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Rocker Bogie

Mohit Dhawale[1], Rohan Bedarkar[2], Raj Warudkar[3], Shantanu Mohod[4], Devanshu Dhawale[5], Tanmay Joshi[6], Prof. Y.D. Bansod[7]

[1, 2, 3, 4, 5, 6]*Department of Mechanical Engineering, P. R. Pote College of Engineering and Management*
[7]*Guide*

Abstract: ***The Rocker-Bogie Mobility System was design to be used at slow speeds. It is capable of overcoming obstacles that are on the order of the size of the wheels. However, when surmounting a sizable obstacle, the vehicle motion effectively stops while the front wheel climbs the obstacle. When operating at slow speed, dynamic shocks are minimized when this happens. For many future planetary missions, rovers will have to operate at human level of speeds. Shocks resulting from the impact of the front wheel against an obstacle could damage the payload or the vehicle. This paper describes a method of driving a Rocker-Bogie vehicle so that it can effectively step over most obstacle rather than impacting over them. Most of the benefits of this method can be achieved without any modification to existing design only a change in control strategy. Some mechanical modification changes are suggested to gather the maximum benefits and to greatly increase the effective operational speed of future rovers.***
Keywords: rocker, bogie, mars-rover, suspension, obstacles

I. INTRODUCTION

This The Rocker-Bogie Mobility system was a designed to be used at the slow speeds. It is capable of overcoming obstacles that are on the order of the size of a wheel. However, when surmounting a sizable obstacle, the vehicle motion effectively stops while the front wheel climbs the obstacle. When operating at slow speed, dynamic shocks are minimized when this happens. For many future planetary missions, rovers will have to operate at human level of speeds. Shocks resulting from the impact of the front wheel against an obstacle could damage the payload or the vehicle. This paper describes a method of driving a Rocker-Bogie vehicle so that it can effectively step over most obstacle rather than impacting over them. Most of the benefits of this method can be achieved without any modification to existing design only a change in control strategy. Some mechanical modification changes are suggested to gather the maximum benefits and to greatly increase the effective operational speed of future rovers.

One of the major shortcomings of current planetary rover is that they are slow. In order to be able to overcome significantly rough terrain (i.e., obstacles more than a few percent of wheel radius) without significant risk of flipping the vehicle or damaging the suspension over the obstacles by having wheels list each piece of the suspension over the obstacle on portion at a time.

NASA's currently favoured design, the rocker-bogie, uses wheeled rocker arm on a pivot Design a robotic vehicle of performing tasks for a sample return mission within the parameter and requirements of the university rover challenge, attached to a main bogie that is connected differentially to the main bogie on the other side.

The rocker-bogie suspension mechanism which is currently NASA's approved design for wheeled mobile robots, mainly because it has its sturdy or resilient capabilities to deal with obstacles and because it uniformly distributes the payload over its 6 wheels at all times. It also can be used for the other purpose to operate in rough roads and to climb the steps. It is having lots of advantages but one of the major disadvantages is the rotation of the mechanism when and where is required. The rotation can be possible by providing individual motors to individual wheels which can cause arise in cost and complicacy in design. Here an attempt is made to modify the existing design by incorporating a gear type steering mechanism which will be operated by a two motor which simplifies the design as well as the total cost and operating cost of the mechanism.

The rocker-bogie mechanism is one of the most popular linkage mechanisms, which was initially designed for space travel vehicles having its own deep history embedded in its development. By construction it is a wheel robot which comprises of 8 actuator wheels. The suspension system and these rockers are connected to each other and the vehicle chassis through a selectively modified differential in order to balance the bogie. By construction it has main frame containing two linkages on each side that are called the "rocker". One end of the rocker is connected to rear wheel, and the other end is connected to a small to maintain centre of gravity entire vehicle as accordance with the motion, when one rocker moves down-word, the other goes upward. The chassis plays vital role to maintain the average pitch angle of the both rockers to move as per the situation. As per the acute design, one end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie which provides required motion and degree of freedom. In the system, "bogie" refers to the conjoining links that have a drive wheel attached at each end.

