FABRICATION OF ROCKER BOGIE MECHANISM FOR SIX WHEEL VEHICLE

A Major Project Report

Submitted

in the partial fulfillment of the requirements forthe award of the degree of

Bachelor of Technology

in

Mechanical Engineering

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CERTIFICATE

This is to certify that the major project report entitled **FABRICATION OF ROCKER BOGIE MECHANISM FOR SIX WHEEL VEHICLE** tha is being submitted in the Department of Mechanical Engineering, Sreenidhi Institute of Science and Technology by

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in partial fulfillment for the award of B.Tech. Mechanical Engineering, Jawaharlal Nehru Technological University Hyderabad, Kukatpally, Hyderabad – 500 085, T.S. is a record of bonafide work carried out by them under our guidance and supervision.

The results embodied in this report have not been submitted to any other university or Institute for the award of any degree or diploma.

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DECLARATION

We, V.Arun, M. Rakesh, D.Ishwarya and A.Poojitha bearing Roll No. 20311A03A7,20311A03E8,20311A03F6,20311A03F9 students of Sreenidhi Institute of Science And Technology, Yamnampet, Ghatkesar, studying IV th year II nd semester, Mechanical Engineering solemnly declare that the Major Project report, titled "FABRICATION OF ROCKER BOGIE MECHANISM FOR SIX WHHEL VECHILE" is submitted to SREENIDHI INSTITUTE OF SCIENCE AND TECHNOLOGY for partial fulfilment for the award of the degree of Bachelor of Technology in Mechanical Engineering. It is declared to the best of our knowledge that the work reported does not form part of any dissertation submitted to any other University or Institute for the award of any degree.

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ABSTRACT

The Rocker bogie mechanism is primarily used in Mars rovers to traverse basic terrainwhile maintaining balance. It is NASA's chosen technique for space vehicles and rovers. It has twoarms with steering wheels for everyone. Each component is joined together via a moveable joint.This enables the use of a suspension-based mechanism that distributes the vehicle tonnage asconsistently as possible on protrusions and odd surfaces. The appearance includes a spring-freesuspension-dependent differential drive method, which allows the bogie to easily traverse over debris and stones. The cameras and sensors put on a rover must be in good working order in orderto extend their life. Additional shocks and jerks cause receptor damage to occur faster. Additionalvibrations and jerks result in faster damage to sensors, circuit boards, and digital cameras. Therocker-bogie system was developed to retain this specific of the brain by providing maximum stability in all terrains. As a consequence, we investigate the design and manufacturing of the rocker-bogie mechanism through the construction of this basic surface vehicle using bogie mechanismconcepts. All-terrain moveable robots differ from regular portable robots in that they consider theinfluence of unstructured surfaces and their surroundings. The Rocker Bogie Mechanism and itstraction control through a microprocessor. The model above depicts the simplest yet most effectiveRocker Bogie traction system that may be employed in.The model below demonstrates the mostbasic yet successful implementation of the Rocker Bogie traction system, which may be employed inany application involving uneven terrain conditions. Keywords: Rocker-Bogie Mechanism, TractionSystem, Shocks And Jerks, Suspension, Rovers, Maximum Stability

INDEX

TOPICS

CHAPTER 1: INTRODUCTION

1.1 Introduction:

The Rocker-Bogie design has no springs and stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity. Systems using springs tend to tip more easily as the loaded side yields. The system is designed to be used at slow speeds of around 10 cm/s, so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

The Rocker-Bogie system has been the suspension arrangement used in the Mars rovers. It is currently NASA's favored design.

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.

Control buttons are used to control the movement of the robot. In this project we are using control buttons for the user to choose the direction mode in which the robot should operate whether forward, backward or left, right directions. Using control buttons we can select the particular direction of operation of the robot.

The DC motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary permanent magnets, and rotating electrical magnets. Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed.

1.2 Project Overview:

The project “**Rocker Bhogie**” can be done using DC motors, control buttons, rechargeable battery, and Robot model.

1.3 Thesis:

The thesis explains the implementation of “ **Rocker Bhogie**”**.** The organization of the thesis is explained here with:

Chapter 1 Presents introduction to the overall thesis and the overview of the project. In the project overview a brief introduction of “**Rocker Bhogie**” and its applications are discussed.

Chapter 2. Literature Review

Chapter 3 : OBJECTIVE, PROBLEM DEFINATION AND METHODOLOGY

Chapter 4 Presents the hardware description. It deals with the block diagram of the project and explains the purpose of each block. In the same chapter the explanation of geared DC motor, battery power supply, control buttons, rechargeable battery, Robot model are considered.

Chapter 5 Presents the results, conclusion and future scope of the project.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction:

The rocker-bogie system is a type of suspension system designed to allow wheeled vehicles to traverse uneven terrains. It was originally developed for planetary rovers, notably by NASA for its Mars exploration missions, due to its capability to handle large obstacles while maintaining stability.

2. Historical Background and Development

The concept of the rocker-bogie mechanism was first introduced in the late 1980s, and it gained prominence through its use in NASA's Mars rovers, such as Pathfinder, Spirit, Opportunity, Curiosity, and Perseverance. The mechanism is composed of two main parts: the "rocker" and the "bogie." The rocker connects the front and rear wheels and is linked to the chassis through a differential, allowing for independent movement. The bogie is a secondary structure connecting the rocker to a set of wheels, usually creating a three-wheel arrangement on each side.

3. Mechanism and Design Principles

The key design elements of the rocker-bogie system include:

-Articulated Structure: The ability to move independently allows the vehicle to maintain contact with the ground even when traversing uneven or rocky terrain.

-Differential Mechanism: A differential is used to maintain stability while allowing independent motion between the left and right sides of the vehicle. This feature contributes to the system's ability to keep the chassis level even when one wheel is higher than the others.

Obstacle Climbing: The rocker-bogie system can climb obstacles up to twice the diameter of its wheels, making it ideal for rough terrains.

- **Low Impact and Minimal Shock**: This system is designed to minimize shocks and vibrations, protecting sensitive instruments and equipment.

4. Applications in Robotics and Planetary Exploration

The primary use of the rocker-bogie mechanism has been in planetary rovers, where stability and mobility are critical. The system has been successful in enabling rovers to navigate the challenging terrains of Mars, providing valuable data and contributing to the success of various missions. The following applications are notable:

- **NASA's Mars Rovers**: As mentioned earlier, NASA has employed the rocker-bogie mechanism in its Mars rover missions, enabling these rovers to traverse craters, rocks, and other challenging terrains while collecting scientific data.

- **Lunar Rovers and Beyond**: The success of the rocker-bogie system on Mars has prompted considerations for its use in lunar missions and other off-Earth explorations.

5. Current Developments and Innovations

In recent years, the rocker-bogie mechanism has seen further development and refinement. Innovations focus on improving stability, weight, and energy efficiency. Researchers are exploring new materials and manufacturing techniques to reduce weight without compromising durability. Additionally, advancements in robotics and AI contribute to enhancing the system's navigation and obstacle avoidance capabilities.

