REEV REPORT

Research and Development of REEV vehicle which is conducted by SAE India. In this Report we copied whole work what we done in this competition.

By
TEAM SPIRIT
Aditya College of Engineering

About this competition:

The SAEINDIA REEV competition is set to be a game-changing student competition in India. Engineering students from various branches such as Computer Science, Electrical,Electronics, Mechanical,Automobile and Production will be able to come together to form an industry-ready team and compete for this prestigious title. SAEINDIA REEV is conceived to mimic an OEM level engagement to provide an excellent exposure to students – starting from design and development to putting on road an urban mobility solution!

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Executive Summary

The design and development of a range-extended electric vehicle (REEV) represent a pioneering initiative in the automotive industry, aiming to address the challenges of limited electric range while maintaining sustainable and eco-friendly transportation solutions. This innovative approach combines the efficiency of electric propulsion with an auxiliary power source, typically an internal combustion engine or a range-extender generator. The primary goal is to overcome range anxiety by providing users with an extended driving range, making electric vehicles more versatile and practical for a broader range of applications. This project involves intricate engineering to seamlessly integrate electric and combustion systems, optimizing energy efficiency and minimizing environmental impact. Through meticulous design and advanced technology, the range-extended electric vehicle is positioned as a transformative solution, contributing to the ongoing evolution of the automotive landscape towards sustainable and energy-efficient transportation.

CONTENTS :

1. Introduction

The Society of Automotive Engineers (SAE) REEV (Range Extended Electric Vehicle) is an international collegiate design competition sponsored by the Society of Automotive Engineers, challenging engineering students annually to devise a mechanical system and actualize the design by constructing an off-road electric vehicle with extended range capabilities. The design process is distributed among specialized sub-teams, each concentrating on one of the five designated subsystems. These subsystem teams collaborate with the overall group to achieve shared team objectives. Each team generates a SolidWorks model of its subsystem, which is subsequently integrated into the complete vehicle model. This comprehensive model enables the compilation of stress/strain data, facilitating ongoing improvements to the car's design. SolidWorks Simulation plays a crucial role, conducting finite element analysis and motion analysis to optimize the performance and efficiency of each component and subsystem throughout the project.

2.Frame and Chasis:

The most important feature of the vehicle is the highly engineered crash-absorption component that safeguards the driver during an impact by dispersing the effects of forces imposed on the vehicle more predictably. The frame is the primary structure of the REEV vehicle because it is the foundation into which all other subsystems are integrated for the ideal engineering design. This year, the goals for the frame were lightweight, simple, solid, strong, and safe. The engineering processes geared towards meeting the goals of the frame are discussed in the following sections;

Materials

There are different materials for car chassis, including alloys of aluminum, steel, and carbon fiber. Carbon fiber is very lightweight and strong, but making a chassis from carbon fiber is not an economical decision. Now, there are three materials that meet the requirements.

	AISI 1010	AISI 1018	AISI 4130
Density	7.87 g/cm3	7.87 g/cm3	7.85 g/cm3
Tensile strength	365 MPa	440 MPa	560 MPa
Yield strength	305 MPa	370 MPa	370 MPa
Elastic modulus	190-210 Gpa	205 GPa	190-210 GPa
Bulk modulus	140 Gpa	140 GPa	140 GPa
Shear modulus	80 Gpa	80.0 GPa	80 GPa
Poissons ratio	0.27-0.30	0.29	0.27-0.30

From the comparison of the above three materials, AISI 4130 has a high strength-to-weight ratio.Therefore, it was selected for rollcage.

Criteria for Frame Material Selection:

Equations:

$$I = \frac{\pi\left(d_o^{\ 4} - d_i^{\ 4}\right)}{64}$$

$$c = \frac{d_o}{2}$$

$$M = \frac{S_y I}{c}$$

$$\frac{M}{\kappa} = EI$$

κ = curvature

Required Tubing Specification: 1010 carbon steel.
Outer diameter, d0 (mm):25.0
Wall thickness, t (mm):3.00
Inner diameter, d_i (mm):19.0
Modulus of Elasticity, E (GPa):205
Yield Strength, S_y (MPa):365

From Tubing Geometry:
Distance to Extreme Fiber, c (mm):12.5
Area moment of inertia, I (mm^4):12777.6

- **Bending strength, M (N-mm): 373107.**
- **Bending stiffness, M/κ (N-m²): 2619.**

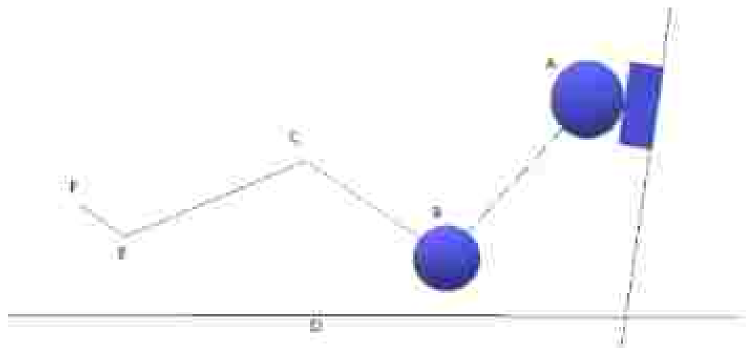
Alternate Tubing Specification: 4130 Carbon Steel (Chromoly)
Outer Diameter, d0 (mm): 31.75
Wall thickness, t (mm): 1.65
Inner diameter, d_i (mm): 28.45
Modulus of Elasticity, E (GPa): 205.
Yield Strength, S_y (MPa): 435.

From Tubing Geometry:
Distance to Extreme Fiber, c (mm): 15.875
Area moment of inertia, I (mm^4): 17723.4

Bending strength, M (N-mm): 485648.
Bending stiffness, M/κ (N-m²): 3633

Design Considerations:

Taking measurements and requirements from the driver:



Driver Sitting Arrangement

The alphabet indications tells that measurements of the driver or co-driver from one point to another. Here, Driver and Co driver is sitting like sitting position in the vehicle and taken every measurements from the drivers. This measurements helps us to know the length and width of the vehicle. And also be know that Wheel base and track width of the vehicle.

From the Diagram,

A-B ---> It is the distance between driver head to hip of the driver ---> 80-90 cm
B-C ---> It is the distance between driver hip to leg knee of the driver ---> 46-50 cm
C-D ---> It is the distance between driver leg knee to Frame ---> 36-40 cm
C-E --->It is the distance between driver leg knee to Foot of the driver --->52-56 cm
D-F ---> It is the distance between driver Foot to tip of the foot ---> 22-26 cm

Other Measurements:
Width of the Driver :- 36-40 cm
Length of of the Driver from tip of foot to hip of the driver :- 124-126 cm
Frame to Driver Head :- 105-110 cm
Main Hoop to Front Hoop (Assumption) :- 810-815 cm

These are the basic required Dimensions to design a roll cage by Driver comfort.After taking dimensions from the driver we started the Design the roll cage

TAKING MEASUREMENTS FROM E-POWER TRAIN SUBSYSTEM:

E-Power Train Subsystem is a combination of battery,Generators & motors and IC Engine Subsystems.They worked together as a one subsystem and gives requirements for mounting the respective E-Power Train parts on the Roll cage.

Dimensions and considerations from the Batteries subsystem:

Batteries are placed according to the perspective of Battery subsystem members.They said taking two batteries is better to transmit power distribution to the required components in the vehicle.And it is placed sides of the driver to balancing the vehicle by weight.

Lithium-ion 24v 100Ah 2.6kWh battery (*2)

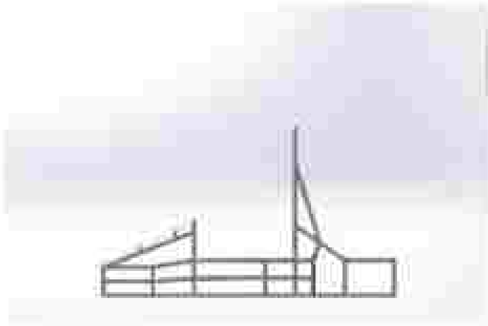
Measurements,
Length of the Battery :592 mm
Width of the Battery :154 mm
Height of the Battery :278 mm

And Other components like Generators&Motors,Engine and its accessories which is packed on the backside of the main hoop.Here,the components which is placed on the back side of the main hoop have different dimensions according to their manufacturing shape. So, We calculate average dimensions and assumed a certain value based on their value we design the roll cage.

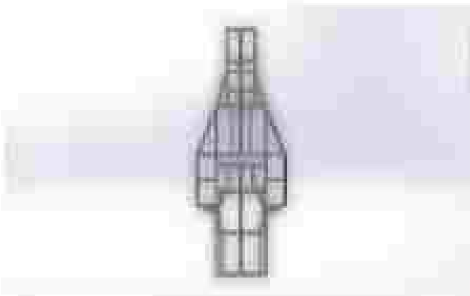
Assumed Dimensions: 90cm*60cm

Views:

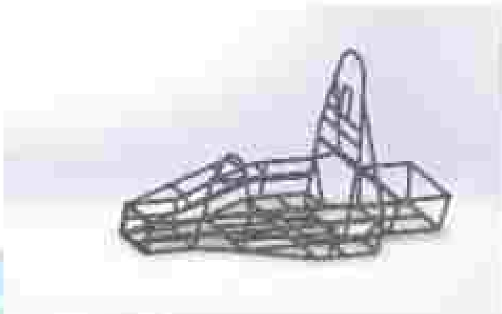
Front View



Side view



Top View



Iso View

CAE:

CONSTANT VALUES		units
Kerb weight (m)	290	kgs
ACC DUE TO GRAVITY(g)	9,81	m/s^2

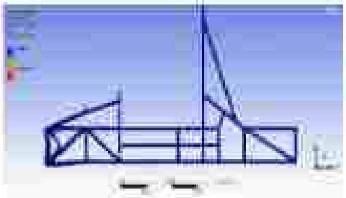
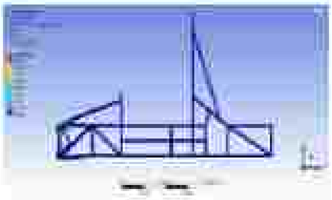
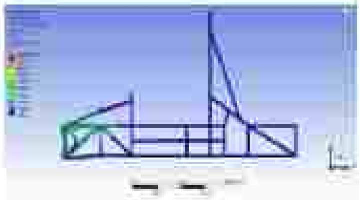
Forces	UNITS	FORMULA	RESULT	UNITS
1	G	1*m*g	2844,9	N
2	G	2*m*g	5689,8	N
3	G	3*m*g	8534,7	N
4	G	4*m*g	11379,6	N
5	G	5*m*g	14224,5	N
6	G	6*m*g	17069,4	N
7	G	7*m*g	19914,3	N
8	G	8*m*g	22759,2	N
9	G	9*m*g	25604,1	N
10	G	10*m*g	28449	N