Each of the front wheels is connected to the gears at their horizontal shaft. The body contains one motor at each lower side. The motor shaft is connected to each wheel to produce high torque and frictional surface for gripping. The gears are connected to the wheel gears with the help of idler. The motor can be controlled by the help of micro controller or directly. Here it is connected to a cable and the cable is connected to a control panel. Whenever it is required to have the turn of the mechanism then the controller in the control panel will be operated which in turn will rotate the motor. The master gear connected to the motor will also rotate with the motor. As the idlers are connected to the motor they will rotate in the opposite direction to the rotation of motor. The wheel gears connected the idler will also rotate along with this which will enable to rotate the wheels in the required direction. Here the idlers are incorporated to avoid the confusion of operation. This enables the operator to get sure that if the controller is rotated clock wise the mechanism will also rotate clock wise and vice versa. Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain.

II. LITERATURE REVIEW

The initiation of rocker bogie suspension system can be traced to the development of planetary rover which are mobile robots, especially designed to move on a planet surface. Early rovers were tele-operated like the Lunokhod I while recent ones are fully autonomous, such as FIDO, Discovery and recently developed Curiosity mars exploration rover. The rovers needed to be very robust and reliable, as it has to withstand dust, strong winds, corrosion and large temperature changes under mysterious conditions. Maximum rovers remain powered by batteries which are recharged by solar panels during the day installed over there surface. The locomotion system of rovers remains crucial to enable it to reach objective sites, conduct research, and collect data and to position itself according to the demand. There are three main types of rover locomotion developed so far i.e. wheeled, legged and caterpillar locomotion. The main difference between the miscellaneous designs of planetary robots lies in the type of locomotion system. Even after developing many legged and hybrid robots, most researchers still focus on wheeled locomotion for rovers because of its locomotive ease and advantages and among wheeled locomotion design, the rocker bogie suspension system is based design remain most favoured. The ancient FIDO rover and the Sojourner contain 6 independently steered and driven wheels suspended from a rocker-bogie mechanism for maximum suspension and ground clearance. Rocky Seven Rover has a similar suspension system just differ in front wheels. The Nano-rover & Nomad Rovers have four steered wheels suspended from two bogies & CRAB Rover utilizes two parallel bogie mechanisms on each side to overcome obstacles and large holes. As far as the initial research is concerned, the software optimization seeks for an optimum in the constrained solution space given an initial solution and Dr. Li et al. derive a mathematical model to generalize rover suspension parameters which define the geometry of the rocker-bogie system. The objective behind evolution of rocker bogie suspension system is to develop a system which minimizes the energy consumption, the vertical displacement of the rover's centre of mass and its pitch angle. In this research, our endeavour is to transfer these major advantages embedded with the rocker bogie system into conventional vehicles in order to remove discomfort and complexities present in conventional suspension system in general and suspension system of heavy vehicles in particular.

III.PRINCIPLE

The rocker-bogie design consisting of no springs and stub axles in each wheel which allows the chassis to climb over any obstacles, such as rocks, ditches, sand, etc. that are up to double the wheel's diameter in size while keeping all wheels on the ground maximum time. As compared to any suspension system, the tilt stability is limited by the height of the centre of gravity and the proposed system has the same Systems employing springs tend to tip more easily as the loaded side yields during obstacle course. Dependent upon the centre of overall weight, any vehicle developed on the basis of Rocker bogie suspension can withstand a tilt of at least 50 degrees in any direction without overturning which is the biggest advantage for any heavy loading vehicle. The system is designed to be implemented in low speed working vehicles such as heavy trucks, Bulldozers which works at slow speed of around 10 centimetres per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles

IV.METHODOLOGY

As per the research it is find that the rocker bogie system reduces the motion by half compared to other suspension systems because each of the bogie's six wheels has an independent mechanism for motion and in which the two front and two rear wheels have individual steering systems which allow the vehicle to turn in place as 0^{o} degree turning ratio. Every wheel also has thick cleats which provides grip for climbing in soft sand and scrambling over rocks with ease. In order to overcome vertical obstacle faces, the front wheels are forced against the obstacle by the centre and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle and obstacle overtaken.

Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over. At last, the rear wheel is pulled over the obstacle by the front two wheels due to applying pull force. During each wheel's traversal of the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles centre of gravity. The above said methodology is being practically proved by implementing it on eight-wheel drive ATV system in order to gain maximum advantage by rocker bogie system.

