# Design and Development of Rover Based Rocker Bogie Mechanism

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*Abstract* — Robust capabilities to deal with obstacle and the way the payload are distributed to all 6 wheels are the distinguish features of rocker bogie suspension system designed by National Aeronautics and Space Administration (NASA). The system is good at dealing with obstacle but, the short come noted in the rocker bogie is its speed of its operation. This inadequacy in travel speed restricts the system to be used where the high speed operation on hard flat surfaces because it causes stability problems are required. In the current investigation it is intended to improve the stability of the system by expanding support polygon, making it more adaptable and stable while moving at higher speeds, but maintaining its robustness against obstacles. Initially the system was designed to be used in lower speeds, since it has capability to overcome obstacles of greater size compared to its wheel radius. When the system is operating at lower speeds greater than 173 mm/s the shocks on the system are minimum. But, in future mission's rovers will have to work at human speeds, as the shocks from the obstacle may reduce the payload capacity of the rover. In the current design it is planned to develop an effective driving system to work more effectively in overcoming obstacle of greater size. Change in control strategy may improve the same without any change in the mechanical linkages in the system. But some of the mechanical changes are made to achieve greater advantages and also to improve the working speed of the vehicle.

***Keywords:*** Rocker Bogie; Wheel Type Mobile Robot; Stair Climbing; Rover

## I. INTRODUCTION

Mobile robots are able to operate in unorganised environment in extremely uneven terrains are in demand. These robots are alternates where humans cannot perform and are not safe. To accomplish these tasks, Robot needs to have a relative mobile system according to each situation. Among these systems, its rocker – bogie system which was deployed in mars rover sojourner and is NASAs favoured design for suspensions in rovers.

Rocker-bogie suspension system is a mechanism that enables a six-wheeled vehicle to passively keep all six wheels in contact with a surface even when driving on severely uneven terrain. There are few key advantages to these features. The first advantage is that the wheels' pressure on the ground will be equilibrated. This is important in soft terrain where excessive ground pressure can result in the vehicle sinking into the driving surface. The second advantage is that while climbing over hard, uneven terrain, all six wheels will nominally remain in contact with the surface and under load, assists to propel the vehicle over the terrain.

One of the shortcomings of this rocker-bogie rover is that they are very slow. In order to be able to overcome notable rough terrain (i.e., obstacles greater than a few percent of wheel radius) without significant risk of rollover of the vehicle or harming the suspension, these robots move very slowly and go up over the obstacles by having wheels lift each piece of the suspension over the obstacle one portion at a time. While its performance on rough terrain obstacles is important, it should also considered situations where the surface is even or it has almost unnoticeable obstacles, where the rover should operate at higher speed to move faster from one to another place.

Space exploration are divided into three categories: a quest to better understand our universe, interest, and economic potential in using natural resources outside our planet, and the future colonization of extra-terrestrial bodies. Furthermore, most interest has been in our moon and Mars, as these planetary bodies are close by, and have environments that are hospitable enough for rovers, and potentially for future colonization. Babu et al. [1] has reported "Rocker Bogie mechanism Geo survey Rover" deals with the important aspect of improving the rover from its previous designs. Focus of the research is to overcome restrictions or to decrease it to within an acceptable range for its smooth performance. Research mainly focuses on the drive systems and its modules those were not efficient, the linkage, the overturning or tilt range of the rover and the battery inefficiency. The stability of the rover was improves by constructing it with PVC material.

In the investigation conducted by S Wang et al. [2] that rocker bogie system has robust capabilities to works with unstructured terrain because of its distribution of the pay load over its six wheels uniformly, while there is one major shortcoming to high-speed traversal over the planar terrain. Analysis on dynamic stability and kinematical simulation on the two operating modes of rocker-bogie are employed to analyze and verify the rationality and effectiveness of the modification in the structure. Similarly [3-8] many researchers have attempted to improve the dynamic and static stability of the rocker bogie mechanism. In the current investigation, one of the major shortcoming will be focused, rover are low speed vehicles. The modification in the mechanism improved the operational speeds of the rover for the said application by modification in the mechanical linkages.

