and weld, making it suitable for various fabrication processes.
- Formability: One of the notable properties of mild steel is its excellent formability. It can be easily bent, rolled, stamped, or pressed into various shapes without significant risk of fracturing.
- Cost-Effectiveness: Mild steel is economical compared to many other engineering materials, making it a popular choice for applications where cost is a significant factor.

Sr. No.	**Parameters**	**Mild Steel**
1.	Thickness	3mm
2.	Density	$7.8x10^{-6}$ Kg/mm^3
3.	Youngs Modulus	$2x10^5$ N/mm^2

4.	Poisson Ratio	0.3
5.	Yield Strength	260 MPA

TABLE 4.1 MATERIAL PROPERTIES

MANUFACTURING TECHNIQUE:

- **Laser Cutting:**

Laser cutting is a highly precise manufacturing technique widely used across industries for cutting various materials with exceptional accuracy and efficiency. Employing a focused laser beam to melt, vaporize, or burn through the material, laser cutting offers numerous advantages, making it a preferred method for producing intricate parts and components.

- **Principles of Laser Cutting:**

Laser cutting operates based on the principles of focused, high-energy laser beams. The process begins with the generation of the laser beam through a laser resonator, typically using carbon dioxide (CO2), neodymium-doped yttrium aluminum garnet (Nd:YAG), or fiber lasers. The laser beam is then directed through a series of mirrors and lenses, focusing it into a concentrated, high-energy point.

- **Materials Suitable for Laser Cutting:**

Laser cutting is compatible with a wide range of materials, including metals (such as steel, stainless steel, aluminum), plastics, wood, ceramics, and composites. The process is particularly well-suited for thin to medium-thickness materials, although advancements in laser technology have expanded its capabilities to thicker materials as well.

- **Key Components of Laser Cutting Systems:**

Laser Source: This is the device that generates the high-energy laser beam. The type of laser source used (CO2, fiber, Nd:YAG) depends on the material being cut and the desired cutting characteristics.

- **Laser Optics:**

Consisting of mirrors and lenses, laser optics are responsible for directing and focusing the laser beam onto the workpiece with precision.

Workpiece Support: The workpiece is securely held in place during cutting to prevent vibration or movement that could affect cutting precision.

Advantages of Laser Cutting:

- High Precision: Laser cutting offers exceptional accuracy and repeatability, allowing for the production of intricate and complex geometries with tight tolerances.

- Minimal Material Waste: The narrow kerf width of the laser beam results in minimal material wastage, making laser cutting a cost-effective manufacturing method.

- Versatility: Laser cutting can be used for a wide range of materials and thicknesses, providing flexibility in manufacturing various components.

- Non-contact Process: Since laser cutting is a non-contact process, there is no physical tooling involved, reducing the risk of tool wear and minimizing maintenance requirements.

- High Speed: Laser cutting is a rapid manufacturing process, capable of cutting intricate shapes at high speeds, leading to increased productivity.

Laser cutting stands as a cornerstone of modern manufacturing, offering unparalleled precision, versatility, and efficiency. With continuous advancements in laser technology and process optimization, laser cutting continues to revolutionize various industries, enabling the fabrication of complex components with unprecedented accuracy and speed. Due to this advatages we have use this technique for cutting sheet metal.

FIG 4.2.1 LASER CUTTING

ARC WELDING

Arc welding is a widely used fusion welding process employed in the fabrication of rover components, offering strong and durable joints suitable for withstanding the rigors of space exploration. This technique utilizes an electric arc generated between a consumable or non- consumable electrode and the workpiece to melt and fuse the base metals, creating a metallurgical bond. In the context of rover construction, arc welding plays a crucial role in joining structural components, ensuring the integrity and reliability of the vehicle in demanding environments. Arc welding processes are commonly used in rover construction is Gas metal arc welding.

Gas Metal Arc Welding (GMAW):

Commonly referred to as MIG (Metal Inert Gas) welding, GMAW utilizes a consumable wire electrode fed continuously through a welding gun.
A shielding gas, typically a mixture of argon and carbon dioxide, is used to protect the weld pool from atmospheric contamination.
GMAW offers high deposition rates and excellent control over welding parameters, making it suitable for both thin and thick materials in rover construction.

Key Components of Arc Welding Systems:

- Power Source: Arc welding machines provide the necessary electrical power to sustain the welding arc. They come in various types, including transformer-based, inverter-based, and engine-driven units, with different voltage and amperage capabilities.
- Electrode: Depending on the welding process, electrodes can be consumable (e.g., flux- coated stick electrodes in SMAW, wire electrodes in GMAW) or non-consumable (e.g., tungsten electrode in GTAW).
- Shielding Gas: In processes like GMAW and GTAW, shielding gas is used to protect the molten weld pool from atmospheric contamination. The choice of shielding gas depends on factors such as material type, welding position, and desired weld properties.
- Welding Torch or Gun: The welding torch or gun holds the electrode and directs the arc onto the workpiece. It also serves as a conduit for the shielding gas in processes like GMAW and FCAW.

MECHANICAL COMPONENTS OF ROVER:

- **Rocker Arm**: The rocker arm is a structural component that connects the body of the rover to the suspension system. It typically consists of two arms, one on each side of the rover, and serves as a pivot point for the suspension system. The rocker arm allows the suspension system to articulate, accommodating changes in terrain and keeping the rover body level.

- **Bogie Assembly:** The bogie assembly is the set of wheels and associated components attached to each rocker arm. It usually consists of multiple wheels arranged in a configuration that allows the rover to distribute its weight evenly and traverse obstacles efficiently. The bogie assembly may include features such as suspension springs, shock absorbers, and motorized actuators for controlling wheel movement.

- **Wheels:** The wheels of the rocker-bogie mechanism are specially designed to provide traction and stability on various types of terrain. They may have a unique tread pattern or be equipped with features such as cleats or grousers to improve grip.

- **Differential:** The Differential of the rocker-bogie mechanism allows the rover to overcome rolling and friction.

Electronic Components of Rover :

Gear Motor : DC Motor, 12 volts, 30 RPM A basic DC motor and a gearbox are the typical components of geared motors. This has a wide range of robotic applications, including all-terrain robots. The center of the shaft of these motors has a 3 mm threaded drill hole, making it simple to attach them to wheels or other mechanical assemblies.

30 RPM 12V DC geared motors are commonly used in robotics. Very user- friendly and available in standard sizes. Additionally, controlling motors with an Arduino or another similar board doesn't have to be expensive. The most popular L298N H- bridge module with an onboard motor driver can drive this motor, which runs between 5 and 35V DC. Alternatively, you can choose the most precise motor diver module from the wide selection available in our Motor divers category based on your specific needs.

Simple connection is made possible by an internally threaded shaft and nut, and the shaft has threads on both sides. DC Robotics and industrial applications are the perfect fit for geared motors with sturdy metal gearboxes for heavy-duty applications. Extremely user-friendly and offered in regular sizes. The shaft is threaded on both sides and has an internally threaded nut for easy connection.

Sr.No.	SPECIFICATIONS	FEATURES
1.	RPM	30
2.	OPERATING VOLTAGE	6-12V
3.	GEARBOX	SPUR METAL GEAR
4.	SHAFT DIAMETER	6MM
5.	TORQUE	30 KG-CM
6.	NO LOAD CURRENT	60MA
7.	LOAD CURRENT	300MA

TABLE 5.2 MOTOR SPECIFICAIONS

Motor Driver : Robodo L298 Motor Driver Module

The Robodo L298 Motor Driver Module is a crucial component in the rover's propulsion system, responsible for controlling the movement of the wheels. This section provides an overview of the module, its features, specifications, and its integration into the rover's design.

Overview:

The Robodo L298 Motor Driver Module is a dual H-bridge motor driver module, specifically designed to control the direction and speed of DC motors. It utilizes the popular L298N dual H-bridge motor driver integrated circuit, which allows for bidirectional control of two DC motors.

Features:

- Dual H-bridge motor driver, capable of driving two DC motors independently.
- Operating voltage: 5V to 35V.
- Maximum current per channel: 2A continuous (with proper heat sinking).
- Peak current per channel: 3A.
- Built-in diodes for reverse polarity protection.
- Onboard voltage regulator to power the logic circuitry (5V).
- Screw terminal connectors for easy connection to motors and power supply.
- Control interface: TTL logic level signals (compatible with Arduino, Raspberry Pi, and other microcontrollers).
- Compact size for easy integration into rover.