A. Working Of Rocker-Bogie

1) Rocker and Bogie Frame mechanism

Rocker mechanism is to get the oscillatory motion for the upward and downward rotary motion provide ng better surface friction which improves the climbing on the tilting surface. Also, this mechanism provides benefits such as while the one part of the mechanism is in the upward motion the other one is free to oscillates along the shaft which is joints to the storage space. Also, the wheels connected to the rocker end is use to provide backup motion increasing the friction torque and helps to push the bogie.

Bogie is a structure which provide the robot steering motion as well as the support for the main frame. It is attached to the one end of the connection of the rocker and the bogie providing the rotary motion with angle of 210^0 .

2) Main Frame

It is the frame which is supporting the rocker and bogie frame, also all the components of the robot such as motors, wheels, supporter, control unit, etc.

B. Circuit Configuration

There are two circuit configuration one is for the Steering mechanism and the other one is for the Forward and backward motion. We have used a parallel circuit configuration for this. The two-circuit configuration are

1) The Steering System Configuration

There are four motors which are connected to the battery passing through the toggle switch having 6 terminals. The connection to each motor is done parallelly. When we push the toggle switch in the forward direction the current get pass across the circuit which rotates the motor in clockwise direction providing right direction and when toggle switch is push to backward direction the robot moves in the left direction. The steering angle is limited to a total angle of 90^0.

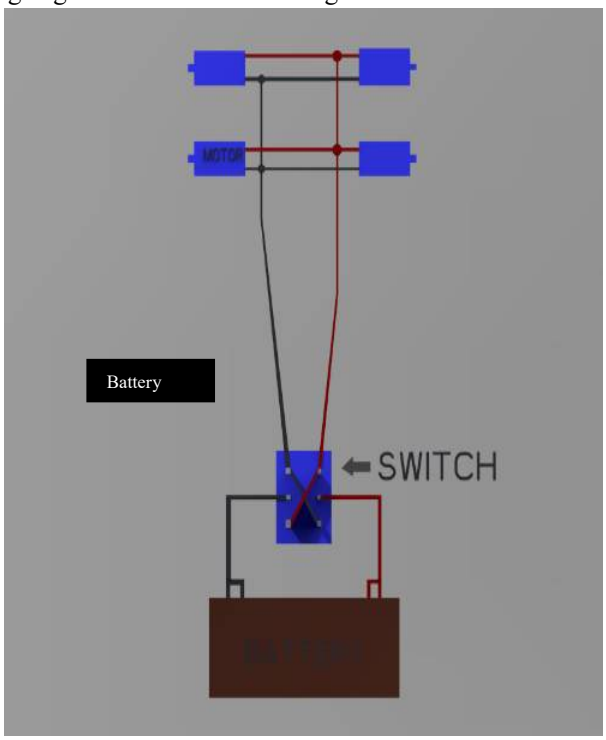

Fig – Circuit diagram for steering system

2) Forward and Reverse Circuit Mechanism

The circuit configuration is same as the steering system but the no of motors connected is eight connect parallelly giving all wheels the torque required to climb the wheel. If the toggle switch is push to forward then the robot moves to the forward direction and if the toggle switch is push to backward then the robot moves in the reverse direction.

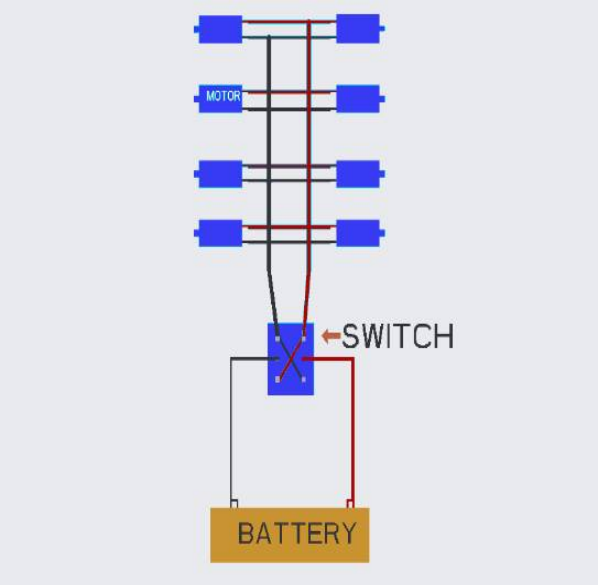

Fig – The Forward and Reverse Circuit Mechanism

V. HOW A GEAR MOTOR WORKS

A gear motor is a specific type of electrical motor that is designed to produce high torque while maintaining a low horsepower, or low speed, motor output. Gear motors can be found in many different applications, and are probably used in many devices in your home.

Gear motors are commonly used in devices such as can openers, garage door openers. washing machine time control knobs and even electric alarm clocks. Common commercial applications of a gear motor include hospital beds, commercial jacks, cranes and many other applications that are too many to list.

A. Basic Principles of Operation

A gear motor can be either an AC (alternating current) or a DC (direct current) electric motor. Most gear motors have an output of between about 1,200 to 3,600 revolutions per minute (RPMS). These types of motors also have two different speed specifications: normal speed and the stall-speed torque specifications. Gear motors are primarily used to reduce speed in a series of gears, which in turn creates more torque. This is accomplished by an integrated series of gears or a gear box being attached to the main motor rotor and shaft via a second reduction shaft. The second shaft is then connected to the series of gears or gearbox to create what is known as a series of reduction gears. Generally speaking, the longer the train of reduction gears, the lower the output of the end, or final, gear will be.

B. Gear Motors and Increased Force

Gear motors are commonly used in commercial applications where a piece of equipment needs to be able to exert a high amount of force in order to move a very heavy object. Examples of these types of equipment would include a crane or lift Jack. If you've ever seen crane in action, you've seen a great example of how a gear motor works. As you have probably noticed, a crane can be used to lift and move very heavy objects. The electric motor used in most cranes is a type of gear motor that uses the basic principles of speed reduction to increase torque or force.

Gear motors used in cranes are usually specialty types that use a very low rotational output speed to create incredible amounts of torque. However, the principles of gear motor use in a crane are exactly the same as those used in the example electric time clock. The output speed of the rotor is reduced through a series of large gears until the rotating, RPM speed, of the final gear is very low. The low RPM speed helps to create a high amount of force which can be used to lift and move the heavy objects.

VI. WORKING DIAGRAM ON CREO

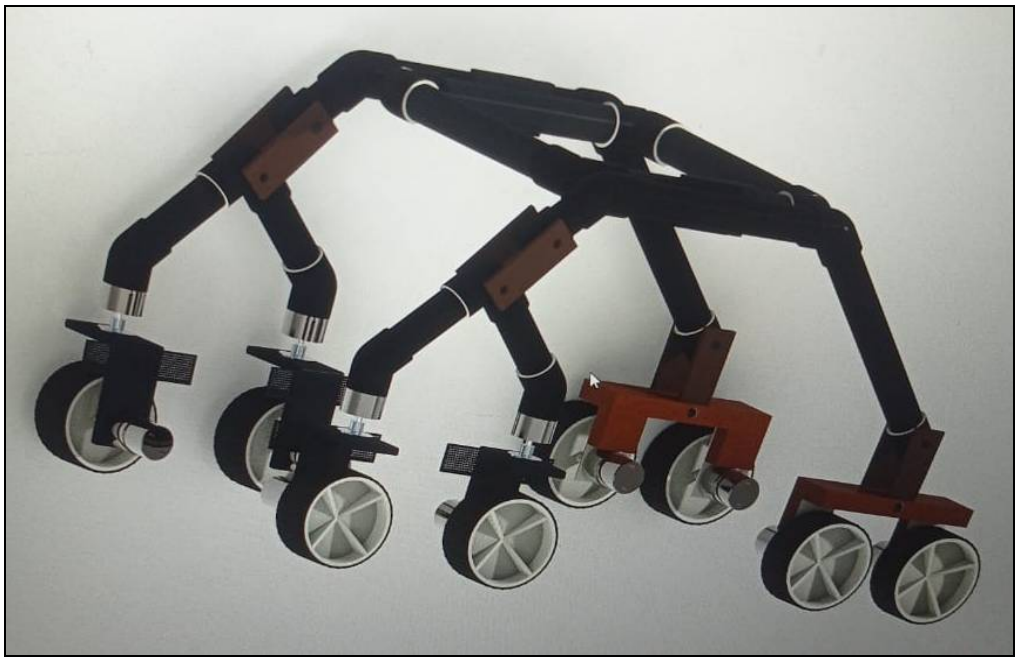

Fig – Diagram of Creo

The working diagram of the Rocker-Bogie made on the designing software Creo.