## II. MECHANISM & ITS COMPONENTS

As indicated in the previous section the following section unfold the hardware and software requirements for the raising the mechanism. The primary requirement of any mechanism is the power source i.e. the battery having specification tabulated in the table 1 is adopted in the assembly. Figure 1 illustrates the battery acquired in the construction of the mechanism.


Fig. 1: Powerplus Battery of 12V

| Particulars | Specification |
|---|---|
| Voltage | 12 V |
| Rated capacity (20 hour rate ) | 4.5 AH |

Table 1: Specification of Powerplus battery

Arduino UNO R3 based 20A control board of a robot is a versatile motor controller for driving dual dc motor rated upto 20A each. Key features include multi-functionality, incorporation of ATmega328P-AU microcontroller and 20 A motor driver into a unit control board designed for robotics applications. It can drive two robot driving motors (Connected 2 motors in parallel for 4 wheeled robot) in skid steer control with analog speed control. Also can control up to eight servo motors connected at servo port and motor connector-3.

Most important feature it includes is that it can be programmed by Arduino IDE with the use of USB slot provided on the board. It can be controlled by UART communication, PS2 or IR remote control.

Due to its vast capabilities the board can be adopted to control all robots starting from beginner version to high end robots with multiple functionalities like PlayStation 2 or IR controlled robot. It can control up to 20 A of current on each channel.

### *A. Features of board:*

Robot control board provides the following features:

- Incorporation of ATmega328P-AU microcontroller (Arduino UNO R3based) and 20A motor driver
- Included all the features of Arduino UNO
- Support Arduino IDE Interfacing Analog speed control for 2 DC driving DC motors with Skid Steer Control
- Up to 8 servo motor control capability
- PS2 and IR remote compatible for wireless robot control applications
- Support UART Interfacing.
- Integrated USB Virtual COM port for programming
- Screw terminals for all power and signal wiring
- Status LEDs indicate Power
- Dimensions : 690 mm x 640 mm x 15 mm

### *B. Wheel Control Theory:*

Skid steering is a driving mechanism implemented on vehicles with either tracks or wheels which uses differential drive concept.

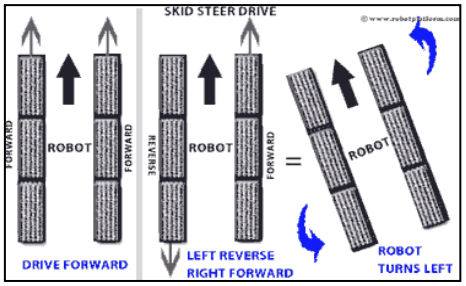



Fig. 2: Wheel Control

Most common Skid steered vehicles are tracked tanks and bulldozers. This method engages one side of wheels and rotating motion is performed by generating differential velocity at other side of a vehicle as the wheels or tracks in the vehicle are non- steerable.

If you have understood differential drive concept, there Skid steering is no different. In differentially driven robot, there is a castor which steadies the robot and in Skid Steer drive, the castor is restored with two driving wheels. Suppose robot needs to be turn left; then the right wheels or tracks are driven forward and the left wheels or tracks are driven backward until the robot turns right. If the drive continuous in the same way, then the robot will have a 360° turn with almost zero radiuses. Suppose if there are four wheels attached on each side, then the front and rear wheels rotate more and the center wheels almost skid to turn. Thus the name Skid steer.

### *C. DC Geared Motor:*

DC geared motors can be defined as an extension of DC motor which already had its Insight details demystified figure 3. Geared DC motor has a gear assembly fastened to the motor. The angular speed of motor is counted in terms of RPM (rotation per minute) of the shaft. The gear assembly helps to maximize the torque and decreasing the speed. Using the correct set of gears, its speed can be decreased to any required magnitute. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will lists all the details that make the gear head and hence the working of geared DC motor.