Analysis calculation

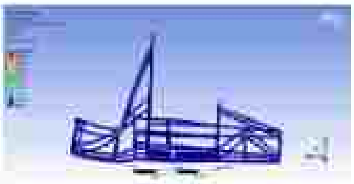
S.NO	REQUIRED DATA	(user has to enter) INPUT VALUE	UNITS	FORMULA	RESULT	UNITS
1	massof the vehicle (m)	200				
note	change the mass of the vehicle in the above automatically changes in the below columns					
	Front impact					
1	massof the vehicle (m)	200	kg			
2	initial velocity (vi)	16,67	m/s			
3	final velocity (vf)	0	m/s			
4	impact time (t)	0.3	sec			
5	**work done (WD)**			**F*S**		
	WD			**(0,5* m*(vf)^2-0,5*m*(vi)^2**	**-40293,8905**	**J**
6	**Displacement (s)**			**vi*t**	**5,001**	**m**
7	**Force**			**WD/S**	**-8057,166667**	**N**
	Rare impact					
1	massof the vehicle (m)	200	kg			
2	initial velocity (vi)	16,67	m/s			
3	final velocity (vf)	0	m/s			
4	impact time (t)	0.3	sec			
5	**work done (WD)**			**F*S**		
	WD			**(0,5* m*(vf)^2-0,5*m*(vi)^2**	**-40293,8905**	**J**
6	**Displacement (s)**			**vi*t**	**5,001**	**m**
7	**Force**			**WD/S**	**-8057,166667**	**N**
	Side impact					
1	massof the vehicle (m)	200	kg			
2	initial velocity (vi)	12.5	m/s			
3	final velocity (vf)	0	m/s			
4	impact time (t)	0.3	sec			
5	**work done (WD)**			**F*S**		
	WD			**(0,5* m*(vf)^2-0,5*m*(vi)^2**	**-22656,25**	**J**
6	**Displacement (s)**			**vi*t**	**3,75**	**m**
7	**Force**			**WD/S**	**-6041,666667**	**N**
	Roller impact					
1	Effected members			RHO &FBM MEMBERS		
2	Height of drop	10	feet			
3	Impact time (t)	0.3				
4	acc due gravity	9.81	m/s			
5	Mass of the vehicle (m)	200	kg			
6	Height in meters	3	m			
7	Potential energy =kenetic enery			m*g*h= 0.5*m*(v)^2		
8	v^2			m*g*h/(0.5*m)	58.86	m/s
	v			**square root of (v)^2**	7.672027112	m/s
9	Work done (WD)			0.5*m*(v)^2	5886	J
10	Displacement (s)			vi*t	2.301608133	m
11	Force (F)			WD/s	2558.149437	N

CAE:

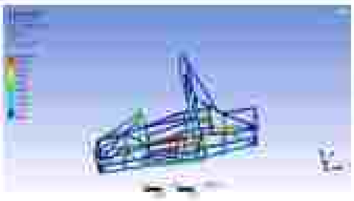
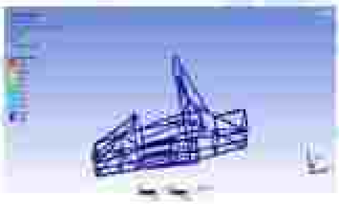
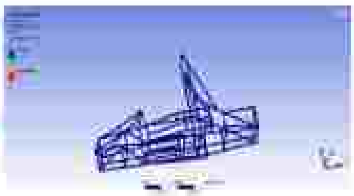
Front Ipact

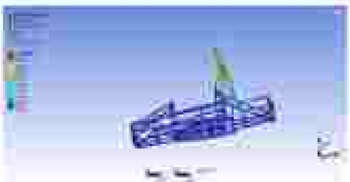
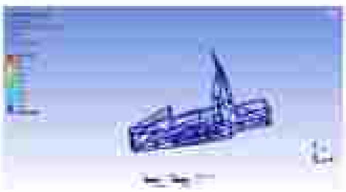
Rear Impact



Side Impact

RollOver

Impacts	**Forces,N**
Front Impact	3g
Rear Impact	3g
Side Impact	3g
Roller Impact	2g

	Front	**Rear**	**Side**	**Roll over**
Total Deformation	0.627mm	0.844mm	1.056mm	4.23mm
Equivalent stress	213.62 Mpa	340.24 Mpa	256.42 Mpa	989.78 Mpa
Factor of Safety	2.15	1.32	1.79	-

3.Driver Ergonomics and Prototype:

Designing an automotive product such as a car or truck involves the integration of inputs from many disciplines (e.g., designers, body engineers, chassis engineers, powertrain engineers, manufacturing engineers, product planners, market researchers, ergonomics engineers, electronics engineers). The design activities are driven by the intricate coordination and simultaneous consideration of many requirements (e.g., customer requirements, engineering functional requirements, business requirements, government regulatory requirements, manufacturing requirements) and trade-offs between the requirements of different systems in the vehicle. The systems should not only function well, but they must also satisfy the customers who purchase and use the products. The field of ergonomics or human factors engineering in the automotive product development involves working with many different vehicle design teams (e.g., management teams, exterior design teams, interior design teams, package engineering teams, instrument panel teams, seat design teams) to assure that all important ergonomic requirements and issues are considered at the earliest time and resolved to accommodate the needs of the users (i.e., the drivers, passengers, personnel involved in assembly, maintenance, service) while using (or working on) the vehicle.

Safety Points:

- 5 Point Safety Harness
- Neck Restraint (360) &A Arm Rest
- Rubber Padding on Roll Cage Pipes
- Head Rest

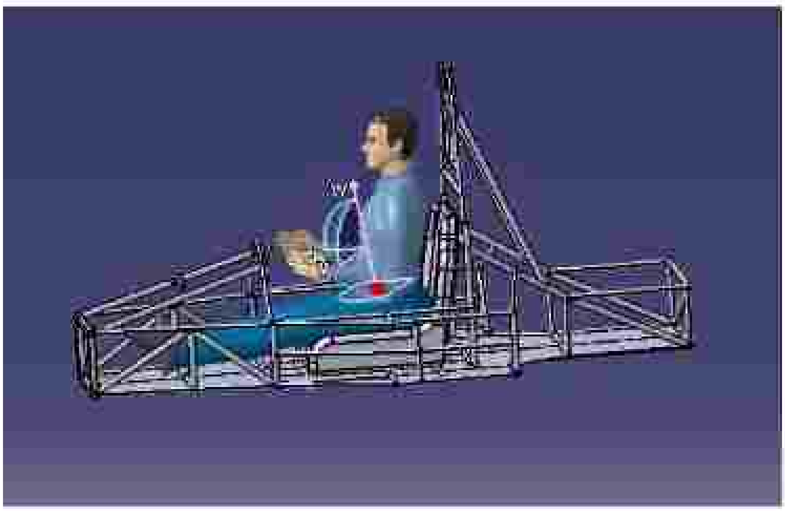
Sitting Layout & Ease of Egress :

- Steering wheel fully up and fully forward.
- Seat height at its lowest.
- Cushion tilted so that front edge is in
- lowest position.
- Back rest approximately 30 degrees reclined from vertical.
- Seat fully rearwards.
- Driver can move the seat forward until he can easily push the pedals through his full range with his whole foot, not just with his toes.

POSTURE OF 95% PERCENTILE MALE

- Head Room: 203.2 mm (8")
- Side Clearance: 101.6 mm (4")
- Sitting Length: 928mm (36.5"")
- Arm Angle: 22.13 deg
- Forearm Angle: 82.87 deg
- Hand Angle:22.7 deg
- Backrest Angle: 10 deg
- Seat Pan Angle: 5 deg
- Thigh Angle: 7.83 deg
- Knee Angle: 162.17 deg
- Leg Angle: 38.7 deg
- Foot Angle: 100.21 deg

RULA Analysis:



RULA Analysis in CATIA

Overall Rating in Rula analysis which is held in CATIA software got 3. These Rating will be decided by the given Table.

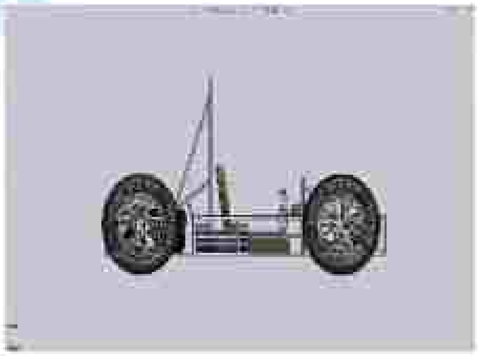
Score	Level of MSD Risk
1-2	neglibible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

Prototype:

4.Packaging:

"Packaging" is a term used in the automobile industry to describe the activities involved in locating various systems (e.g., powertrain system, climate-control system, fuel system) and components (including occupants) in the vehicle space. Thus, it is about space allocation for various vehicle systems (i.e., hardware), accommodating "people" (i.e., the driver and the passengers) and providing storage spaces for various items (e.g., suitcases, boxes, golf bags) that people store in their vehicles. The term "packaging" was used in the industry because the task of the package engineering is essentially "bringing in systems and components" produced by others (e.g., different suppliers) and fitting them into the vehicle space so that they will function properly to satisfy customers and users of the vehicle.

The seating package layout is thus a drawing or a three-dimensional model shown in computeraided design (CAD) applications (e.g., SOLIDWORKS and CATIA) showing locations and positioning of the driver and all other occupants (mostly in the form of manikins), eyellipses (drivers' eye locations specified in SAE standard J941), various reach, clearance and visibility zones (e.g., hand reach (HR) envelopes, head clearance contours, and fields of view), and other relevant vehicle details (e.g., steering wheel, floor, pedals, seats, arm rests, gear shifter, parking brake, mirrors, hard points, fiducial marks points, eye points, sight lines) and dimensions.

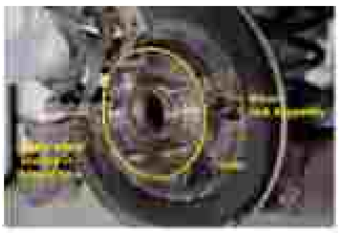


5.Wheel and tire:

We choose our vehicle tire with our requirements and road conditions where the vehicle run/race.We research the tires and we select the tyre with specification is 165/65 R13 77T. The tire with the specifications 165/65 R13 77T is designed for a variety of vehicles, particularly those with 13-inch wheels. The first number, 165, represents the tire's width in millimeters. The second number, 65, is the aspect ratio, indicating the height of the tire's sidewall as a percentage of its width. The "R" signifies a radial construction, and the following number, 13, denotes the wheel diameter in inches. The load index, 77, indicates the maximum load capacity, and the speed symbol, T, represents the maximum speed capability (118 mph or 190 km/h). This tire is well-suited for asphalt roads due to its tread pattern and compound, providing excellent traction, stability, and handling on smooth surfaces. The specified load index of 77T suggests that it can support vehicles with a weight capacity of 908 pounds (412 kilograms) per tire. As for cost, prices may vary, but it's often chosen for its balance of performance and affordability, making it a practical choice for everyday driving on asphalt roads.

Description	**value**
Width of wheel	165mm
Aspect Ratio	65%
Rim Dia	13in

Wheel Mounting:
The act of placing tires on the wheels/rims and installing them onto the axels of the car.



6.Suspension System:

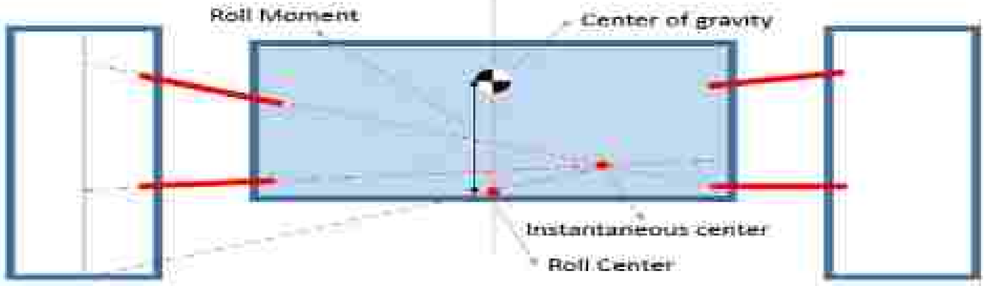
This suspension is designed on the basis of drivers safety and calculations are done comparatively with different journals and textbooks for the basic idea. We know that driver safety is major criterion for engineer and calculations are done on those bases. The type of suspension system is use to decide how forces are transferred from the tire to the chassis and also at the time of braking and acceleration the forces on wishbone arms. The control arm suspension consists of upper and lower arm. The upper arm and lower arm have different structure based on the model and purpose of the vehicle.The weight of vehicle impact on the working of suspension system. A large sprung weight to unsprung weight ratio can also impact vehicle control. The double wishbone type of suspension system is used for this vehicle. The wishbone model is made by modeling software and structural analysis is done on ANSYS. The basic procedure of suspension design is consists of the following steps.