VII. OBSERVATION

A The main problem associated with current suspension systems installed in heavy loading vehicles rovers (including those with active and semi active suspension systems) is their slow speed of motion which derail the rhythm to absorb the shocks generated by wheels which remain the result of two factors. First, in order to pass over obstacles, the vehicle must be geared down significantly to allow for enough torque to raise the mass of the vehicle. Consequently, this reduces overall speed which cannot be tolerated in the case of heavy loading vehicles. Second, if the vehicle is travelling at a high speed and encounters an obstacle (height greater than 10 percent of wheel radius), there will be a large shock transmitted through the chassis which could damage the suspension or topple down the entire vehicle. That is why current heavy loading vehicles travel at a velocity of 10cm/s through uneven terrain. The software-based testing of rocker bogie suspension system describes the momentum and efficiency related utilities in cumulative manner

VIII. COMPONENTS OF ROCKER-BOGIE

Components of the Rocker-Bogie are as follows

1) Battery
2) Wire
3) Six Terminal Switch
4) Nut, Bolt and Rod
5) Gear Motor
6) Wheel
7) PVC Pipe and Bends
8) Wood
9) Metal Plates
10) PCB Board
11) Rocker and Bogie Frame

A. Battery

Fig - Battery

A battery is a device that stores chemical energy and converts it to electrical energy. The chemical reactions in a battery involve the flow of electrons from one material (electrode) to another, through an external circuit. The flow of electrons provides an electric current that can be used to do work.

B. Wires

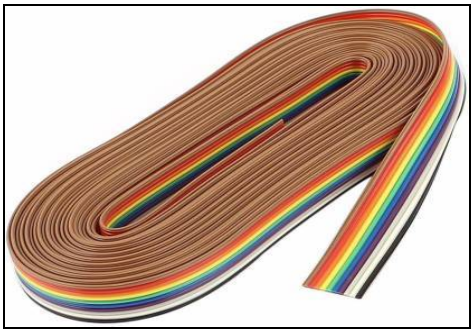

Fig – Wires

A wire is a single usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity and telecommunications signals. Wire is commonly formed by drawing the metal through a hole in a die or draw plate

C. Terminal Switch

Fig – Terminal Switch

A push-button (also spelled pushbutton) or simply button is a simple switch mechanism to control some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal.

D. Nuts and Bolts

Fig – Nuts and Bolts

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction, a slight stretching of the bolt, and compression of the parts to be held together. This use for flexibility connecting with rocker and bogie link

E. Gear Motor

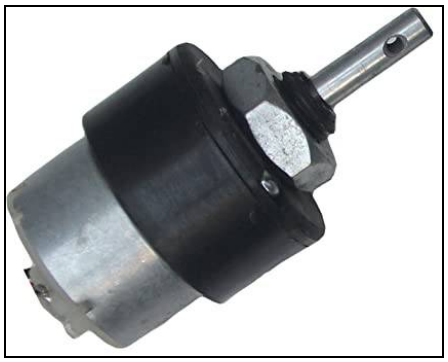

Fig – Gear Motor

A Direct Current (DC) motor is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy. An Inductor (coil) inside the DC motor produces a magnetic field that creates rotary motion as DC voltage is applied to its terminal.

F. Wheels

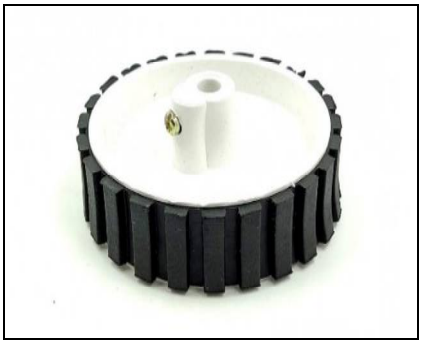

Fig – Wheel

A wheel is a circular component that is intended to rotate on an axle bearing. The wheel is one of the key components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labour in machines.

G. Pipes and Bends

Fig - Pipe and Bends

Bend is a generic term for any offset or change of direction in the piping. It is a vague term that also includes elbows. An elbow is an engineering term and they are classified as 90º or 45 º, short or long radius.

Pipe is a long tube of metal, plastic, etc, used to convey water, oil, gas, etc. a long tube or case. an object made in any of various shapes and sizes, consisting of a small bowl with an attached tubular stem.

H. Wood

Fig - Wood

The principal strengthening and nutrient-conducting tissue of trees and other plants and one of the most abundant and versatile natural materials. The wood we use her is Mango wood.

I. Metal Plate

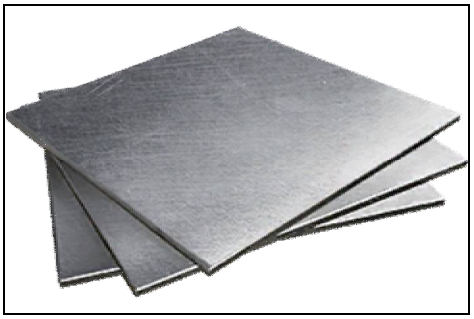

Fig – Metal Plate

Iron is a lustrous, ductile, malleable, silver-grey metal. It is known to exist in four distinct crystalline forms. Iron rusts in damp air, but not in dry air. It dissolves readily in dilute acids.

J. PCB Board

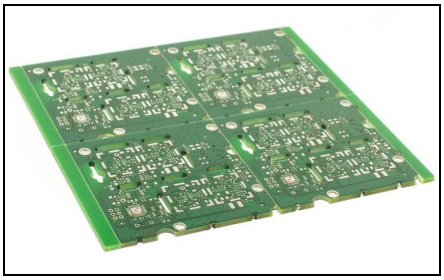

Fig – PCB Board

A printed circuit board (PCB) is a laminated sandwich structure of conductive and insulating layers. PCBs have two complementary functions.

K. Bogie Frame and Rocker Frame

Fig – Bogie and Rocker Frame

A bogie is a chassis or framework that carries a wheelset, attached to a vehicle—a modular subassembly of wheels and axles. Bogies take various forms in various modes of transport. A bogie may remain normally attached be quickly it may contain a suspension within it. Rocker Mechanism is a four-bar linkage. In this linkage, the shortest link rotates fully while the other link pivoted to the fixed link oscillates. It is a Gasthof's linkage for which the sum of the lengths of the shortest link and the largest link is less than the sum of the lengths of the other two links.
In rocker mechanism, the link adjacent to the shortest link is fixed. The position of the other three links does not affect the nature of the mechanism.

IX.COST OF ESTIMATION

Sr. No	Component	Specification	Units	Cost
1	CPVC Pipe	Length- 7 feet Diameter – 1 Inch	1	480
2	Gear motor	12 V, RPM-60	8	1800
3	Gear Motor	12V, RPM-45	4	740
4	Elbow	90 deg	6	180
5	Elbow	45 deg	8	240
6	Cast iron plate	Thickness - 4 mm	4	70
7	Wood	Dimension – 10*5ft	8	50
8	Nut bolts	6 Inch	11	40
9	Screw	1 Inch	20	20
10	End cap	1 Inch	2	30
11	Wire	2-Core	8ft	35
12	Wheels	4 Inch	8	640
13	Foam sheet	4x4 ft	1	50
14	Rainbow wire	6-Core	12	60

15	Remote PCB board	12x8 cm	1	100
16	Toggle switch	6-terminal	2	120
17	Battery	Lithium ion 19.5 V, 8 Amp	1	1200
18	Spring	Length - 15 cm	4	20
19	Jumper wire	Length - 15cm	10	45
20	Hose pipe	Diameter - 20mm	3 ft	20
21	Motor Coupling	Diameter - 40mm	4	80
			Total	6100

X. ADVANTAGES AND DISADVANTAGES

A. *Advantages*

1) The main advantage of this mechanism is no suspension is required, and total loads are distributed equally over all wheels.
2) More stable over rough terrains while maintaining stability.
3) Easily overcome obstacles over some extend.
4) Ability to climb any tilt surface.
5) Mechanism is very useful when the robot is driving on the dry sand like surface.

B. *Disadvantages*

1) Normal wheels will be the drawback in the rocker bogie if any vertical obstacle comes its way wheels will not ride over it.
2) It is not suitable for high speed applications.
3) Due to heavy duty motor battery usage is very high.

XI. APPLICATION OF ROVER ROBOTS

The various application of the Rocker-Bogie are as follows

1) Mobile robots can be used in several applications.
2) Dangerous area operations such as Nuclear plants.
3) Planetary exploration and pipe investigation.
4) Extreme temperature and narrow field investigations.
5) Pyramid exploration robots.
6) Mine Detection

XII. FUTURE SCOPE

1) With the development in technology the rover can be used for reconnaissance purposes with the cameras installed on the rover and minimizing the size of rover.
2) With some developments like attaching arms to the rover it can be made useful for the Bomb Defusing Squad such that it can be able to cut the wires for diffusing the bomb.
3) By the development material through a rough terrain or obstacles containing regions like stairs.
4) We could develop it into a Wheelchair too. It can be sent in valleys, jungles or such places where humans may face some danger.
5) It can also be developed into Suspension System for the automobile vehicles through proper research.

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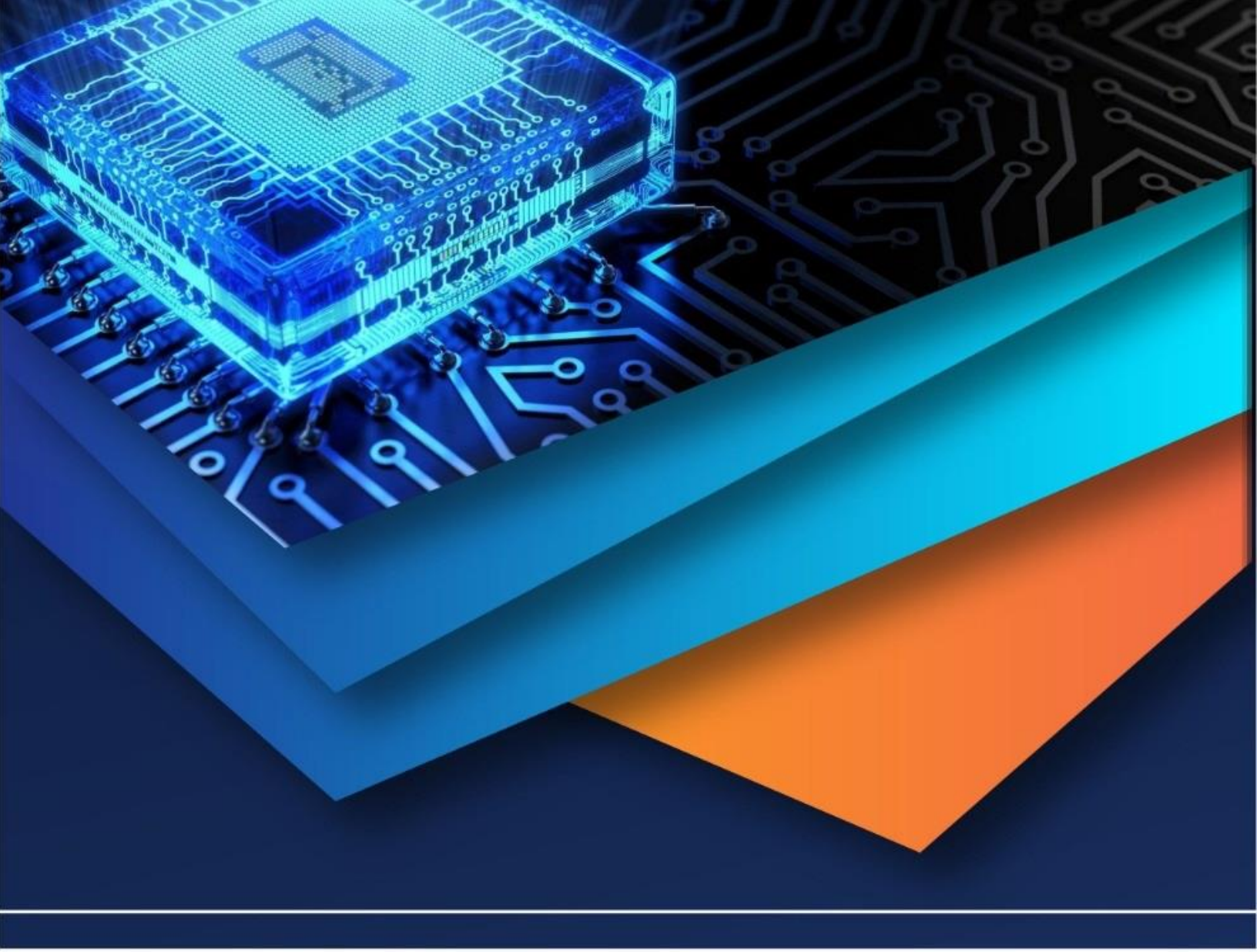

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