Fig. 3: DC Geared Motor

### *D. Rover wheel:*

Wheeled robots are robots that navigate around the ground using motorized wheels to propel themselves. This design is simpler than using treads or legs and by using wheels they are easierto design, build, and program for movement in flat, not-so-rugged terrain.

Fig. 4: Rover Wheel

*E. PS2 Joystick:*

The PS2 wireless controller is a standard controller for the PlayStation 2 and is identical to the original Dual Shock controller for the Play Station console. It features twelve analog (pressure-sensitive) buttons ( X, O, Π, Δ, L1, R1, L2, R2, Up, Down, Left and Right), five digital button (L3, R3 Start, Select and the analog mode button) and two analog sticks.Here we have interfaced the PS2 controller with robot controller. We are showing how to interface a rover with robot controller and the rover is controlled with PS2 joystick. Only Analog stick is used to control the rover. We followed the standard PS2 protocol for realizing the communication algorithm, identical to the SPI protocol. Our program on the arduino detects Analog stick values and decides the movements.

Fig. 5: PS2 JoyStick

*F. Poly Vinyl Chloride (PVC) Pipes:*

PVC is a high strength thermoplastic widely used in pipes and medical equipment and many more. It is the world's 3rd most widely used synthetic polymer plastic. It is a white in colored, brittle solid available in market either in powder form or granules. Thanks to its versatile nature such as low cost, lightweight, durable and easy processing ability, PVC is now replacing conventional building materials like metal, wood, ceramics, concrete and rubber etc. in various applications.

*G. Arduino IDE:*

The Arduino Integrated Development environment (IDE) is a cross platform app that is written in functions from C to C++. It is used to write and upload programs to arduino compatible boards but also with the help of third party cores, other vendor development boards.

Most important feature it includes is that it can be programmed by Arduino IDE with the use of USB slot provided on the board. It can be controlled by UART communication, PS2 or Infra-Red remote control.

Due to its expansion capabilities the board can be used to control all robots starting from basic version robot to high end robots with multiple functionalities like PS2 or IR controlled robot. It can control up to 20 A of current on each channel.

Thus our goal during the development of rover would be to optimize the speed such that the rover do not rollover and may travel at higher speeds too and also make it cost effective with maximum possible rigidity.