- Selecting various design targets
- Selecting the type of geometry
- Choosing the hard points
- Analyzing the loads in the suspension

General parameters of suspension

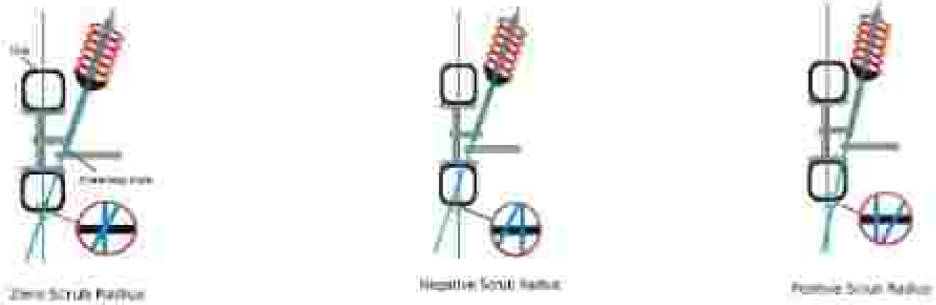
An unequal length, double-wishbone suspension system was chosen. Damper is mounted to the lower wishbone at front and rear. The main reason to choose this suspension is:

- Double wishbone is more rigid and stable than other suspension systems.
- As we have lowered the un-sprung weight to make the ride more comfortable we use, double wishbone suspension.
- One of its primary benefits is the increase of negative chamber as a result of the vertical suspension movement of the upper and lower arms.
- Tires maintain more contact with the road surface. Handling performance also increases.



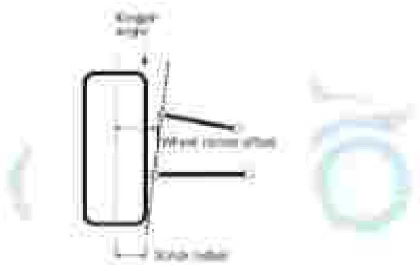
Scrub Radius:

The scrub radius is the distance in front view between the king pin axis and the centre of the contact patch of the wheel, where both would theoretically touch the road. It can be positive, negative or zero.

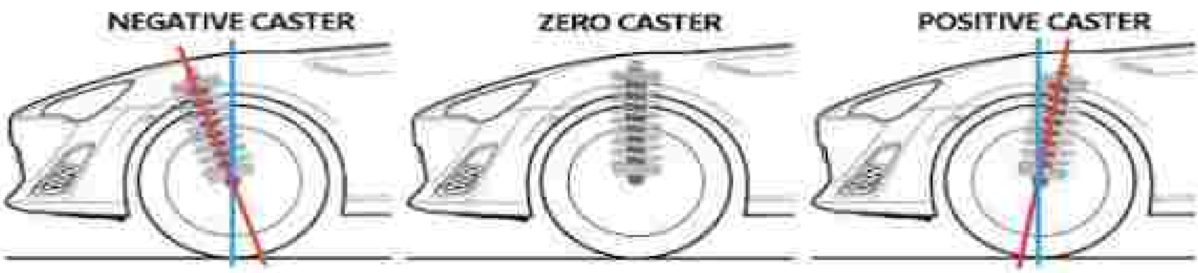


Steering axis inclination:

The steering axis inclination (SAI) is the angle between the centreline of the steering axis and vertical line from centre contact area of the tire (as viewed from the front).



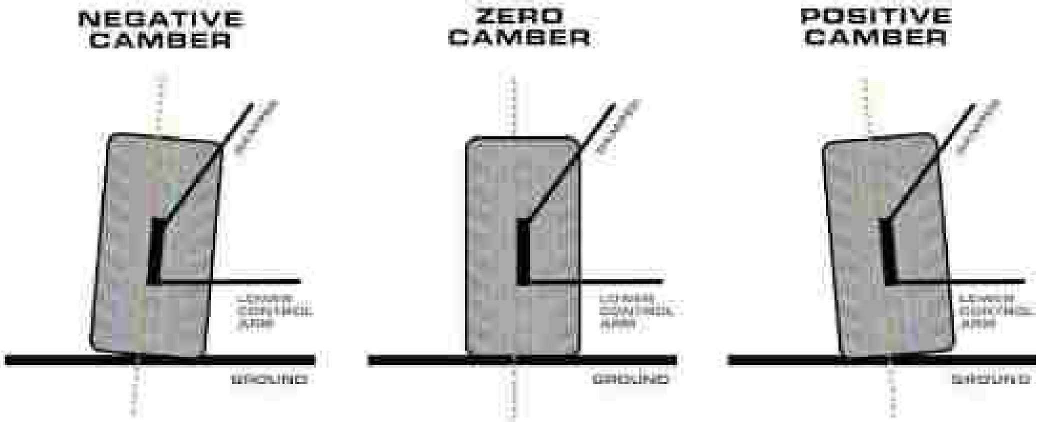
Caster Angle:



Caster angle (viewed from the side) is the angle between the vertical steering axis and the vertical plane of the wheel. It can be positive, negative, zero.

Camber Angle:

Camber angle is the vertical angle between the wheels and the road. It is used to provide better cornering traction, tyre grip and for smooth operation of the suspension.



Design of suspension system:

The design procedure for the chosen suspension system is as follows:

- Design and development of the components of the suspension
- considering dynamic factor and hence modifying the design parameters
- Static testing
- Dynamic testing
- modifying the component design based on Dynamic Testing results

The following components were designed:

- Spring
- Knuckle
- A-arms

The basic consideration for the design of the various suspension components is the overall geometry of the suspension, based on parameters given by SAE.

- **Table 1 – Specifications of Suspension system:**

PARAMETER	FRONT	REAR
SUSPENSION TYPE	DOUBLE WISHBONE	TRAILING ARM
NATURAL FREQUENCY	1.2 Hz (1.2 - 1.5 Hz)	1.5Hz (1.5 Hz -1.8 Hz)
WHEEL TRAVEL	100 MM JOUNCE=50 MM REBOUND=50 MM	100 MM JOUNCE=50 MM REBOUND=50 MM
SPRUNG MASS	115.148 KG	172.722 KG
UNSPRUNG MASS	30.32 KG	45.48 KG

SPRING STIFFNESS	3.26 N/MM	6.67 N/MM
ROLL RATE	2.16 N-M	4.33 N-M
DAMPING FORCE	153.57 N	313.55 N
DAMPING RATIO	0.589	0.688
SPRING DAMPER LENGTH	300 MM (spring outer dia (60 mm) wire dia(8mm)	300 MM (outer dia (60 mm),wire dia (8mm)
HUB MATERIAL	AL 6065 T6 series	
KNUCKLE MATERIAL	AL 6065 T6 series	

- **Table 2 – Wheel geometry:**

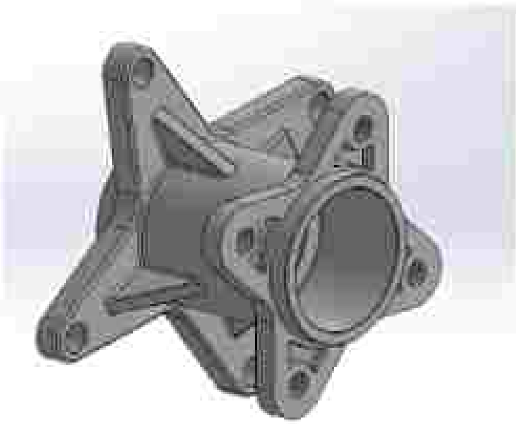
PARAMETER	FRONT	REAR
CAMBER	1 DEG	1 DEG
CASTER	4 DEG	3 DEG
SCRUB RADIUS	20 MM	30 MM
ROLL CENTER HEIGHT	33 MM	32MM
GROUND CLEARANCE	150 MM	150MM

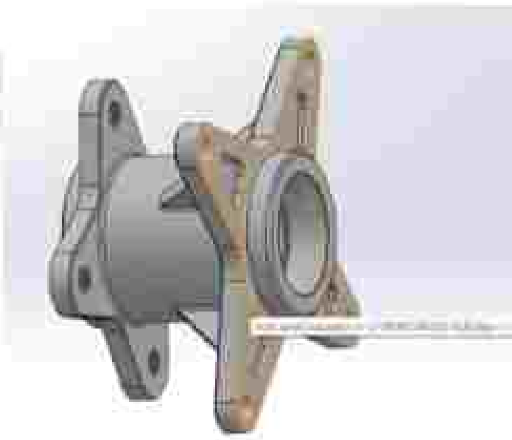
A-Arm:

The a-arms are the linkages to connect wheel assembly to the vehicle that transfers the loads from vehicle to wheel assembly or vice versa. These must be with sufficient strength to ensure the free from failure. For this the A- arms are modelled and analysed for the load cases. The braking is worst condition.

Design of knuckle:

Design of front wheel hub:



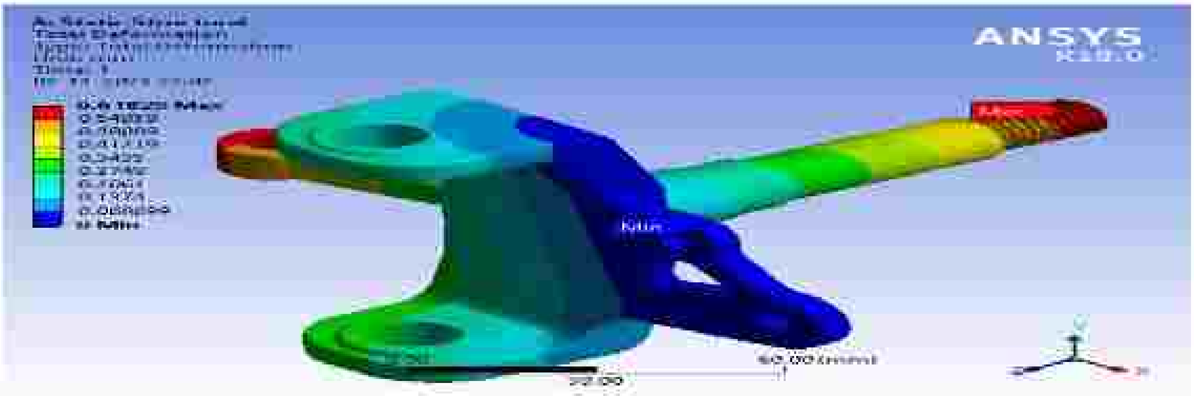


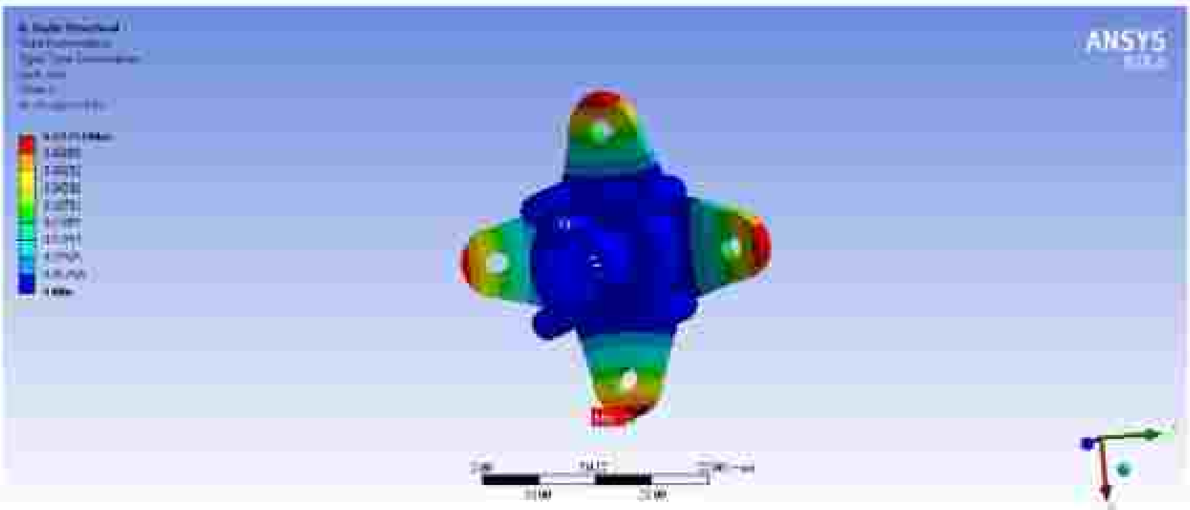
Design of rear wheel hub:

Design and setup of arms with knuckle and spring damper:

These Designs are done by Solidworks Software

Analsys of components:





These analysis done in Ansys R18.0

7.Braking system:

Functionality: - A brake is mechanical device which is used to reduce the speed or to stop within the smallest possible distance. When the brakes are engaged the kinetic energy is converted into the heat energy due to friction and slows the vehicle. Brakes plays a crucial role in ensuring the safety and control of the vehicle.

Types of brakes: -
• Mechanical brakes
• Hydraulic brakes
• Electric brakes
• Vacuum Brakes
• By-Wire Brakes

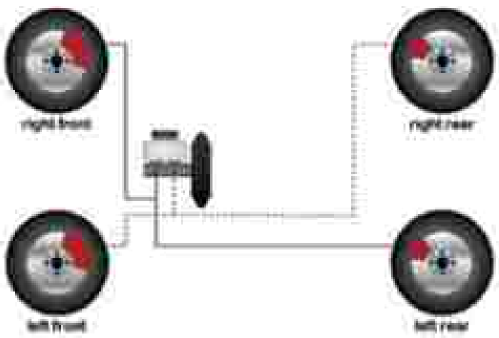
Selection of suitable braking system:

For better performance, we choose the Hydraulic disc braking system. The fundamental principle behind hydraulic disc brakes involves the conversion of mechanical force into hydraulic pressure to actuate the braking mechanism. The system consists of a brake lever, brake lines, a master cylinder, and brake calipers. When the rider applies force to the brake lever, a piston inside the master cylinder is activated, pressurizing the hydraulic fluid (usually brake fluid) within the system. This pressurized fluid is then transmitted through the brake lines to the calipers located near the disc rotor. At the calipers, the hydraulic pressure forces pistons to move, squeezing brake pads against the disc rotor. This friction between the pads and the rotor generates the braking force that slows down or stops the vehicle.

Reasons to choose:

• The work efficiency and durability of the hydraulic disc is better
• It provides more braking power with small pressure because they have more contact area
• The heat and pressured is distributed evenly components.
• Master cylinder.
• Brake callipers.
• Brake fluid.

Specifications:-
• Braking system: - Hydraulic
• Brake type: - Hydraulic disc brakes
• Brake circuit: - Diagonal split type
• Brake fluid: - Dot 3
• Master cylinder type: - Tandem master cylinder
• Disc diameter: - 180 mm
• Thickness: - 5 mm
• Caliper type: - Floating type
• Pedal ratio: - 6:1
• Master cylinder diameter: - 19.05 mm
• Caliper piston diameter: - 36mm
• Wheel base: - 1.75 m



Diagonal split type brake circuit

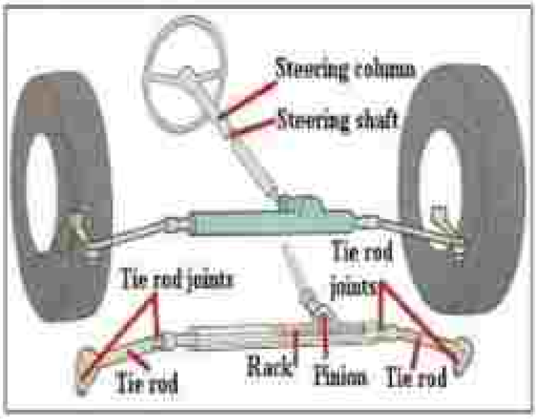
Disc rotor

Tandem master cylinder

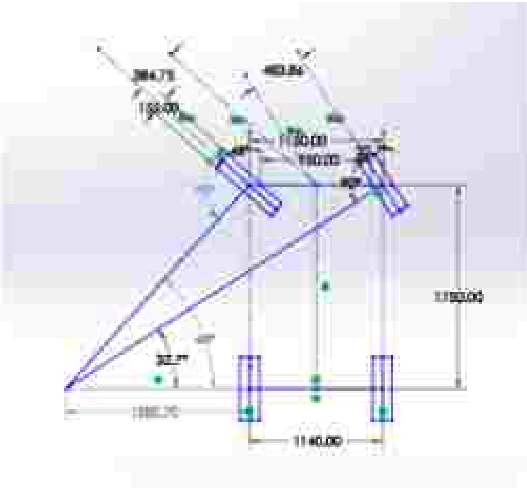
Brake pedal

8.Steering System:

A schematic of the steering system is shown .The steering system comprises of a steering wheel turning a steering column. The steering column is connected to an intermediate shaft through a universal joint. The universal joint transmits torque to a lower shaft through another universal joint. A pinion at the end of the lower shaft mates with the rack and converts the column rotary motion into the translatory motion of the rack.



PARAMETER	MEASURE
Track Width	1150 mm
Wheel Base	1750 mm
Steering Condition	Oversteer
Steering Mechanism	Ackerman Mechanism
Ackerman Percentage	100.04%
Steering Inside Angle	48 deg
Steering Outside Angle	32.702 deg
Turning circle Radius	3.2 m
Steering Gear	Rack & Pinion
Drive Type	Central Drive
Rack Travel (End to End)	108 mm
Lock To Lock Turn	1.5 Turn
Steering ratio	8:1
Length Of the Tie rod	103 mm
Steering Wheel Diameter	300 mm
Steering Column Type	Collapsible (without Power Assist)
Steering Wheel Torque	7.18 Nm



Ackermann steering
Gear Mechanism

Steering System
Design

9.Engine:

APACHE RTR 160CC

Mileage (Overall)47 kmpl
Displacement159.7 cc
Engine TypeSI, 4 stroke, Air cooled, Fuel Injection
Max Power16.04 PS @ 8750 rpmMax Torque13.85 Nm @ 7000 rpm

DIFFERENTIAL:

The gear ratio is 5.9(as per rule book)

It means for every 5.9 times rotation of pinion shaft, the wheel makes one complete rotation.

Differential

As per the generator requirement we have to fix the engine at a constant speed. to set this we have to follow the following steps

1.Locate the Throttle Control:The throttle control on small engines like the Briggs and Stratton is typically located near the carburetor. It is often a lever or a knob that can be moved to adjust the engine speed.

2.Idle Speed Adjustment:If you want to adjust the idle speed, find the idle speed adjustment screw on the carburetor. It is usually a small screw or knob. Turning it clockwise (right) will increase the idle speed, and turning it counterclockwise (left) will decrease it. You may need to consult your engine's manual for the exact location of this screw.

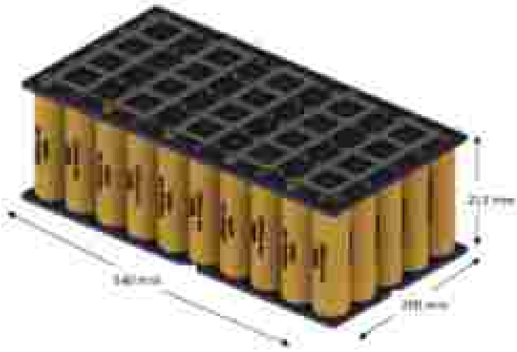
3.Full Throttle Adjustment:To adjust the full throttle speed, move the throttle control to the full throttle position. Then locate the high-speed adjustment screw on the carburetor. This is another small screw or knob. Turn it clockwise to increase the full throttle speed, and counterclockwise to decrease it.

4.Fine Tuning:After making these adjustments, you may need to fine-tune the engine speed. Start the engine and let it run for a few minutes to stabilize. If you find that it's not running at the desired speed or is idling unevenly, make minor adjustments to the idle and full throttle settings until you achieve the desired engine speed and smooth running.

5.Safety Precautions:Make sure to adjust the engine speed while the engine is off, and be cautious when working with the engine's moving parts. Always follow safety guidelines in your engine's manual.

10.Battery System:

1. BATTERY(RESS):
   48V and 100ah lithium phosphate(LiFePo4).



2. Constraints:

- Voltage and current limits.
- Temperature limit.
- State of charge (SOC).
- Cycle life limit.

3. Physical specifications:

Parameter	Values	Qty
1. Nominal voltage & Capacity	24v,100ah	2
2. BMS	80*61*21.5 in mm(0.3kg)	2
3. Battery Container Size	550*215*223 in mm(0.5kg)	2
4. Main Battery Size	540*205*213 in mm(28kg)	2
5. 12v, 5ah Battery Size	90*70*102 in mm(3kg)	1
6. Fuse Box Size	130*80*35 in mm (0.3kg)	2

4. Battery electrical specifications:

Parameter Name	Values
1. Nominal Voltage & Capacity	48V,100AH
2. Capacity (Watts)	4800W
3. Charging Voltage	57V-58V
4. Charging Current	30A-32A
5. Discharge Cut-off voltage	40V
6. Charge & Discharge temp of Battery	+45-65 degrees

5. Actual max discharge current, continuous current consumption:

Max Discharge Current	200A
Continuous current	105A

6. Consideration for efficiency and health of battery:

- Avoiding fast charging
- Using a high-quality charger
- Avoiding overcharging
- Avoiding deep discharge
- Recommended temperature range

BATTERY CALCULATIONS

What is C-rate?

The C-rate of a battery is a measure that represents the rate at which a battery is charged or discharged relative to its maximum capacity.

For example, a 1C rate means that the discharge current will discharge the entire battery in 1 hour. So, for a battery with a capacity of 100Ah, a 1C rate would mean a discharge current of 100A. Similarly, if the battery is being discharged at a rate of 0.5C, it means it will provide half of its capacity in one hour.

In other words, the C-rate gives you an idea of how fast the battery is being charged or discharged. It's important to note that charging or discharging a battery at very high C-rates can lead to reduced battery life and other potential issues3.

Here's how we can calculate the C-rate:

C-rate = Current of charge or discharge (Amps) / Rated energy (Ah)

So, if you know the current at which your battery is being charged or discharged, you can calculate the C-rate.

If this battery is being charged or discharged at a rate of 100A, then the C-rate is 1C. This is because the current of charge or discharge (100A) is equal to the rated capacity of the battery (100Ah). So, the battery will be fully charged or discharged in 1 hour at this rate.