Specifications:

- Operating Voltage: 5V to 35V
- Maximum Continuous Current per Channel: 2A
- Peak Current per Channel: 3A

INTEGRATION OF ELECTRONIC COMPONENT

Arduino and HC-05 Bluetooth Module:

- Connect the TX pin of the Bluetooth module to the RX pin (usually digital pin 0) of the Arduino.
- Connect the RX pin of the Bluetooth module to the TX pin (usually digital pin 1) of the Arduino.
- Connect the VCC and GND pins of the Bluetooth module to the appropriate power (+5V) and ground pins on the Arduino.

Arduino and Motor Driver Module:

- Connect the digital output pins of the Arduino (digital pins 10, 9, 8, and 7) to the appropriate input pins (IN1, IN2, IN3, and IN4) on the motor driver module.
- Connect the ENA and ENB pins of the motor driver module to the on board High state pin with the help of female header.
- Connect the OUT1, OUT2, OUT3, and OUT4 pins of the motor driver module to the appropriate terminals of the motors.
- Connect the VCC (+5V) and GND pins of the motor driver module to the appropriate power (Vin) and ground (GND) connections on the Arduino.

module.

CONTROL SYSTEM :

Setup the Android App for controlling Mars Rover

To connect the Bluetooth-controlled car with your phone, follow these steps:

- Open the "**Bluetooth RC Car**" app on your Android device. Please note that currently, this app is only available for Android users.
- Turn on the Bluetooth on your phone by going to your phone's settings.
- Connect your phone to the HC-05 Bluetooth module. If you have a new HC-05 module, there is an additional step before connecting.
- Go to the Bluetooth settings on your phone.
- Search for Bluetooth devices.

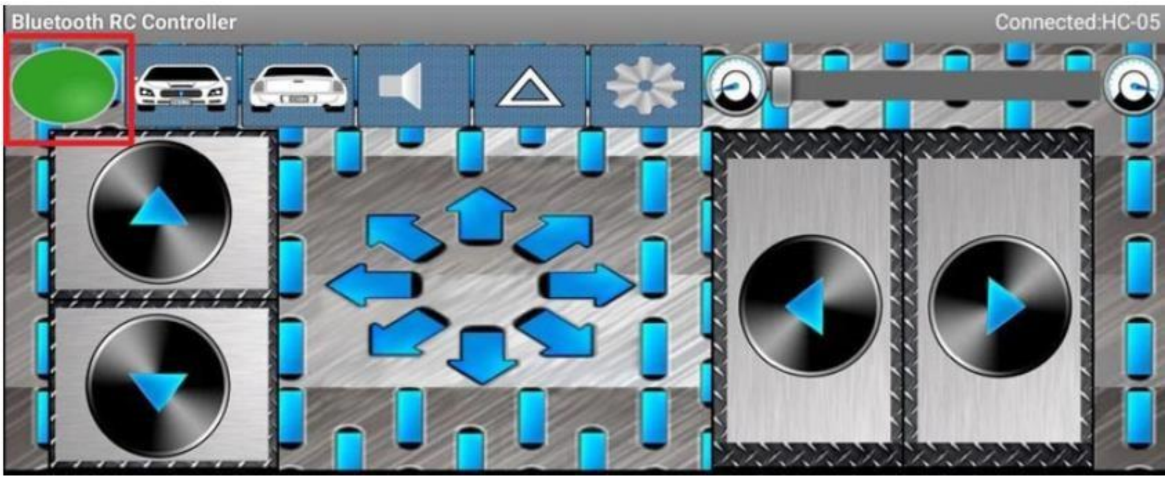


FIG 5.9 CONTROL SYSTEM

ANALYSIS

The rocker bogie consists of the Rocker that works on the rocking aspect of the larger links on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through a differential. The forces that act on the suspension system are the reaction forces i.e. the weight of the vehicle acting upwards and the force due to surface irregularities acting upwards. In this study we neglect the forces due to surface irregularities.The force on each wheel mount due to the reaction is 42N/6wheels, i.e. 7N per wheel. Thus the net force acting on the rocker end pin is 7N and the net force at the rocker-bogie pivot point is 14N. Using these two forces and a fixed support at the rocker to UGV pivot, the maximum deformation and the von mises stress are simulated.

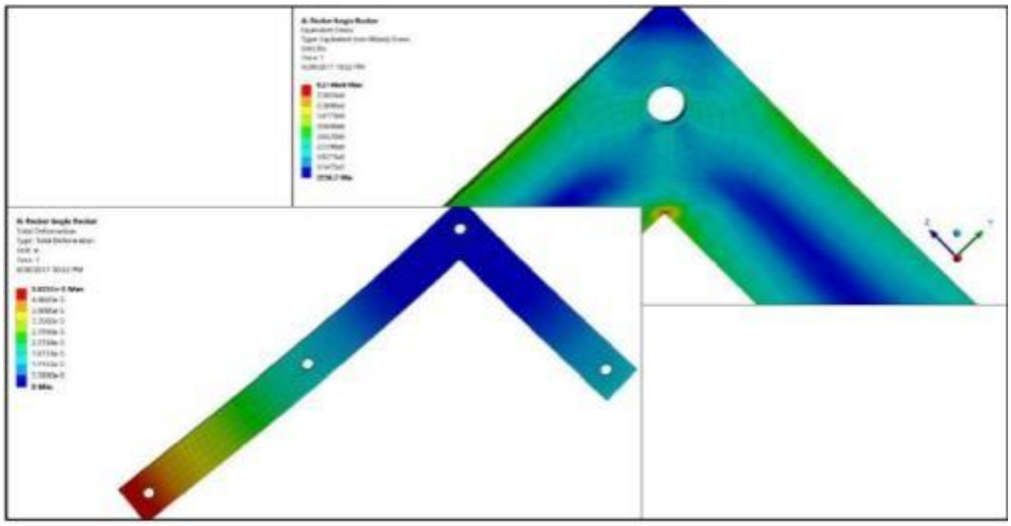


FIG 6.1.1 MAXIMUM DEFORMATION

The bogie link is the link that has a wheel mount at both ends. The bogie link is connected to a pivot on the rocker

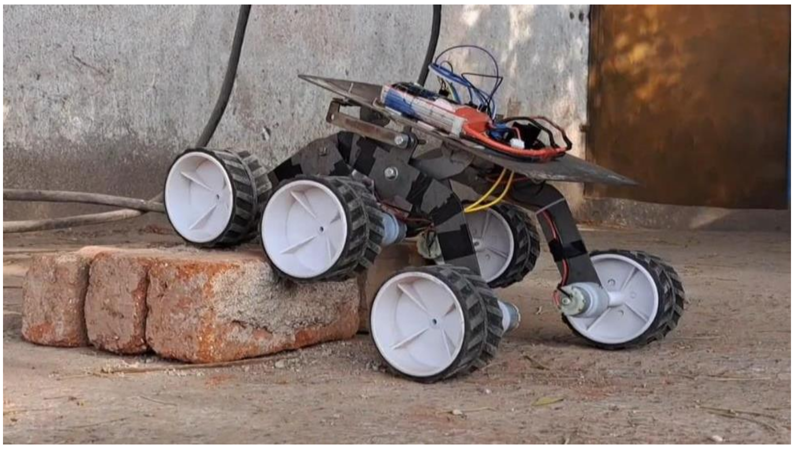
RESULTS:

PART	MAX DEFORMATION (M)	VON-MISES STRESSES (N/M^2)
Wheel Mount 1	0.0013421	9.6044e8
Wheel Mount 2	0.0013421	9.6044e8
Rocker Link	5.0253e-5	8.2148e6
Bogie Link	6.6028e-6	4.672e6

TABLE 6.1 ANALYSIS

6.1 TESTING

We have conducted various tests upon stairs and rough terrain and it was a safe design and and the objectives were achieved successfully. It was designed for maximum height climbing capacity of 15 cm but it climbed the height of 20 cm.
Below are some testing photos:-



Conclusions:

The six-wheel rocker bogie mechanism is a type of suspension system used in vehicles, particularly in rovers used for space exploration. It consists of six wheels, with the middle wheels on a pivoting rocker arm and the front and back wheels mounted on bogies. This design allows the rover to traverse rough terrain without getting stuck or tipping over.

One of the key advantages of the rocker-bogie mechanism is its ability to keep all six wheels on the ground, even when driving over large obstacles or uneven terrain. This provides excellent stability and traction, which is critical for a rover exploring a planet with little or no atmosphere.

In conclusion, the six-wheel rocker bogie mechanism is an innovative and effective suspension system that has been successfully used in multiple space exploration missions, military vehicles, and agriculture. Its ability to traverse rough terrain and maintain stability makes it an ideal choice for rovers exploring the challenging terrain of other planets. The six-wheel rocker bogie mechanism is an innovative and effective suspension system that has been successfully used in multiple space exploration missions, military vehicles, and agriculture. Its ability to traverse rough terrain and maintain stability makes it an ideal choice for rovers exploring the challenging terrain of other planets.

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