*H. 2D Drafting of Rover:*

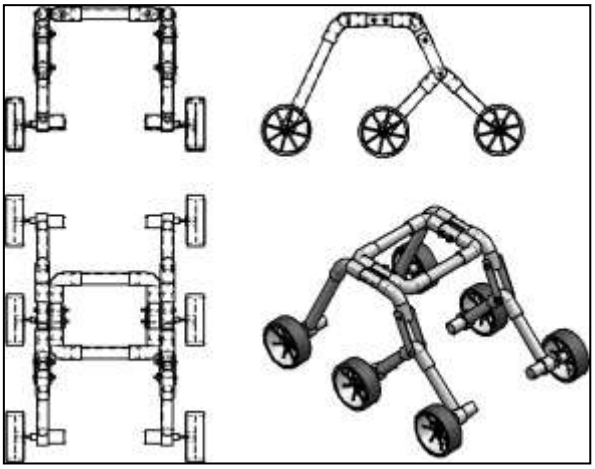


Fig. 6: 2D Drafting of Rover

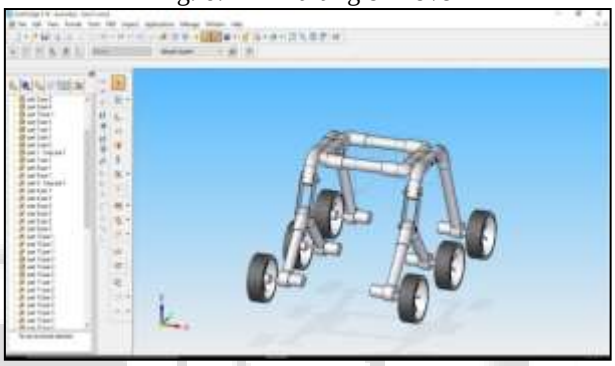


Fig. 7: Isometric View of Rover

## III. FABRICATION

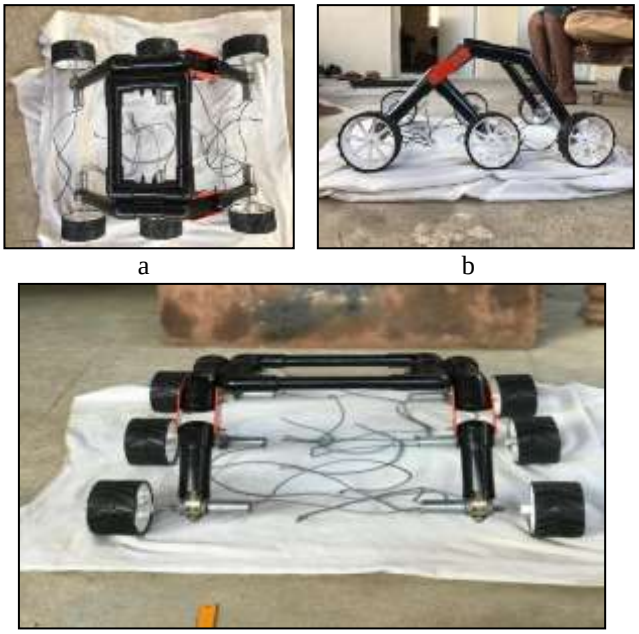
As mentioned in the introduction chapter parts required for the fabrication of the rover were procured and processed according to design. Some of the images of the fabricated models are depicted in Figure 8.

## IV. RESULT & DISCUSSION

The following tests were conducted to check the design stability and ability of the rover to climb an obstacle and load distribution test, independent wheel drive test were also executed. AV system was also verified to examine the working condition and range of the system. The results of the speed test were tabulated in Table 2. Images for the test conducted were shown in figure 9.

| Terrain | Speed (m/Sec) |
|---|---|
| Rough terrain | 0.1776 |
| Smooth terrain | 0.2092 |

Table 2: Results of the speed test



a b c

Fig. 8: a) Top View b) Side View c) Front View

a b c

Fig. 9: a) Load Distribution b) Climbing Ability c) Independent Wheel Drive

## V. CONCLUSION

The proposed paper introduces a novel design in pursue of increasing the rocker-bogie mobility system in conventional heavy loading vehicle behaviour when high-speed traversal is required and to increase the battery efficiency and operating time of the rover, which was made possible using the independent directional control system which uses minimum drive modules dependent upon the operating situation and conditions. Under reasonable assumptions, it is possible to estimate the rover attitude and configuration, given its ground characteristics and position, and whether the rover will tip over, slid or maintain its balance using instruments and sensors. The near zero tilt system which uses the rovers power supply attached to the body of the rover to as a counter weight and self-balance itself decreases the percentage of tilt or overturning. The mechanics of the rover has been established, and the over- actuation of system tends to the ability to affect the forces by applying specific torques at wheels. This property has been examined experimentally and can be utilized for the design of an active traction control system. A graphical interface can be developed and executed onto the current resurvey rover design to improve understanding of the system and to view all data pertaining to its operation which will be handy in further enhancement in the system.

This research illustrates how a rocker bogie system works on different terrains. As per the different weights acting on link estimates torque applied on it. By assuming accurate stair dimensions, accurately dimensioned rocker bogie can climb the stair with improved stability.

The designed and manufactured system can climb the angle till 45˚. Also it is tested for the Web cam with AV recording mounted on mechanism and found satisfactory performance of its capabilities for providing video with imaging.

## BIBLIOGRAPHY

[1] B.Babu, N.Dhayanidhi, S.Dhamotharan "Design and Fabrication of Rocker Bogie Mechanism Geosurvey Rover", 2018 Vol. 3, Pp. 2455-2631.

[2] Sunxin Wang and Yanli "Dynamic Rocker-Bogie: Kinematical Analysis in A High- Speed Traversal Stability Enhancement", International Journal of Aerospace Engineering Volume 2016, Article ID 5181097, 8 Pages.

[3] D. S. Chinchkar, S. S. Gajghate, R. N. Panchal, R. M. Shetenawar, P. S. Mulik" Design Of Rocker Bogie Mechanism" Vol. 4, Special Issue 1, January 2017.

[4] Dongmok Kim A, Heeseung Hong A, Hwa Soo Kim B, Jongwon Kim "Optimal Design And Kinetic Analysis Of A Stair-Climbing Mobile Robot With Rocker-Bogie Mechanism", Mechanism And Machine Theory 2012, Pp. 90-108.

[5] Shumei Wu, Linhui Lia*, Yibing Zhao, Ming Li "Slip Ratio Based Traction Coordinating Control Of Wheeled Lunar Rover With Rocker Bogie", Procedia Engineering, Vol. 15 (2011), Pp. 510-515.

[6] S. F. Toha1 And Zakariya Zainol"System Modelling Of Rocker-Bogie Mechanism For Disaster Relief", Procedia Computer Science Vol. 76(2015), Pp. 243–249.

[7] Aswath Suresh, Nitin Ajithkumar, Sreekuttan T. Kalathil, Abin Simon, V.J. Unnikrishnan, Deepu P. Mathew, Praveen Basil, Kailash Dutt, Ganesha Udupa, C.M. Hariprasad, Maya Menon, Arjun Balakrishnan, Ragesh Ramachandran, Arun Murali And Balakrishnan Shankar "An Advanced Spider-Like Rocker-Bogie Suspension System For Mars Exploration Rovers" January 2017 : 10.1007/978-3-319-31293-4_3

[8] G Sai Santhosh Sivan, Deepak Kumar, Amneesh Singla "Design OfRocker Bogie for Military Applications", 2018.

[9] Meet Upadhyay 1, B. Suresh, Dr.Guruprasad K R, Asavari Limaye, NischitaKaza, Prachi Shahi, Vedant Dhruv, Vignesh Radhakrishnan "Rover With Rocker-

Bogie Linkage Mounted With An Ultrasonic Sensor And Bluetooth Module", 5th International Engineering Symposium - IES 2016 March2-4, 2016, Kumamoto University, Japan.

[10] Brian D Harringtone, ChishVoorheees, "The Challenges OfDesigning the Rocker- Bogie Suspension for the Mars Exploration Rover", June 2004.

[11] ThajibIbna, RoufUday "Design AndImplementation of the Next Generation Mars Rover", December 2018.

[12] Jun Yang, Mingming Dong, Jiatong Ye "Literature Review of the Rocker-Bogie Suspension for the Planetary Rover", ANIT 2017 Pp. 1951-6851.

[13] Nitin Yadav, Suresh Bharadwaj "Design Analysis OfRocker Bogie Suspension System And Access The Possibility To Implement In Front Loading Vehicles", May 2015.

[14] NitheshNaik, D.K.Shetty, "Design and Analysis of UGV with Rocker Bogie Mechanism for Landmine Extraction", January 2019.

[15] Yuki Mori, Isaku Nagai "Development of an Omnidirectional Mobile Platform with A Rocker-Bogie Suspension System", October 2016.

[16] Franziska Shaw, Salah Sukkarieh, "Design Optimization of a Mars Rover's Rocker- Bogie Mechanism Using Genetic Algorithms", January 2010.