C-rate=30A / 100Ah= 0.3C

We can charge the battery up to 1C rate.

1.Battery Capacity:

The capacity of our battery is 100Ah. This is the amount of energy the battery can store. It means the battery can theoretically deliver 100A for one hour.

2. Battery Power:

The power of the battery can be calculated using the formula:

$$P=V\times I$$

Where:

P is the power in Watts

V is the voltage in Volts

I = current in Amperes

So, for our 48V 100Ah battery, the power would be:

P=48V x 100A=4800W

3. Battery Energy (Watt-hours):

The energy stored in your battery can be calculated by multiplying the capacity in Ah by the voltage2. So, for your 48V 100Ah battery, the energy would be:

$$E=V \times Ah=48V\times100Ah=4800Wh$$

4. Battery charging time calculations (Through plug in charger):

Battery chargers are available in a wide range of ratings in the market. For a 48V 100Ah lithium-ion battery, we can find chargers with different current ratings such as 10A, 20A, 30A, and even up to 100A

If we charging our 48V 100Ah lithium-ion battery at 30A, we can calculate the charging time using the formula:

Charging Time= Battery Capacity (Ah) / Charging Current (A)

Substituting the given values:

Charging Time=100Ah/30A ≈3.33hours

So, it would take approximately 3.33 hours to fully charge your battery from a completely discharged state at a charging current of 30A.

With losses:

When charging a battery, there are always some losses due to factors such as heat generation and internal resistance. These losses can be accounted for by considering the charging efficiency of the battery.

For lithium-ion batteries, the charging efficiency is typically around 85-90%. However, it has been noted that 15% of losses can occur in case of battery charging. This means that if we want to charge 100Ah into the battery, you actually need to provide about 115Ah of charge.

So, if we charging our 48V 100Ah lithium-ion battery at 30A, taking into account an average charging efficiency of 85% (considering 15% losses), the actual charging time would be:

Charging Time= Battery Capacity (Ah) /
Charging Current (A) * Charging Efficiency

Substituting the given values:

Charging Time=100Ah / 30A* 0.85 ≈4 hours

So, it would take approximately 4 hours to fully charge our battery from a completely discharged state at a charging current of 30A, taking into account charging losses.

5. State of Charge (SOC) Calculation:

The SOC of a battery represents its remaining capacity and is usually expressed as a percentage. It can be calculated by comparing the present capacity with its rated capacity. However, this requires real-time monitoring of the battery's charge and discharge processes.

For example, if we have used 20Ah from our 100Ah battery, then the Depth of Discharge (DoD) would be:

$$\mathbf{DoD = 20Ah/100Ah \times 100\% = 20\%}$$

And the SOC would be:

$$\mathbf{SOC = 100\% - DoD = 100\% - 20\% = 80\%.}$$

6. Energy Consumption Calculation (Battery discharging):

The energy stored in our battery can be calculated by multiplying the capacity in Ah by the voltage. So, for our 48V 100Ah battery, the energy would be:

$$\mathbf{E = V \times Ah}$$

$$\mathbf{= 48V \times 100Ah = 4800Wh}$$

If we have a load that consumes power at a rate of P watts, then the time that this load can be powered by the battery can be calculated as follows:

$$\mathbf{T = E/P}$$

Where,

T= Time

E = Battery Power

P = Power taken from battery to the motor

Note: These calculations are done by assuming the load of 8.6 kw with the speed of 50 km/hr. We will change if the parameters are changed by placing changed values in the formula.

Here, 48V 100Ah battery and a load of 8600W, the time would be:

$$\mathbf{T = 4800Wh/8600W = 0.56\ hours}$$

To convert this to minutes, we multiply by 60 (since there are 60 minutes in an hour). So, 0.56 hours is:

$$\mathbf{0.56\ hours \times 60 = 33.6\ minutes}$$

So, our battery would last approximately **34 minutes** under a load of **8600W.**

I. If the vehicle is moving at a speed of 50 km/h, the distance it can cover in the time the battery lasts can be calculated using the formula:

$$\mathbf{D = S \times T}$$

Where:

D is the distance in kilo meters
S is the speed in kilo meters per hour
T is the time in hours

From our previous calculation, we know that the battery would last approximately 0.56 hours (or 34 minutes) under a load of 8600W. So, the distance covered would be:

$$\mathbf{D=50\ km/h\times0.56\ hours=28\ km}$$

So, our vehicle would cover approximately **28 kilo meters** in that amount of time (0% to 100%).

II. For 1% of charge what is the distance travelled by our REEV in how much amount of time?

So, the energy corresponding to 1% of the total battery capacity would be:

$$\mathbf{E1\% \quad =E\ total \quad \times 1 / 100}$$

$$\mathbf{=4800Wh \times 1 / 100 = 48Wh}$$

Then, we can calculate the time that this energy can power a load of 8600W:

$$\mathbf{T1\% = P * E1\%}$$

$$\mathbf{= 8600W * 48Wh= 0.0056\ hours}$$

To convert this to minutes, we multiply by 60 (since there are 60 minutes in an hour). So, 0.0056 hours is:

$$\mathbf{0.0056\ hours\times60=0.336\ minutes}$$

So, our battery would last approximately 0.34 minutes or about 20 seconds under a load of 8600W for every 1% of battery charge.

If the vehicle is moving at a speed of 50 km/h, the distance it can cover in this time can be calculated using the formula:

$$\mathbf{D1\% \quad = S\times T1\%}$$

$$\mathbf{= 50\ km/h\times0.0056\ hour = 0.28\ km}$$

So, our vehicle would cover approximately 0.28 kilometers for every 1% of battery charge.

III. Let's calculate the distance that our Range-Extended Electric Vehicle (REEV) can travel when the battery discharges from 90% to 30%.

First, let's calculate the usable energy in the battery when it discharges from 90% to 30%. This is 60% of the total battery capacity. For our 48V 100Ah battery, the total energy is:

$$E_{total} = V * Ah = 48V * 100Ah = 4800Wh$$

So, the usable energy would be:

$$E_{usable} = E_{total} * 60 / 100 = 4800Wh * 60 / 100 = 2880Wh$$

Time:

Then, we can calculate the time that this load can be powered by the battery:

$$T = E_{usable} / P$$

Where:

T is the time in hours
E usable is the usable energy in Watt-hours
P is the power in Watts

So, for our 48V 100Ah battery and a load of 8600W, the time would be:

$$T = 2880Wh / 8600W = 0.33 \text{ hours}$$

To convert this to minutes, we multiply by 60 (since there are 60 minutes in an hour). So, 0.33 hours is:

$$0.33 \text{ hours} \times 60 = 20 \text{ minutes}$$

So, our battery would last approximately 20 minutes under a load of 8600W when it discharges from 90% to 30%.

Distance:

If the vehicle is moving at a speed of 50 km/h, the distance it can cover in the time the battery lasts can be calculated using the formula:

$$D = S \times T$$

Where:

D is the distance in kilo meters
S is the speed in kilo meters per hour
T is the time in hours

So, for our vehicle moving at a speed of 50 km/h and a battery lasting for 0.33 hours, the distance covered would be:

$$D = 50\ km/h \times 0.33\ hours = 16.5\ km$$

So, our vehicle would cover approximately 16.5 kilo meters when the battery discharges from 90% to 30%.

7. Battery Life Calculation:

The life of a battery can be calculated based on its cycle life, depth of discharge, and operating conditions. However, this requires real-time monitoring of the battery's charge and discharge processes.

For example, if your lithium-ion battery has a cycle life of 1500 cycles at a depth of discharge of 80%, then theoretically, if we discharge our battery by 80% every day, the battery could last:

$$\text{Battery Life} = \text{Cycle Life} / \text{Number of Days in a Year}$$

$$= 1500/365 \quad \approx 4.1\ \text{years}$$

BATTERY CELLS DETAILS

If each Lithium Iron Phosphate (LiFePO4 or LFP) cell has a capacity of 6000mAh (or 6Ah), we would need to connect multiple cells in series and parallel to create a 24V 100Ah battery pack. Here's how we can calculate the number of cells required:

Series Configuration (for Voltage):

The nominal voltage of an LFP cell is 3.2V. To achieve a total voltage of 48V, we would need to connect cells in series. The number of cells 'n' needed can be calculated using the formula:

$$n = V\ total \quad / V\ cell$$

Substituting the given values:

$$n = 24 / 3.2 \quad = 7.5$$

So, we would need 8 cells in series to achieve a 24V battery pack.

Parallel Configuration (for Capacity):

If each cell has a capacity 'C' Ah, then we would need 'm' cells in parallel to achieve a total capacity of 100Ah. The number 'm' can be calculated as:

$$m = C\ total \quad / C\ cell$$

Substituting the given values:

$$m = 100 \quad / 6 = 17$$

So, we would need 17 cells in parallel to achieve a 100Ah capacity

So, we will end up with a configuration of 8 cells in series and 17 strings in parallel, which is a total of (8 * 17 = 136) cells.

These are the number of cells to obtain 24v and 100ah.

Weight:

The total weight of 136 Lithium Iron Phosphate ($LiFePO_4$ or LFP) cells, each weighing approximately 180 grams, can be calculated as follows:

Total weight = Number of cells * Weight of each cell

= 136 cells * 180 grams = 24,480 grams

Since 1 kilogram is equal to 1000 grams, the total weight in kilograms is:

Total weight = 24480 grams / 1000 = 24.48 kilograms

Dimensions:

The dimensions of our battery pack would depend on how we arrange the cells. If we arrange the cells in a grid with 8 cells (one series string) along the width and 17 cells (parallel strings) along the length, then:

Width: The width would be the diameter of one cell times the number of cells in one series string, which is (32mm \times 8 = 256mm).

Length: The length would be the diameter of one cell times the number of parallel strings, which is (32mm \times 17 = 544mm).

So, if we lay the cells flat in this arrangement, the approximate dimensions of our battery pack would be **544mm (length) x 256mm (width) x 70mm (height).**

Battery Cell Dimensions

11.Generator:

The duration for which the motor will run depends on the capacity of your battery and the power draw of the motor. battery has a capacity of 48V * 100Ah = 4800Wh or 4.8kWh . If motor is running at full power (4.8 kW), it will theoretically deplete the battery in about 1 hour.

If the motor is running at full power (4.8 kW), it will draw 100A current from your 48V battery (since Power = Voltage * Current).

Generator:

Power Generation: The power generated by a generator can be calculated using similar formulas as for a motor. The electrical power output of a generator can be calculated using the formula:

$$\mathbf{Pout = V \times I}$$

Where Pout is the output power in watts (W), V is the voltage provided by the generator in volts (V), and I is the current in amperes (A).

The power generated by an IC engine connected to a generator depends on the engine's capacity and efficiency.

For a 160cc engine, we can estimate its power output using a general rule of thumb that equates each cc (cubic centimeter) of engine displacement to about 0.040-0.045 horsepower[12]. This is a rough estimate and actual values can vary based on factors like engine design, fuel type, and operating conditions.

Using this rule of thumb, a 160cc engine would produce approximately:

HP=160cc×0.040HP/cc=6.4HP (or) HP=160cc×0.045HP/cc=7.2HP

So, the power output of a 160cc engine is estimated to be between **6.4 to 7.2 horsepower**.

This power would then be used to run the generator. The actual power delivered to the battery by the generator would depend on the efficiency of the generator and any losses in the electrical system.

The generator rating required to charge a battery depends on the battery's capacity and the desired charging time.

