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Design and fabrication of a radio-controlled mini rover with audio-visual sensors, suspension and four-wheel steering

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ABSTRACT

The use of an electronic vehicle in perilous areas, even in the absence of human intervention in providing the view of the location is a requirement. We, therefore, intend to provide a solution by fabricating a mini-rover that has the capability of monitoring the ambience of a place providing the First-Person View. Rover is radio controlled with a range of 200m distance using a specialized transmitter or remote and at the same time, Sensors send the audio and video received by the rover. The camera and microphone uploads data using IP address or Internet while the controller transmits at 2.4 GHz Radiofrequency. The rover is equipped with microcontrollers, camera, Li-Po battery, microphone, Servo motor and DC motors which enables it to travel up to 25kmph. Moreover, having Suspension makes the vehicle attain greater stability. Alongside it has four wheels steering with a range of 60° which enables precise manoeuvring. The project involves design, fabrication and pictorial demonstration of the above-said mini-rover.

Keywords— *RC car, Made from scratch, Non-independent type suspension, Four wheel steering, and, 5 Volts, Fly-Sky CT6B, Tower Pro SG90 6g Servo Motor, OTG*

1. INTRODUCTION TO DESIGN

Radio controlled (or) R/C cars are battery/gas-powered model cars that can be controlled from a distance using a specialized transmitter or remote. The term "R/C" has been used to mean both "remote controlled" and "radio controlled", where "remote controlled" includes vehicles that are connected to their controller by a wire, but common use of "R/C" today usually refers to vehicles controlled by a radio-frequency link[8].

1.1 Principal of Operation

- Transmitters send radio waves or electromagnetic frequencies to an RC car or another remote-controlled device. The operator moves the controls on his remote-control radio.
- The transmitter talks to the receiver via the radio carrier wave. The receiver can be a circuit board with internal antennas or a larger antenna on the exterior of the remote-controlled car.
- Any radio signals coming from the transmitter end up at the receiver. The receiver then converts these signals for the servo motor.
- The receiver transforms all radio signal broadcasts received from the transmitter into the suitable electronic signals that are required for all other components within the control system.
- Many of the available systems apply the amplitude modulation for the radio signals, and then they encode positions using pulse width modulation.
- The radio is wired up to either electronic speed controls or servomechanisms which perform actions such as throttle control, braking, steering, Electronic speed controls, and servos are commanded by the receiver through pulse width modulation; pulse duration sets either the amount of current that an electronic speed control allows flowing into the electric motor or sets the angle of the servo.

- On the models the servo is attached to at least the steering mechanism, rotation of the servo is mechanically changed into a force which steers the wheels on the model, generally through adjustable turnbuckle linkages.
- Rotation of the servo in the other direction causes torque to be applied to a piece which causes friction with the braking material.

Chassis: The rectangular, usually aluminum or mild steel frame, supported on springs and attached to the axles, that holds the body and motor of a radio-controlled car. The chassis should be light in weight; strong and also able hold all the body components.

1.2 Design overview

This project consists of two main components: A transmitting controller unit and a receiving microcontroller. Each of these two components is part of the communication medium. In this case radio-controlled operation. Therefore, this project comprises of three main modules. A controller circuitry to generate signals to be transmitted, a receiver medium to process the generated signals from controller to car and the motor circuitry to transform the received signal into a voltage able to drive the motors.

1.2.1 Mechanical design of the car

- The rectangular sheet, made with mild steel, supported on springs and attached to the axles, that holds the body and motor.
- Sheet metal was used to fabricate rover chassis by considering the centre of gravity and balancing the suspension.
- The chassis is light in weight and strong which enables to hold all the body components.
- This project consists of two main components: A transmitting controller circuit and a receiving unit. Each of these two parts has part of a communication medium:
  - Magnetic Waves (Wi-Fi)
  - Radio Frequency
- Four low R.P.M high torque servo motors were mounted on both axles.
- In this model, each servo motor is attached to all the wheels.
- The steering mechanism is operated by links attached to the servo motor and the motors knuckle joint which results steer the wheels on the model.

The design of the ROVER was done by using Auto CAD & CATIA V5 software. After the successful design of the car, it was set for fabrication where chassis, steering arms, shock towers, etc. were fabricated. Finally, after fabrication and assembly, the car was set to run.

2. SPECIFICATIONS OF PROTOTYPE

2.1 Configuration

The mini rover was designed in such a way that it can be easily assembled or disassembled as and when required the mini-rover was made using complex assembly by using steel, metal bolts so, it can be easily dismantled.

Most of the components of the prototype are chosen such that they are readily available in the market so as to reduce the overall costs incurred and they are categorized broadly into:

- Mechanical components
- Electrical components

2.2 Mechanical Components

2.2.1 Steering

2.2.1.1 Steering Links: instead of using steering rod a steering mechanism is designed used sheet metal links with rectangular cross section this has been done to reduce cost.

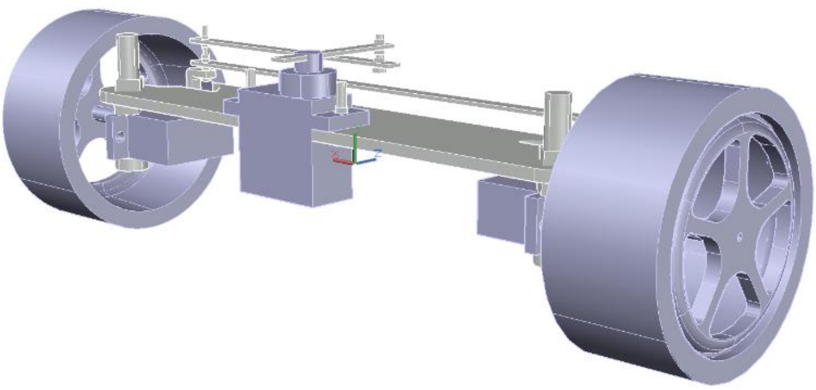


Fig. 2.1: CAD model of steering links

2.2.1.2 Steering Mechanism

- Four-wheel steering Mechanism (also called Rear Wheel steering Mechanism)
- Steering angle – 25°
- Separate servomotors are used to steer front and rear axles
- Four-wheel steering is a method developed for the effective turning of the vehicle and to increase the maneuverability [3]

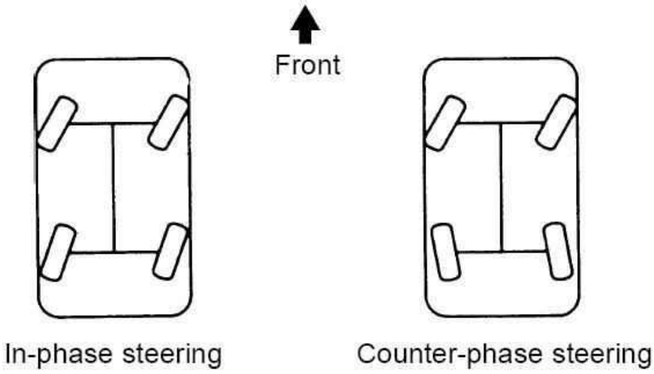


Fig. 2.2: Figure depicting different steering movements [2]

2.2.1.3 Steering system

The basic function of this system is to steer the car in the desired direction without putting much effort by the diver. This can be achieved by following some specific geometry while installing the wheels and parts attached to the wheels. Steering geometry is the mechanics of keeping the front wheels in proper relative alignment as the wheels are turned. It describes the angular relationship between front wheels and parts attached to front wheels and the car frame. Factors that to be considered for steering are Steering stability, Tyre wears and steering comfort of the car. Thus, the steering depends on following factors [2].

(a) Camber: The outward tilt of the front wheels from the vertical plane at the top is called Positive camber. If the wheels are tilted inward then it is called 'Negative camber', in this case, the reaction force on the wheels, which act through kingpin, creates some bending action on the pivots. If the wheels are cambered, when the vehicle is loaded, the load will tend to bring the wheels near the vertical position.

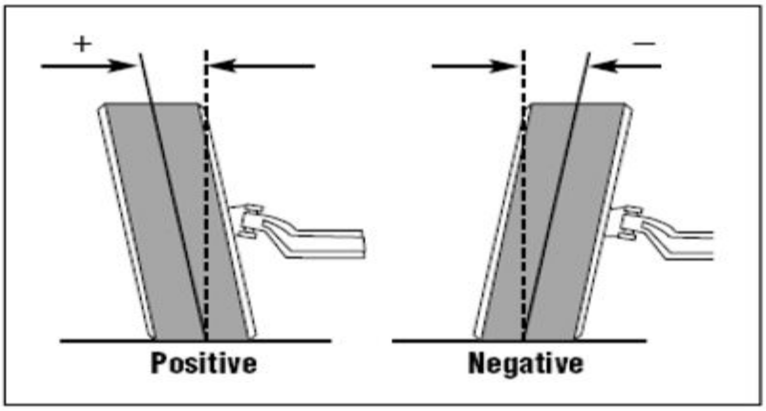


Fig. 2.3: Positive and Negative Camber [2]

(b) Caster: It is the angle of inclination between the king pin axis and wheel vertical axis in side view. The backward tilt of kingpin from the vertical axis is called Positive caster and forward tilt in the same plane is called Negative caster. If the caster is not provided then the axle is horizontal with the kingpin vertical, the weight of the vehicle will be directly acting above the contact point then the wheels would wonder which leads to lack of steering stability. By providing caster, wheels wandering action is prevented and vehicle load is made to move ahead of the contact point causing the run to be straight even after the turn.

(c) King Pin Inclination: King pin inclination is the angle between king pin and vertical axis from the vehicle front view. This also provides direction stability along with caster. It also reduces excess camber and provides self-centring action.

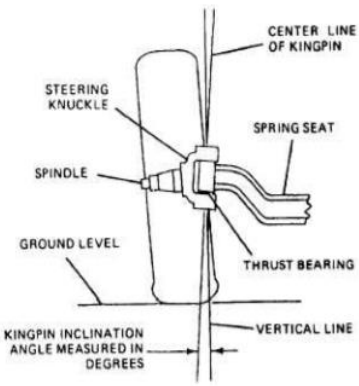


Fig. 2.4: King Pin Inclination

(d) Toe'in and Toe' out: From the top view, if the front part of wheels is pointing outward and back part inward then it is called toe out. During turns, the inner wheel has to rotate more than the outer wheel. Due to toe out, as the inner wheel is already turned, it takes less time to take a turn. Toe out increases cornering ability of the fast-moving vehicle. If the front part of wheels is pointed inward then it is a toe in. When the wheels are positively cambered, then the vehicle tends to move outward

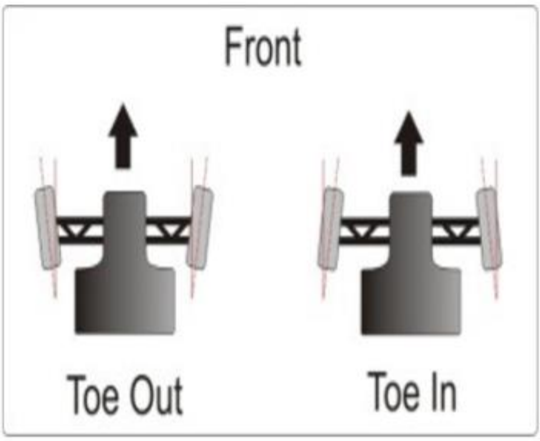


Fig. 2.5: Toe in and Toe Out

2.2.1.4 Kinematic Steering: For the kinematic analysis of a steering system, it is important to have an understanding of the basic kinematics of the steering [1]. For this purpose, the basic steering system is studied.

According to Ackerman condition for a front wheel steering system, the difference of the cotangents of the angles of the front outer to the inner wheels should be equal to the ratio of width and length of the vehicle being considered as shown in Fig. 2.7. The terms δo represents outer wheel angle and δi represents inner wheel angle. The term w represents the wheel track and l represents wheel base [1].

$$\mathrm{Cot}\delta_o - \cot\delta_i = \frac{w}{l}$$

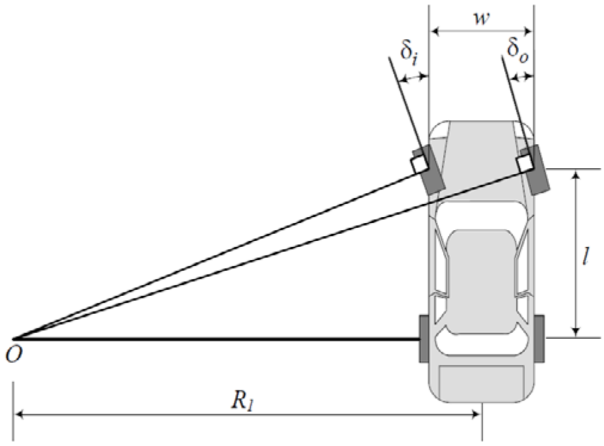


Fig. 2.6: Diagram for calculating Turning Radius of Front Wheels [1]

(a) Turning radius: The turning radius of the vehicle is usually measured using the formula represented as shown in Fig. 2.7 and 2.8.

$$R = \sqrt{a_2^2 + l^2 cot^2\delta}$$

$$cot\delta = (cot\delta_o + cot\delta_i)/2$$

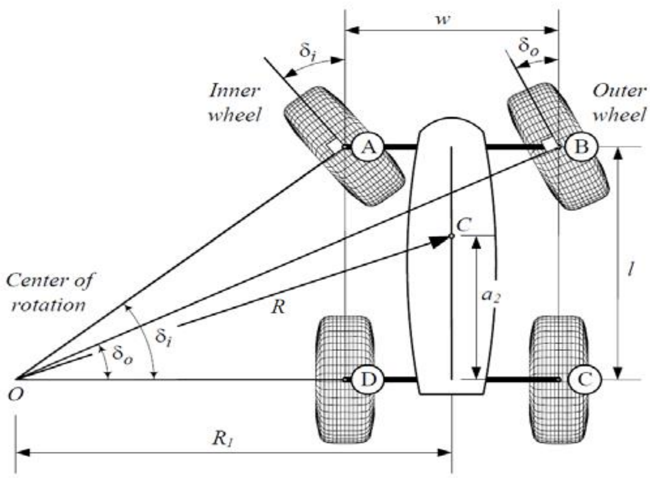


Fig. 2.7: Turning Radius of Front Two Wheels [1]

2.2.1.5 Four wheel steering types: There are two types of four-wheel steering configurations. The one in which both the front and the rear wheels turn in the same direction is called positive four-wheel steering system and the one in which they turn in opposite to each other is called negative four-wheel steering system [1].

(a) Positive Four-Wheel Steering System

The condition for positive four-wheel steering system is as given in the below equation and the system is as shown in Fig. 2.9.

$$\cot\delta_{of} - \cot\delta_{if} = \frac{w_f}{l} - \frac{w_r}{l}\frac{\cot\delta_{of} - \cot\delta_{if}}{\cot\delta_{or} - \cot\delta_{ir}}$$

$R_1 = 12.5$, $C_1=11$, $C_2=6.5$

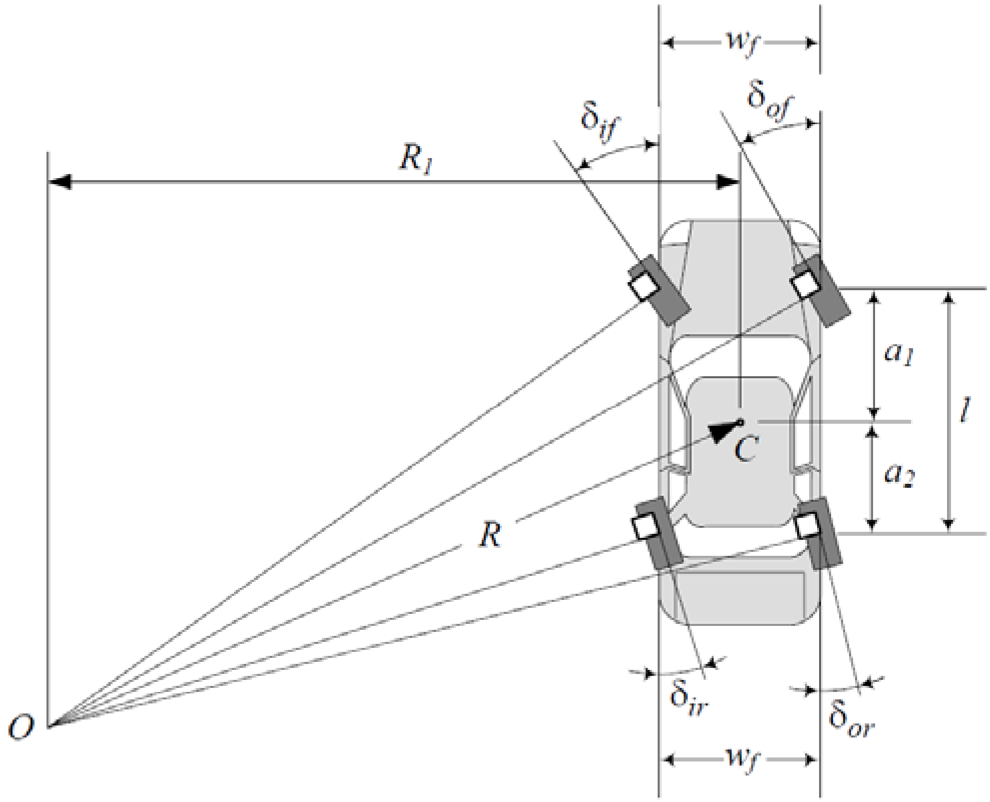


Fig. 2.8: Measurements of Positive Four-Wheel Steering [1]

The equations for the positive four-wheel steering system are derived from the following equations and are illustrated in Fig. 2.9.

$\tan\delta_{if} = C_1 / (R_1 - w_f / 2) = 11/11.25 = 0.97$

$\tan\delta_{if} = C_1 / (R_1 - w_f / 2) = 11/13.75 = 0.8$

$\tan\delta_{if} = C_1 / (R_1 - w_f / 2) = 6.5/11.25= 0.57$

$\tan\delta_{if} = C_1 / (R_1 - w_f / 2) = 6.5/13.75 =0.47$

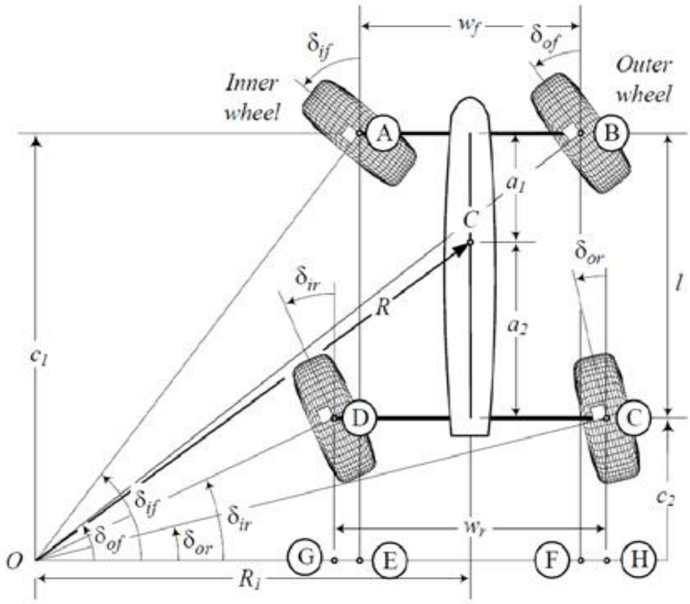


Fig. 2.9: Dimensions of Positive Four-Wheel Steering System [1]

$Cot\delta_{of} - cot\delta_{if} = w_f/C_1 = 2.5/11 = 0.22$

$Cot\delta_{or} - cot\delta_{ir} = w_r/C_2 = 2.5/6.5 = 0.38$

$C_1\text{-}C_2 = 1$

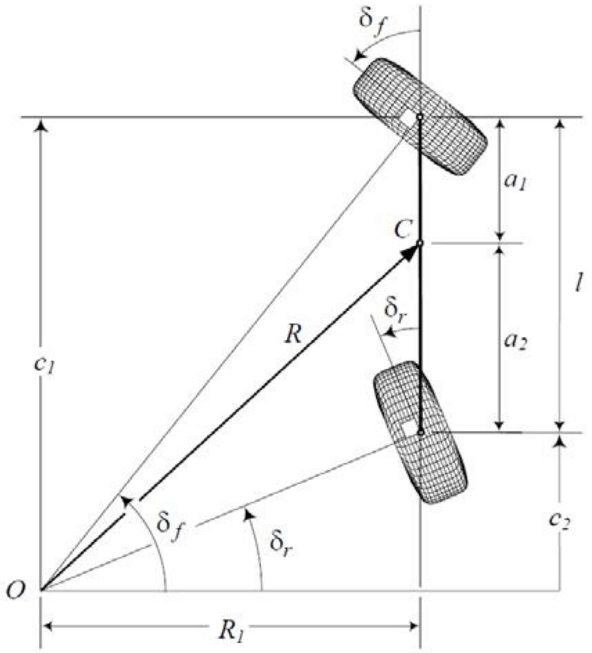


Fig. 2.10: Angles of Right Wheel [1]

The turning radius for this system is derived from the bicycle model as shown

$$R = \sqrt{(a_2 + c_2)^2 + c_1^2 cot^2 \delta_f}$$

(b) Negative Four-Wheel Steering System

The condition for negative four-wheel steering system is as given in the following equation and the system is as shown

$$cot\delta_{of} - cot\delta_{if} = \frac{w_f}{l} - \frac{w_r}{l}\frac{cot\delta_{of} - cot\delta_{if}}{cot\delta_{or} - cot\delta_{ir}}$$

The equations for the negative four-wheel steering system are derived from the following equations

$\tan \delta_{if} = C_1 / (R_1 - w_f / 2) = 0.66$

$\tan \delta_{if} = C_1 / (R_1 - w_f / 2) = 0.45$

$\tan \delta_{if} = C_1 / (R_1 - w_f / 2) = 15.64$

$\tan \delta_{if} = C_1 / (R_1 - w_f / 2) = 10.7$

$Cot\delta_{of} - cot\delta_{if} = w_f/C_1 = 2.5/3.5 = 0.71$

$Cot\delta_{or} - cot\delta_{ir} = w_r/C_2 = 2.5/1.5 = 1.66$

$C_1\text{-}C_2 = l$

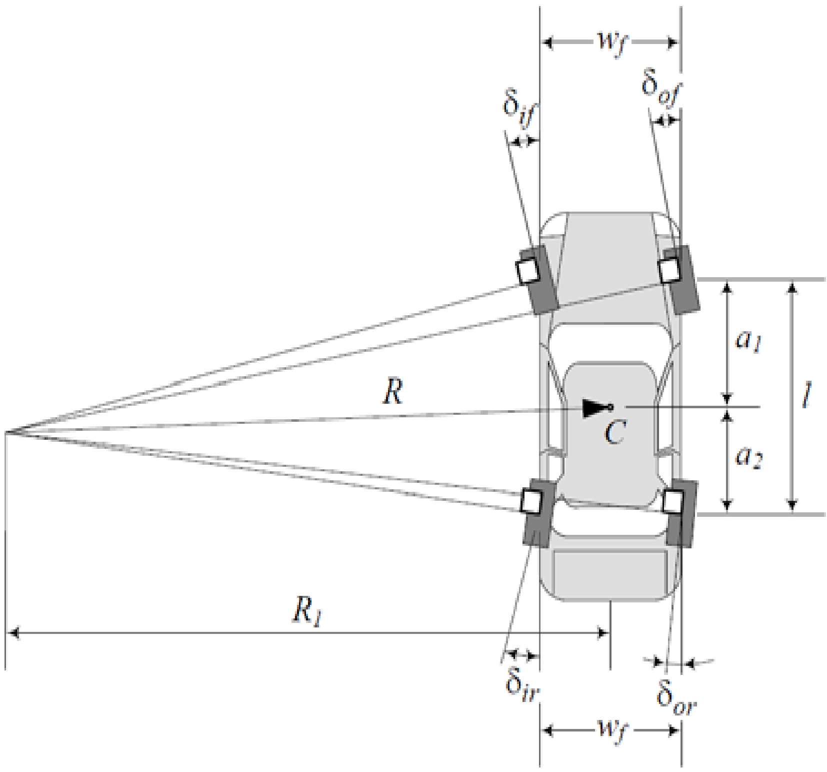


Fig. 2.11: Measurements of Negative Four-Wheel Steering System [1]

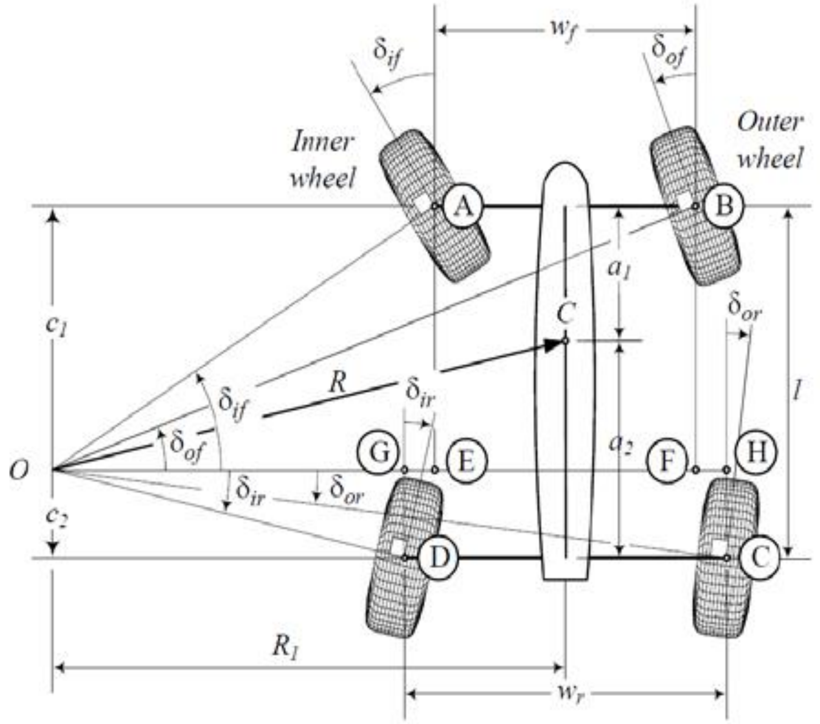


Fig. 2.12: Diagram for Calculating angles of Negative Four-Wheel Steering System [1]

2.2.2 Suspension: The non-independent suspension has both right and left wheel attached to the same solid axle. When one wheel hits a bump in the road, its upward movement causes a slight tilt of the other wheel [5].

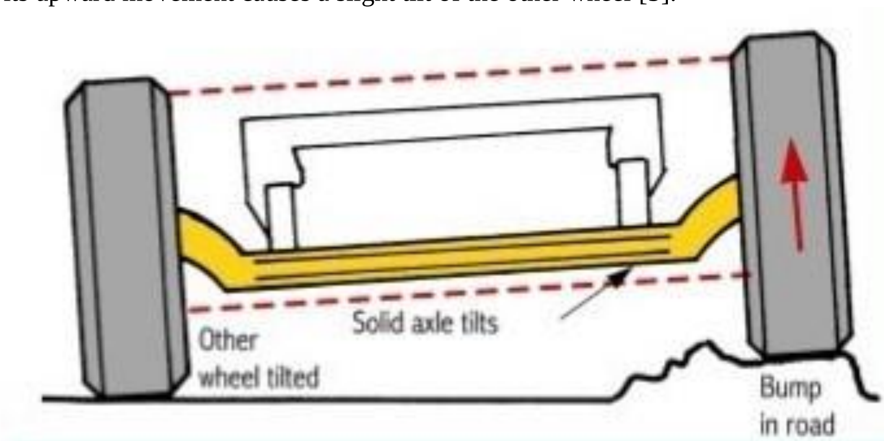


Fig. 2.13: Non-Independent Suspension System [6]

2.2.2.1 Suspension system: The suspension of an RC car is usually a plastic or metal piece mounted low and called an "a-arm." This connects to the chassis and to a smaller part (hub carrier or caster block) that ultimately holds the wheel. The a-arm is hinged at either end to allow up & down movement. Above the lower a-arm is either another (upper) a-arm or a thinner, simpler "camber link." This is roughly parallel to the lower a-arm and keeps the wheel standing straight up.

The suspension system is designed to achieve low initial cost, minimum weight, minimum tyre wear along with Minimum deflection consistent with the required stability.

2.2.2.2 Elements of the suspension system

(a) Spring: the springs are used in the suspension system to absorb road shocks or impacts due to unevenness in road/terrain. Tyres also provide spring effect, but to a smaller extent. Springs used for suspension system should absorb road shocks quickly and return to the original position slowly.

Springs are resilient members and as such act as reservoirs of energy. They store the energy due to the sudden force which comes when the vehicle encounters a bump or a ditch. This energy is released subsequently and with the action of damper, the energy is converted into heat and bounce is avoided.

(a)Types of springs:

1. Leaf spring
2. Coil spring
3. Torsion bars

4. Air and gas spring
5. Rubber spring

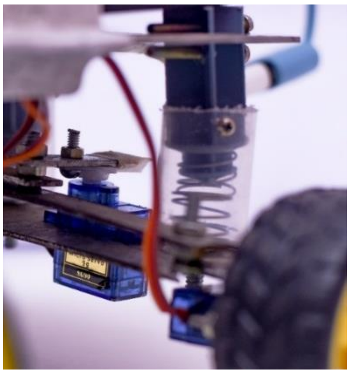


Fig. 2.14: Figure of suspension system

For the current prototype coil spring has been employed A section of spring steel rod wound in a spiral pattern or shape. Coil spring is widely used in both Front and Rear suspension systems similar to large metal bed springs which are mostly used in heavier automobiles. The coil springs provide cushioning and absorb the shocks and bumps as the vehicle is driven. They are usually mounted near the front wheels, but some cars have them in the rear as well. The shock absorber is placed in concentric with coil spring.

The suspension system arrangement used for the prototype is Linear acting springs mounted in series and arranged in parallel.

Table 2.1: Properties and specifications of suspension

Suspension Specifications:			Properties of Suspension:
No. of Units Used	:	4	Solid axle suspended by leaf or coil spring at each end • Reliable • High load capacity • Used for front and rear suspension
Height:			
*Without Deflection	:	7 cm	
*With Deflection	:	5.5 cm	
Diameter	:	2.3 cm	
Spring Dimensions:			
Type	:	Helical coil	
Diameter of spring	:	1.5 cm	
Height:			
*Without Deflection	:	1.3 cm	
*With Deflection	:	0.3 cm	

2.2.3 Frame and Links

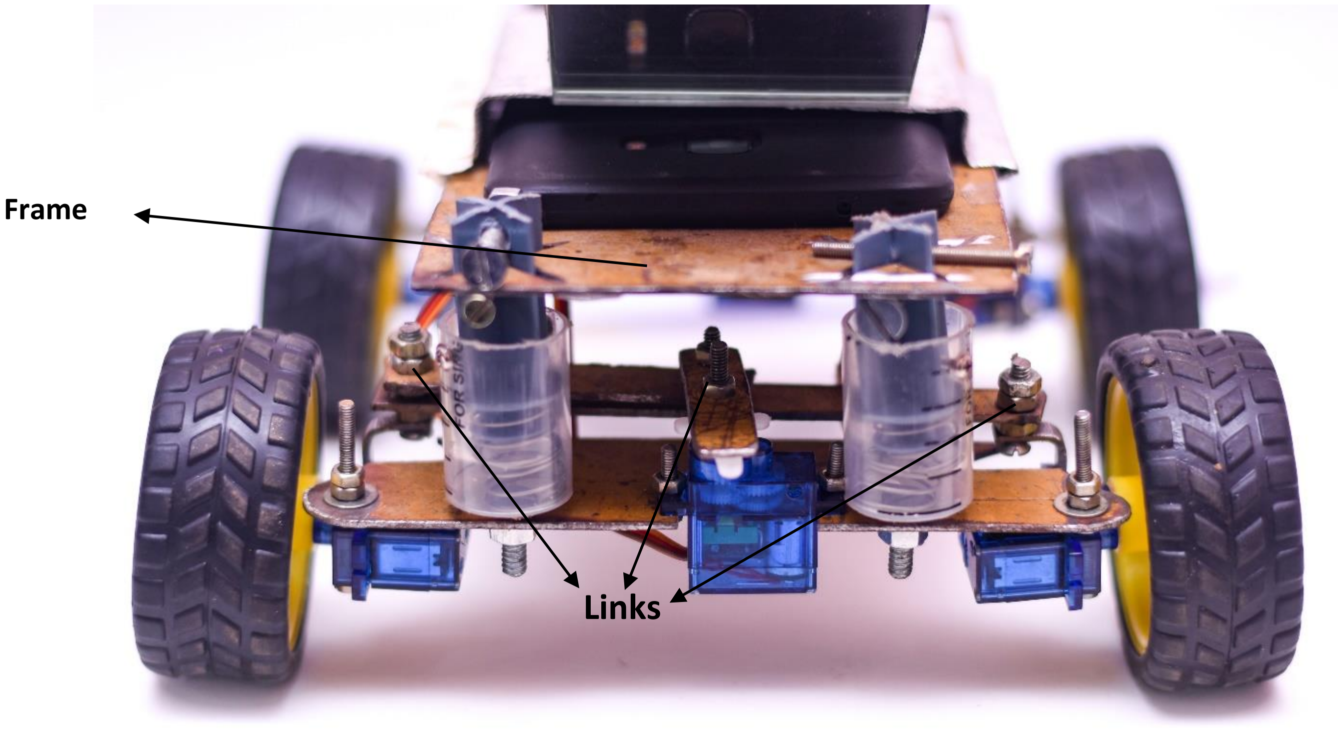


Fig. 2.15: Figure to identify frames and links

(a) Frame Specifications

Table 2.2: Dimensions of Frame and Rover

Name	:	RC Car Frame
Material	:	Mild Steel, Stainless Steel, and Plastic
Scale	:	1/10
Wheel Base	:	200 mm
Track Width	:	10 mm
Height	:	90 mm
Ground Clearance	:	40 mm
Weight	:	1713g

(b) Advantages of frames
- Aluminum mounts are less likely to be damaged when paired with plastic arms.
- In almost any case, the plastic will break instead of leaving the aluminum unharmed.

(c) Disadvantages of frames
- When aluminum stresses, it's, in general, less likely to bend and break, but, if it bends, it won't return to its original shape.

2.2.4 Wheels

(a) Super soft tires: should be used when the track has the blue groove conditions. Which is when there is practically no dust on the racing surface and he track is just a rock-hard surface where the racing line comes up blue from deposited rubber. Super Soft tires should be used when the rubber compound generates tire traction.

(b) Soft compound tires: In general, these will perform best. Well, packed track surfaces with some loose material on the surface are particularly well suited to these types of tires. Dusty conditions also suit soft tires.

(c) Medium compound tires: these tires can be most effectively used when the track condition is bad. When predominantly loose material is on the surface, when the track starts to break up into rubble or in moderately wet conditions, medium compound tires should be your first choice.

(d) Hard tires: they are rarely used. Only if the track is particularly wet or muddy, or if the track surface is grass, should hard compound tires be used.

Fig 2.16: High Quality Nylon wheels

2.2.4.1 Specifications
- Tracked wheel for DC motors:
- Hole Diameter-5 mm
- Diameter- 60 mm
- Width-27mm
- Made from high-quality Nylon.
- Attached with a screw to lock on the standard motor shaft of 6 mm.

2.2.4.2 Advantages of Wheels
- The compound or softness of the tire can often have a major impact on its performance.
- Smaller wheels tend to weigh less than larger ones, thus bringing the performance benefits of light wheels.
- Small wheels, all else being equal, have slightly higher rolling resistance.
- On the other hand, they may have lower aerodynamic drag due to their smaller area, which is proportional to their radius.
- Smaller wheels are more maneuverable.

2.3 Electrical components

2.3.1 Controller

Fly-Sky CT6B 2.4Ghz 6 Channel Transmitter and Receiver (FS-R6B) Remote are the popular 6 Channel Radio CT6B manufactured by Fly-Sky. CT6B FLYSKY 2.4GHZ 6CH TRANSMITTER is an entry-level 2.4 GHz radio system offering the reliability of 2.4 GHz signal technology and a receiver with 6 channels. CT6B FLYSKY 2.4GHZ 6CH TRANSMITTER radio is a value for money, entry level 6 channel transmitter, ideal for quad-copters and multi-copters that require 6 channel operation[9].

This radio has a very lightweight and handy design with two retract switches and proportional flap dials in easy reach for channels 5 and 6. It can be powered by 8 x AA Size Batteries or a 12V Power Supply. It comes with a trainer port to help beginners learn flying. This remote comes with FS-R6B receiver which is one of the best receivers we had in the class at a very reasonable cost. It can be configured by connecting it to the computer. Use the T6 config Software to configure your radio on a computer.

2.3.1.1 Features

- 8 model memory, digital control.
- Full range 2.4GHz 6-channel radio.
- Programmable by PC with the included software.
- It covers the entire bandwidth of the antenna bandwidth range.

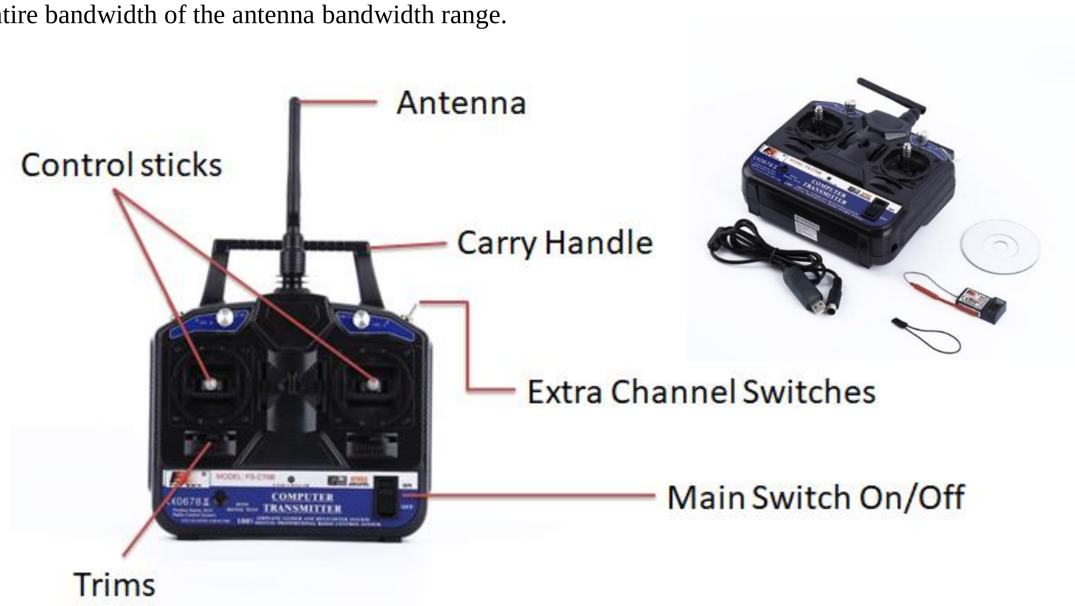


Fig. 2.17: Radio Controller (Transmitter and Receiver)[9]

TABLE 2.3: Parameters of Transmitter and Receiver [9]

Transmitter Parameters	Receiver Parameters
• Channels：6 • Charger port: Yes • Frequency band: 2.4GHz • Simulator port: PS-2 • Power resource：1.5V • 8 -"AA" Battery • Program type: GFSK • Modulation type: FM • RF power：19db • Static current：≤250mA • Voltage display type：LED • Size：189*97*218mm • Weight: 575g • Colour: black • Antenna length：26mm • Sub Trim：Yes • Support multiple user mode • Support trim movement • Support programmable channel	• Frequency band: 2.4GHz • Power resource：1.5V • 4 "AA" Battery • Program type: GFSK • Modulation type: FM • RF Receiver sensitivity：-76db • Static current：≤85mA • Size：45*23*13.5mm • Size：25*16.8*6.5mm • Weight: 12g • Colour: Gray semi-transparent • Antenna length：26mm

2.3.1.2 Receiver and Servo Connection

CH1 - LEFT SERVO MOTORS IN SERIES
CH2 - RIGHT SERVO MOTORS IN SERIES
CH3 - NULL
CH4 - STEERING SERVOS
CH5 –FRONT STEERING MASTER CONTROL
CH6 –RARE STEERING MASTER CONTROL

2.3.1.3 Advantages of the controller

- High receiving sensitivity.
- High quality and stability.

- Very low power consumption.
- Super active and passive.
- Anti-jamming capabilities.

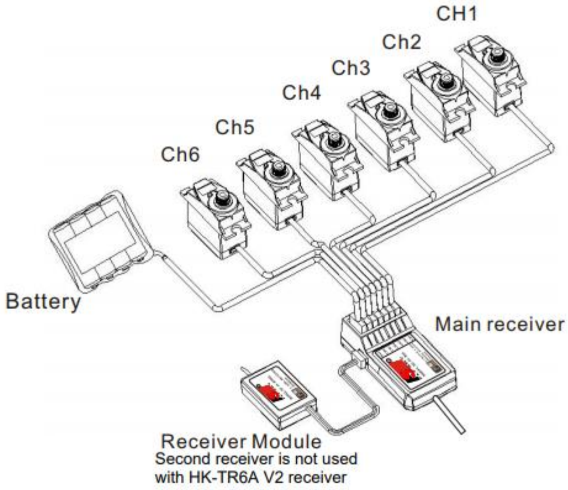


Fig. 2.18: Receiver and Servo connection layout [9]

2.3.2 Servo Motor

Tiny and lightweight with high output power. The servo can rotate approximately 180 degrees (90 in each direction) and works just like the standard kinds but smaller. You can use any servo code, hardware or library to control these servos. Good for beginners who want to make stuff move without building a motor controller with feedback & gearbox, especially since it will fit in small places. It comes with 3 horns (arms) and hardware [10].

Fig. 2.19: Servo Motor and Pinouts (Wires) [10]

2.3.2.1 TowerPro SG-90 Features

TABLE 2.4: Specifications of servo motor [10]

Operating Voltage	+ 5V
Torque	2.5kg/cm
Operating speed	0.1s/60°
Gear Type	Plastic
Rotation	0°-90°
Weight of motor	9gm
Package includes gear horns and screws	

2.3.2.2 Advantages of Servo motors

- Simple, portable and inexpensive equipment
- Accuracy is a Servo Motor advantage.
- The continuous speed rating of the Servo Motor exceeds that of the comparable stepper motor.
- Properly tuned Servo Motors are extremely quiet. The biggest source of noise in servo-driven applications is often the drive train or bearing.
- With the advantages of torque control, many applications accomplish all the required pressing, holding, pushing and twisting motions at very precise torques.
- High output power is relative to motor size and weight.
- Encoder determines accuracy and resolution.
- High efficiency. It can approach 90% at light loads.
- High torque to inertia ratio. Servo Motors can rapidly accelerate loads.

- Has 2-3 times more continuous power for short periods.
- Has 5-10 times more rated torque for short periods.
- Servo motors achieve high speed at high torque values.
- Quiet at high speeds.
- Encoder utilization provides higher accuracy and resolution with closed-loop control.

2.3.2.3 Limitations of servo motors

- Tuning a motor can be a very difficult and a troublesome process
- The Servo Motor can only operate in this peak torque range for a short interval and must allow generated heat to be dissipated
- If the torque applied is too high, crushing of the widget and similar damage can result.
- If the torque is too low, not enough holding force is created and the end result could be slippage resulting in defects or wasted product.
- Servos Motors requires tuning to stabilize the feedback loop.
- Servo Motor will become unpredictable when something breaks. So, safety circuits are required.
- Complex controller requires encoder and electronic support.
- Peak torque is limited to a 1% duty cycle. Servo Motors can be damaged by sustained overload.
- Gear boxes are often required to deliver power at higher speeds.

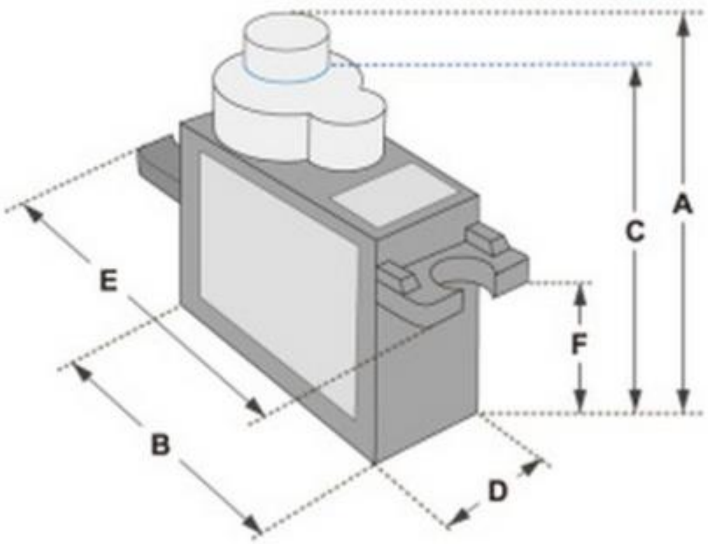


Fig. 2.20: Servomotor Specs [10]

TABLE 2.5: Dimensions of servo motor [10]

A (mm)	33
B (mm)	32
C (mm)	28.5
D (mm)	12
E (mm)	32
F (mm)	19.5
Speed (sec)	0.1
Torque (kg-cm)	2.5
Weight (g)	14.7
Voltage (V)	4.8-6

TABLE 2.6: Description of Wires in Servomotor [10]

Wire Number	Wire Color	Description
1	Brown	Ground wire connected to the ground of the system
2	Red	Powers the motor typically +5V is used
3	Orange	PWM signal is given in through this wire to drive the motor

2.3.2.4 Working of Servomotors

To make this motor rotate, we have to power the motor with +5V using the Red and Brown wire and send PWM signals to the Orange color wire.

Torque: 2.5kg/cm torque which comes with the Towerpro SG90 Motor. This 2.5kg/cm torque means that the motor can pull a weight of 2.5kg when it is suspended at a distance of 1cm. So, if you suspend the load at 0.5cm then the motor can pull a load of 5kg similarly if you suspend the load at 2cm then can pull only 1.25. Based on the load we used this sg-90 motor in the project for proper torque.

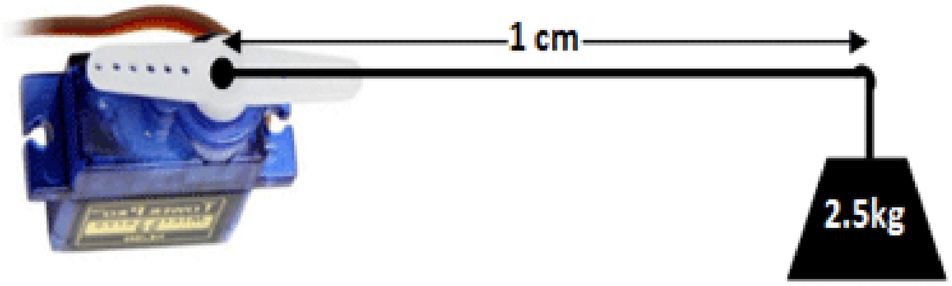


Fig. 2.21: diagram to elaborate Torque of the Servomotor

2.3.2.5 Applications

- Used as actuators in many robots like Biped Robot, Hexapod, robotic arm, etc.
- Commonly used for a steering system in RC toys
- Robots where position control is required without feedback
- Less weight hence used in multi DOF robots like humanoid robots

2.3.3 Other Electrical components

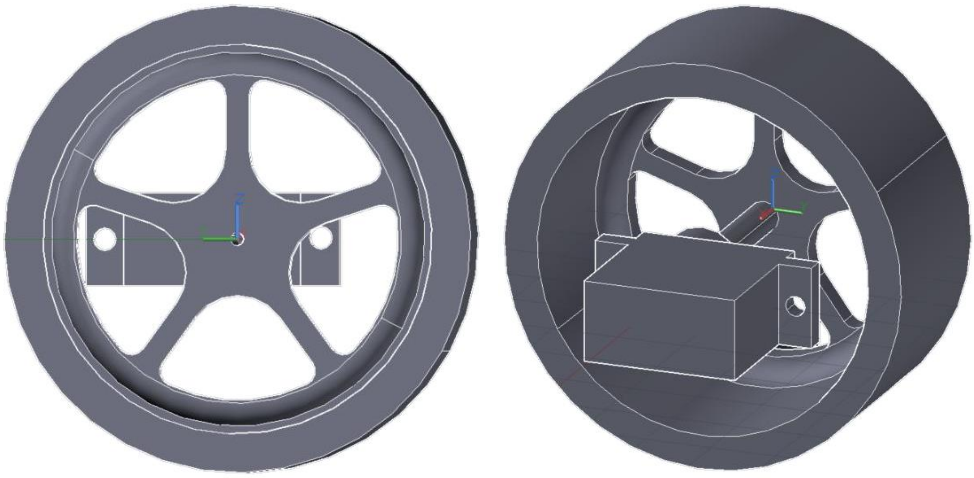
The other Components used in this prototype are the battery, a microphone, and a camera.

To minimize the design and considering the budget we decided to use a mobile phone to satisfy our need for battery, microphone, and camera.

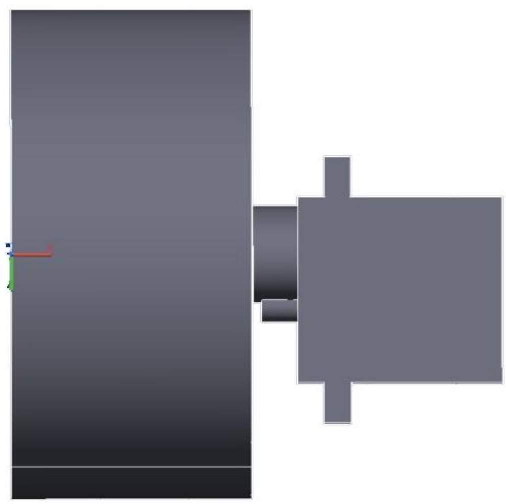
- Using OTG connector any device can be used as a battery with common circuit power (5 volts and max. 1 amp). Which is perfect for all six servo motors with minimum power consumption [11].
- On the other side, camera and microphone installed to the device are programmed to communicate through the internet or local Wi-Fi using IP Webcam application [12].

3. CAD MODELLING

3.1 Wheel and Motor



(a) **(b)**



(c)

Fig. 3.1: CAD Model of Servo motor Attached to Wheel; (a) Size View, (b) Isometric View, (c) Top View.

3.2 Steering Mechanism

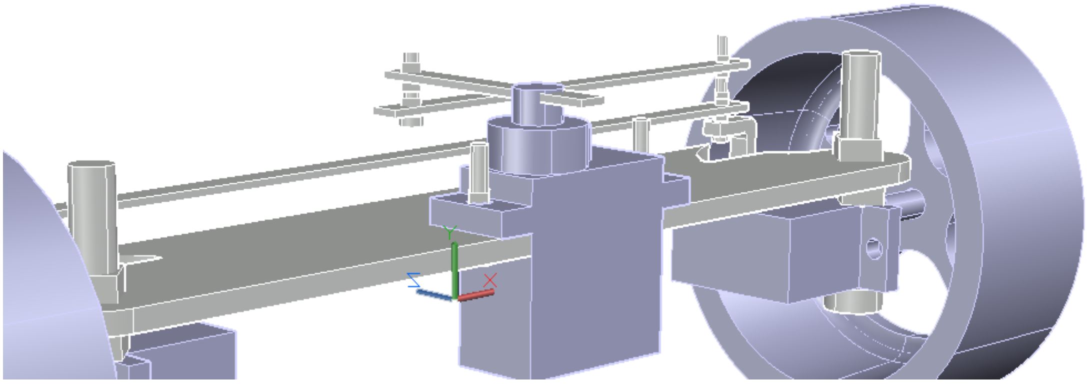


Fig. 3.2 Steering Links

3.3 Axle with Suspension

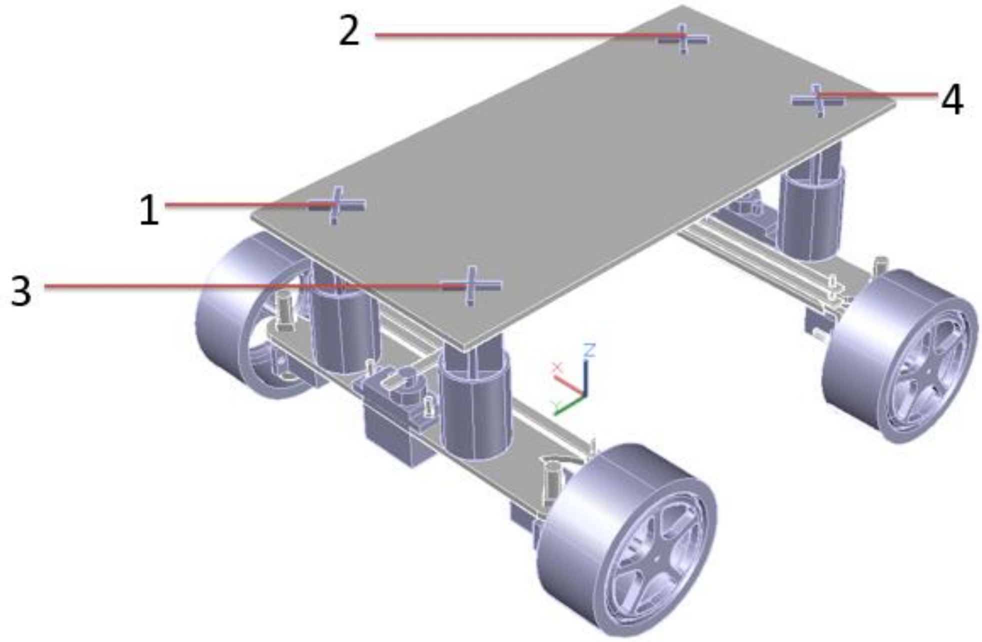


Fig. 3.3 Suspension Mounting Points (1,2,3,4)

3.4 Complete Model

3.4.1 Frame and Chassis

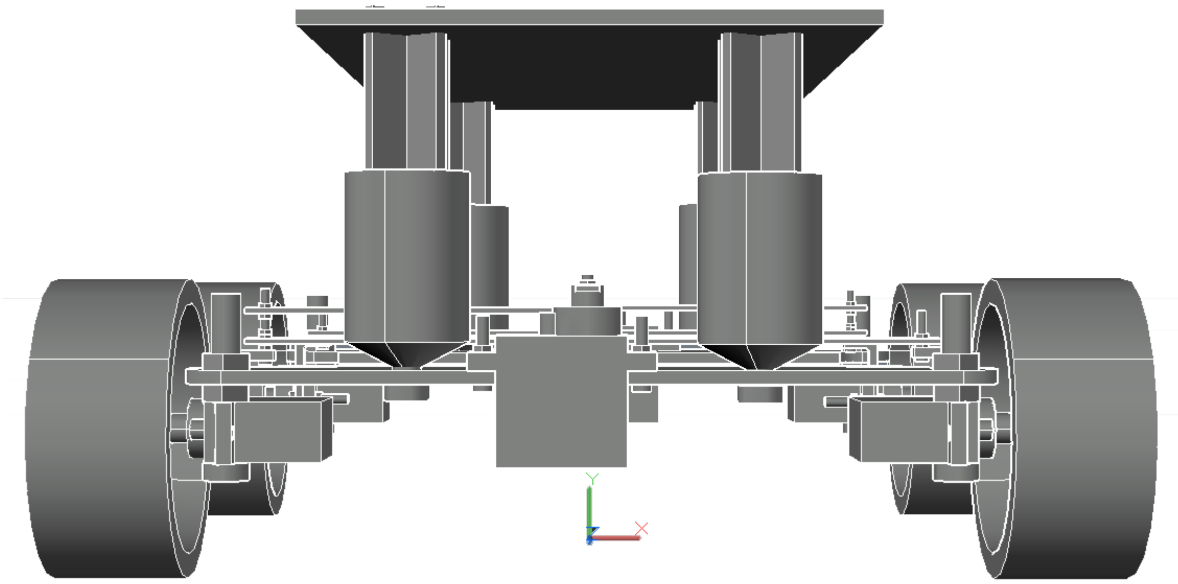


Fig. 3.4 CAD Model of Frame & Chassis

3.4.2 Top View of Mini Rover

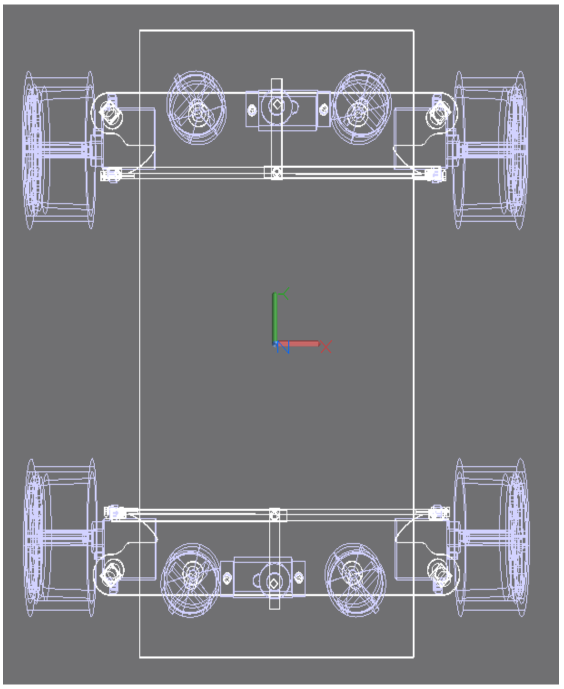


Fig. 3.5: Top View of Mini Rover (CAD & Original)

3.4.3 Isometric view of 3D Wireframe

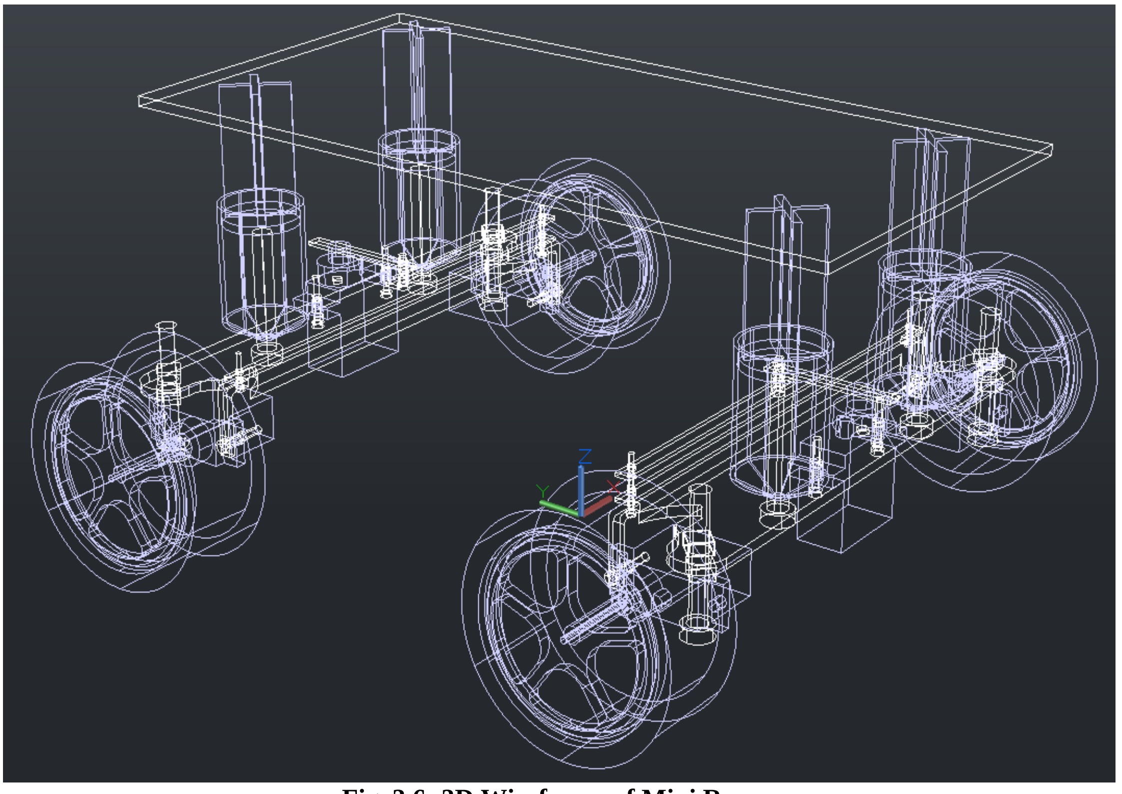


Fig. 3.6: 3D Wireframe of Mini Rover

4. FABRICATION PROCESS

4.1 Frame Preparation

- The entire model is designed in Auto cad and CATIA
- Mild steel alloy of 3mm thickness has been used for making the compact chassis and Shock towers for its better stability.
- The fabrication is started by plotting the complete chassis and studying its various regions of weight distribution for the mini-rover to have good cornering speed
- The chassis dimensions have been taken and the servomotor mounting is placed a bit center to make the weight distribution uniform.
- The center of mass of the vehicle should also be as low as possible so that when it absorbs a major impact and tend to topple, there will be a very good chance that it will land perfectly.
- It also has many structural applications with high strength and can be heat treated.

Fig. 4.1 Cutting of Mild Steel Sheet

4.2 Steering Preparation

- Four servo motors have been used for wheels and drilled its edge and fitted it with 2.5mm Nuts & Bolts
- The frame has been designed with accurate dimensions from Auto Cad and the design is attached to the mild steel sheet and it was cut according to the outline drawn.
- Instead of using metal rods the rectangular cross-sectioned bar has been used for steering links.
- The holes on the steering links are been drilled by marking required positions on the sheet.
- To attach the servomotor with links L Bracket has been used.

4.3 Suspension Preparation

- Four medical injections have been used and marked dimensions for the suspension fittings which was cut using hack-saw.
- Two valve springs are mounted in series inside the injection for extra compression
- Two screws have been used as an obstacle for preventing the springs from coming out.
- Four individual suspensions have been fabricated and attached them to an axle by inserting a screw through the bottom part of the injection.

Suspension Type: Non-Independent Suspension

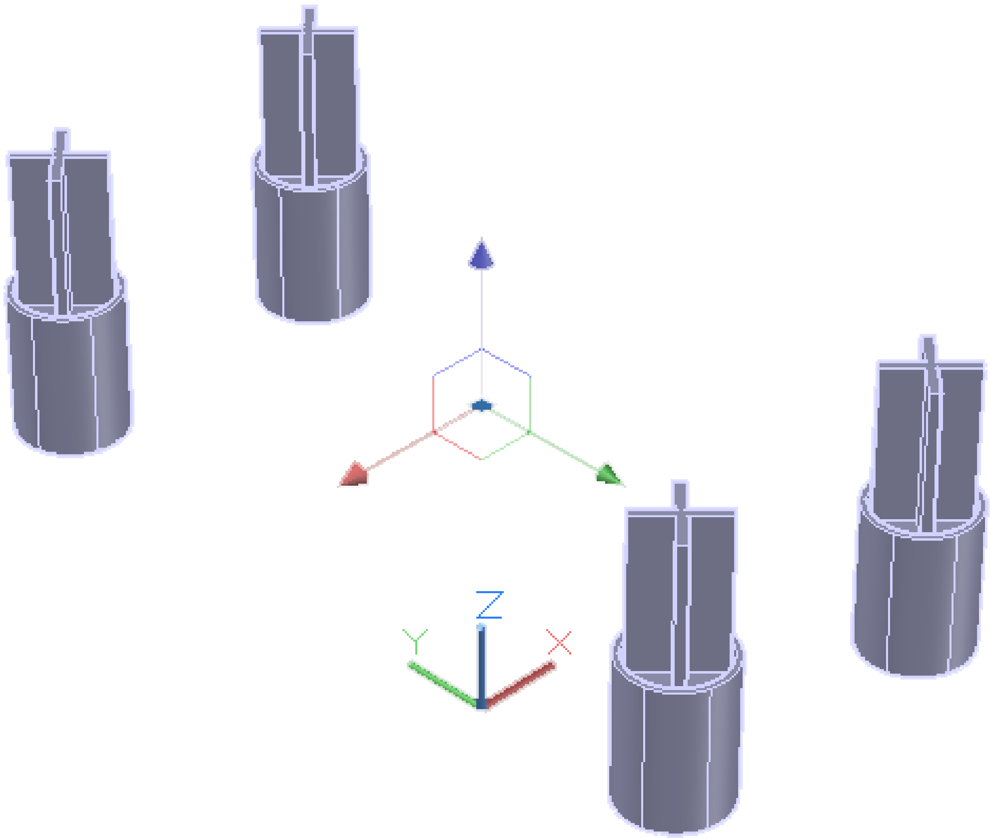


Fig. 4.2: 3D view of suspension position

4.4 Assembly

Mild steel had been cut into the required shape for fitting the servomotors. Two Rectangular cross-section bars are taken for both rear and front servomotors and wheel setups.

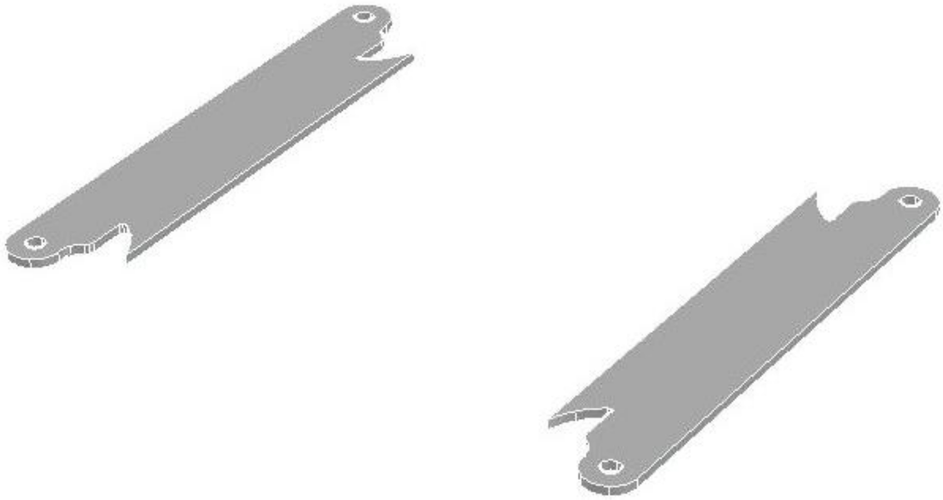


Fig. 4.3: 3D view of front and rear axle plates

A servomotor is attached such that its shaft axis is at the center of both rectangular bars using nuts & bolts. It is used to control the steering setup.

Steering links are attached accordingly such that one link is common to both wheels and one shorter link is attached to the motor using an L-clamp which converts linear into rotary motion. It is connected to the wheel to be attached.

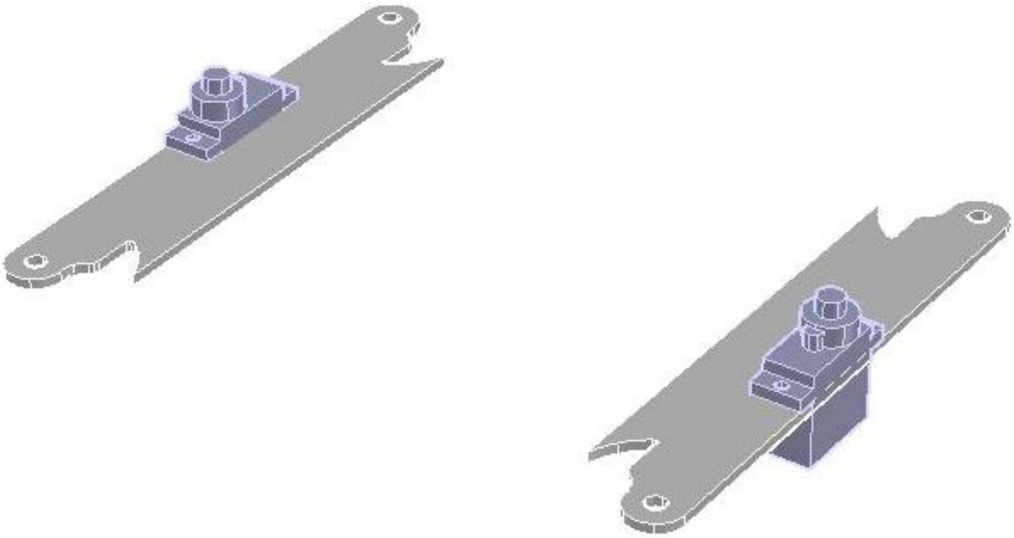


Fig. 4.4: 3D view of axles with servo motors for Steering movements

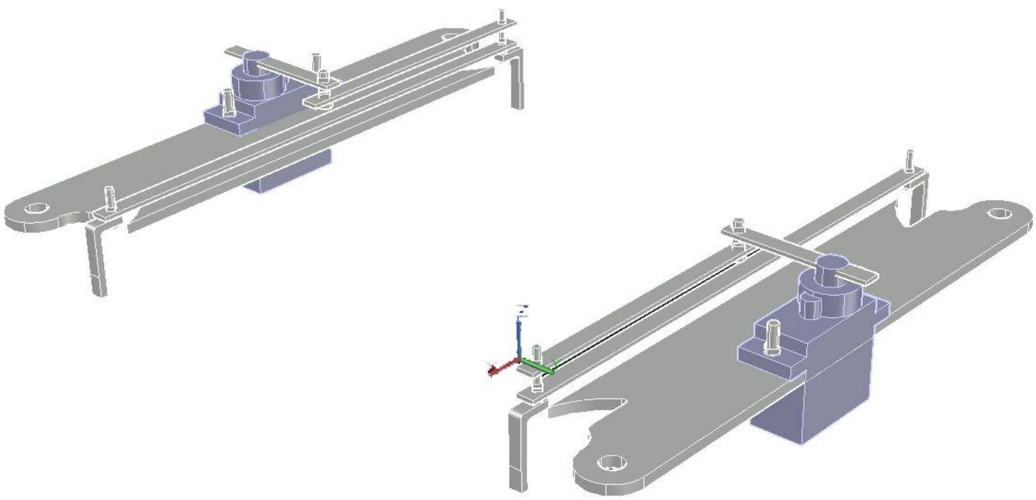


Fig. 4.5: 3D view of steering links with L bracket at four ends

Wheels & Servomotors are attached to links present on both ends of the frame.

Bolts are attached slightly loose to reduce load to the servomotor.

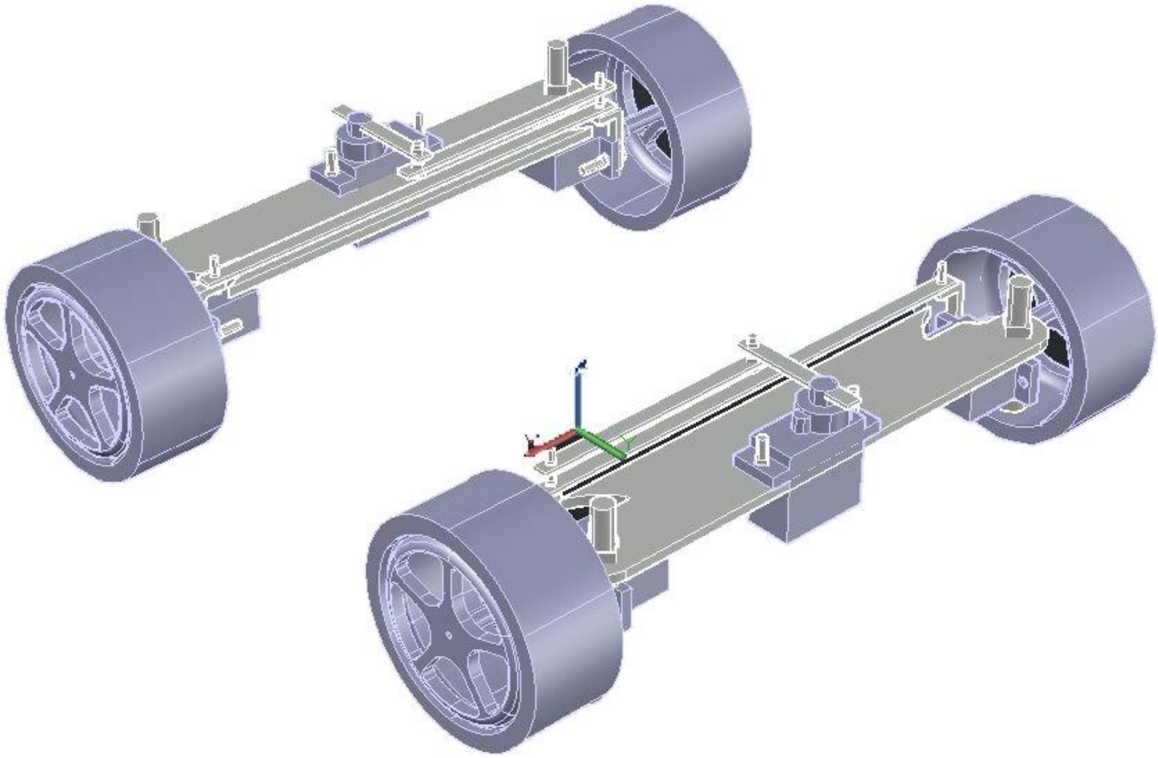


Fig. 4.6 3D view of axles with wheel and motor assembly

Suspensions made from the injections are attached on either side of the servomotor situated at the center which forms Non-Independent suspension. Rear and front Suspension mounting points are perfectly aligned and fixed by using screws tightly.

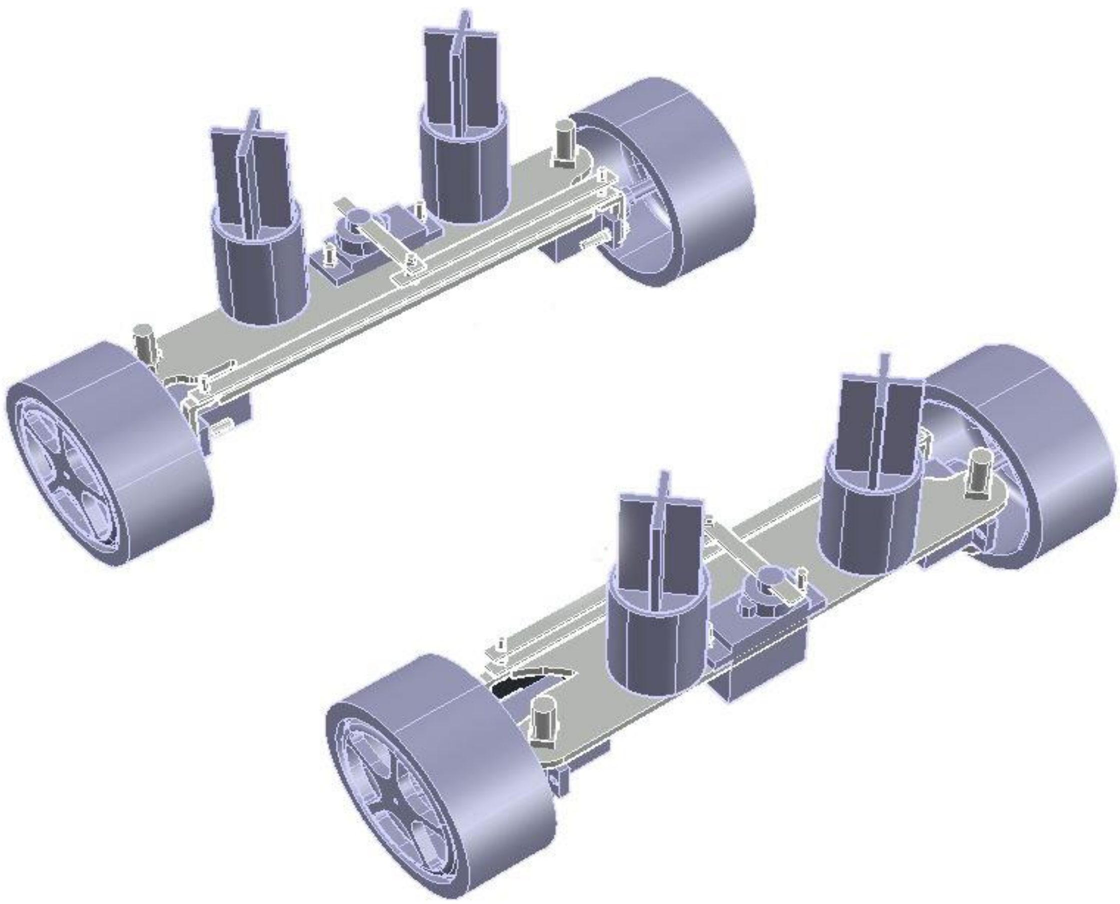


Fig. 4.7: 3D view of total CAD Model without frame assembly

The frame which was prepared has been made with holes cut in shape of X to fit suspensions into it.

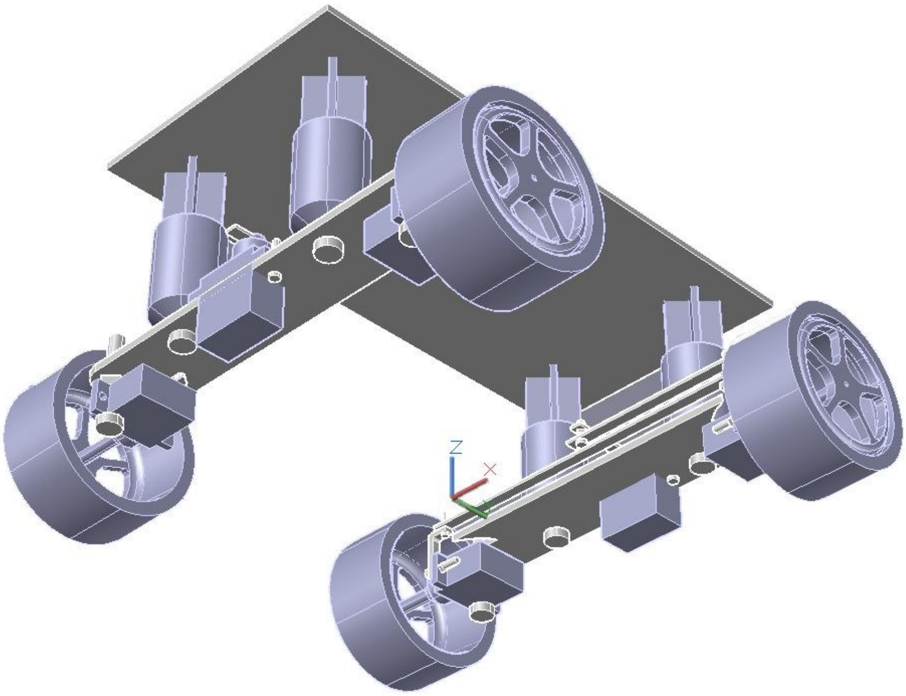


Fig. 4.8: Isometric view of CAD model

4.5 Prototype

Specifications of Car:

- Length: 515 mm; Front Width: 307 mm; Rear width: 303 mm; Height: 188mm; Wheel base: 325-330 mm;
- Weight – 3300gms
- Camber (rear -0° and front- 2°)
- kick up angle -15° and toe in -5°
- 2.4 GHz radio system with plastic gear servos
- Soft 16mm pro shock springs

Fig. 4.9: Complete Model of The Prototype

Fig. 4.10: Mini-rover on Off-Terrain

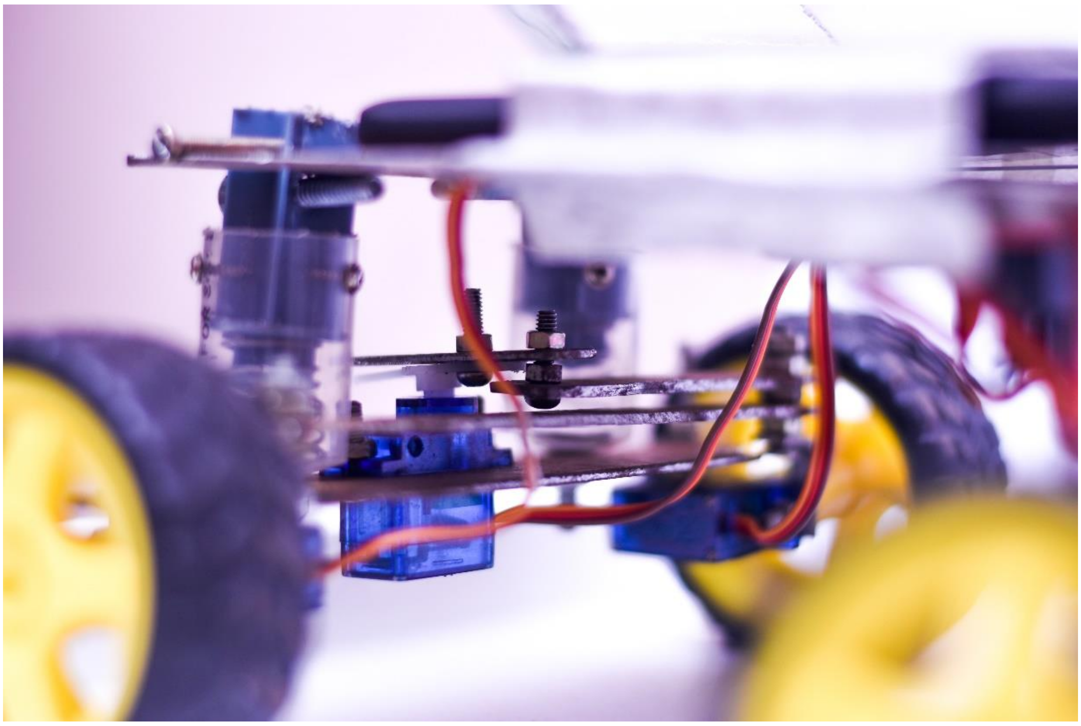


Fig. 4.11: Steering links of Mini-Rover

5. ADVANTAGES

- To identify bomb threats in a war zone without any human life loss.
- As a stealth weapon and can also be used as a scout vehicle for police before engaging with criminals and many more.
- There is a 53.36% reduction of turning radius.
- It can be used in three different phases or modes like 2-wheel steering, in-phase and counter-phase rear steering.
- By these modes, the stability, lane changing, U-turns and near neutral steering can be achieved.

6. SHORTCOMINGS

As there will be no component which is accurate in the view of dimensions so there always be a chance of dimensional inaccuracy. The applied load is greater than that of load capacity of a servomotor so there is a wheel misalignment and slightly delay in the steering mechanism.

7. CONCLUSIONS

There is a wide scope for gaining knowledge on vehicles by studying these RC cars. One can get complete knowledge of a four-wheeled automobile vehicle because all these vehicles include similar components like steering system, braking system, suspension system, etc. of a radio-controlled car. The design and manufacturing of this car by us enable us to build up our design skills, teamwork skills. We have designed and manufactured almost all the parts like Chassis, Steering mechanism and suspension arms. Several changes had been made from first to the final product. A lot was learned in terms of how to design, build, and test a product. Each stage a lot of insight into what makes a good RC design had been archived. For example, the initial design phase was excellent in building an understanding of how lastly, testing the finished product demonstrated what modules work well and what can be improved or restructured for future iterations.

In this particular RC car design, one important lesson was that the body should be built to create a robust design. there should be alternative methods available to still create a functioning product. Planning ahead of time what alternatives were available for each module saved a lot of wasted time and worry when certain modules did not function as expected because of the wireless communication link between the Mini-rover and a remote PC, it is also an excellent platform for developing automotive driving technology, which requires advanced distributed and networked control

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