6. Future Directions and Challenges

As exploration missions target more challenging environments, the rocker-bogie mechanism faces several challenges:

- **Scaling for Larger Vehicles**: While the system works well for smaller rovers, scaling it up for larger vehicles presents engineering challenges.

- **Energy Efficiency**: Improving the efficiency of the system to extend rover operational time on missions with limited energy sources.

- **Advanced Autonomy**: Enhancing the autonomous navigation and obstacle avoidance capabilities of rovers equipped with the rocker-bogie system.

- **Application in Non-Space Environments**: There is interest in applying the rocker-bogie mechanism in terrestrial environments, such as search-and-rescue operations or off-road exploration.

7. Conclusion

The rocker-bogie mechanism is a critical innovation in the field of robotics and planetary exploration, providing rovers with the ability to navigate challenging terrains with stability and reliability. Its continued development and refinement are likely to contribute to the success of future exploration missions and potentially find applications in other fields, further cementing its significance in the robotics landscape.

CHAPTER 3: OBJECTIVE, PROBLEM DEFINATION AND METHODOLOGY

3.1 Objective

The objective of the rocker-bogie mechanism is to design a robust suspension system capable of navigating challenging terrains with high stability, optimal load distribution, and minimal tilting. This mechanism is commonly used in planetary rovers, such as NASA's Mars rovers, to traverse uneven surfaces with varying obstacle sizes, all while maintaining a stable platform for scientific instruments or payloads.

3.2 Problem Definition

Robotic rovers designed for exploration and inspection often face rough terrains with rocks, craters, and other irregularities. Traditional wheeled vehicles can experience instability, wheel slippage, or excessive tilt when encountering such obstacles. This instability can lead to compromised data collection, damage to equipment, or the risk of overturning. The rocker-bogie mechanism is designed to address these challenges by providing a suspension system that maintains stability and allows the rover to traverse large obstacles relative to wheel size.

3.3Methodology;

To develop and implement the rocker-bogie mechanism, consider the following steps:

1.Conceptual Design:

- Design the basic structure of the rover, incorporating the rocker-bogie suspension system. The system consists of two sets of links or "rockers" on each side, connected by a differential mechanism (the "bogie").

- Ensure the design allows for independent movement of each rocker, providing flexibility in adapting to terrain variations.

2.Mathematical Modeling and Analysis:

- Develop a mathematical model of the rocker-bogie system to analyze the dynamics and kinematics. Use software tools to simulate the movement of the system over different terrains, calculating angles of tilt, load distribution, and stress on components.

- Analyze the stability and equilibrium conditions of the system, ensuring that it maintains a low center of gravity and minimal tilt during operation.

3.Component Design and Material Selection:

- Design each component of the rocker-bogie system, considering factors such as strength, durability, and weight.

- Select appropriate materials to ensure the system can withstand the harsh environments typically encountered by rovers.

4.Prototyping and Fabrication:

- Build a physical prototype of the rover with the rocker-bogie mechanism. This step involves manufacturing, assembly, and integration of components.

- Incorporate sensors, actuators, and control systems to enable the rover to navigate autonomously.

5. Testing and Validation:

- Test the prototype on various terrains to validate its stability, obstacle-clearing ability, and overall performance. Perform controlled experiments to measure the system's tilt, stability, and ability to traverse obstacles.

- Analyze the test results and identify any areas for improvement in terms of design or performance.

6.Optimization and Iteration:

- Based on test results, optimize the design to improve stability and performance. Make necessary modifications to components or the overall structure.

- Iterate through additional rounds of testing and validation until the desired performance is achieved.

7. Deployment and Field Testing:

- Deploy the final rover in real-world scenarios or environments similar to those it will encounter during its intended use.

- Conduct extensive field testing to ensure the system operates reliably and effectively in practical scenarios.

These steps form a comprehensive methodology for designing, developing, and testing a rocker-bogie mechanism. It aims to create a robust and reliable suspension system for rovers and other applications where stability and terrain adaptability are critical.

CHAPTER: 4 HARDWARE DESCRIPTION

INTRODUCTION

In this chapter the block diagram of the project and design aspect of independent modules are considered. Block diagram is shown in fig: 3.1:

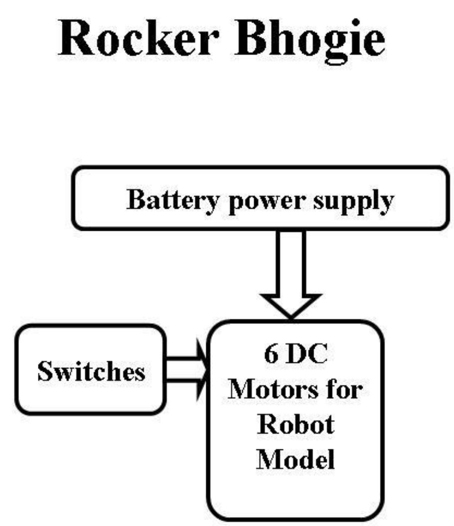


FIG 4.1: Block diagram of Rocker Bogie

The main blocks of this project are:

1. Battery power supply (RPS)

2. Geared DC motor

3. Rocker Bhogi

4.2 12v Rechargeble Battery

A rechargeable battery, storage battery, or accumulator is a type of electrical battery. It comprises one or more electrochemical cells, and is a type of energy accumulator. It is known as a secondary cell because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging frombutton cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of chemicals are commonly used, including: lead–acid,nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

Rechargeable batteries have lower total cost of use and environmental impact than disposable batteries. Some rechargeable battery types are available in the same sizes as disposable types. Rechargeable batteries have higher initial cost but can be recharged very cheaply and used many times.

Usage and applications

Rechargeable batteries are used for automobile starters, portable consumer devices, light vehicles (such as motorized wheelchairs, golf carts, electric bicycles, and electric forklifts), tools, and uninterruptible power supplies. Emerging applications in hybrid electric vehiclesand electric vehicles are driving the technology to reduce cost and weight and increase lifetime.[1]

Traditional rechargeable batteries have to be charged before their first use; newer low self-discharge NiMH batteries hold their charge for many months, and are typically charged at the factory to about 70% of their rated capacity before shipping.

Grid energy storage applications use rechargeable batteries for load leveling, where they store electric energy for use during peak load periods, and for renewable energy uses, such as storing power generated from photovoltaic arrays during the day to be used at night. By charging batteries during periods of low demand and returning energy to the grid during periods of high electrical demand, load-leveling helps eliminate the need for expensive peaking power plants and helps amortizethe cost of generators over more hours of operation.

The US National Electrical Manufacturers Association has estimated that U.S. demand for rechargeable batteries is growing twice as fast as demand for non rechargeables.

Charging and discharging

Further information: Battery charger

During charging, the positive active material is oxidized, producing electrons, and the negative material is reduced, consuming electrons. These electrons constitute the current flow in the external circuit. The electrolyte may serve as a simple buffer for internalion flow between the electrodes, as in lithium-ion and nickel-cadmium cells, or it may be an active participant in the electrochemicalreaction, as in lead–acid cells.

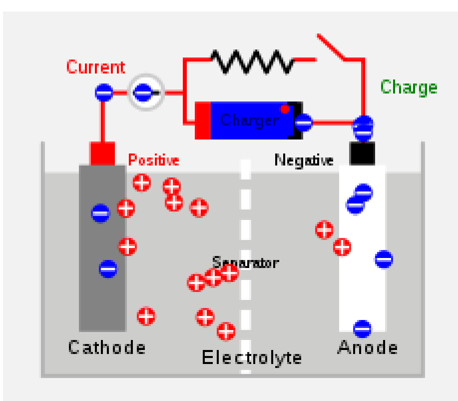


Diagram of the charging of a secondary cell battery

Battery charger

A solar-powered charger for rechargeable AA batteries

The energy used to charge rechargeable batteries usually comes from a battery charger using AC mains electricity, although some are equipped to use a vehicle's 12-volt DC power outlet. Regardless, to store energy in a secondary cell, it has to be connected to a DC voltage source. The negative terminal of the cell has to be connected to the negative terminal of the voltage source and the positive terminal of the voltage source with the positive terminal of the battery. Further, the voltage output of the source must be higher than that of the battery, but not much higher: the greater the difference between the power source and the battery's voltage capacity, the faster the charging process, but also the greater the risk of overcharging and damaging the battery.

Chargers take from a few minutes to several hours to charge a battery. Slow "dumb" chargers without voltage- or temperature-sensing capabilities will charge at a low rate, typically taking 14 hours or more to reach a full charge. Rapid chargers can typically charge cells in two to five hours, depending on the model, with the fastest taking as little as fifteen minutes. Fast chargers must have multiple ways of detecting when a cell reaches full charge (change in terminal voltage, temperature, etc.) to stop charging before harmful overcharging or overheating occurs. The fastest chargers often incorporate cooling fans to keep the cells from overheating.

Battery charging and discharging rates are often discussed by referencing a "C" rate of current. The C rate is that which would theoretically fully charge or discharge the battery in one hour. For example, trickle charging might be performed at C/20, while typical charging and discharging may occur at C/2. (In practice, charging and discharging batteries incurs losses, so the "C" rate is more of an approximation.) In general, the higher the current relative to battery capacity, the worse the effective storage capacity and overall life of the battery will be Flow batteries, used for specialised applications, are recharged by replacing the electrolyte liquid.

Battery manufacturers' technical notes often refer to VPC; this is volts per cell, and refers to the individual secondary cells that make up the battery. (This is typically in reference to 12-volt lead-acid batteries.) For example, to charge a 12 V battery (containing 6 cells of 2 V each) at 2.3 VPC requires a voltage of 13.8 V across the battery's terminals.

Non-rechargeable alkaline and zinc–carbon cells output 1.5V when new, but this voltage drops with use. Most NiMH AA and AAA cells are rated at 1.2 V, but have a flatter discharge curve than alkalines and can usually be used in equipment designed to use alkaline batteries.

Reverse charging

Subjecting a discharged cell to a current in the direction which tends to discharge it further, rather than charge it, is called reverse charging; this damages cells. Reverse charging can occur under a number of circumstances, the two most common being:

- When a battery or cell is connected to a charging circuit the wrong way around.
- When a battery made of several cells connected in series is deeply discharged.

When one cell completely discharges ahead of the rest, the remaining cells will force the current through the discharged cell. Instead of supplying a forward voltage to the load, the discharged cell becomes part of the load and presents a reverse voltage to the rest of the circuit. This is known as "cell reversal", and can happen even to a weak cell that is not fully discharged. If the battery drain current is high enough, the weak cell's internal resistance can create a reverse voltage that is greater than the cell's remaining internal forward voltage. This results in the reversal of the weak cell's polarity while the current is flowing through the cells.[3][4] "Pushing" current through a discharged cell causes undesirable and irreversible chemical reactions to occur, resulting in permanent damage to the cell. The higher the required discharge rate of the battery, the better matched the cells should be, both in kind of cell and state of charge, in order to reduce the chances of one cell completely discharging before the others. Also, many battery-operated devices have a low-voltage cutoff that prevents deep discharges from occurring that might cause cell reversal.

In critical applications using Ni-Cad batteries, such as in aircraft, each cell is individually discharged by connecting a load clip across the terminals of each cell, thereby avoiding cell reversal, then charging the cells in series.[citation needed]

Depth of discharge

Main article: Depth of discharge

Depth of discharge (DOD) is normally stated as a percentage of the nominal ampere-hour capacity; 0% DOD means no discharge. Seeing as the usable capacity of a battery system depends on the rate of discharge and the allowable voltage at the end of discharge, the depth of discharge must be qualified to show the way it is to be measured. Due to variations during manufacture and aging, the DOD for complete discharge can change over time or number of charge cycles. Generally a rechargeable battery system will tolerate more charge/discharge cycles if the DOD is lower on each cycle.[5]

Table of rechargeable battery types

Type	Voltage[a]	Energy density[b]			Power[c]	Effi.[d]	E/$[e]	Disch.[f]	Cycles[g]	Life[h]
	(V)	(MJ/kg)	(Wh/kg)	(Wh/L)	(W/kg)	(%)	(Wh/$)	(%/month)	(#)	(years)
Lead–acid	2.1	0.11-0.14	30-40	60-75	180	70%-92%	5-8	3%-4%	500-800	5-8 (automotive battery), 20 (stationary)
Alkaline	1.5	0.31	85	250	50	--	7.7	<0.3	100-1000	<5

Nickel–iron	1.2	0.18	50		100	65%	5-7.3[6]	20%-40%		50+
Nickel–cadmium	1.2	0.14-0.22	40-60	50-150	150	70%-90%	1.25-2.5[6]	20%	1500	
Nickel–hydrogen	1.5	0.27	75	60	220	85%			20,000+	15+ (satellite application with frequent charge-discharge cycles)
Nickel–metal hydride	1.2	0.11-0.29	30-80	140-300	250-1000	66%	2.75	30%	500-1000	
Nickel–zinc	1.7	0.22	60	170	900		2-3.3		100-500	
Lithium-air	2.7	7.2	2000	2000	400				~100	

(organic)[7]										
Lithium-ion	3.6	0.58	150-250	250-360	1800	99%+[citation needed]	2.8-5[8]	5%-10%	1200-10000	2-6
Lithium-ion polymer	3.7	0.47-0.72	130-200	300	3000+	99.8%[citation needed]	2.8-5.0	5%	500~1000	2-3
Lithium iron phosphate	3.25	0.32-0.4	80-120	170[citation needed]	1400	93.5%	0.7-3.0		2000+[9]	>10

Common rechargeable battery types:

Nickel–cadmium battery (NiCd)

Created by Waldemar Jungner of Sweden in 1899, it used nickel oxide hydroxide and metallic cadmium as electrodes. Cadmium is a toxic element, and was banned for most uses by the European Union in 2004. Nickel–cadmium batteries have been almost completely superseded by nickel–metal hydride (NiMH) batteries.

Nickel–metal hydride battery (NiMH)

First commercial types were available in 1989.[20] These are now a common consumer and industrial type. The battery has a hydrogen-absorbing alloy for the negative electrode instead of cadmium.

Lithium-ion battery

The technology behind the lithium-ion battery has not yet fully reached maturity. However, the batteries are the type of choice in many consumer electronics and have one of the best energy-to-mass ratios and a very slow loss of charge when not in use.

Lithium-ion polymer battery

These batteries are light in weight and can be made in any shape desired.

Less common types:

Lithium sulfur battery:

A new battery chemistry developed by Sion Power since 1994.[21] Claims superior energy to weight than current lithium technologies on the market. Also lower material cost may help this product reach the mass market.[22]

Thin film battery (TFB):

An emerging refinement of the lithium ion technology by Excellatron The developers claim a very large increase in recharge cycles, around 40,000 cycles. Higher charge and discharge rates. At least 5C charge rate. Sustained 60C discharge, and 1000Cpeak discharge rate. And also a significant increase in specific energy, and energy density. Also Infinite Power Solutions makes thin film batteries (TFB) for micro-electronic applications, that are flexible, rechargeable, solid-state lithium batteries.

Smart battery

A smart battery has the voltage monitoring circuit built inside. See also: Smart Battery System

Carbon foam-based lead acid battery

Firefly Energy has developed a carbon foam-based lead acid battery with a reported energy density of 30-40% more than their original 38 W·h/kg, with long life and very high power density.

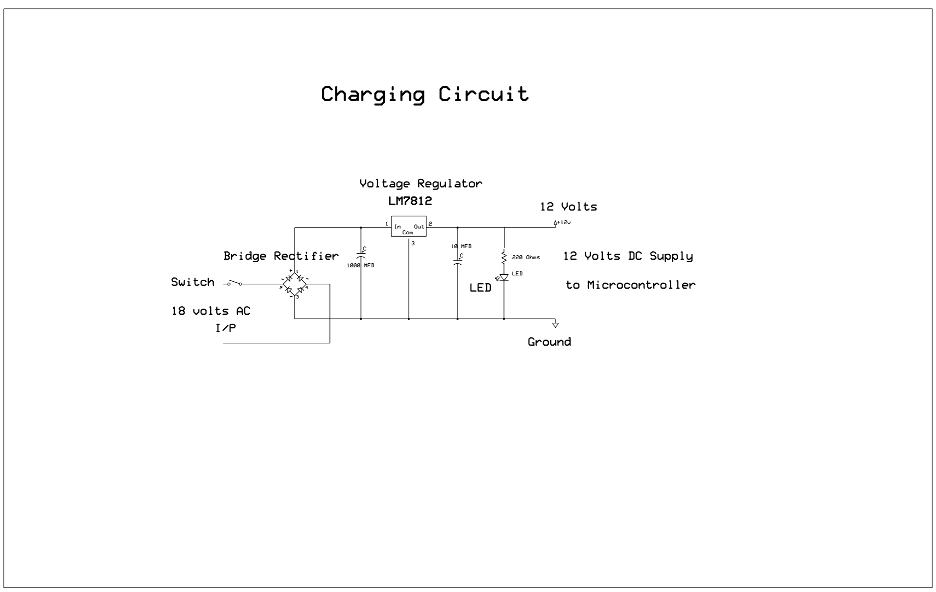
Potassium-ion battery

This type of rechargeable battery can deliver the best known cycleability, in order of a million cycles, due to the extraordinary electrochemical stability of potassium insertion/extraction materials such as Prussian blue.

Sodium-ion battery

This type is meant for stationary storage and competes with lead–acid batteries. It aims at a very low total cost ownership per kWh of storage. This is achieved by a long and stable lifetime. The number of cycles is above 5000 and the battery does not get damage by deep discharge. The energy density is rather low, somewhat lower than lead–acid

Charging Circuit:



From the above circuit diagram, we can see that the 18v AC is being converted to 18V pulsating DC which is in turn converted to smooth DC with the help of the Capacitor. This 18V Smooth DC is converted to 12V DC by the Voltage Regulator 7812. At the output of the regulator, we get some spikes which are not desirable.

These spikes are removed with the help of another capacitor used. We can get 12V Steady DC at the output terminal which can be indicated if the LED glows.

4.3 D.C. Motor:

A dc motor uses electrical energy to produce mechanical energy, very typically through the interaction of magnetic fields and current-carrying conductors. The reverse process, producing electrical energy from mechanical energy, is accomplished by an alternator, generator or dynamo. Many types of electric motors can be run as generators, and vice versa. The input of a DC motor is current/voltage and its output is torque (speed).

Fig 3 DC Motor

The DC motor has two basic parts: the rotating part that is called the armature and the stationary part that includes coils of wire called the field coils. The stationary part is also called the stator. Figure shows a picture of a typical DC motor, Figure shows a picture of a DC armature, and Fig shows a picture of a typical stator. From the picture you can see the armature is made of coils of wire wrapped around the core, and the core has an extended shaft that rotates on bearings. You should also notice that the ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the commutator, and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine.

Operation:

The DC motor you will find in modem industrial applications operates very similarly to the simple DC motor described earlier in this chapter. Figure 12-9 shows an electrical diagram of a simple DC motor. Notice that the DC voltage is applied directly to the field winding and the brushes. The armature and the field are both shown as a coil of wire. In later diagrams, a field resistor will be added in series with the feild to control the motor speed.

When voltage is applied to the motor, current begins to flow through the field coil from the negative terminal to the positive terminal. This sets up a strong magnetic field in the field winding. Current also begins to flow through the brushes into a commutator segment and then through an armature coil. The current continues to flow through the coil back to the brush that is attached to other end of the coil and returns to the DC power source. The current flowing in the armature coil sets up a strong magnetic field in the armature.

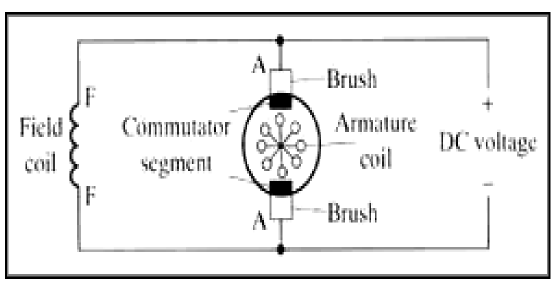


Fig 3. Simple electrical diagram of DC motor

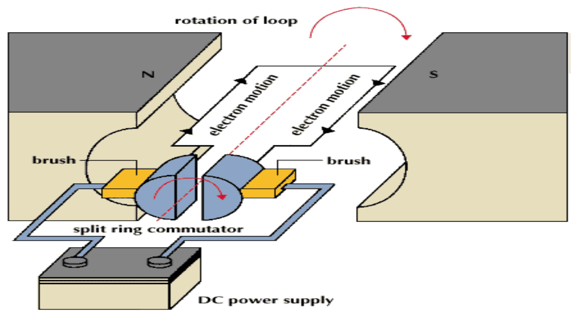


Fig 3 Operation of a DC Motor

The magnetic field in the armature and field coil causes the armature to begin to rotate. This occurs by the unlike magnetic poles attracting each other and the like magnetic poles repelling each other. As the armature begins to rotate, the commutator segments will also begin to move under the brushes. As an individual commutator segment moves under the brush connected to positive voltage, it will become positive, and when it moves under a brush connected to negative voltage it will become negative. In this way, the commutator segments continually change polarity from positive to negative. Since the commutator segments are connected to the ends of the wires that make up the field winding in the armature, it causes the magnetic field in the armature to change polarity continually from north pole to south pole. The commutator segments and brushes are aligned in such a way that the switch in polarity of the armature coincides with the location of the armature's magnetic field and the field winding's magnetic field. The switching action is timed so that the armature will not lock up magnetically with the field. Instead the magnetic fields tend to build on each other and provide additional torque to keep the motor shaft rotating.

When the voltage is de-energized to the motor, the magnetic fields in the armature and the field winding will quickly diminish and the armature shaft's speed will begin to drop to zero. If voltage is applied to the motor again, the magnetic fields will strengthen and the armature will begin to rotate again.

Types of DC motors:

1. DC Shunt Motor,

2. DC Series Motor,

The rotational energy that you get from any motor is usually the battle between two magnetic fields chasing each other. The DC motor has magnetic poles and an armature, to which DC electricity is fed, The Magnetic Poles are electromagnets, and when they are energized, they produce a strong magnetic field around them, and the armature which is given power with a commutator, constantly repels the poles, and therefore rotates.

1. The DC Shunt Motor:

In a 2 pole DC Motor, the armature will have two separate sets of windings, connected to a commutator at the end of the shaft that are in constant touch with carbon brushes. The brushes are static, and the commutator rotate and as the portions of the commutator touching the respective positive or negative polarity brush will energize the respective part of the armature with the respective polarity. It is usually arranged in such a way that the armature and the poles are always repelling.

The general idea of a DC Motor is, the stronger the Field Current, the stronger the magnetic field, and faster the rotation of the armature. When the armature revolves between the poles, the magnetic field of the poles induce power in the armature conductors, and some electricity is generated in the armature, which is called back emf, and it acts as a resistance for the armature. Generally an armature has resistance of less than 1 Ohm, and powering it with heavy voltages of Direct Current could result in immediate short circuits. This back emf helps us there.

When an armature is loaded on a DC Shunt Motor, the speed naturally reduces, and therefore the back emf reduces, which allows more armatures current to flow. This results in more armature field, and therefore it results in torque.

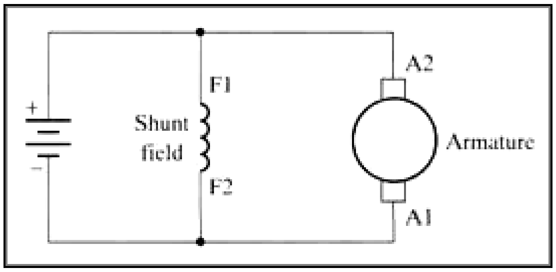


Fig: Diagram of DC shunt motor

When a DC Shunt Motor is overloaded, if the armature becomes too slow, the reduction of the back emf could cause the motor to burn due to heavy current flow thru the armature.

The poles and armature are excited separately, and parallel, therefore it is called a Shunt Motor.

2. The DC Series Motor:

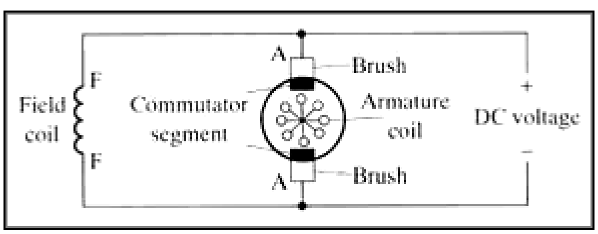


Fig: Diagram of DC series motor

A DC Series Motor has its field coil in series with the armature. Therefore any amount of power drawn by the armature will be passed thru the field. As a result you cannot start a Series DC Motor without any load attached to it. It will either run uncontrollably in full speed, or it will stop.

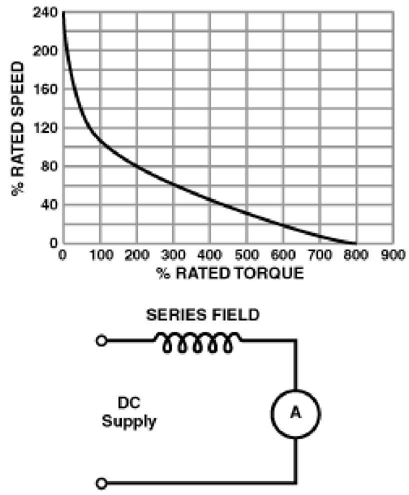


Fig: Diagram of DC series motor graph representation

When the load is increased then its efficiency increases with respect to the load applied. So these are on Electric Trains and elevators.

4.4 Rocker-bogie

The Rocker-Bogie design has no springs and stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity. Systems using springs tend to tip more easily as the loaded side yields. The system is designed to be used at slow speeds of around 10 cm/s, so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

The Rocker-Bogie system has been the suspension arrangement used in the Mars rovers. It is currently NASA's favored design.

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.

Types Of Joints

Robots using rocker bogie mechanism make use of a suspension mechanism that consists of several rigid elements connected through joints of a certain number of degrees of freedom (DoF) resulting in a structure that has one system DoF. This enables them to move along uneven terrain without losing contact with the ground. Following table represents 3 such possible joints:

The suspension has 6 wheels with symmetric structure for both sides.Each side has 3 wheels which are connected to each other with two links. The main linkage called rocker has 2 joints. while first joint connected to front wheel, another joint assembled to another linkage called bogie, which is similar to train wagon suspension member.

Advantages:

- Load on each wheel is nearly identical
- Has no axles or springs which helps to maintain equal traction force on all the wheels.
- Can climb over blocks twice the height of the wheel while keeping all 6 wheels on the ground
- Each wheel can individually lift almost the entire mass.

As with any suspension system, the tilt stability is limited by the height of the center of gravity.

Inflatable Rover

The **rocker-bogie** system is the suspension arrangement used in the Mars rovers (mechanical robot) introduced for the Mars Pathfinder and also used on the Mars Exploration Rover (MER) and Mars Science Laboratory (MSL) missions.[1][2][3] It is currently NASA's favored design.[4]

The term “rocker” comes from the rocking aspect of the larger links[clarification needed] on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through adifferential. 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. Bogies were commonly used as load wheels in the tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi trailer trucks. Both applications now prefer trailing arm suspensions.

Design

The rocker-bogie design has no springs or stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity. Systems using springs tend to tip more easily as the loaded side yields. Based on the center of mass, the *Curiosity* rover of the Mars Science Laboratory mission can withstand a tilt of at least 50 degrees in any direction without overturning, but automatic sensors limit the rover from exceeding 30-degree tilts.[5] The system is designed to be used 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.

JPL states that this rocker bogie system reduces the motion of the main MER vehicle body by half compared to other suspension systems. Each of the rover's six wheels has an independent motor. The two front and two rear wheels have individual steering motors which allow the vehicle to turn in place. Each wheel also has cleats, providing grip for climbing in soft sand and scrambling over rocks. The maximum speed of the robots operated in this way is limited to eliminate as many dynamic effects as possible so that the motors can be geared down, thus enabling each wheel to individually lift a large portion of the entire vehicle's mass.

In order to go over a vertical obstacle face, the front wheels are forced against the obstacle by the center and rear wheels. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle. The middle wheel is then pressed against the obstacle by the rear wheels 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, forward progress of the vehicle is slowed or completely halted. This is not an issue for the operational speeds at which these vehicles have been operated to date.

One of the future applications of rovers will be to assist astronauts during surface operations. To be a useful assistant, the rover will need to be able to move much faster than human walking speed or at least equivalent. Other missions which have been proposed, such as the Sun-Synchronous Lunar Rover, require even greater speeds (4–10 km/h).

Wheels and Legs

The rover's wheels and "legs"

The Mars Science Laboratory has six wheels, each with its own individual motor.

The two front and two rear wheels also have individual steering motors (1 each). This steering capability allows the vehicle to turn in place, a full 360 degrees. The 4-wheel steering also allows the rover to swerve and curve, making arching turns.

How the Wheels Move

Big Wheels Cross The Finish Line...for Now!

One of the black, cleated wheels of the Mars Science Laboratory rover.

The design of the suspension system for the wheels is based on heritage from the "rocker-bogie" system on the Pathfinder and Mars Exploration Rover missions. The suspension system is how the wheels are connected to and interact with the rover body.

The term "bogie" comes from old railroad systems. A bogie is a train undercarriage with six wheels that can swivel to curve along a track.

The term "rocker" comes from the design of the differential, which keeps the rover body balanced, enabling it to "rock" up or down depending on the various positions of the multiple wheels. Of most importance when creating a suspension system is how to prevent the rover from suddenly and dramatically changing positions while cruising over rocky terrain. If one side of the rover were to travel over a rock, the rover body would go out of balance without a "differential" or "rocker," which helps balance the angle the rover is in at any given time. When one side of the rover goes up, the differential or rocker in the rover suspension system automatically makes the other side go down to even out the weight load on the six wheels. This system causes the rover body to go through only half of the range of motion that the "legs" and wheels could potentially experience without a "rocker-bogie" suspension system.

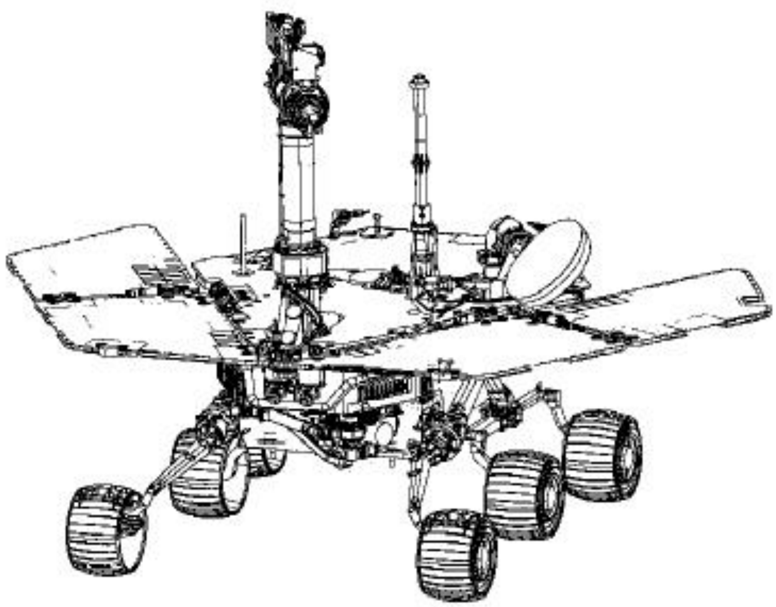
The rover is designed to withstand a tilt of 45 degrees in any direction without overturning. However, the rover is programmed through its "fault protection limits" in its hazard avoidance software to avoid exceeding tilts of 30 degrees during its traverses.

The rover rocker-bogie design allows the rover to go over obstacles (such as rocks) or through holes that are more than a wheel diameter (50 centimeters or about 20 inches) in size. Each wheel also has cleats, providing grip for climbing in soft sand and scrambling over rocks.

Rover Speed The rover has a top speed on flat hard ground of 4 centimeters per second

Reading the Rover's Tracks

The straight lines in Curiosity's zigzag track marks are Morse code for JPL, which is short for NASA's Jet Propulsion Laboratory in Pasadena, Calif., where the rover was built and the mission is managed.

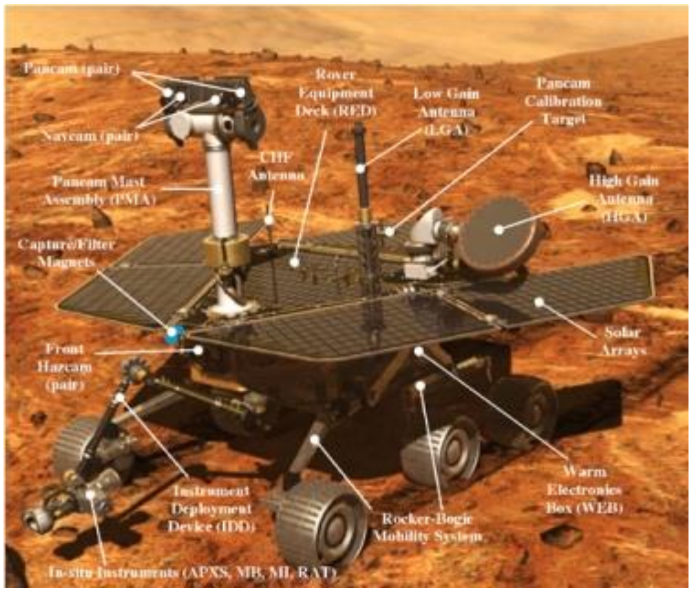


Preface

This page is the outgrowth of a growing frustration with the paucity of flight hardware and software details that NASA/JPL have released about the MER. In an attempt to learn more about the operational parameters of these two fine pieces of machinery, this page has been created to serve as a running notepad for myself, and hopefully will be of interest to others (especially the crew on irc.freenode.net's #maestro channel.

2. High level MER hardware specifications

2.1 MER Hardware features



2.2 Major Dimensions

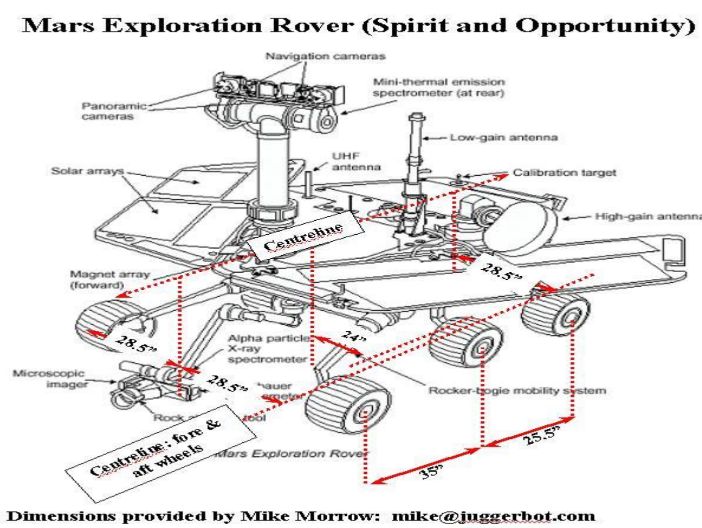


Image courtesy of Mike Morrow

- Height: 1.5m / 4.9 ft (inc. deployed PMA)
- Width: 2.3m / 7.5 ft
- Length: 1.6m / 5,2 ft
- Mass: 174 kg / 384 lb : However, this may not be quite correct. According to Design and Verification of the MER Primary Payload, the total mass of the Mars Exploration Rover is 180.1 kg. Of this, the mass of the Rover WEB is 145.6 kg, and the mass of Rover mobility components (e.g. wheels, rocker-bogie suspension) is 34.5 kg.

2.3 Power

Solar panel power generation, with Li-ion battery storage, providing 140w peak on surface.

2.4 Science instruments, aka Athena Package :

- Panoramic cameras
- Miniature thermal emission spectrometer (mini-TES)
- Mossbauer spectrometer (MB)
- Alpha particle X-ray spectrometer (APXS)
- Microscopic imager (MI)
- Rock abrasion tool (RAT)
- Magnet arrays

2.5Cameras:

- Dual front hazcams (hazard detection and avoidance cameras)
- Dual rear hazcams
- Dual navcams (navigational cameras)
- Dual pancam (high resolution panoramic camera)

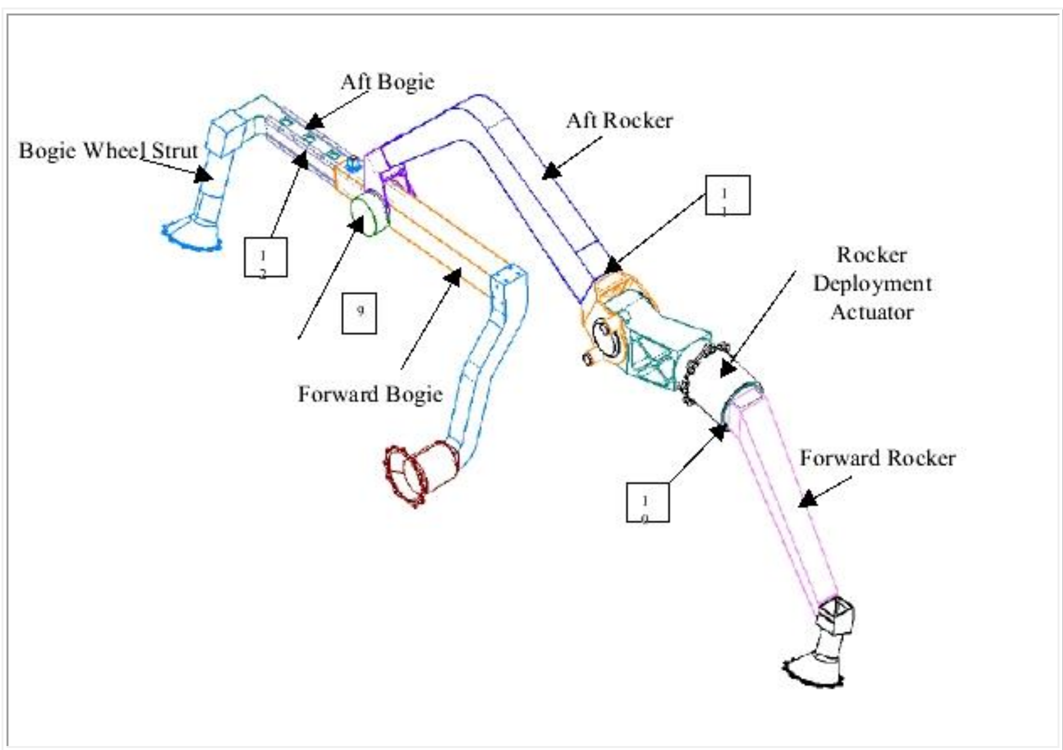
2.6Antennae:

- High Gain Antenna (HGA)
- Low Gain Antenna (LGA)
- UHF Antenna

2.7 Major MER structural components

- **Pancam Mast Assembly (PMA)**
- **Rover Equipment Deck (RED)**
- **Warm Electronics Box (WEB)**
- **Solar Arrays**
- **Instrument Deployment Device (IDD)**
- **Rocker-Bogie Mobility System**

2.8 Rocker Bogie Mobility System Components



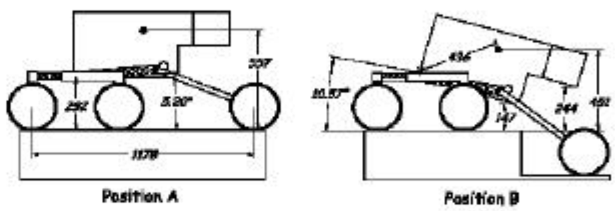
One side of the RB system, with primary structural and mechanical components illustrated.

The MER provides a separate RB system for the left and right wheels. Each RB consists of a forward and aft bogie, to which are attached corresponding forward and aft bogie wheel struts. The end of each wheel strut provides an attachment point for a drive motor and wheel assembly. The aft bogie structure slides into the forward bogie's structural cavity, and is secured to the FB by way of a square bolt, which can be inserted into one of four available positioning holes. The aft rocker arm is affixed to the forward bogie, near the AB/FB attach point through a hinge and actuator assembly. A U shaped adapter bracket fits onto the other end of the AR. The bracket holds a structural member that provides a mount for the Rocker Deployment Actuator, which permits the forward bogie that it's attached to to be rotated around the longitudinal axis of the rover. The end of the forward bogie has an attach point for a drive motor and wheel assembly.

2.9 Rocker-Bogie Specifications

Structural material	CNC machined titanium
Maximum tilt angle (about lateral axis)	45 degrees
Maximum tilt angle (about longtudinal axis)	45 degrees
Maximum forward wheel drop (tested)	25 cm
Rated mobility load	3.4g with an angular velocity (alpha) of 82 rad/sec^2 (this

(wheel drop, suspended mass)	is probably at the forward rocker/aft bogie hinge point, but the document isn't clear)



Schematic illustrating 25 cm forward wheel drop test

MARS ROVER ROCKER-BOGIE DIFFERENTIAL

Today's is a guest post, brought to you by my father, engineer, physicist, computer programmer, and Lego, Mars, and animation enthusiast: **Keith Enevoldsen**. If you're not caught by the title of the post, scroll down and look at the pictures… then scroll back up

and read the rest of the article because it is fascinating stuff! (P.S. He has a website full of awesome science stuff too!)

The Rocker-Bogie

All the Mars rovers have six wheels and use a rocker-bogie suspension system to drive smoothly over bumpy ground. The rocker-bogies are easy to see in pictures of the rovers (see pictures below). There is one rocker-bogie assembly on each side of the rover. The rocker is the larger link that connects to the rover body (the chassis) in the middle (at the rocker pivot), has a wheel on the front, and connects to the bogie in the back. The bogie is the smaller link that connects to the rocker in the middle (at the bogie pivot), and has wheels at both ends. Each of the six wheels has its own motor.

Tail

The backside of the rover is less crowded with instruments than other parts of the rover. The power source is the main feature, giving electrical power to allow the rover to perform all of its functions. Since the rover may at times move in reverse, hazard avoidance cameras showing the ground view are important (and help with driving at all times).

Mission name: Mars Science Laboratory

Rover name: Curiosity rover

Size: About the size of a small SUV -- 10 feet long (not including the arm), 9 feet wide and 7 feet tall -- (about 3 meters long (not including the arm), 2.7 meters wide, and 2.2 meters tall), or about the height of a basketball player.

Arm Reach: About 7 feet (2.2 meters)

Weight: 900 kilograms (2,000 pounds)

Features: Geology lab, rocker-bogie suspension, rock-vaporizing laser and lots of cameras

Mission: To search areas of Mars for past or present conditions favorable for life, and conditions capable of preserving a record of life

Launched:
7:02 a.m. PST, Nov. 26, 2011 (10:02 a.m. EST)

Landed:
10:32 p.m. PDT, Aug. 5, 2012 (1:32 a.m. EDT, Aug. 6, 2012)

Length of mission on Mars: The prime mission will last one Mars year or about 23 Earth months.

Follow Your Curiosity: Participate

Mission Fact sheet: Download theMars Science Laboratory Fact Sheet (PDF, 1.44 MB)

CHAPTER 5: PROJECT DESCRIPTION ,RESULTS, CONCLUSION, FUTURE PROSPECTS

5.1: PROJECT DESCRIPTION:

In this chapter, schematic diagram and interfacing of components to DC motor, battery,

Brushes,areconsidered

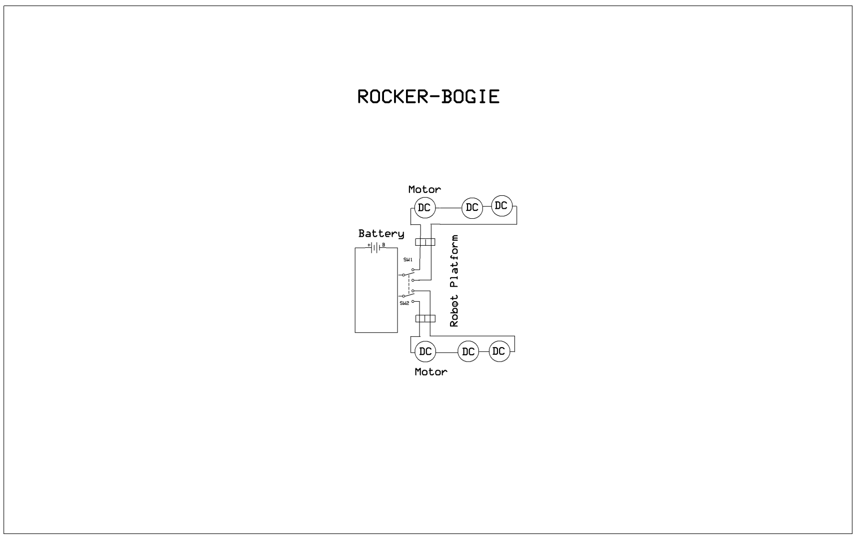
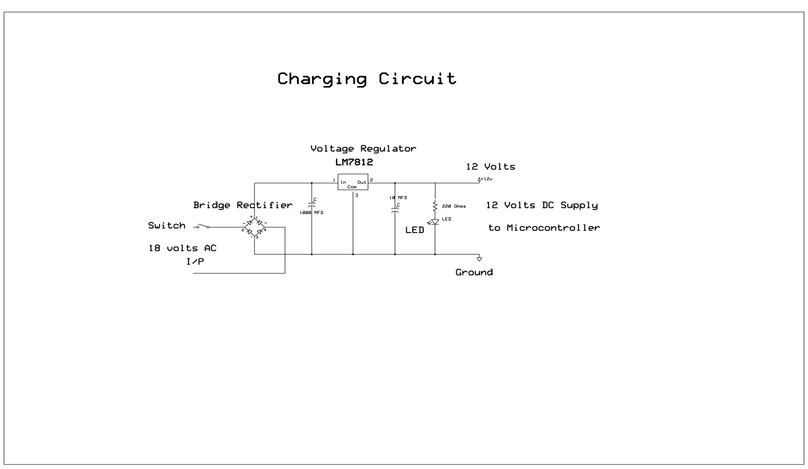


Fig 5.1: schematic diagram of ROCKER BOGIE

Charging Circuit:



From the above circuit diagram, we can see that the 18v AC is being converted to 18V pulsating DC which is in turn converted to smooth DC with the help of the Capacitor. This 18V Smooth DC is converted to 12V DC by the Voltage Regulator 7812. At the output of the regulator, we get some spikes which are not desirable. These spikes are removed with the help of another capacitor used. We can get 12V Steady DC at the output terminal which can be indicated if the LED glows.

5.2 RESULTS:

The project “RCKER BOGIE ” The Rocker-Bogie design has no springs and stub axles for each wheel, allowing the rover to climb over obstacles, such as rocks, that are up to twice the wheel’s diameter in size while keeping all six wheels on the ground. As with any suspension system, the tilt stability is limited by the height of the center of gravity. Systems using springs tend to tip more easily as the loaded side yields. The system is designed to be used at slow speeds of around 10 cm/s, so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

CHAPTER 6: CONCLUSION

Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Thus the project has been successfully designed and tested.

5.4 Future Scope:

Our project “**ROCKER BOGIE”** is mainly intended to design a robot.

The system makes use of robotic model with the motorized mechanism is attached to the Dc motors interfaced with robot platform, Rechargeable battery, buttons.

In this project we use a robot model which can control in four directions using buttons through DC motors interfaced to it. The controlling device of the whole system is battery power supply and DC motors interfaced with the brushes.

The drawback of this project is that the status of robot is not known. This can eliminate by having a GSM module, which gives the status of robot working. We can also add Ultrasonic module, which is used for obstacle detection with GSM module which gives respective information about the rocker along with container information wither it is empty or filled. Were can also interfaced wireless remote control through which the system can be movable and controlled through remote mechanism.

By connecting wireless camera to the robot, then we can see the outer world from our personal computer only by using GPRS and GPS. We can use this robot at so many fields and we can use to handle so many situations.

By connecting temperature sensor to the robot we can get the temperature of dangerous zones in personal computer itself instead of sending human to there and facing problems at field we can send robot to there and sensor will detect the temperature and it gives information to the micro controller and micro controller gives the information to the transceiver from that we can get the data at pc side. By connecting smoke sensor to the robot we can get the information related concentration of smoke or gases in respective field’s i.e. (coal mines, dangerous zones, etc). sensor sense the information and it give to the micro controller and it gives to the transceiver and from that we get the information in personal computer.

By connecting corresponding instruments to the robot we can use it in agriculture for farming purpose. This robot can move either forward and backward and left and right depend upon our instructions so we can do some part of agriculture from pc only by using robot.

REFERENCES

The sites which were used while doing this project:

1. www.wikipedia.com

2. www.electronicforu.com

3. www.allaboutcircuits.com

Books referred:

1. Electronics for You- Garrett - OKM - Minelab Authorised

2. Basic Skills: Electronics by Tom Duncan

3. Electronics-A First Course by Owen Bishop