Your battery has a capacity of **48V * 100Ah = 4800Wh or 4.8kWh**[1]. If you want to fully charge this battery from 0% to 100% in, say, 5 hours, you would need a generator with a power output of at least:

$$\mathbf{P=tE=5h4.8kWh=0.96kW}$$

So, a generator with a power output of around **1 kW** should be sufficient to charge your battery in about 5 hours.

If you want to fully charge your 48V 100Ah battery in 1 hour, you would need a generator with a power output of at least:

P=tE=1h4.8kWh=4.8kW

So, a generator with a power output of around **4.8 kW** should be sufficient to charge your battery in about 1 hour.

The weight that a 4.8 kW PMDC motor can carry depends on various factors such as the efficiency of the motor, the gear ratio, the terrain, and the speed at which you want the vehicle to move.

As a reference, some electric vehicles of similar weight (around 400 kg) have used motors with power ratings around 5 kW.

Generator size & specifications:

Peak power	7KW
Continuous Power	3.2KW
Max RPM	3600 RPM
RPM at Continuous Power	3000RPM
Peak And Continuous Current Ratings	57-54A
Torque at Peak Power	10 NM
Starting Torque Requirement	15NM

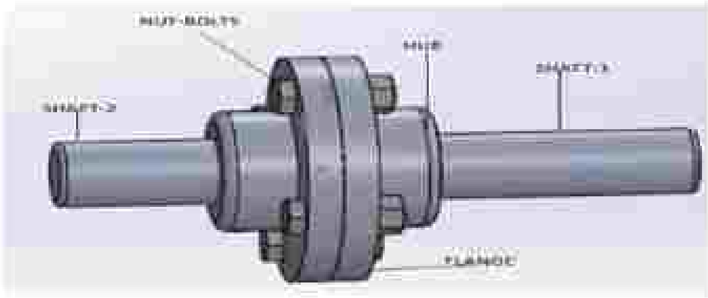
Constraints:

- Maximum Efficiency(85%)
- Output Power (3.2KW)
- Running Speed (3000)

Coupling mechanism:

- Flange coupling

The flange coupling is a sensitive to the moment, torque and load path.



12.Motor:

Type of Axial flux motors

Features

- ➢ Highly Efficient
- ➢ Lightweight and Compact
- ➢ High Continuous Power
- ➢ High Power Weight Ratio
- ➢ Simple and Light Controller
- ➢ No External Cooling
- ➢ Low Maintenance
- ➢ Competitively Price

Necessity of axial flux motor

Compact Design: Axial flux motors have a flat and compact design, which allows for a low-profile and space-efficient motor. This makes them suitable for applications with tight space constraints.

High Power Density: They often have a high power density, meaning they can generate a significant amount of power for their size and weight, making them suitable for high-performance applications.
Efficient Cooling: The open and flat design of axial flux motors enables effective cooling, which helps dissipate heat and maintain motor performance, especially under high load conditions.
Improved Heat Dissipation: These motors can dissipate heat efficiently due to their larger surface area, which is beneficial for prolonged and high-speed operation
Scalability: Axial flux motors are generally easier to scale up or down, allowing for adaptability to a wide range of applications.

Application program

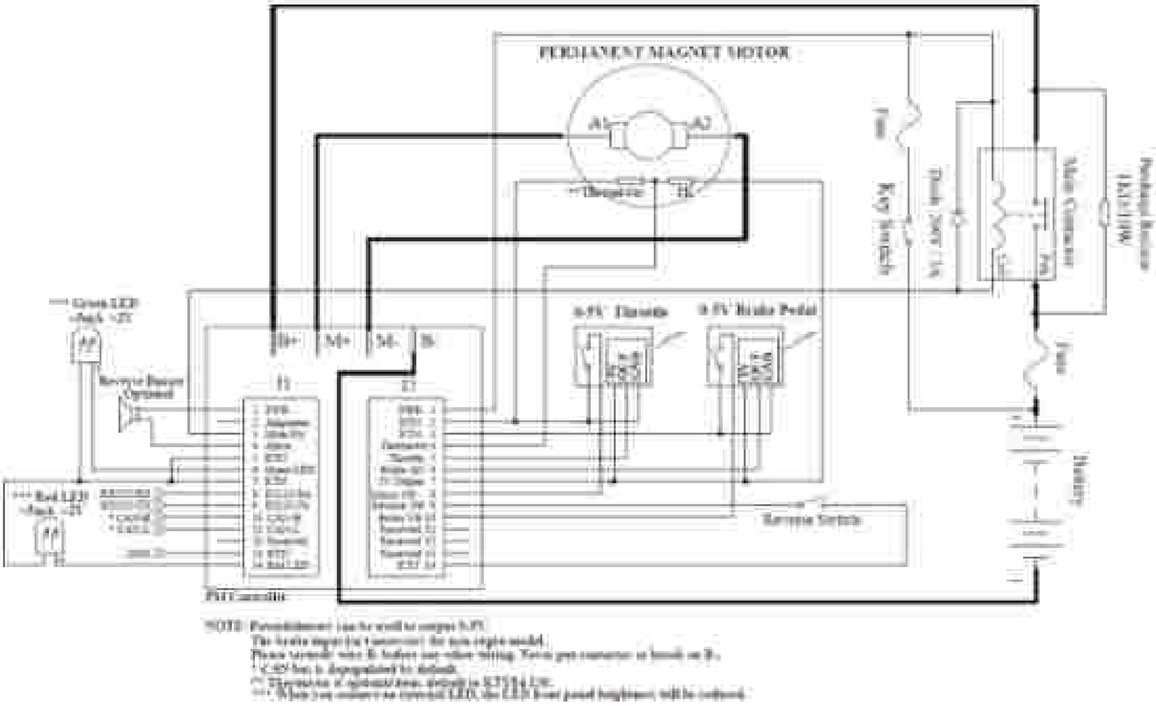
Axial flux motors have an extended range of possible applications, specifically for high torque density and compact space applications. Its technology is being enhanced and improved continuously to make it cost-effective for different power levels and power density applications.

One of the considerable application areas is the e-axle. Due to its smaller width, the motor and gearbox to- gether can be packaged in the axle. Important application areas of axial flux motors are electric motorbikes, large electric buses and trucks, hybrid applications, and electric aircraft.

Need of axial flux motor

- Axial flux motors are preferable for EVs due to their multiple advantages.
- The axial flux motor can be mounted on a wheel-hub due to its shape and size.
- Seven times higher flux interaction can be obtained in axial flux technology, which results in higher power density, developing 30-40% more torque than a radial motor of the same size.
- Axial flux motor is highly efficient (about 96%), which is due to the smaller flux path in comparison to radial flux motors.
- A greater torque-to-weight ratio is obtained in axial flux motors as a result of dual permanent magnet rotors.

Motor controller wiring diagram



Motor Calculations:

To design an electric vehicle with a weight of 400 kg and a top speed of 45 km/ hour. The vehicle should overcome three resistance forces they are

1) Rolling resistance

2) Gradient resistance

3) Aerodynamic resistance (aero drag)

The total resistance force

$F_{total} = F_{rolling} + F_{gradient} + F_{aerodrag}$

Rolling resistance:

$F_{rolling} = C_r \times (ma)$

C_r =coefficient of rolling resistance (0.017 is for asphalt road)

m= 400kgs

a =9.81 m/s^2

$F_{rolling}$ =(0.017 x 400 x 9.81)

$F_{rolling}$ = 66.708 N

Grade resistance

$F_{gradient} = m \times a \times \sin\theta$

Consider as flat surface θ= 0

There for flat surface $F_{gradient=0}$

Let us consider a inclined surface θ=15=0.25

Then
$F_{gradient} = 400 \times 9.81 \times 0.25$
$\mathbf{F_{gradient} = 981 N}$

Aerodynamic resistance

$F_{Aerodrag} = 0.5 \times (\times v^2 \times C_A \times Af)$

$F_{Aerodrag} = 0.5 \times (1.23 \times 12.5^2 \times 0.3 \times 1.5)$

$\mathbf{F_{Aerodrag} = 43.24 N}$

$F_{total} = F_{rolling} + F_{gradient} + F_{aerodrag}$

$F_{total} = 66.708 + \mathbf{981 + 43.249}$

F_{total}= 1090.94 N (on inclined surface)

F_{total} = 66.708 + 43.249

F_{total} =109.95 N (on flat surface)

1090.94 N is the total resistance force to get propelled.

Power =total resistance force x velocity of the vehicle

Power = 1090.4 x12.5

Power = 13630 watts (13630 /1000) =13 kW

Power= 13 kilowatts (on inclined surface)

Power = 109.95 x 12.5

Power=1374.37 watts

Power = 1.3 kilowatts (on flat surface)

1) Motor rpm :

Power = 1374 watts
Let us take the diameter of the vehicle wheel =432 mm =0.432 m
Radius of the wheel (r) =216 m = 0.216 m
Circumference of the wheel =2 r
(2 x 3.14 x 0.216)= 1.357 m
For one revolution of wheel it covers 1.357 m
We have taken the speed of the vehicle =45 km/hr
45 x 1000/ 60
= 750 meter /minute
It means when a vehicle drives at a speed of 45 km/hr it will be reached 750 meter for 1 minute
Maximum wheel rpm = Distance reached per minute at top speed

Distance covered by wheel for 1 revolution

=750/ 1.357

Maximum wheel rpm = 552.68 rpm

Motor rpm =sprocket ratio x wheel rpm

Sprocket ratio = number of teeth in wheel sprocket

Number of teeth in motor sprocket

=44/12 =3.66

Motor rpm = 3.66 x 552.68

Motor rpm = 2020 rpm

2.) Motor Torque:

We know that power = 2nTX 3.14/ 60

1374 = (2 X 3.14 X 2020 T)/ 60

T= (60 X1374) / (2 X 3.14 X2020)

T=6.498 N/M

Maximum Torque:

We know that newton's law of motion

V= u + at

a= acceleration (m/s)

v = final velocity (m/s)

u = initial velocity (m/s)

t = 10 seconds (o to 45 km/hr to reach from o to top speed)

We know F = m X a

F = 400 x 0.625

F= 250N

Maximum torque required to move the vehicle

Maximum torque =Force x radius of the wheel

Maximum torque = 250x 0.216

Maximum torque of the motor = 54n/m

Conclusion: required motor = 1.5 kW to 13 kW but our battery can bare up

to 7 Kw only

Motor with 54 n/m torque for 400 kg vehicle with a speed of 45 km/ hr theoretically

Practically if we take Ather 450 x vehicle it runs with a 3.3 kWh motor

It can bare up to 250 kg so if we double it so we get 6.6 so a 7kw is sufficient to drive our REEV (theoretically)

Aim: To run an electric vehicle with a 48 v 5000 watts motor how much Ampere hour of lithium ion battery is needed.

Step 1: Find out the current (in amps) consumed by the motor to run

We know that power = voltage x current

5000 = 48 x current

Current = 5000/48

Current =104.16 amps (theoretically)

Step 2: find out watt hour of the battery to run the 5000 watts motor for 1 hour

Simply multiply (5000 watts x 1 hour)

= 5000x 1 = 5000 watt hour

Let us take the efficiency of 85% for battery

(Imagine the warning notification charge your mobile battery is 20%)

85% =0.85

5000/0.85 = 5882.3 watt hour

Instead of taking 5000 watt hour we are taking some more that is 5882.3 watt hour so that we can run vehicle without any losses.

Note: in market most company batteries are available in AH (ampere hour)

We know that power = voltage x current

Also watt hour = voltage x ampere hour

5882.3 = 48 x ampere hour

Ampere hour = 5882.3/ 48

Ampere Hour =122.5 AH theoretically

Take 100 AH (available in market)

Conclusion: to run a 5000 watt motor for 1 hour 48 volts 100 AH lithium ion battery is needed.

If the electric vehicle is running at an average speed of 35 km/ hr 48 volts 100 AH provides 35 KM mileage.

If the electric vehicle is running at an average speed of 70 km/ hr

The 48 volts (100x2) 80 AH is needed.

Safety and life of the battery is the paramount

STEP 1: note down the lithium ion battery capacity in AH

(If the battery is mentioned in kWh then convert into AH)

STEP 2: Calculate the charging current

Note: the charging current I_c should not exceed 30% of the ampere hour of the battery

Step 3: calculate the charging time in hours by using the following formula

T_C = battery capacity in AH / charging current in ampere

Step 4: consider some 30 % of losses during charging the battery

(Thermal run away= due heat dispassion)

Example:

Battery capacity = 40 ah

The charging current I_c = 30% multiplied with battery capacity

= 0.3 X 40 **I_c =12 amps**

T_C = battery capacity in AH / charging current in ampere

= 40 /12

Total charge time (T_C) = 3.33 hours

Therefore due to heat dissipation losses 30% (0.99) time will be extra taken to charge the battery

Conclusion: Total charge time = 3.33 + 0.99 =4.32 hours to charge a lithium ion battery from 20% to 97%

(Don't charge battery to 100% it decreases the charge cycles)

Overall conclusion:

To drive a 400 kg vehicle with a 45 km/hour speed on an asphalt road which is flat surface

1.5 kilowatt motor with 20 n/m torque, 2000 rpm is needed

48 v 40 AH li ion phosphate battery is needed

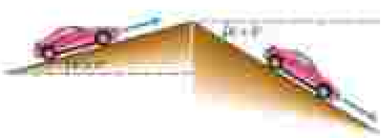
HVIL (High Voltage Interlock) is a safety feature that uses a low-voltage loop to monitor the integrity of a high-voltage circuit.
The HVIL system is designed to protect people who may come into contact with high-voltage components of electric vehicles.

SPEED,ACCELERATION,GRADEABILITY

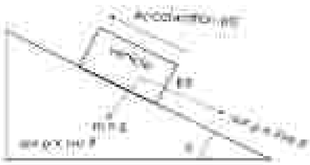
The vehicle load power can increase or decrease depending on whether the car is ascending or descending an incline. The climbing resistance or downgrade force is given by

$$Fc = mg \sin\theta$$

where θ is the angle of incline and g is the acceleration due to gravity. The climbing forceis positive, resulting in motoring operation. The down grade force is negative and can result in energy regeneration to the battery, a mode commonly used in electrically propelled vehicles rather than friction braking to slow the vehicle.
The gradability is the maximum slope it is the ratio of the rise to the run.



Gradiability



Grade Resistance

Rolling Resistance

Aerodynamic Drag

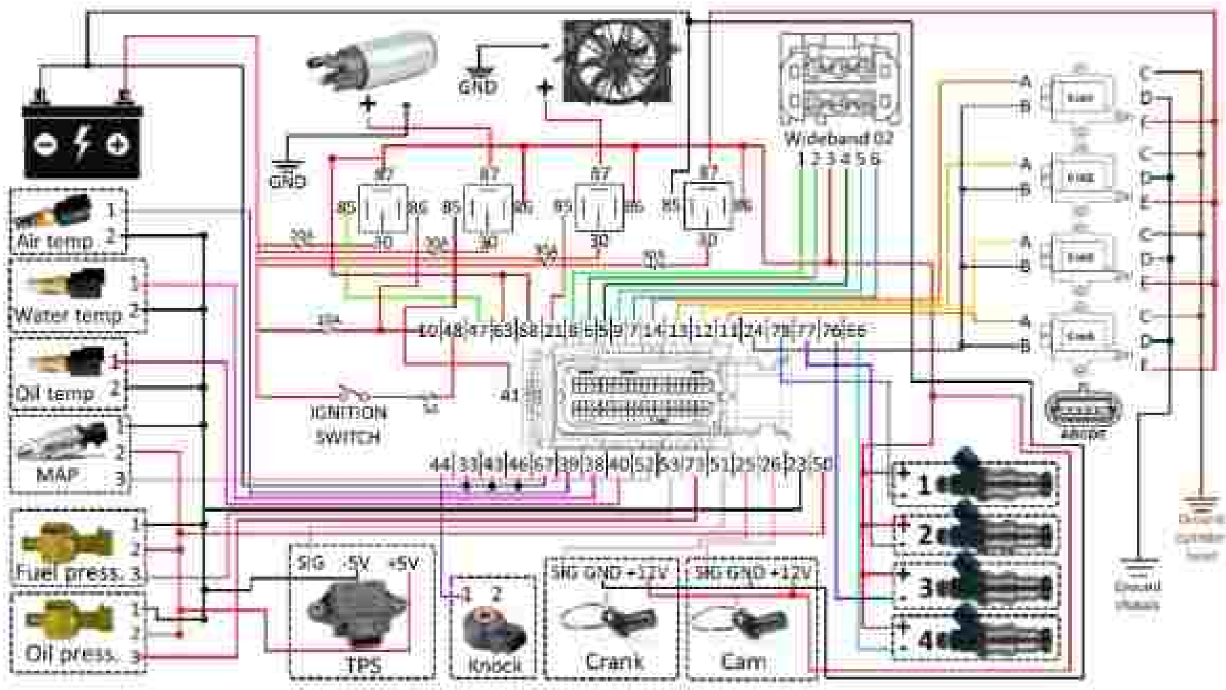
PARAMETER	VALUE
Rolling Resistance	67 N
Aerodynamic Drag	43 N
Grade Resistance	981 N
Total Tractive Force (on inclined surface)	1091 N
Total Tractive Force (on Flat surface)	110 N
Power (on inclined surface)	13 K.W
Power (on Flat surface)	1.3 KW
Motor RPM	2020 Rpm
Motor Torque (min,max)	6.4-54 n.m
acceleration	1.25 m/s²
Speed	45kmh

13.Vehicle Control Unit(VCU):

A Vehicle Control Unit is an electronic control unit that manages a vehicle's subsystems. A VCUs' responsibility is usually to interact, aggregate data, and then make decisions. It interacts with different ECUs (Electronic Control Units) within a vehicle ecosystem.
These different ECUs would ideally involve components like

- Motor Controller (MCU),
- Battery Management System (BMS),
- On Board Charger (OBC),
- DC DC, Instrument Cluster (IC), and
- Telemetry Control Unit (TCU).

Vcu of a Ic engine



VCU function in an electric vehicle

In an electric vehicle, the VCU regulates and optimizes the power flow between the battery and the motor.

It also monitors and controls other systems, such as the regenerative braking system and the charging system.

It receives signals from various sensors in the vehicle and uses that information to control the power train system.

For example, when the driver presses the accelerator, the VCU receives a signal from the pedal position sensor and sends a signal to the motor controller to increase the power output to the electric motor.

Or when the driver presses the brake, the VCU sends a signal to the motor controller to reduce the power output and engage the regenerative braking system to slow down the vehicle.

Types and applications

There are different kinds of VCUs available, and the choice depends on the vehicle's application and requirements.

We must analyze EV operation parameters such as road conditions and other criteria to ensure that control unit designs are robust and adaptive, enabling system improvement in dynamic and steady-state performance.

Reflashed OEM

An original equipment manufacturer (OEM) is generally perceived as a company that produces non-aftermarket parts and equipment that may be marketed by another manufacturer. It is a common industry term recognized and used by many professional organizations such as SAE International, ISO, and others.

StandaloneECU

Conclusion

A VCU should be

1) Easy installation and compact size less weight

2) Its display and design should match perfectly

3) Easy user interface for the driver

4) Efficient and economic cost

5) Easy OS installation

6) Easy to trouble shoot

7) Connectivity (Bluetooth)

8) Spontaneous reaction (fast)

9) Ram management

10) Rider data storage access (previous ride history)

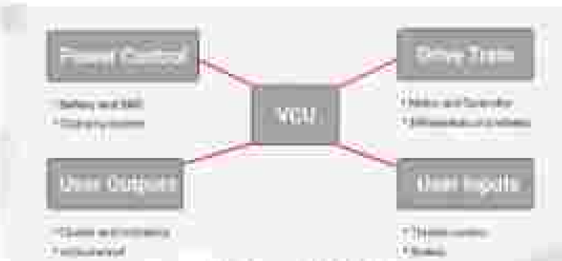
11) Energy saving

12) Vehicle health status (give alerts)

13) NCV feature (in case of wiring issue)

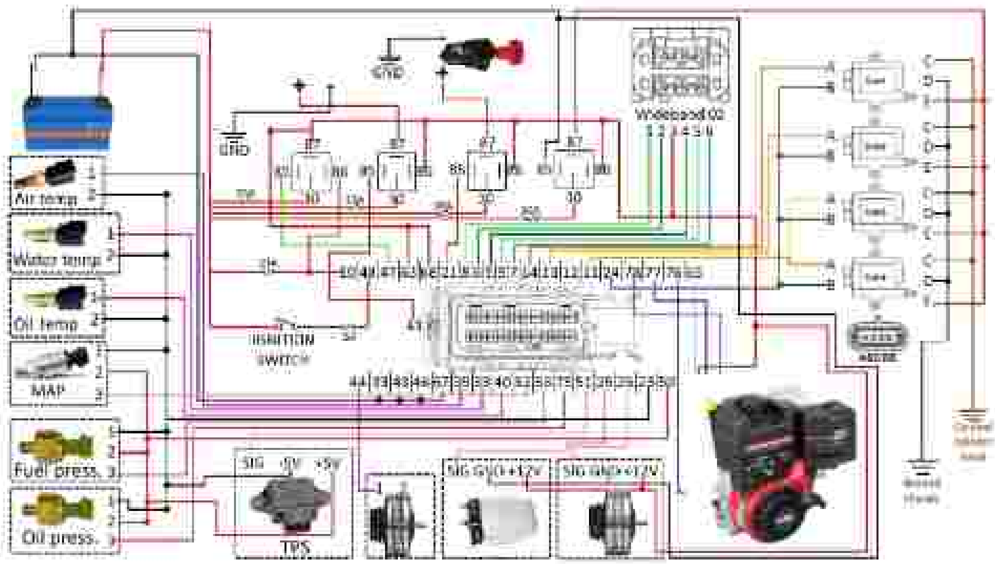
14) Seat belt warnings

15) Flexible in connecting sensors......



Working Of VCU

Electrical Architecture:



Types of sensors:

Here some of the sensors are used in our REEV vechicle,

- Engine speed sensors
- Wheel speed sensors
- Vehicle speed sensor
- Throttle position sensor
- Temperature sensor
- Air flow sensor

Sensor placement:

The current sensors is used to monitor the output current of the generator.The temperature sensor checks the temperature of the engine,battery and motor.The fuel level sensor determines the fuel level.

Integration:

Integration of sensors in REEV involves combining data from multiple sensors provide a comprehensive understanding of vehicle performance.

14.App Development

App Design

Introduction:

In response to the evolving landscape of sustainable transportation, we embarked on the creation of a groundbreaking mobile application designed to enhance the driving experience and functionality of smart electric vehicles. This documentation delves into the design and development process of this innovative app, a pivotal component of our REEV project.

Work Progress:

Our journey commenced with a meticulous analysis of user needs and industry trends, leading to the identification of key features critical for a comprehensive user experience. These include a dynamic battery display, fuel tank information, live location and vehicle tracking, TPMS (Tyre Pressure Monitoring System), a robust fault detection system, and an engine temperature tracker.

To bring these features to life, we outlined the necessary sensors and technologies. From Battery State of Charge (SOC) Sensors to GPS modules and TPMS sensors, each component was chosen with precision to ensure optimal functionality and data accuracy. Additionally, we integrated an OBD-II scanner for the fault detection system and a coolant temperature sensor for the engine temperature tracker.

In establishing a secure and user-friendly environment, we prioritised backend authentication. Users can create accounts and log in securely via email and password, providing a personalised experience while ensuring data privacy.

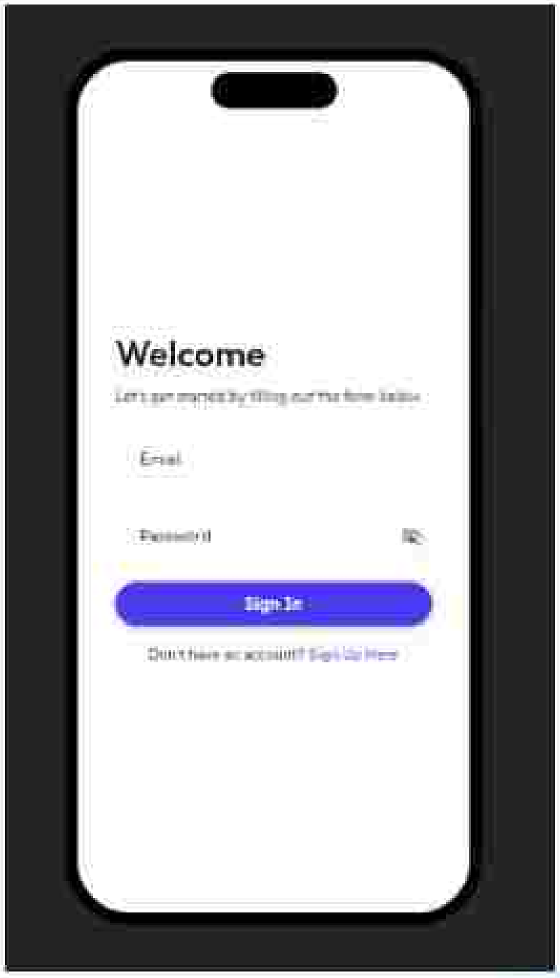
Working Process Conclusion:

The working process of our app is seamlessly interconnected. Upon login, users are greeted with an intuitive dashboard displaying real-time battery status, fuel information, and live location tracking. The TPMS ensures optimal tyre conditions, while the fault detection system proactively identifies issues, guaranteeing uninterrupted and safe driving.

The engine temperature tracker and other advanced features contribute to a holistic and user-centric driving experience. Regular updates, push notifications, and a user-friendly interface enhance overall usability.

Conclusion

Our app design reflects a harmonious fusion of innovation, functionality, and user-centricity. The careful integration of sensors, robust backend authentication, and a feature-rich interface make this app a cornerstone in the paradigm shift towards sustainable and intelligent electric vehicles. Below are some glimpses of the app's interface, showcasing its user-friendly design and comprehensive feature set.


Welcome
Email
Password
Sign In


80
Battery
Engine
Charge
Other


Chaitu
Passenger Documents
Tracker Notifications
Help Center
Settings


Charge Management
Battery Status
Battery Level
75%
Battery Health
Good
Charging Status
Charging
Not Charging
Unknown

15.Cost and Weight Analysis:

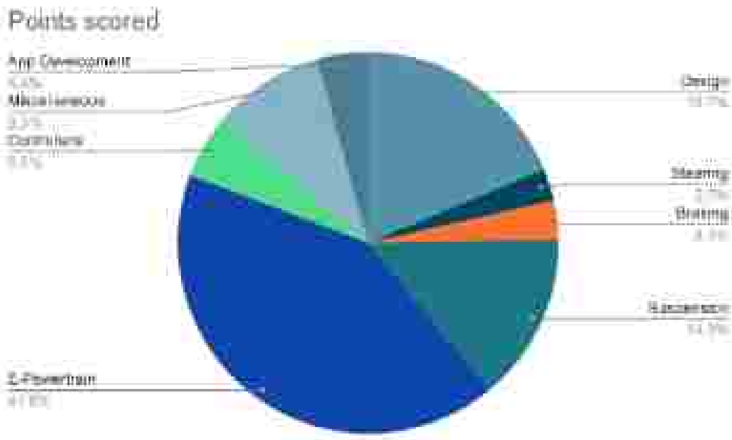
Cost Analysis.

We estimated the cost of our vehicle by referencing the market and old vehicle manufacturing rates. These estimated values are shown in the given table.And also represented in pie chart.

Estimated cost:

Design	170000
Steering	25000
Braking	30000
Suspension	130000
E-Powertrain	380000
Controllers	50000
Miscellaneous	85000
App Development	40000

Estimated Cost Represented in Pie Chart:

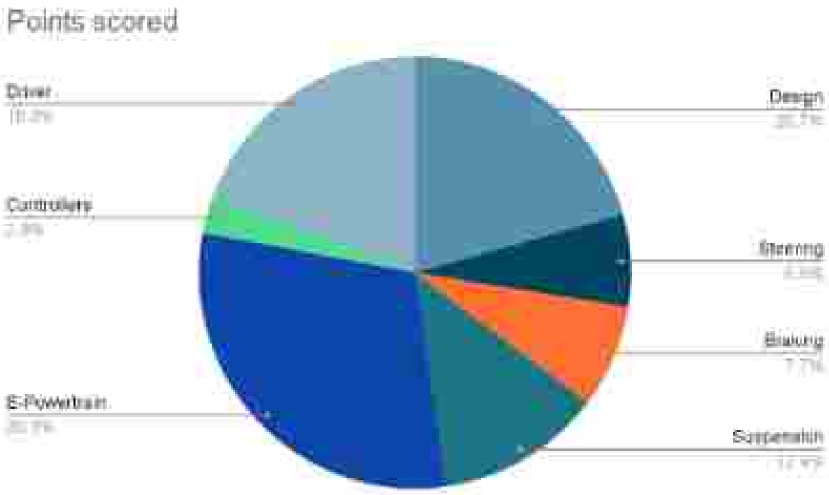


Weight Analysis.

We estimated the whole vehicle weight by referencing the our design requirements, internet and old vehicle weights.These estimated values are shown in the given table.And also represented in pie chart.

Design	75 KG
Steering	25 KG
Braking	25 KG
Suspension	45 KG
E-Powertrain	110 KG
Controllers	10KG

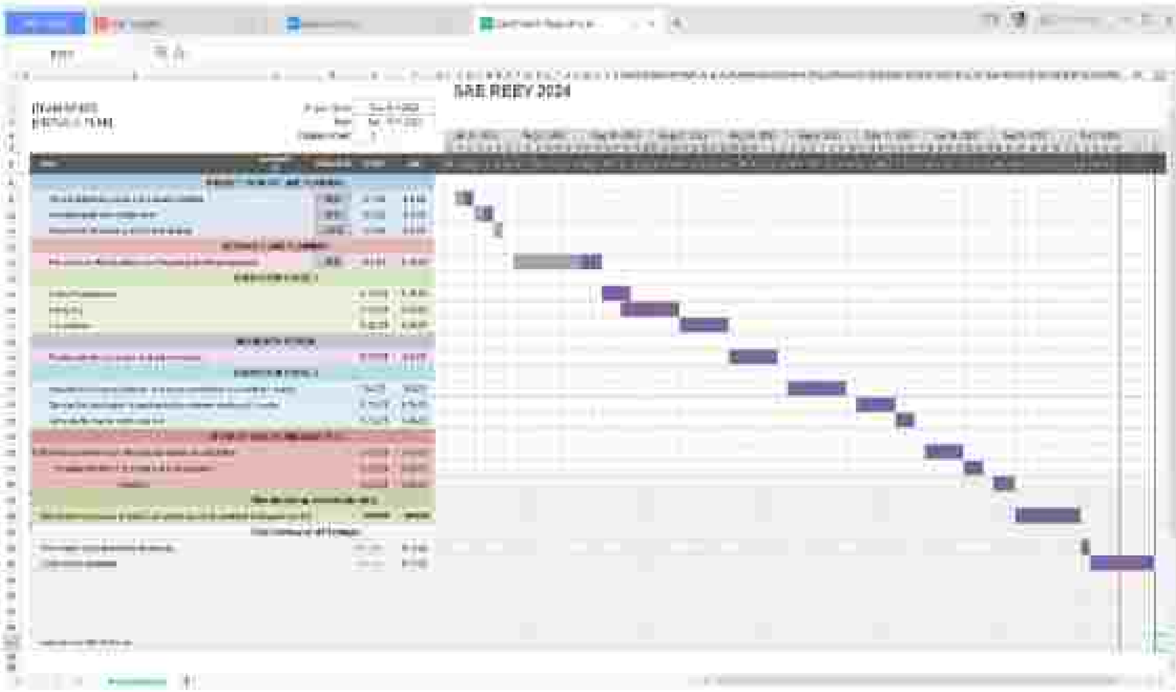
Estimated Cost Represented in Pie Chart:



16.DFMEA Analysis:

SL.NO	COMPONENTS	FAILURE MODE	FAILURE CAUSE	FAILURE EFFECT	S*	O*	D*	RPN* S*O*D	PREVENTIVE ACTIONS
1	**Frame**	Structural failure bending & breaking of frame	Axial stress exceeds yield stress of material due to excess load & impact loading	Overall damage to roll cage.Frame breaks or bends	10	6	7	420	Choose material with appropriate /high factor of safety,effective design & analysis
2	**Engine**	Mechanical failure, engine component damage	Unavailability clean air & proper fuel	Vehicle become inoperable due to engine failure	9	3	4	108	The engine position should be such that it has free access to clean air & risk to driver is minimum
3	**Transmission**	Mechanical failure	Fatigue cyclic loading	Vehicle becomes inoperable	8	2	4	64	Choose transmission system according to given load,performance
4	**Springs**	Spring fracture & fails	Due to faulty choose of springs,spring fails due to load exceeding the yield stress of material	Damage to suspension system & rough of the vehicle	6	1	3	18	Choose springs to vehicle loads & other specification
5	**Dampers/ shock absorbers**	Mechanical failure ,Leaking of suspension oil	Cylinder damage due to foreign body debris	Damage to suspension system & rough of the vehicle	6	2	2	24	Verification of specification & testing
6	**Steering column**	Mechanical failure ,excess vibration	Debris leading to steering column failure	Steering failure,safety of driver & others compromised	9	2	2	36	Verification of desired specification & testing
7	**Braking system**	Mechanical failure	Not sufficient braking force	Damage to vehicle in undesired circumstances	9	5	3	135	Choose material with high FOS & careful testing
8	**Driver seat**	Structural failure affecting safety	Excess load leading to bearing stress	Endangers driver's safety	9	2	3	54	Proper fitting & material according to correct specifications of load
9	**Vehicle electrical components**	Electrical failure	Water damage ,electrical failure	Endangers driver's safety due to contact from electricity	9	5	2	90	Proper insulation should be provided & wiring should be done properly

17.Project plan:



18.Our Enagagement in REEV:

19.College Facilities:

Simulation Lab

Machine Tools Lab

R&D Cell With
Ethernet Connection

Four Wheelers Lab

Hostel Facilities

20.Team composition: