FINAL REPORT

ELECTRIC-SOLAR VEHICLE CHAMPIONSHIP

TEAM: **THE PHOTO RAPTORS**

LOVELY PROFESSIONAL UNIVERSITY

SAVE PHOTONS, REPULSE FUTURE

ABSTRACT

Our team PHOTO RAPTORS is basically dedicated towards designing and manufacturing of a well efficient and innovative solar car, which is concerned with harvesting the most abundantly available solar power i.e. a renewable source of energy. We tried to give our best efforts towards successful design and implemented our innovative ideas in our solar vehicle.

Designing a competitive solar car requires the team to successfully integrate many different aspects of engineering into one reliable and high performance package. Each of these aspects is important and critical in the creation of the final product. The foundation of the vehicle ,the chasis, provides the base for which each of these components are built.

CERTIFICATE

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely our team effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.
Mr.

Captain: Arik

Signature

____
Date

ACKNOWLEDGEMENT

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CHAPTER 1 : INTRODUCTION

The environmental and financial impacts of fossil fuels have sparked a furious competition among proponents of renewable energy. While gasoline and diesel powered vehicles may have dominated transportation in the past, hybrid and pure-electric vehicles are quickly increasing their presence in the marketplace. For this reason, many institutions worldwide, including PHOTO RAPTORS, build high efficiency, electric solar car to compete in the events such as the ESVC. To be competitive, teams must cohesively integrate many complex electrical and mechanical systems.

All vehicles are expected to be reliable, safe, and predictable regardless of their power train. The expectations are no different for a solar powered vehicle. Properly engineered chasis and suspension assemblies play a significant role in ensuring these expectations are met. The current PHOTO RAPTOR's solar car components will be engineered to operate efficiently and effectively during long distance travel. Some of the primary objectives of the design will be to avoid unnecessary weight, ensure the chasis reacts predictably to both driver and road input, reduce frictional losses, maintain driver safety and comfort, and allow for future maintenance and repairs. The successful execution of these goals will result in a highly competitive solar car.

Solar Energy :- Solar energy can potentially play a very important role in providing most of the heating, cooling and electricity needs of the world. With the emergence of solar photo-catalytic detoxification technology, solar energy also has the potential to solve our environmental problems. However, we do not see widespread commercial use of solar energy. Some of the emerging developments in solar may change that situation. The heat of the sun is about equivalent to burning a billion trillion tons of coal an hour. Even though only a small fraction of that heat ever reaches the earth it is still more than enough to power the whole world.

Current Applications:-Today we use solar power to do many things. We use solar power for everything from calculators to large power plants that can power large cities.

Most common solar power is used for small things. Many calculators are run by solar cells so they will never run out of batteries. Some watches run on solar cells, too. Also you can buy radios that run on solar cells.
There are also many big things that run on solar power. Almost all satellites run on solar power, because otherwise they would run out of power. There are also large desalinization plants that use solar power in places where there is little or no fresh water. There are solar furnaces in many countries. Solar power is also used commercially and residentially. It is also used for many forms of transportation, but these are all in the experimental stage now. Solar powered cars may soon come out.

1.1 RESEARCH REPORT

The Solar Future

Today the use of solar power is very limited. Today we use very little active solar heating. Though in the future many more homes will be solar heated. More homes will have passive solar heating. Scientists want to make a satellite that will orbit over one place. This satellite would have giant wings made of solar power, this satellite would beam electricity down to earth. This would allow the solar cells not to be obstructed by clouds or buildings. Also ground solar power plants are predicted to be used more frequently. Another thing predicted to be popular is solar powered cars. The drawback of these cars is the fact that you can only travel at high speeds for a short time and they don't work on cloudy days. Solar powered cars are only used for racing and experiments now.

I think if there is another oil crisis there will be much more use of solar power. Solar power will be given more federal funding which will increase studies. The increased studies will make solar power cheaper and more efficient. This will make solar power more available on the market.

As discussed above that the solar powered vehicles are used not quite widely because of the limitations or the drawbacks such as storage of energy, the climatic conditions are another factor that could be stated. We cannot predict how the nature would be in the next 24 hour window which is why we are not able to use the solar energy more efficiently and effectively. Similarly the issue of storage of solar energy is the most prominent one, even if we get good climatic conditions we need to store that absorbed energy into some mode most commonly used are high end batteries that can store the energy in the form of electricity in them but they also are not helping in more or to be precise much efficient usage of the solar energy. Over the years Scientists and researches along with experts in different fields are trying to find new and better ways to harness the abundant solar energy in this modern day. But recently some interesting discoveries or to say new methods have been published that would help the efficiency go up by at least 1%. Now that we are figuring out how to increase the efficiency we need to consider the factor of feasibility on how feasible it could be.

The Frontier Research Center at UNC-Chapel Hill has built a system that converts solar energy into fuel, so power can be used even after the sun sets.

Instead of storing solar electricity in an expensive battery, researchers use the sun's energy to separate water into hydrogen and oxygen. Two of the Center's papers about the process were recently published in the Proceedings of the National Academy of Sciences.

Chemistry Professor Tom Meyer says the system uses solar power during the day to cheaply separate hydrogen and oxygen from water. The elements can then be stored separately and burned for power. Meyer says power utilities already have infrastructure for that last part:

See, that's the beauty of it, I think. With this, you can plug into existing engineering, existing technologies. People know how to generate hydrogen. They know how store it. They know how to use it to extract energy in a power plant. So that's all done. You know, all we want to do is find a way to give it to them in a relatively inexpensive way using the sun.

Meyer says the method could be useful and cost-effective for power utilities someday:

This is a basic research project that's knocking on the door to become a technology. I think the principles are established and it's really important, but the efficiency of the devices that we have are very low. That is, ‘Here's all the sun's energy. How much do you actually use in a useful way?’ And the answer's about one percent.

That means only one percent of the solar power that reaches the device is currently used to convert water into fuel. Meyer says the process wouldn't be viable on a commercial scale until technology reached about 10 percent efficiency, which could take a few decades.

He says his team is also looking at how carbon dioxide could be split into its basic elements for fuel, as well.Solar Storage -- A Big Problem

One of the toughest problems of the alternative energy industry is the question of variability. While utilities can control when to burn fossil fuels, to directly satisfy demand, we can't control when the sun is shining or the wind is blowing. A possible solution is to store the energy, either chemically or mechanically.

Much of the early work has focused on grid storage using spent electric vehicle batteries. But given the low levels of EV sales and distribution difficulties, this method can't fully satisfy the power demands of millions of human beings at present. Compounding that method’s flaws is the fact that these aren't very good storage devices anymore in the first place -- hence why they've been declared "spent."

1.a) Solar is a tantalizing, but inconsistent power source. [Image Source: NASA]

Many have suggested that we break water into diatomic oxygen molecules and hydrogen; plants do this as a precursor to sugar production during photosynthesis. One way to do this is to harvest the solar energy as electricity and then perform on-demand hydrolysis. Energy losses on the PV end are already bad and since most solar cells degrade or short in water, they become worse as you have to transfer electricity out of the solar cell and into an electrolysis device. In short, the compounding losses mean it takes a lot of electricity to produce a little hydrogen.

An alternative method is to use water-soluble catalysts -- chemicals that speed up chemical reactions by reducing the energy barrier that a series of reactants must overcome to transform into a series of products (in this case pure hydrogen and oxygen fuel). To do this you would generally use a chromophore-catalyst -- a catalyst activated by light -- to drive the reaction.

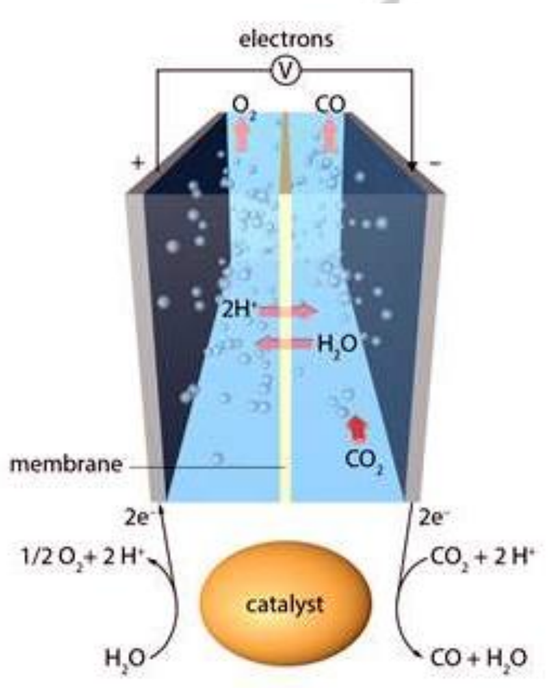


FIG 1.b

Catalysts can rip electrons away from water to produce storable hydrogen fuel.
[Image Source: Meyer Group]

Chromophore catalysts operate by ripping electrons away from a compound such as water, which creates a flow of current that can be used to drive electrochemical reactions (e.g. water splitting). As this process is all localized, theoretically you could minimize losses much more than in an approach relying on standard cells. Better still, its heavy use of abundant materials like carbon and nitrogen, could -- in the long run -- reduce costs.

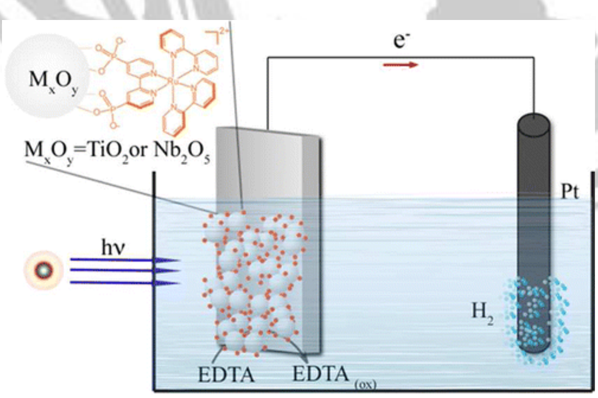


FIG 1.c

Nanoparticle-based systems can create artificial photosynthesis.
[Image Source: The Meyer Group]

Bacteria, protists, and plants have been doing this for billions of years using the chromophore-catalyst chlorophyll to produce electronics, which in turn split water, which in turn is used to produced sugar, the "battery molecule" of the organic world. But chlorophyll isn't necessarily the easiest molecule to produce; so human researchers have been examining novel chromophores (light absorbing compounds, aka pigments) to alternatively use.

Aside from tuning the pigment, there's a host of other issues including mounting of the pigment to a nanoparticle. In plants this is done by nanostructures called "thylakoids", which are stacked inside chloroplasts. Thylakoids vary in diameter, but tend to be around 15 nm thin in higher plants. A crucial question is how plants "glue" their chlorophyll molecules in place inside the thylakoids; in manmade chromophore-loaded nanoparticles, the chromophores tend to break away, decreasing efficiency and slowly killing the conversion cell.

Another key challenge is how to shuttle away electrons to prevent a "traffic jam", electrically. So long as the charge is being transferred elsewhere, the chromophore-catalyst is free to keep ripping electrons away from water. But once the chromophore becomes charged, it has to wait for that charge to dissipate before continuing the process. Again, understanding of how the charge transfer occurs in plants is a topic of ongoing research.

But in terms of synthetic analogs to the plant's stacked thylakoid energy storage system, researchers are making significant advances to overcome these problems, using common nanomaterials.

CHAPTER 2: TECHNICAL SPECIFICATION OF THE VEHICLE (MECHANICAL):

VEHICLE DIMENSIONS	
Wheel base	90 inches
Trackwidth	43.30 inches
Weight of the vehicle without driver (min)	150 kg
Overall wt. Including driver of 65 kg	(130+65)kg= 195 kg

FRAME	
Frame material	4130 (Chromoly) normalized alloy steel , seamless
Cross section	Rectangular pipe
Ultimate tensile strength, psi (min)	97,200
Yield strength, psi (min)	63,100
Rockwell hardness	B92
STEERING AND WHEEL ALIGNMENT	
Control	Two wheels
Allowable free play	5 degrees
Steering gear type	1:1 Link Mechanism
Steering type	Manual
Turning radius	4.1 m
Camber angle	12 degree
Caster angle	25 degree
TYRES	
Type	Activa (CEAT)
Diameter	10 inches
Kg weight	5-5.5 kg
Capacity (wt)	206 kg
Speed	90/100 km/hr
BRAKING SYSTEM	
Front	Disk brakes
Rear	Drum brakes

MOTOR	
Motor Type	PMDC Motor with mount bracket
Motor Output	1.3hp(1KW)

Motor Weight	12.247kg
Commutation Type	Carbon Brush
Field Type	Permanent magnet
Rated Speed	3000RPM
T_{net}	3.183n.m
Rated Voltage	36V
Rated Current	
Diameter	13cm
Length	15.3cm
Class of insulation	H-Type

PWM CONTROLLER	
Max. Current Rating	53A
Max. Voltage Rating	55V
Max. Power Rating	1200W
Speed Control	Potentiometer

SOLAR PANEL	
Power	100W
Voltage	18.34V
Current	5.45A
Efficiency	14.12%
Type	Mono-crystalline silicon (sc-Si) modules

BATTERY	
Current Rating	20-24Ah
Voltage Rating	12V each
Type	Lead –Acid Battery

No. of Battery	3 nos.

CHAPTER 3: Design of vehicle Complete cadModel

Fig 3.a

3.1 CHASIS

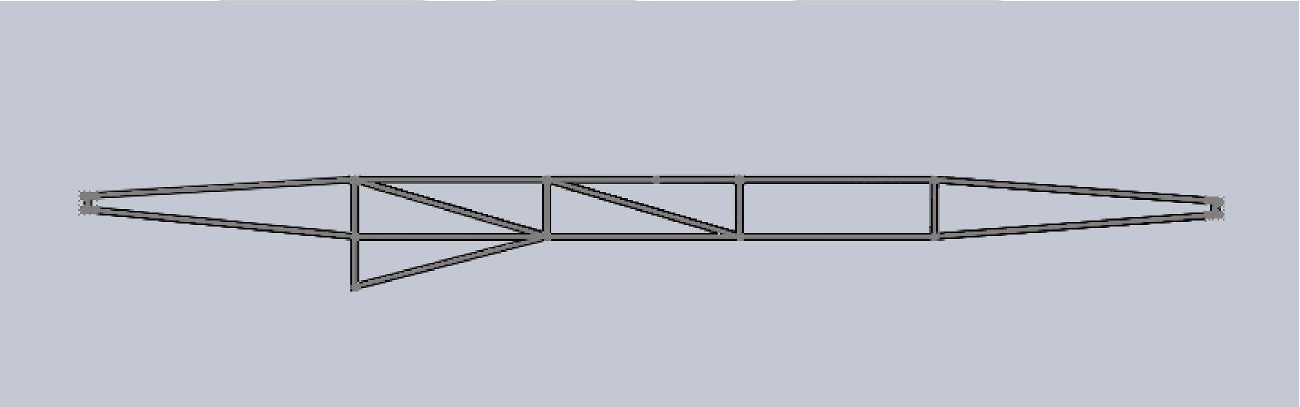


Fig. 3.b

A car chassis is an internal framework which supports the man-made object. It is analogous to an animal's skeleton. The chassis of a car is normally under a motor vehicle. It consists of the frame on which the body is mounted with the wheels and machinery. The rectangular, usually steel frame, supported on springs and attached to the axles, that holds the body and motor of an automotive vehicle. . An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery. In the case of vehicles, the term rolling chassis means the frame plus the "running gear" like engine, transmission, driveshaft, differential, and suspension.

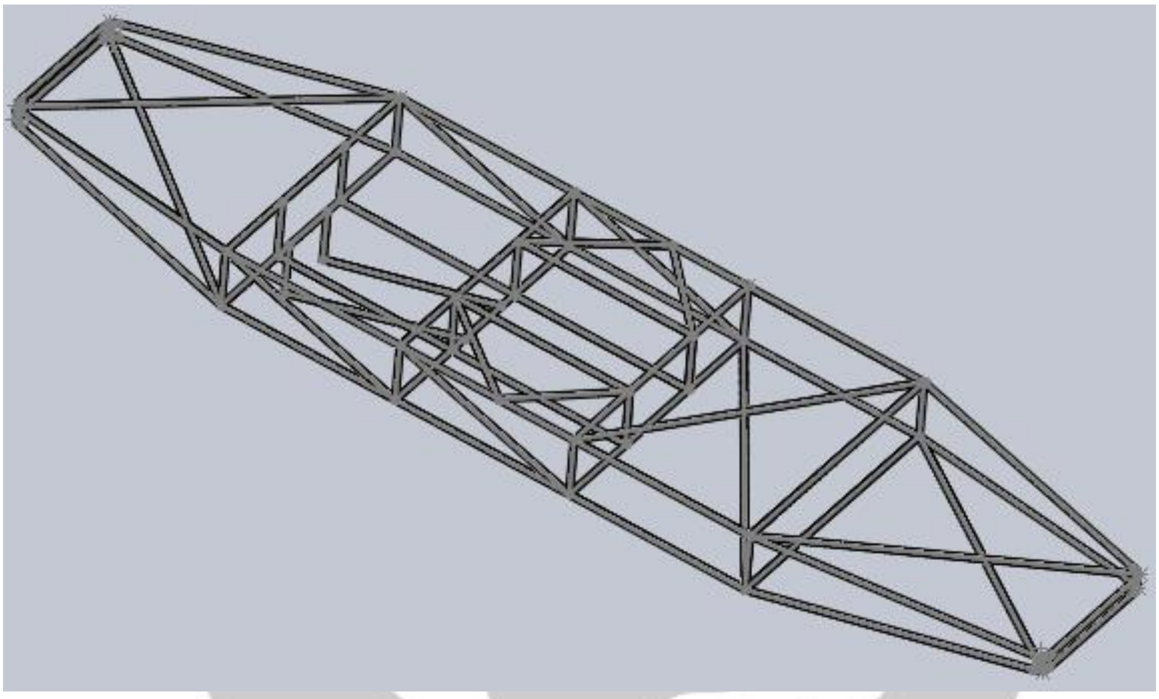


Fig. 3.c

CHAPTER 4 : IMPACT TESTS:

4.1 <u>FRONT IMPACT TEST:</u> It is what most people initially think of when asked about a crash test. These are usually impacts upon a solid concrete wall at a speed of 60 KPH (40MPH), but can also be vehicle-vehicle tests, SUVs have been singled out in these tests for a while, due to the high ride-height that they often have. Only part of the front of the car impacts with a barrier (vehicle).

These are important, as impact forces (approximately) remain the same as with a frontal impact test, but a smaller fraction of the car is required to absorb all of the force. This is where only a small portion of the car's structure strikes an object such as a pole or a tree, or if a car were to clip another. This is the most demanding test as it loads the most force onto the cars structure at any given speed. These are usually conducted at 15-20% of the front vehicle structure.

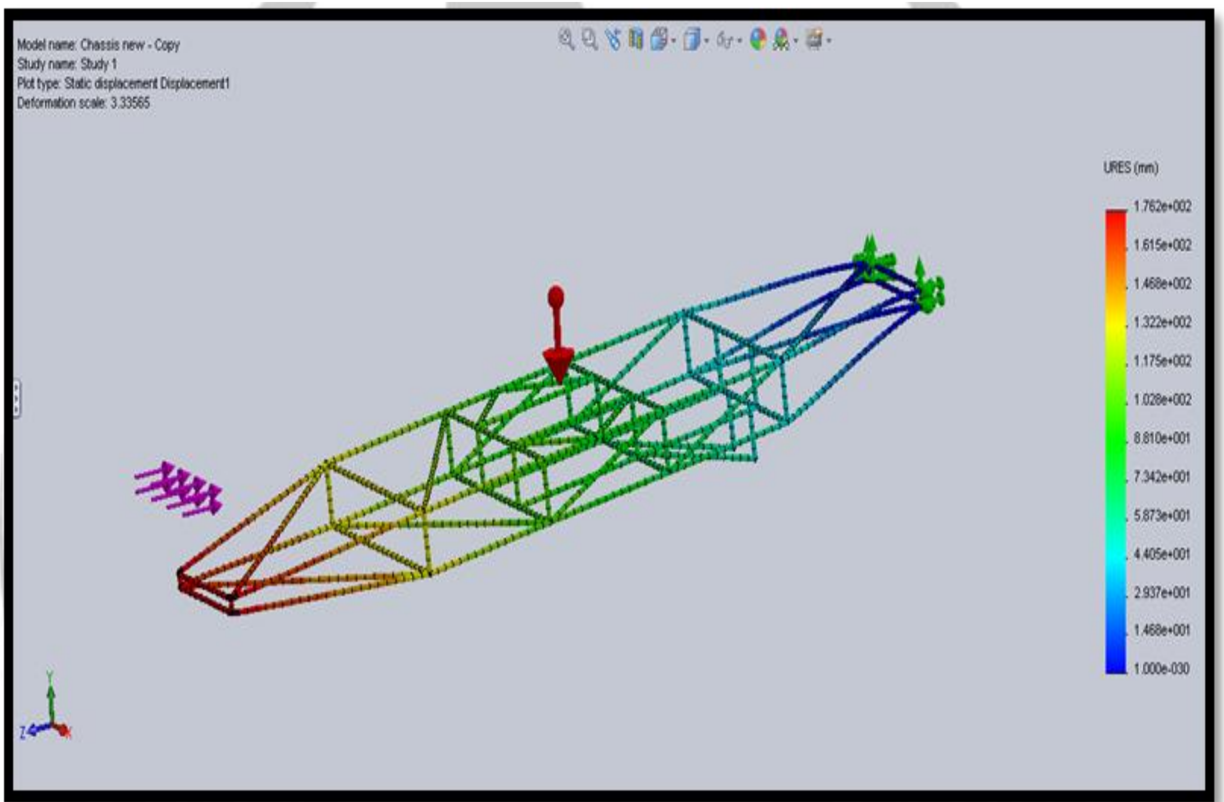
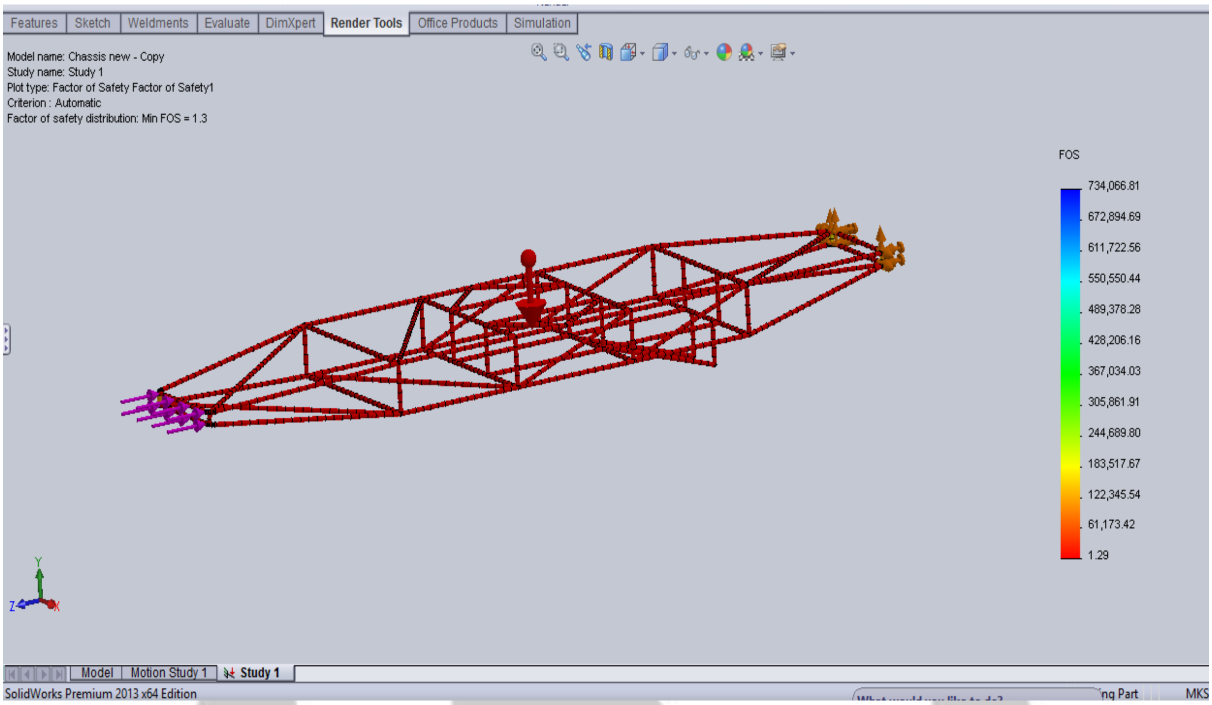


Fig. 4.a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Evaluate
DimXpert
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Office Products
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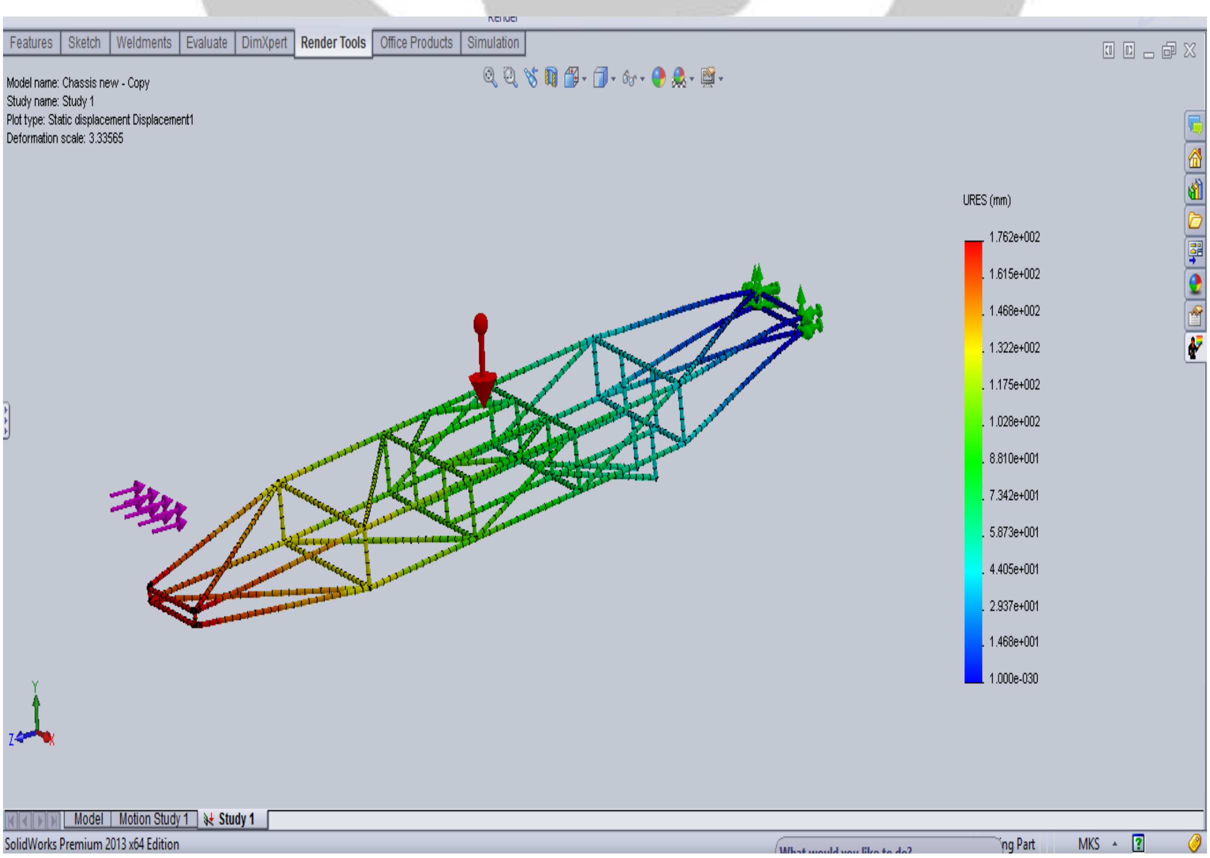
Model
Motion Study 1
Study 1
SolidWorks Premium 2013 x64 Edition
MKS

Fig. 4.b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1.468e+002
1.322e+002
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8.810e+001
7.342e+001
5.873e+001
4.405e+001
2.937e+001
1.468e+001
1.000e-030
Model
Motion Study 1
Study 1
SolidWorks Premium 2013 x64 Edition
MKS

Fig. 4.c

4.2 SIDE IMPACT TEST: The second most important crash configuration is car to car side impact. Euro NCAP simulates this type of crash by having a mobile deformable barrier (MDB) impact the driver's door at 50 km/h. The injury protection is assessed by a side impact test dummy, in the driver's seat. Side impact tests as a crash test for vehicle safety are also very important since side impact accidents in vehicles result in a high fatality rate. This happens because cars usually do not have a significant crumple zone to cushion all the impact forces before the occupant is injured.

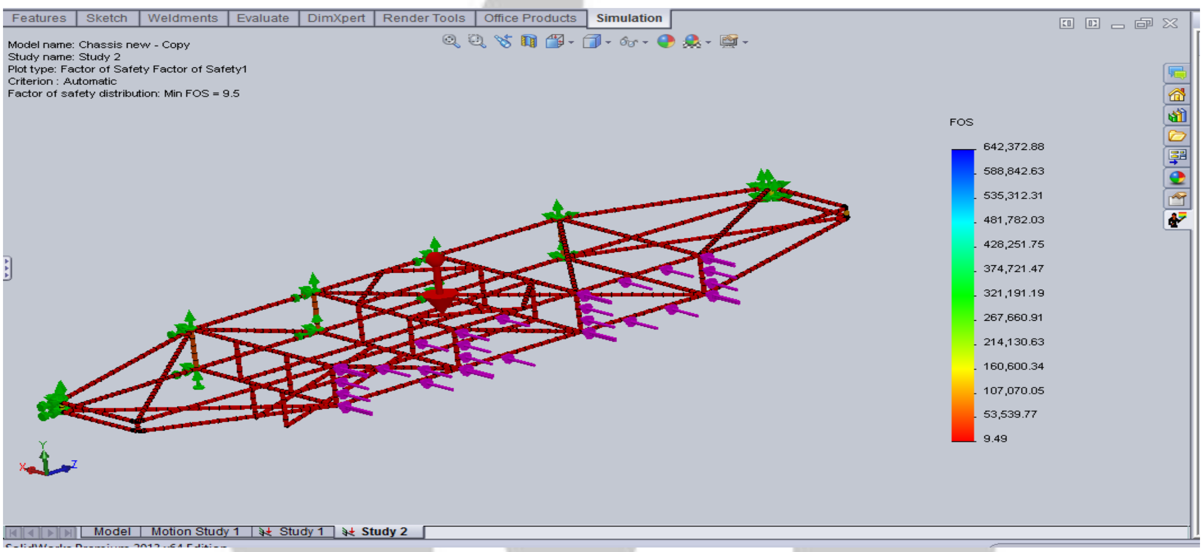


Fig. 4.d

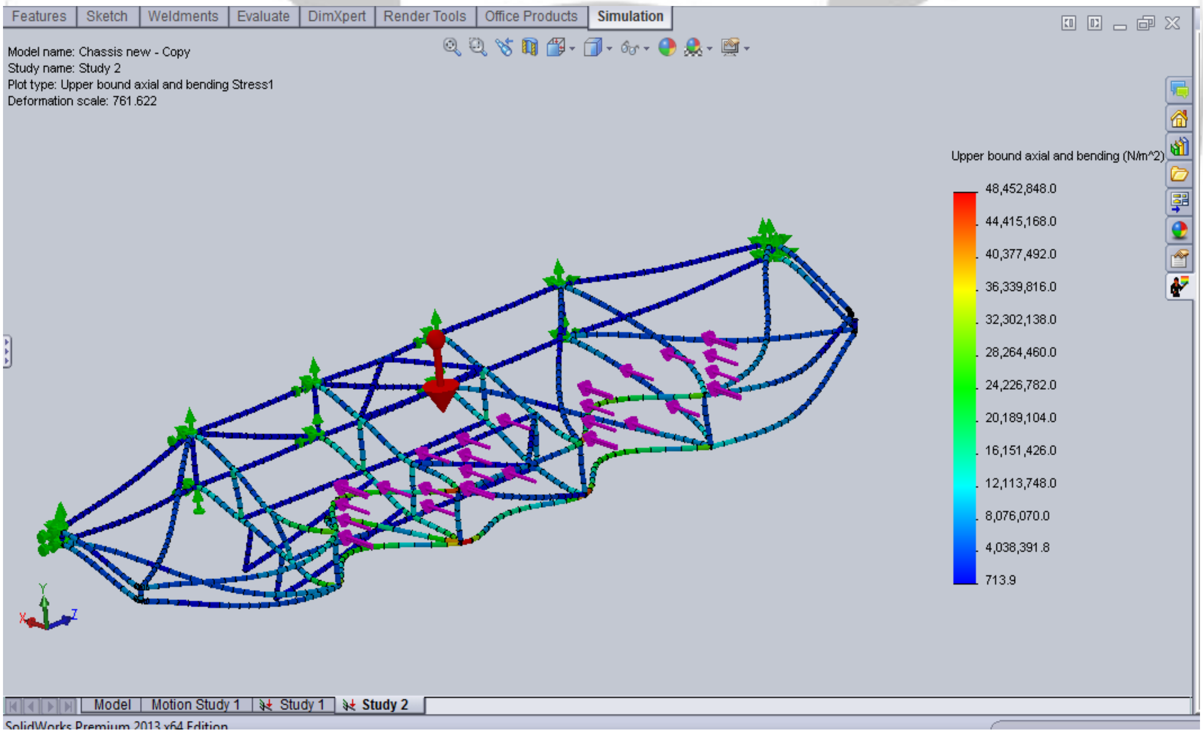


Fig. 4.e

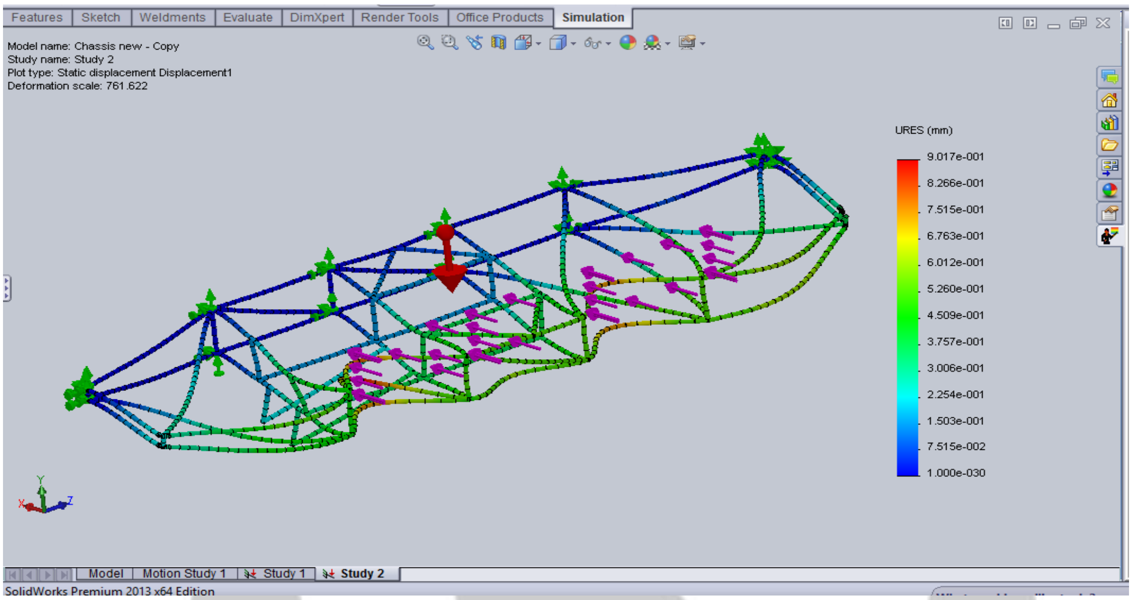


Fig. 4.f

4.3 REAR IMPACT TEST:

It includes impact forces from back.

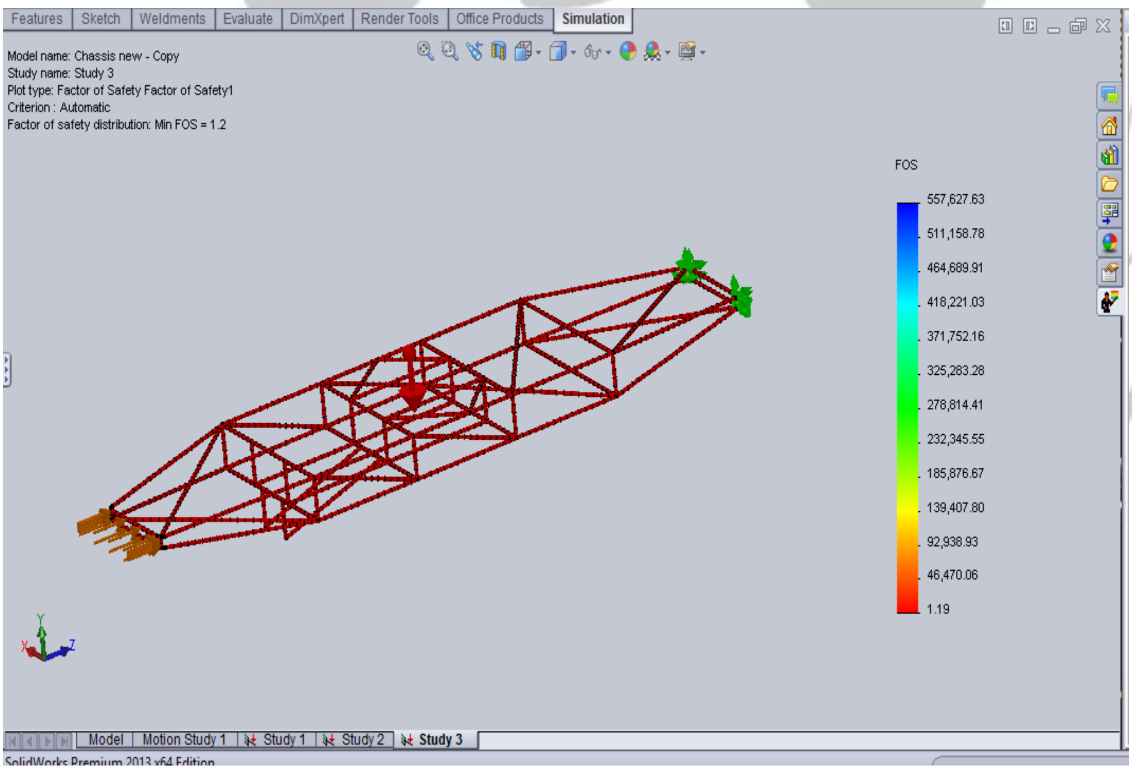
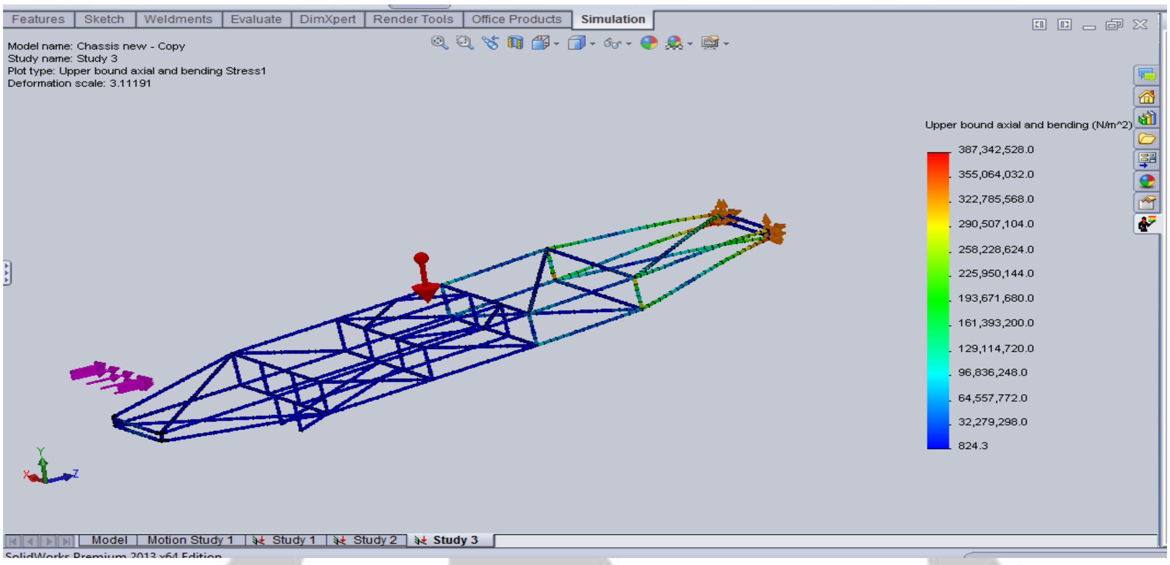


Fig. 4.g



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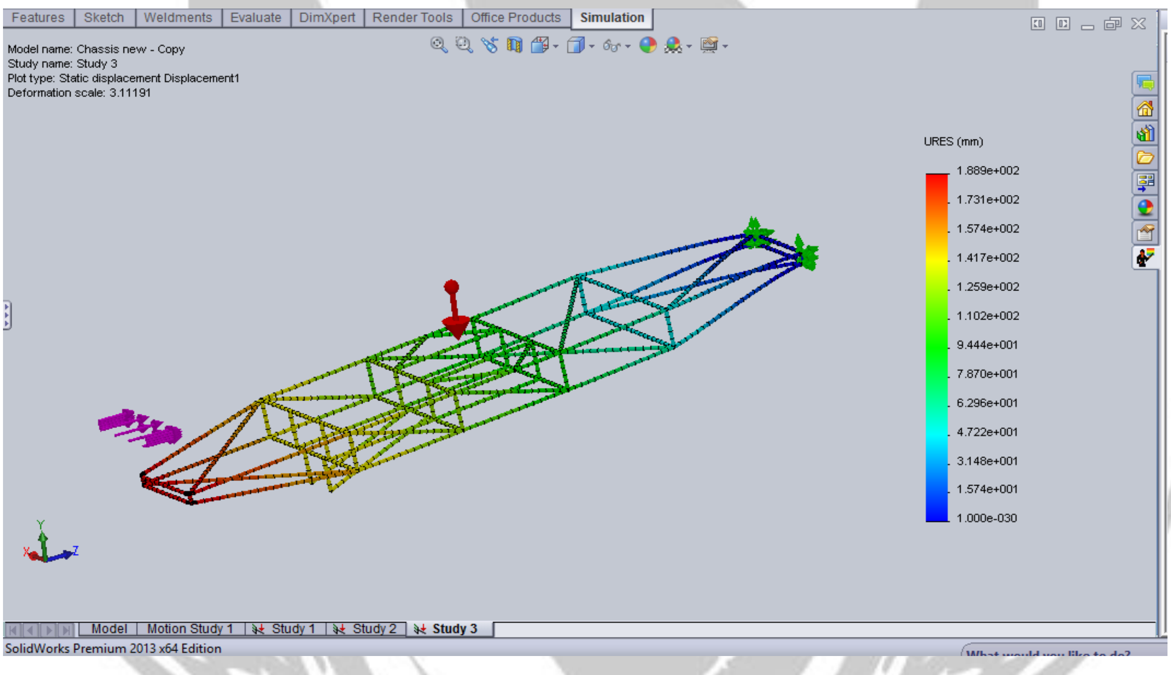
824.3

Fig. 4.h



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7.870e+001
6.296e+001
4.722e+001
3.148e+001
1.574e+001
1.000e-030
SolidWorks Premium 2013 x64 Edition

Fig. 4.i

4.4 TORTIONAL TEST:

It is the moment which acts when suspension is in action or vehicle passes any bump on road. As no suspension is included in our go-kart, Torsional effect will be minimum. However, still there is a chance of getting bumps on road while racing which will produce moment on front and back portion separately.

CROSS TORSIONAL TEST:

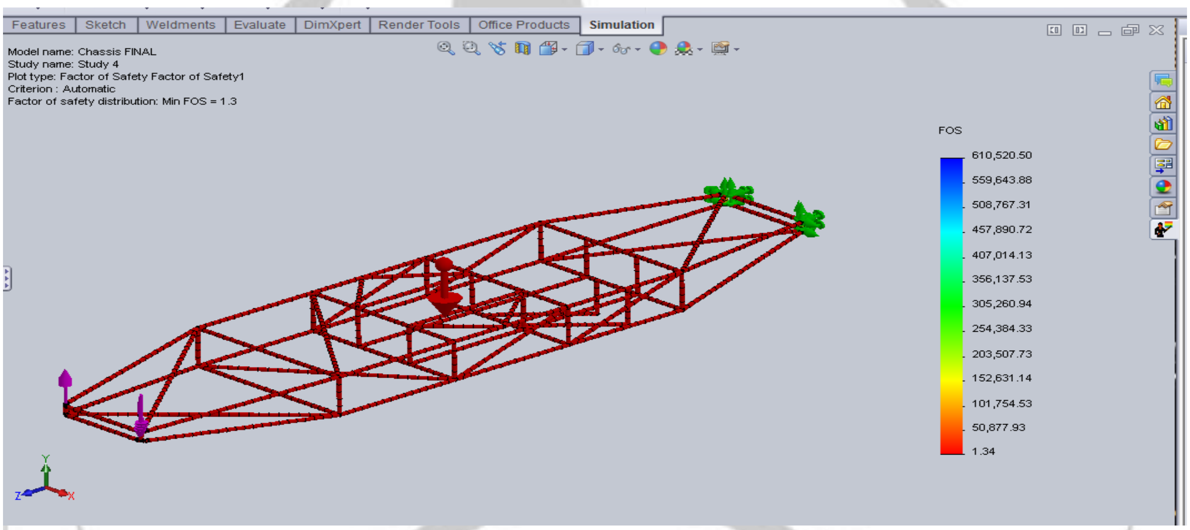
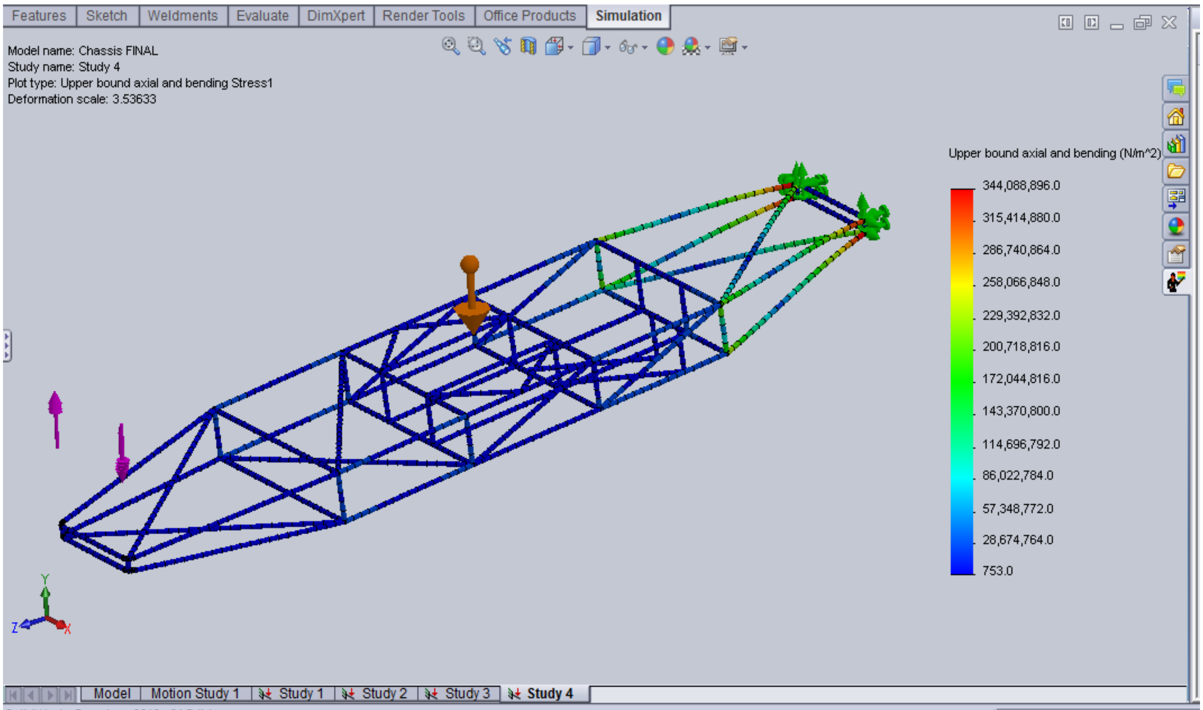


Fig. 4.j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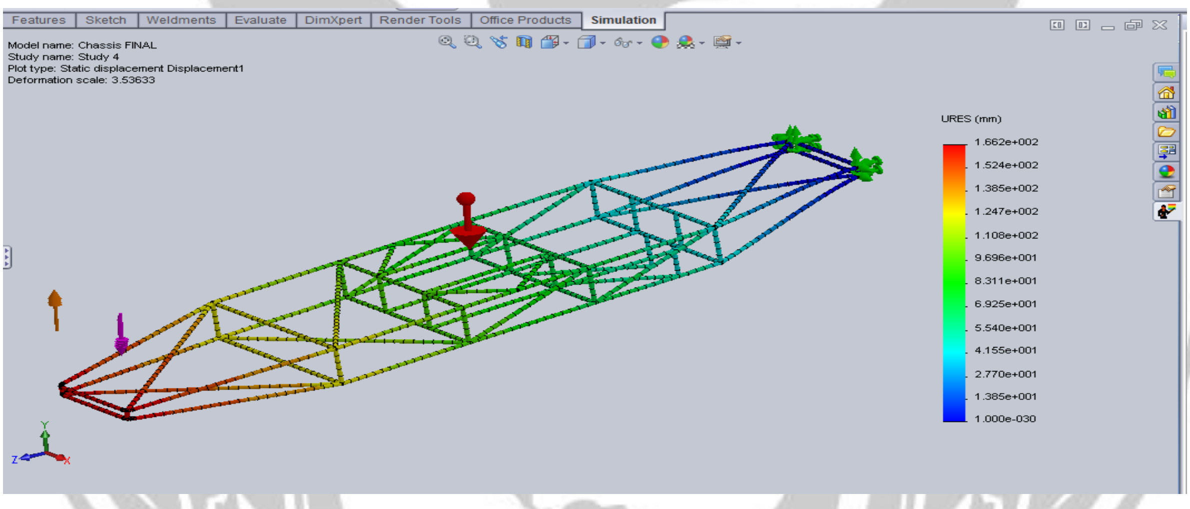
Motion Study 1
Study 1
Study 2
Study 3
Study 4

Fig. 4.k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8.311e+001
6.925e+001
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1.000e-030

Fig. 4.l

DIAGONAL TORSIONAL TEST

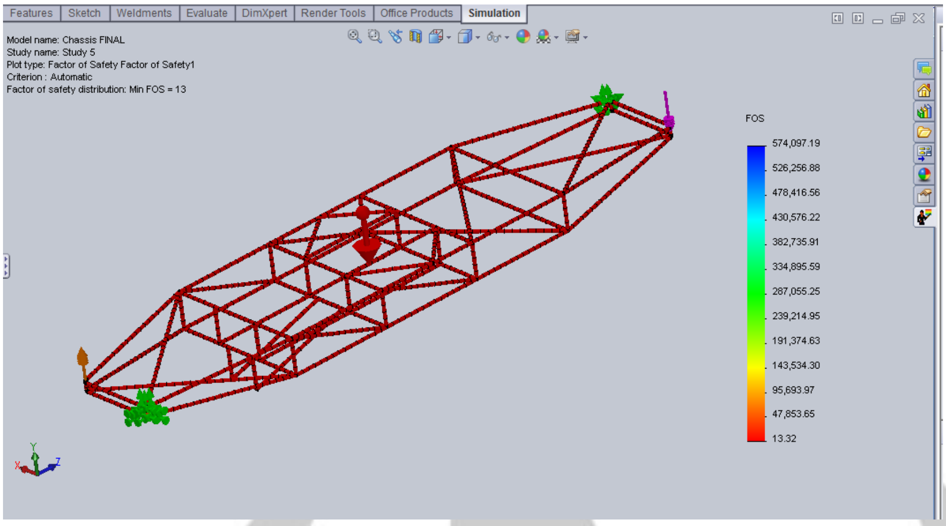


Fig. 4.m

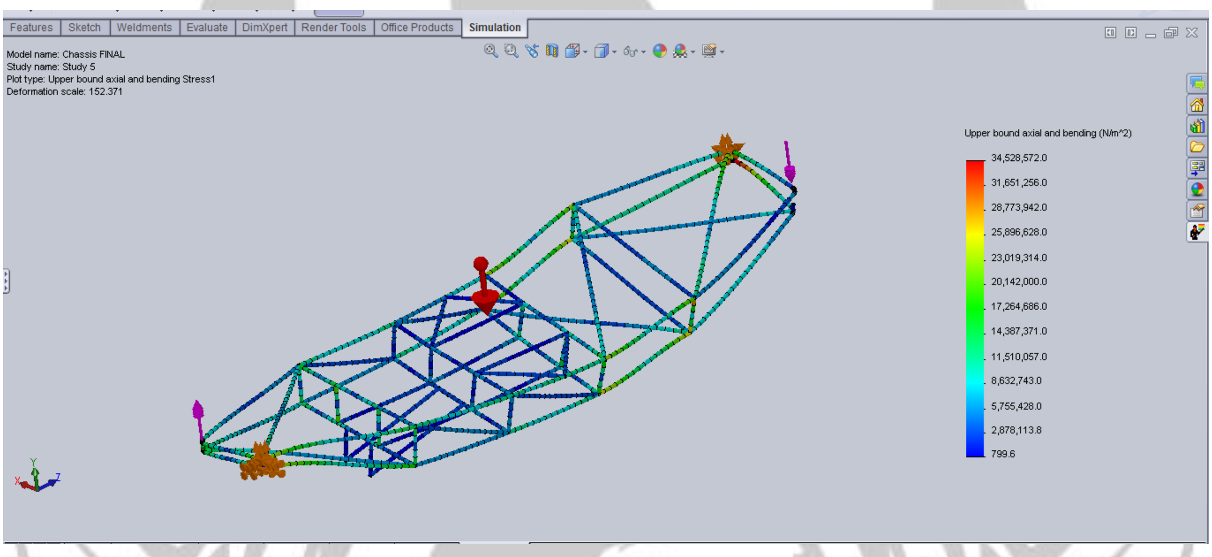
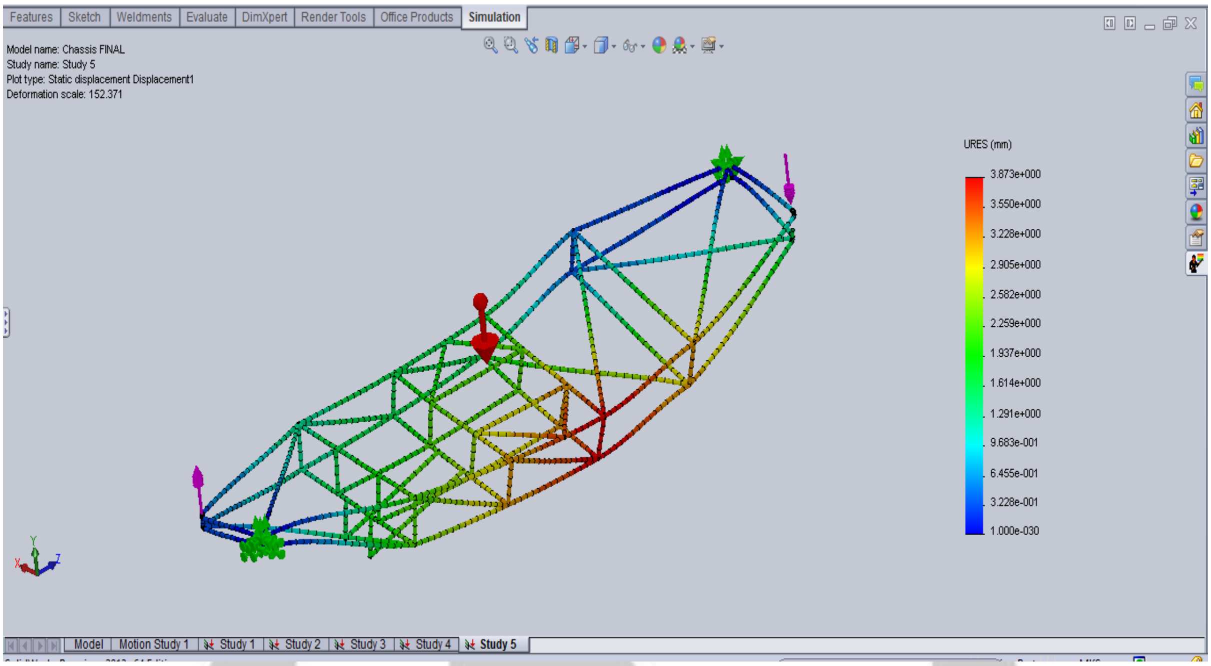


Fig. 4.n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1.291e+000
9.683e-001
6.455e-001
3.228e-001
1.000e-030
Model
Motion Study 1
Study 1
Study 2
Study 3
Study 4
Study 5

Fig. 4.o

CHAPTER 5: STEERING SYSTEM

The vehicle to be developed is based upon the manual steering system. Which is now recently being used in the maruti omni car. This steering system compises of a systematic arrangement of different links which would result in the better handling and control of the vehicle.

Advantages :

A.)It decreases the amount of steering wheel travel.
B.)Decreases the steering effort.
C.)Increases the steering responsiveness.

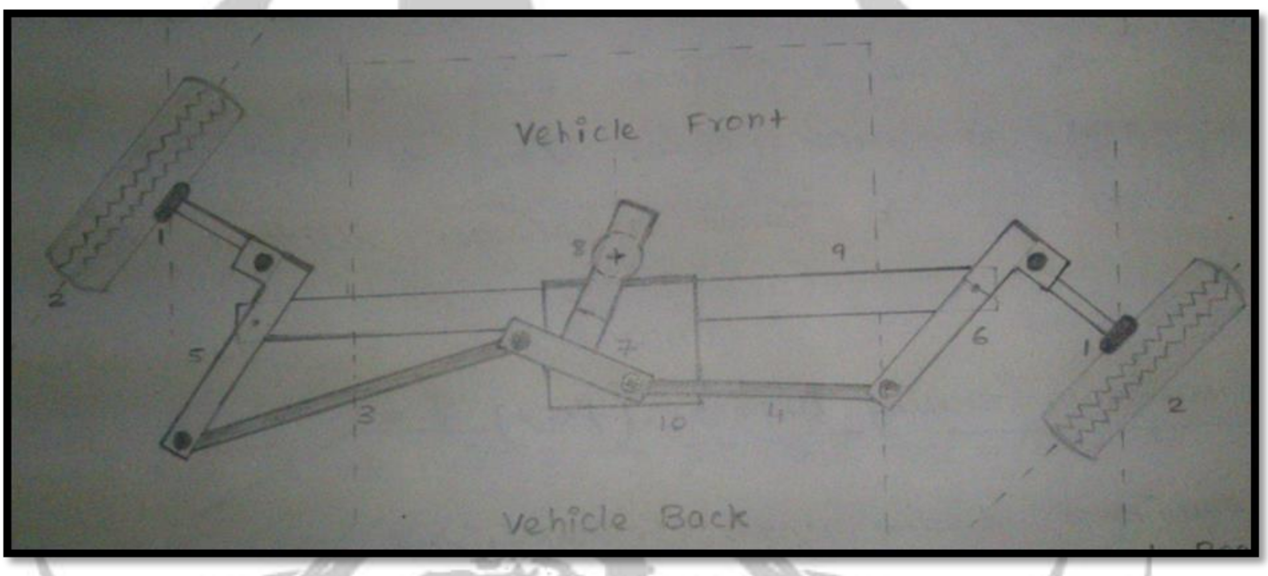


fig. 5.a

Wheel base	90 inches
Track width	43.30 inches
Toe in and toe out	2 degree
Steering free play	2 degree
Camber	12 degree
Caster	25 degree
King pin inclination	NA
Track rod	625 mm

Tie rod	127mm
Scrub radius	NA
Steer angle	70 degrees
Steering ratio	1:1
Turning radius	4.1 m

Formulae used and calculations:

Turning Circle:

(Track width/2) + Wheel base / sin (average steer angle)

= (43.30/2)+ (90/sin 70) = 117.43 inches

Condition for the steering mechanism for perfect rolling of all wheels:

cot C – cot D = x/y

C = angle of outside lock

D = angle of inside lock

x = wheel track

y = wheel base

CHAPTER 6: BREAKING SYSTEM

OBJECTIVE - The brakes are one of the most important safety systems on the vehicle. The car uses two disc brakes, on rear axle, to bring the vehicle to a quick and safe stop regardless of weather conditions or topography.

The vehicle has two independent hydraulic systems and it is actuated by a single brake pedal. The pedal directly actuates the master cylinder. Here no cables are used for this purpose. All rigid brake pipes are mounted securely along the roll cage or along other members

Fig. 6.a

SELECTION OF DISC BRAKES OVER DRUM BRAKES:

In case of disc brakes friction surfaces are directly exposed to the cooling air whereas in the drum type, the friction occurs on the internal surface, from which heat can be dissipated only after it has passed by conduction through the drum.

The friction pads in case of disc brakes are flat as compared to curved friction linings in case of drum brakes. This means that in disc brakes, there is a uniform wear of friction pad. Moreover, the friction pad material is not subjected to any bending, thereby increasing the range of material from which a suitable one can be chosen. Generally, we use asbestos fibre with metal **oxide filler**

bonded with organic compounds as the material for friction pads.
Unlike the conventional drum brake, the design of disc brake is

such that there is no loss of efficiency due to expansion. As the system becomes hot, the drum expands internally and the expanding shoe type of brake tends to move the friction surface apart, causing a loss of effective pedal travel. On the other hand, disc expansion merely changes the relative position on the friction surfaces slightly without tending to increase the clearance.

- Disc brakes weigh less than their conventional drum type.
- Disc brakes have comparatively better anti-fade characteristics.
- Compared to drum type, the disc brakes are simple in design. There are very small numbers of parts which can wear or not function properly.
- It is very easy to replace the friction pads when required, compared to the drum type where the brake linings have to be either riveted or fixed with adhesive to the brake shoes.

Total frictional area of pads in disc brakes is very less as compared with the conventional drum type brakes, the approximate ratio being 1:4. This means that in disc brakes, the pressure intensity must be considerably greater than in the drum type. This implies that frequent relining would be necessary, due to increased rate of wear.

However, there are compensating factors:

i. Pads can be made considerably thicker, for a given initial cost, so that more wear can take place before replacement is necessary.

ii. New wear-resistant friction materials have been developed, that are more suitable for disc brakes than drum brakes.

BRAKE CIRCUITS

- Cross linked hydraulic split was not considered because in case of a failure one front wheel and one rear wheel would lock at the same time increasing the chances of skidding towards the left or the right.
- Diagonal split hydraulic systems are commonly used on front wheel drive vehicles, but our vehicle is rear wheel driven.
- A diagonal split system requires more tubing and more connections than a front rear split system.
- Advantage of the front-rear split design is that in the event of a failed hydraulic circuit, there are still two brakes on the same axle that provide equal braking forces. For this reason, the vehicle won’t turn or pull in either direction under failed-circuit braking.
- A front-rear split design only requires that a single hydraulic line be routed from the master cylinder to the rear of the vehicle. Once the hydraulic line reaches the rear axle it can be split to provide pressure to both the left rear and right rear brakes, but a single hydraulic line can be used for a majority of the distance.

BRAKE FLUIDS:

We have decided to use **DOT 3** brake fluid.

It is inexpensive, and available at most gas stations, department stores, and any auto parts store.
It is completely compatible with DOT 3 and DOT 5.1.

Design constrains:-

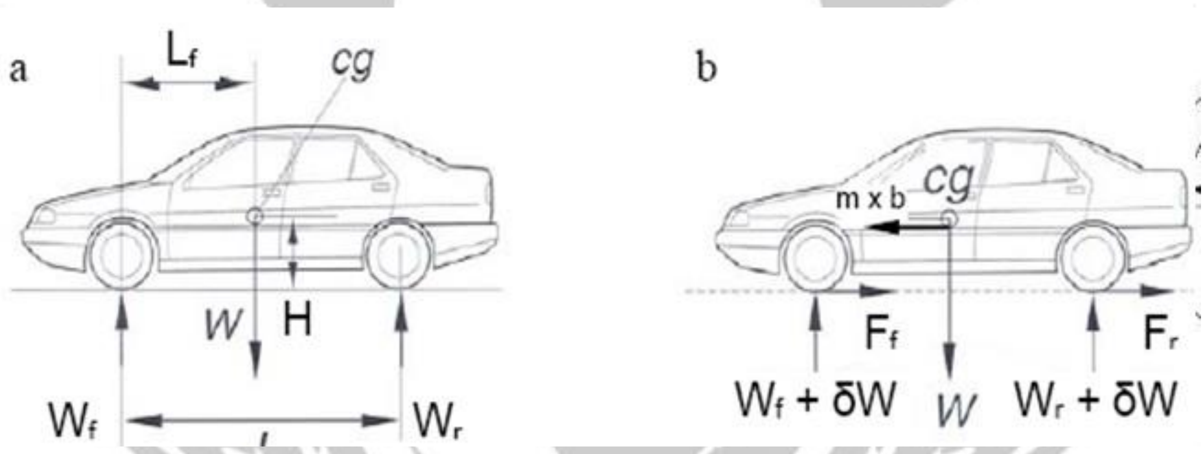
- Brake Disc Thickness [mm]: 10
- Brake Disc Type: Full
- Diameter: 220 mm
- Height: 33 mm
- Hub Bore Ø: 86 mm
- Minimum Thickness: 8 mm
- Number of Holes: 4
- Pitch Circle Ø: 102 mm

METHOD FOR CALCULATIONS:

Weight transfer during braking:

WeightTransferred During Braking On Front Wheel (L_F)(Kg)

Weight Transferred During Braking On Rear Wheel (L_R)(Kg)



CASE 1:

WHEN NO SLIP OCCURS

The fluid pressure that was caused by master cylinder can be calculated as follow:
P = (FP*R*η) / A
Where: P = fluid pressure, MPa
FP = pedal force, N

R = pedal lever ratio
η = Pedal efficiency
A = cross section area of master cylinder
P = (400 x 3 x 0.8) / .0005 = 1.92 Mpa

(Assumption: FP = 400N, R= 3, η= .8, A= 0.0005m2)The normal forces acting on front and rear calipers can be found by following formula:
N = P*AWhere:N = Normal force, lbf
A = caliper area, in^2

Front:
NFC = 0 N

Rear:
NRC = A*P
=(0.0015 * 1.92*106)= 2880 N

Once we found the normal forces the frictional forces could be calculated:
1. FFC = μp* NFC= 0 N
2. FRC =μP * NFC= (0.40 *2880) = 1152 N

*The coefficient of friction was assumed to be 0.40 for our brake pads.
Now we can calculate the torque cause by these forces:
1. TFC = FFC * dFC = 0 N
2. TRC = FRC * dRC= (1152* 0.1) = 115.2 N

Note that "d" is the distance from each caliper to the center of each moving axle.
Assuming the torque is constant over the entire length of the axle we can find the forces that are acting on each tire
1. FFT = (TFC / RFT) = 0 N
2. FRT = (TRC/ RRT) = [115.2 / (0.127)] = 907.086
3. (RRT =10/2=5"= 0.127m)

Where: "R" is the radius of front and rear tires.

The deceleration could be calculated as:
a = - [(FFT + FRT)*2 / m] = -[(0 + 907.086)*2 / (175)] = - 10.366 m/s2

- V= 30km/hr. = 8.33m/s

Stooping Time
- t = V/ a = 8.333/ 10.366= 0.803s

And Stooping Distance
d = (V^2) / (a*2) = (8.33^2) / (10.366*2) = 3.349m
- V= 40km/hr. = 11.11m/s

Stooping Time

- t = V/ a = 11.11 / 10.366= 1.0717s

And Stooping Distance
d = (V^2) / (a*2) = (11.11^2) / (10.366*2) = 5.95m

CASE 2:

WHEN SLIP OCCURS
Weight on the front = 0.4 x 175 x 9.81=686.7 N
Weight on the rear = 0.6 x 175 x 9.81=1030.05N

Braking force on the tire -

- FBRAKE =2*{ WF+W * μ * (h/L)} * μ / 2=0 N
- FBRAKE=2*{ WR-W * μ * (h/L)} * μ / 2

= {1030.05 – 1716.75*0.7*(0.2032/1.27)}*0.7/2
(WR = 1030.05N, W=1716.75N, μ = 0.7, height of C.G. = 8” =0.2032m, wheel base = 50” = 1.27m)
= 586.4418 N

Calculation of retardation –
ax = - FBRAKE/ M
= - 586.4418 / 175
= - 3.351096m/sec^2
V= 30km/hr. = 8.33m/s

Stopping Distance
X = (v2 / 2 * ax)
X = 8.332/2*3.351096 m
= 10.353m
Stopping Time
T = v / ax
= 8.33/3.351096 sec
= 2.485s
V= 40km/hr. = 11.11m/s

Stopping Distance
X = (v2 / 2 * ax)
X = 11.112/2*3.351096 m = 18.41m
Stopping Time

T = v / ax
= 11.11/3.351096 sec
= 3.315s
eight Transfer During Braking
Load Transferred During Braking On Front Wheel (LF)(Kg)
Load Transferred During Braking On Rear Wheel (LR)(Kg)
(M+m)*h=LF*Z - LR*(L-Z)
175*0.2032=LF*0.762-LR*(1.27-0.762)
LF + LR =175
FROM ABOVE EQUATIONS:-
LF = 98Kg
%LF = (175/175)*100%=56%
LR=77Kg
%LR = (77/175)*100%=44%.

CHAPTER 7: BODY WORKS:

Body works in an automobile deals with designing the vehicle and in turn involves the covering of the entire vehicle frame with the help of especially selected materials.

This involves various advantages such as:-

- Protecting the metal surface from corrosion.
- Providing the proper aerodynamics to the vehicle.
- It provides the good vehicle appearance.

Various suggested materials for the vehicle body are:-

a.) Plastic fibre
b.) GI sheets
c.) Aluminium sheets

Advantages of using these material sheets are as follows:

a.) Lighter in weight
b.) Corrosion resistant
c.) Easier to perform manufacturing operations over it.

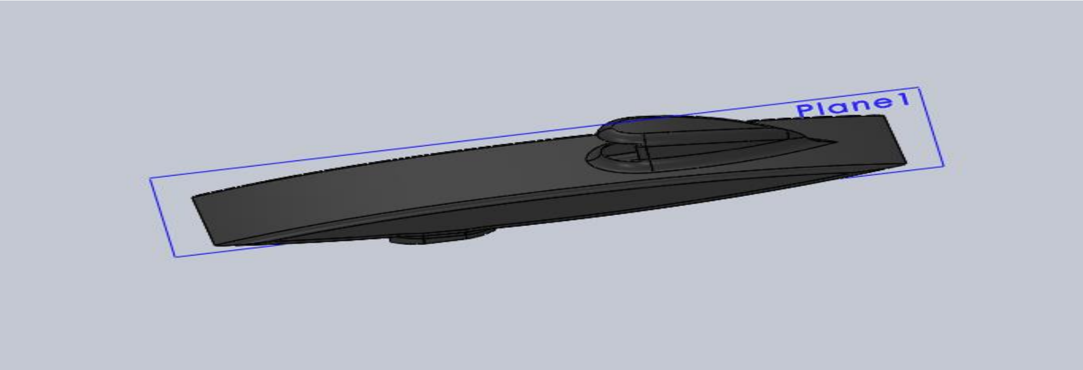


Fig. 7.a

CHAPTER 8: ELECTRIC DRIVE SYSTEM

8.1 PMDC MOTOR

Permanent Magnet DC motors are useful in a range of applications, from battery powered devices like wheelchairs and power tools, to conveyors and door openers, welding equipment, X-ray and tomographic systems, and pumping equipment, to name a few. They are frequently the best solution to motion control and power transmission applications where compact size, wide operating speed range, ability to adapt to a range of power sources or the safety considerations of low voltage are important. Their ability to produce high torque at low speed make them suitable substitutes for gearmotors in many applications. Because of their linear speed-torque curve, they particularly suit adjustable speed and servo control applications where the motor will operate at less than 5000 rpm.

Inside these motors, permanent magnets bonded to a flux-return ring replace the stator field windings found in shunt motors. A wound armature and mechanical brush commutation system complete the motor. The permanent magnets supply the surrounding field flux, eliminating the need for external field current. This design yields a smaller, lighter, and energy efficient motor.

Permanent magnet DC brushed motors (PMDC motors) consist of permanent magnets, located in the stator, and windings, located in the rotor. The ends of the winding coils are connected to commutator segments, that make slipping contact with the stationary brushes. Brushes are connected to DC voltage supply across motor terminals. Change of direction of rotation can be achieved by reversal of voltage polarity.

The current flow through the coils creates magnetic poles in the rotor, that interact with permanent magnet poles. In order to keep the torque generation in same direction, the current flow must be reversed when the rotor north pole passes the stator south pole.

For this the slipping contacts are segmented. This segmented slip ring is called commutator.

Brushes are made from precious metal (metal finger leaf brush) or carbon (graphite brush).

Precious metal brush features:

- Used for low voltage, continuous operation.

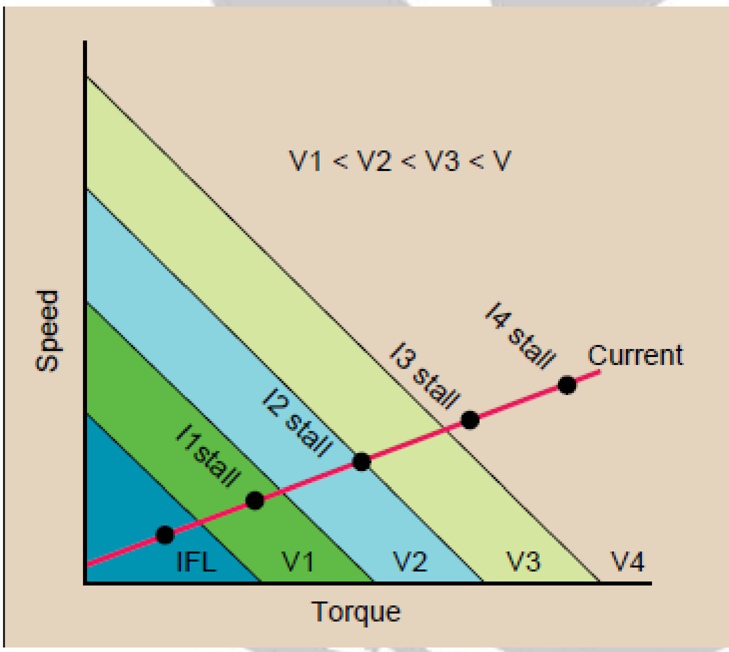
- Lower contact resistance and thus voltage drop than graphite brushes.
- Less electromagnic noise generation than graphite brushes
- Designed as "Finger leaf metal brushes" - brush is splitted into several thin fingers, providing better contact to commutator segments.

Graphite brush features:

- Used for high power , high speed, frequent starting, high lifetime, high voltage.
- Designed as carbon leaf brush or cage brush (for especial high lifetime).

Armature interaction:-

The PM motor’s field has a high reluctance (low permeability) that eliminates significant armature interaction. This high reluctance yields a constant field, permitting linear operation over the motor’s entire speed-torque range. In operation with a constant armature voltage, as speed decreases, available torque increases. As the applied armature voltage increases, the linear speed-torque curves shift upwards. Thus, a series of parallel speed-torque curves, for different armature voltages, represent the speed-torque properties of a PM motor are shown in figure. Speed is proportional to voltage and torque is proportional to current.



Speed control methods:-

Speed is controlled by varying the voltage applied to the armature. Feedback devices sense motor speed and send this information to the control to vary its output voltage up or down to keep speed at or near the set value. Feedback techniques include voltage tachometers, optical encoders, electromagnetic pulse generators, and back emf monitoring. Regulation is the ability of the motor and control system to hold speed constant over the torque range. It extends from 0.1% for highly divided (e.g., 1000 div/rev) optical encoders to 5% for a simple back emf system. Most manufacturers provide the servo constant data for predicting system response.

Permanent magnets:-

A number of magnetic materials are available for permanent magnets. These include ceramic oriented ferrites, rare earth permanent magnets, and Alnico, although Alnico's use is waning. Ceramic oriented ferrites, typically made with barium or strontium, develop into products with lower energy than Alnico. Therefore, they have become the material of choice in most PM motors, replacing Alnico, because of their greater resistance to demagnetization, ease of forming, and low cost. Rare earth magnets may let engineers choose a downsized PM motor, or boost its power rating. They include samarium cobalt and the more recently developed neodymium-iron-boron. Their characteristics, compared to the previously mentioned materials, include high energy and low susceptibility to demagnetization. The cost of these materials, however, remains high. The choice of material depends on the application requirements.

Mathematical calculation:

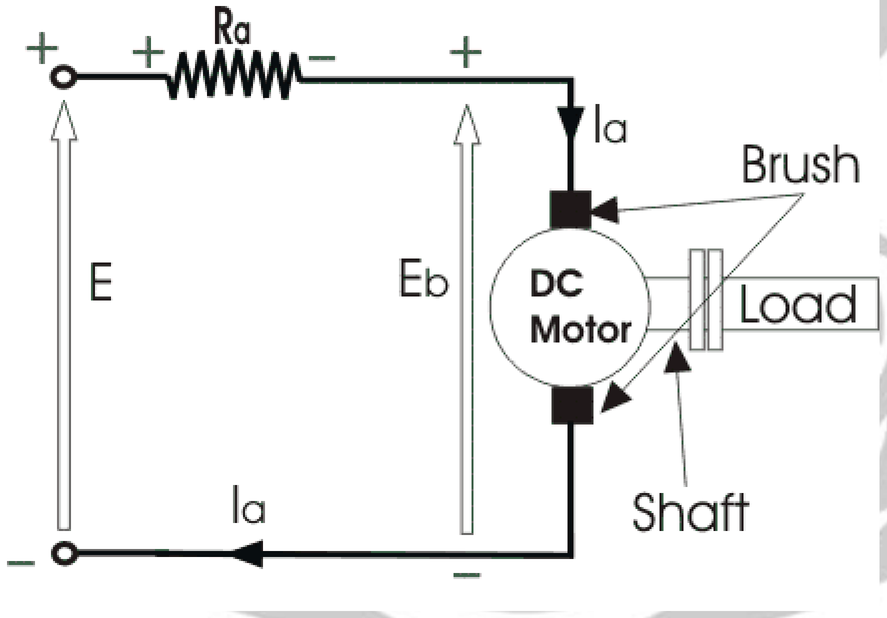


Fig. 8.a

E is the supply voltage, E_b is the back emf produced and I_a, R_a are the armature current and armature resistance respectively then the voltage equation is given by.

$E = E_b + I_a.R_a$

But keeping in mind that our purpose is to derive the torque equation of dc motor we multiply both sides of equation by I_a.

$E\ I_a = E_b\ I_a + I_a^2.R_a$

Now $I_a^2.R_a$ is the power loss due to heating of the armature coil, and the true effective mechanical power that is required to produce the desired torque of dc machine is given by

$P_m = E_b.I_a$

The mechanical power P_m is related to the electromagnetic torque T_g as

$P_m = T_g.\omega$ (Where ω is speed in rad/sec.)

Now From equation we get

$E_b.I_a = T_g.\omega$

Now for simplifying the torque equation of dc motor we substitute

$$E_b = \frac{P\varphi ZN}{60A}.$$

Where, P = No. of poles

φ = flux per pole

Z = No. of conductors

A = No. of parallel paths

N = speed of the D.C. Motor.

And we Know that

$\omega = 2\pi N/60$

Put ω & E_b in T_g

We get

$$T_g = \frac{P.Z.\varphi.I_a}{2\pi A}$$

the torque of dc motor varies with only flux φ and armature current I_a.

The torque we so obtain, is known as the electromagnetic torque of dc motor, and subtracting the mechanical and rotational losses from it we get the mechanical torque.

$T_m = T_g$ - mechanical losses.

Calculations:-

Speed = (π×D×RPM of Motor)/60×Gear Ratio

Let Hero Honda Splendor Gear Ratio Which is 43:18(Axle Side : Motor Side)

Tyre Diameter 11inch = 27.94cm

RPM of PMDC Motor(Standard) = 3000RPM

Speed = (π×27.94cm×3000RPM)/60×(43/18)

= 69 KPH(approx.)

Speed = 70Km/H

Torque Equation

We Know that

$F=BIL$

$=B\times(I_a/A)\times l$

$T=F.r$

$T=B\times(I_a/A)\times l.r$

$B_{av} = (\phi/pole)/(A/pole)$

$= \phi/(2\pi rl/pole)$

$= P\phi/2\pi rl$ Where P = Pole

Therefore

$T=(P\phi I_a lr)/(2\pi\times rlA)$

This is one Conductor Torque Equation.

For No. of Conductor

$T=(P\times Z\times\phi I_a lr)/(2\pi\times r.lA)$

$T=(PZ\phi I_a)/(2\pi A)$

$T \sim \phi \sim I_a$

In D.C. Motor Pole of the electromagnetic torque Developed in armature is not available at the shaft a part of it is loss to overcome the iron and mechanical losses therefore shaft torque is some one less than the torque produce in the armature. Thus actual torque available at the Shaft for doing useful mechanical work is called the shaft torque.

Therefore

$P=T\omega$

$T_a=P\omega$

$T_a=(E_b\times I_a)/(2\pi\times(N/60))$

T_{losses}=Iron & Friction Losses(W)/(2π(N/60))

$T_{net}=T_a-T_{losses}$

$=E_bI_a$ - Losses(W)/(2π(N/60))

T_{net}=(o/p in W)/(2π(N/60))

T_{net}=(9.55×o/p)/N

For Kart, Motor Power is 1000W, 3000RPM Rated

$T_{net}=(9.55\times1000)/3000$

T_{net}=3.183 N.M

Specification:-

Motor Type = PMDC Motor with mount bracket
Motor Weight=12.247kg
Diameter =13cm
Length = 15.3cm
Shaft Length = 2.5cm
Shaft Diameter = 1.4cm
Type = Brush(Carbon Brush)
Field Type = Permanent magnet
Rated Voltage= 36V
Rated Current =
Rated Speed = 3000RPM
Output = 1KW
HP = 1.34
Class of insulation = H-Type
Temp.=Max@130°C

Cost:-

Motor = Rs 7500(approx.)

Manufacturer:-

VIKAS
MANUFACTURERS, JALANDHAR

CHAPTER 9: PWM CONTROLLER:-

Pulse-width modulation (PWM), as it applies to motor control, is a way of delivering energy through a succession of pulses rather than a continuously varying (Analog) signal. By increasing or decreasing pulse width, the controller regulates energy flow to the motor shaft. The motor's own inductance acts like a filter, storing energy during the "on" cycle while releasing it at a rate corresponding to the input or reference signal. In Other words, energy flows into the load not so much the switching frequency, but at the reference frequency.

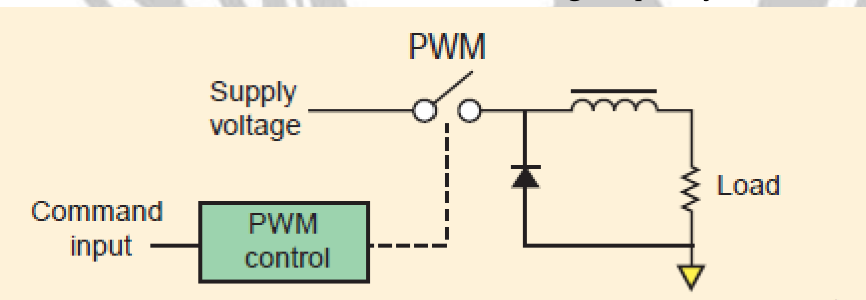


Fig. 9.a

Pulse width modulation is the process of switching the power to a device on and off at a given frequency, with varying on and off times. These on and off times are referred to as "duty cycle". The diagram below shows the waveforms of 10%, 50%, and 90% duty cycle signals.

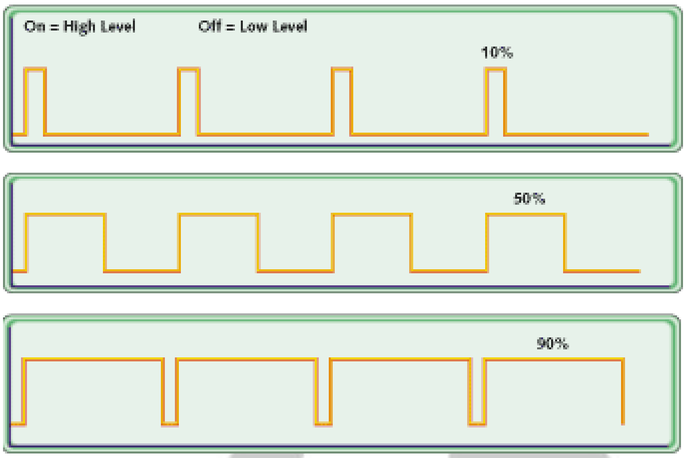
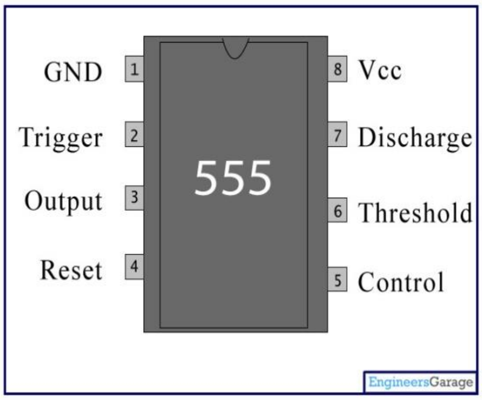


Fig. 9.b

A 10% duty cycle signal is on for 10% of the wavelength and off for 90%, while a 90% duty cycle signal is on for 90% and off for 10%. These signals are sent to the motor at a high enough frequency that the pulsing has no effect on the motor. The end result of the PWM process is that the overall power sent to the motor can be adjusted from off (0% duty cycle) to full on (100% duty cycle) with good efficiency and stable control.

While microcontroller to generate the required PWM signals, the 555 PWM circuit explained here will give the novice robot builder an easy to construct circuit, and good understanding of pulse width modulation. It is also useful in a variety of other applications where the PWM setting need only be changed occasionally.

The 555 timer in the PWM circuit is configured as an a stable oscillator. This means that once power is applied, the 555 will oscillate without any external trigger.



GND:-DC Ground.
Trigger:-The trigger pin triggers the beginning of the timing sequence. When it goes LOW, it causes the output pin to go HIGH. The trigger is activated when the voltage falls below 1/3 of +V on pin 8.
Output:-The output pin is used to drive external circuitry. It has a "totem pole" configuration, which means that it can source or sink current. The HIGH output is usually about 1.7 volts lower than +V when sourcing current. The output pin can sink up to 200mA of current. The output pin is driven HIGH when the trigger pin is taken LOW. The output pin is driven LOW when the threshold pin is taken HIGH, or the reset pin is taken LOW.
Reset:-The reset pin is used to drive the output LOW, regardless of the state of the circuit. When not used, the reset pin should be tied to +V.
Control:-The control voltage pin allows the input of external voltages to affect the timing of the 555 chip. When not used, it should be bypassed to ground through an 0.01uF capacitor.
Thresold:-The threshold pin causes the output to be driven LOW when its voltage rises above 2/3 of +V.
Discharge:-The discharge pin shorts to ground when the output pin goes HIGH. This is normally used to discharge the timing capacitor during oscillation.
Vcc:-DC Power - Apply +3 to +18VDC here.
IRFZ46N MOSFET:-
Maximum Continuous Drain Current = 53A
Maximum Drain Source Voltage = 55V

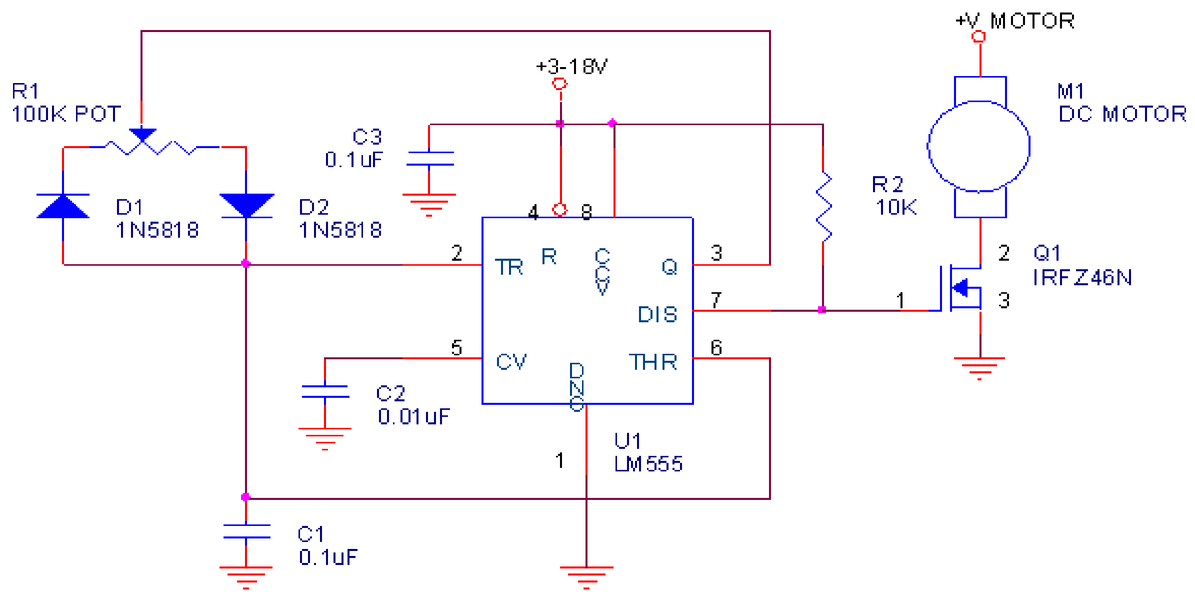


Fig. 9.c

Circuit diagram

Circuit Diagram which is simulated in Proteus software

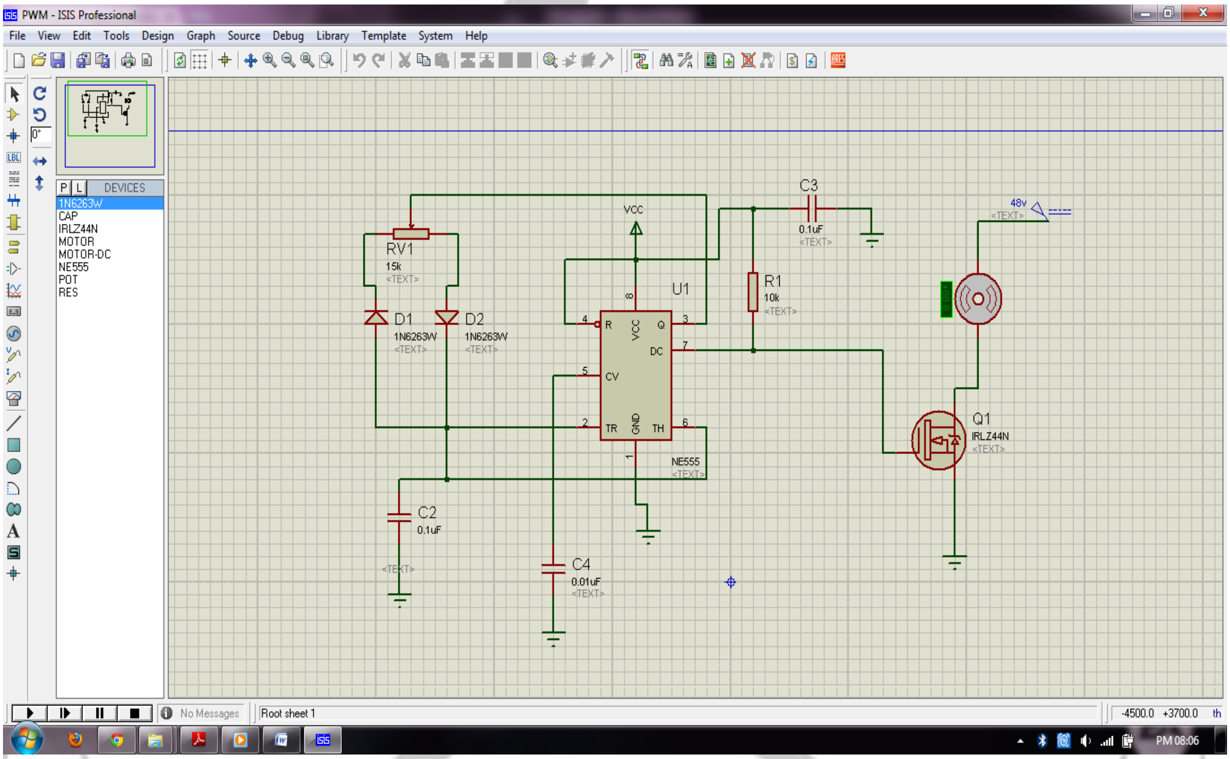


Fig. 9.d

Working:-

When the circuit powers up, the trigger pin is LOW as capacitor C1 is discharged. This begins the oscillator cycle, causing the output to go HIGH.

When the output goes HIGH, capacitor C1 begins to charge through the right side of R1 and diode D2. When the voltage on C1 reaches 2/3 of +V, the threshold (pin 6) is activated, which in turn causes the output (pin 3), and discharge (pin 7) to go LOW.

When the output (pin 3) goes LOW, capacitor C1 starts to discharge through the left side of R1 and D1. When the voltage on C1 falls below 1/3 of +V, the output (pin 3) and discharge (pin 7) pins go HIGH, and the cycle repeats.

Pin 5 is not used for an external voltage input, so it is bypassed to ground with an 0.01uF capacitor. Note the configuration of R1, D1, and D2. Capacitor C1 charges through one side of R1 and discharges through the other side. The sum of the charge and discharge resistance is always the same, therefore the wavelength of the output signal is constant. Only the duty cycle varies with R1.The overall frequency of the PWM signal in this circuit is determined by the values of R1 and C1. In the schematic above, this has been set to 144 Hz.

To compute the component values for other frequencies, use the formula:

$$\boxed{\text{Frequency} = 1.44 / (R1 * C1)}$$

In this circuit, the output pin is used to charge and discharge C1, rather than the discharge pin. This is done because the output pin has a "totem pole" configuration. It can source and sink current, while the discharge pin only sinks current. Note that the output and discharge pins go HIGH and LOW at the same time in the oscillator cycle.
The discharge pin is used to drive the output. In this case, the output is a IRFZ46N MOSFET. The gate of the MOSFET must be pulled high as the discharge pin is open collector only. Being an N channel MOSFET, the IRFZ46N will conduct from drain to source when the gate pin rises above 4 volts or so. It will stop conducting when the gate voltage falls below this voltage. The configuration of the output also serves to invert the signal from the 555 circuit.

After mounting component on Zero size PCB it looks like (similarly)

Fig. 9.e

Connection:-

Connection of PWM Controller with Motor and Battery is

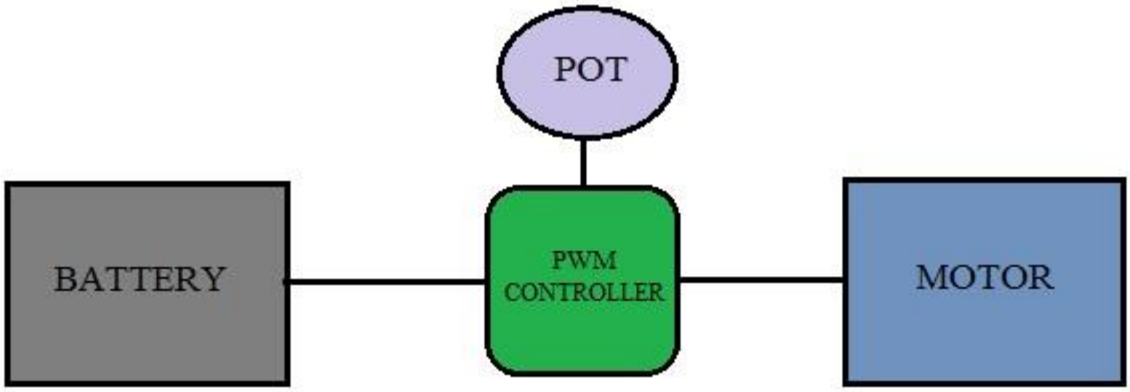


Fig. 9.f

POT is Potentiometer which vary the R1 which regulated the PWM frequency.
POT is connected with throttle with is accelerator of Kart. POT vary the resistance according to throttle position with accelerator or decelerate the Kart.

Specification:-

NE555,3 - Ceramic Capacitor, 1- POT, Resistor,IRFZ46N Mosfet, Zero PCB, 2- 1N5851 Diode.

Cost:-

NE555 = Rs10
3 Capacitor = Rs2
IRFZ46N=Rs200
Zero PCB=Rs27
1N5851=Rs10

CHAPTER 10 : SOLAR PANEL

A solar cell (also called a photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect its electrical characteristics, e.g. current, voltage, or resistance vary when light is incident upon it and can generate and support an electric current without being attached to any external voltage source.

Applications:

1) Solar cells are often electrically connected and encapsulated as a module.

Photovoltaic modules often have a sheet of glass on the front (sun up) side, allowing light to pass while protecting the semiconductor wafers from abrasion and impact due to wind-driven debris, rain, hail, etc.

2) Solar cells are also usually connected in series in modules, creating an additive voltage.

3) Connecting cells in parallel will yield a higher current shadow effects can shut down the weaker(less illuminated) parallel string (a number of series connected cells) causing substantial power loss and even damaging the weaker string because of the excessive reverse bias applied to the shadowed cells by their illuminated partners.

4) Practical use of the solar-generated energy, the electricity is most often fed into the electricity grid using inverters (grid-connected photovoltaic systems), in stand-alone systems, batteries are used to store the energy that is not needed immediately.

5) Solar panels can be used to power or recharge portable devices.

Major types:

1. Crystalline silicon: a) mono-crystalline

b) poly-crystalline

c) mono-like-multi silicon

2. Amorphous silicon

3. Cadmium telluride

4. Copper indium selenide/sulfide

5. Gallium arsenide multi junction

- Mono-crystalline: Single-crystal wafer cells tend to be expensive, and because they are cut from cylindrical ingots.
- Poly-crystalline: made from cast square ingots — large blocks of molten silicon carefully cooled and solidified .Poly-Si cells are less expensive to produce than single crystal silicon cells, but are less efficient.
- Mono-like-multi silicon: uses existing polycrystalline casting chambers with small "seeds" of mono material. The result is a bulk mono-like material with poly around the outsides. It produces mono-like cells at poly-like prices.
- cadmium telluride: uses a cadmium telluride (CdTe) thin film, lowest quoted thin-film module price stands at US$0.84 per watt-peak, with the lowest crystalline silicon (c-Si) module at $1.06 per watt-peak. The cadmium present in the cells would be toxic if

released. However, release is impossible during normal operation of the cells and is unlikely during fires in residential roofs.

- copper indium selenide: CIGS is a direct band gap material. It has the highest efficiency (~20%) among thin film materials.
- Gallium arsenide multi junction: GaAs based multi junction devices are the most efficient solar cells to date. In October 15, 2012, triple junction metamorphic cell reached a record high of 44%.

These multi junction cells consist of multiple thin films produced using metal organic vapor phase epitaxial. E.g. A triple-junction cell, for example, may consist of the semiconductors: GaAs, Ge, and GaInP2 .

Working:

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

1. The absorption of light by semiconductor materials (like silicon), generating either electron-hole pairs or excitants.

2. The separation of charge carriers of opposite types.

3. The separate extraction of those carriers to an external circuit.

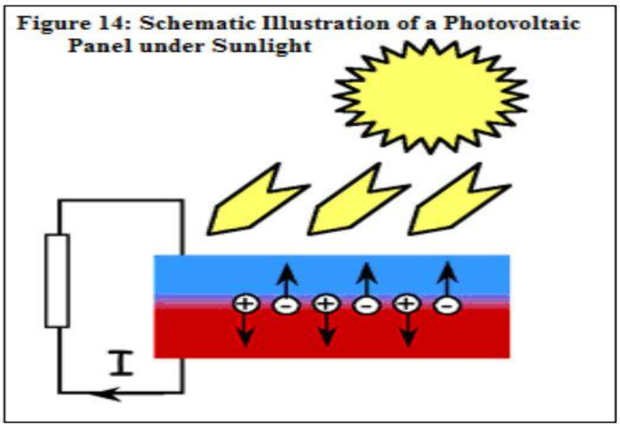
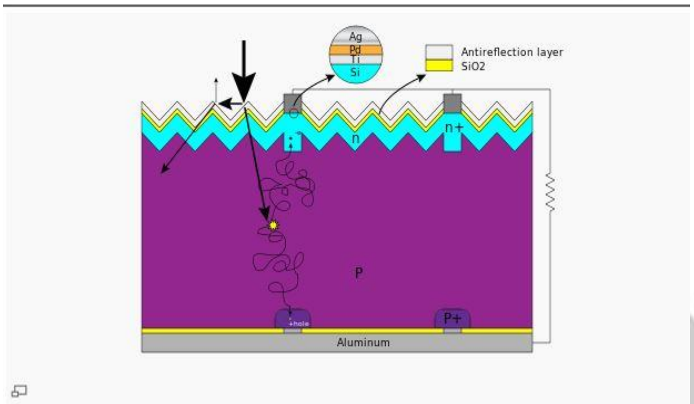


Figure 14: Schematic Illustration of a Photovoltaic Panel under Sunlight



Basic structure of a silicon based solar cell and its working mechanism.

Fig. 9.g

Efficiency:

Single p–n junction crystalline silicon devices are now approaching the theoretical limiting power efficiency of 33.7%.

Comparison between poly-crystalline and mono-crystalline:

1) Atomic arrangement:

Mono-crystalline silicon (sc-Si) modules have ordered atomic structure while Poly-crystalline silicon (mc-Si) has more disordered atomic structure.

2) Efficiency:

Mono-crystalline silicon (sc-Si) modules have higher conversion efficiency about 14% to 20% while poly-crystalline silicon (mc-Si) modules have lower efficiency about 11% to 15%.

3) Economic Cost:

Poly-crystalline is less expensive than mono-crystalline silicon.

4) Degradation:

Poly-crystalline silicon are more resistant to degradation (due to irradiation) while mono-crystalline are less.

(The degradation rate is about 2 percent per year for multiple crystalline technologies).

Note: (some beneficial points why to prefer crystalline silicon)

Due to their proven and reliable technology, long life times and abundant primary resources. Their efficiency is expected to reach 21 percent in the long term.

Circuit diagram:

How to connect multiple solar panels:

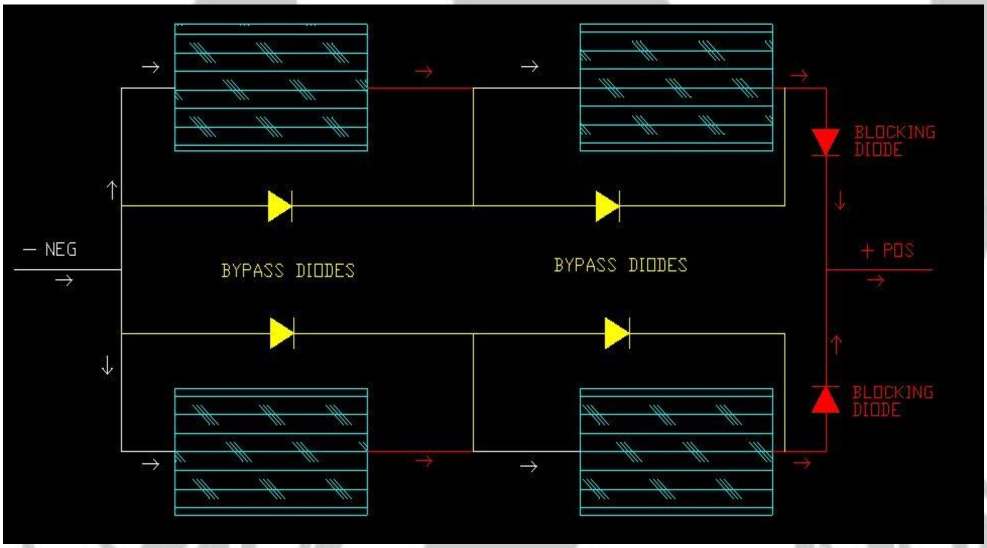


fig. 9.h

As per our battery specification we need approx 25Ah current rating and 4*12V voltage rating
so when charging the battery we connect 2-2 panels in series and combination to parallel as shown in diagram,

Now we got approx 36.68V voltage and 10.9A current which can charge our battery in approx 2 hrs 15 min

And when we have to run motor via panel we connect all the panels in parallel that will give approx 21.8A current and 18.34V voltage that will give 400W rating approx.

Specification:

Specification:

Model: SL100TU18P

Power: 100W

Voltage: 18.34V

Current: 5.45A

Efficiency: 14.12%

Power Tolerance: -3% to +3%

Operating Temperature: -40 to 85*C

Cost:

Quantity: 4 panels
Total cost: Rs 12280 INR approx

CHAPTER 11: MICROCONTROLER

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

Microcontrollers were originally programmed only in assembly language, but various high-level programming languages are now also in common use to target microcontrollers. These languages are either designed especially for the purpose, or versions of general purpose languages such as the C programming language. Compilers for general purpose languages will typically have some restrictions as well as enhancements to better support the unique characteristics of microcontrollers. Some microcontrollers have environments to aid developing certain types of applications. Microcontroller vendors often make tools freely available to make it easier to adopt their hardware.

Circuit Diagram:-

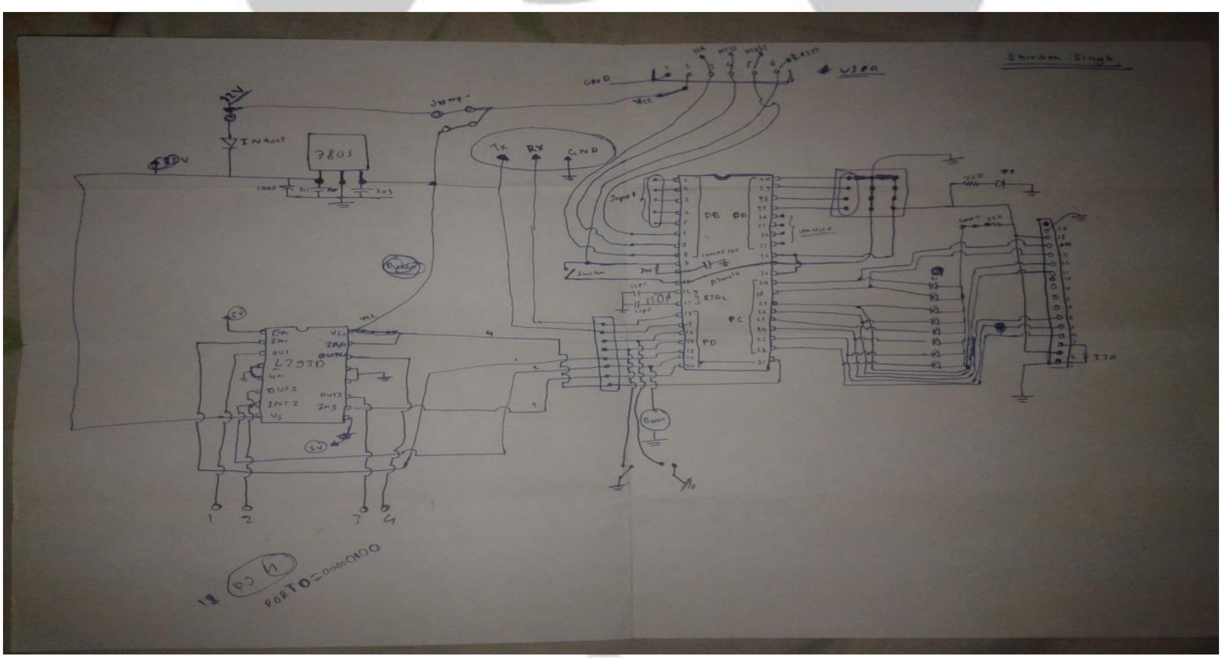


Fig. 11.a

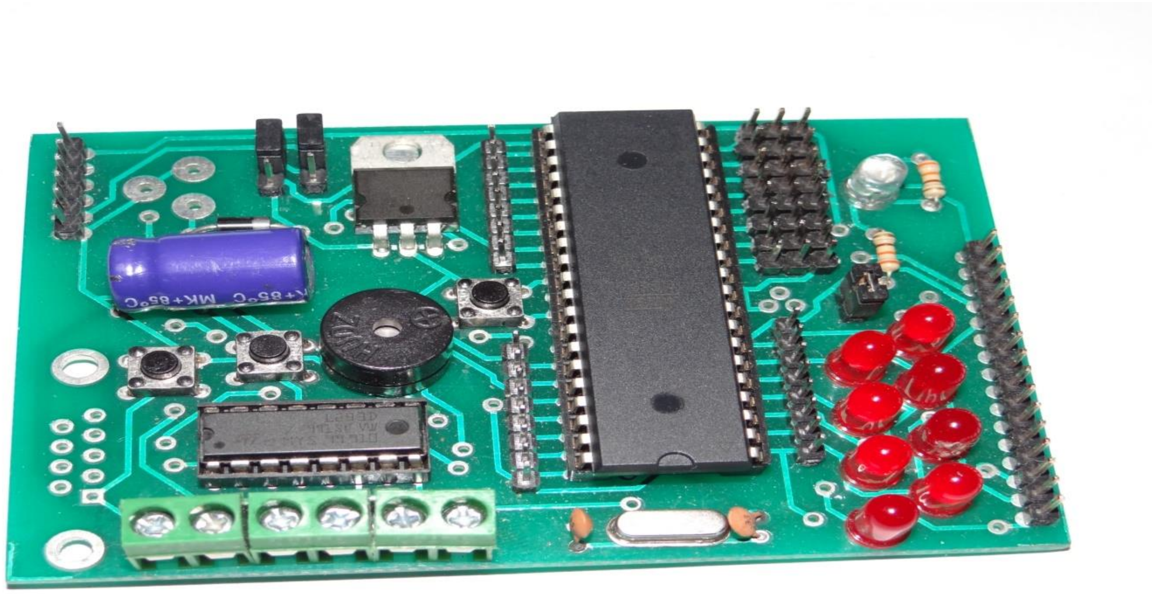


Fig.- 11.b

Display:-There is display system which help the driver visualizes the differ operation on screen like battery level, Loading Capacity, any fault warning, alerting, etc.

Fig.-11.c

Operation:-
Basically Micro controller is use to protect the device like PWM Controller and Motor. Kit is connected with different sensing device which sense different parameter. The Following safety action are taken with help of microcontroller are:-

(i) Current Overloading(Current Sensor)
(ii) Loading Capacity
(iii)Regenerative action control
(iv)Seat belt
(v) Battery capacity

Current Overloading :- Current Sensor or DC current sensor are connected between motor - PWM controller and between PWM controller – Battery. It senses the incoming and outgoing current between Battery, PWM controller & Motor. It help in preventing the short-circuit problem of wire, over current problem. Current sensor sense the current and output signal of sensor is checked by microprocessor whether it is in desire value or not which is feed by programmer according to its bearing capacity. If the current level or there is transitions in current occur, microcontroller detects the transition and disconnect the main component with each other to prevent further Damage and over current problem.

Loading Capacity :- With the help of current sensor we can check that whether our machine is capable to loading at power outcome or not.
Suppose if the drive press the throttle at 0-75% and speed is only its 50% means machine is not capable to give its 25%.Thus driver judged that is no able to get it 75% speed so it lower the throttle to 50% which give it best economy without unless drain of Battery. so we can run its smoothly or Economically.

Regenerative Braking :-It is used to regenerate or to convert friction energy into electrical energy. Generally in vehicle the applied brake is waste in friction energy at its brake point or brake shoes. We know that DC motor work as motor and generator. After acceleration Body maintained it inertia which help DC generator to produce current.
Operation:- Suppose drive accelerated to its full speed and then driver want to hauling it so it engage the regenerative action. Due to inertia, body want to maintain it movement so due to inertia DC motor act or work as generator and produce current which further feed to battery which mean we save energy without loss in friction.

Seat Belt :- It is generally for safety of driver to wear the seat belt before driving. There is limiting switch which enable or disable the PWM Controller according to driver wear seat belt or not. It Alert and flash unless drive wear seat belt.

Battery Capacity :- Its show the battery level or how much energy is remain in battery. It is display on LCD (Fig.-c)which is connected with microprocessor kit(Fig.- b).

CHAPTER 12: BRAKE LIGHT

Red steady-burning rear lights, brighter than the rear position lamps, are activated when the driver applies the vehicle's brakes. These are called "stop lamps" in some countries and "brake lights" in others. They are required to be fitted in multiples of two, symmetrically at the left and right edges of the rear of every vehicle. Outside Northern America, the range of acceptable intensity for a stop lamp is 60 to 185 candela. In Northern America, the acceptable range for a single-compartment stop lamp is 80 to 300 candela.

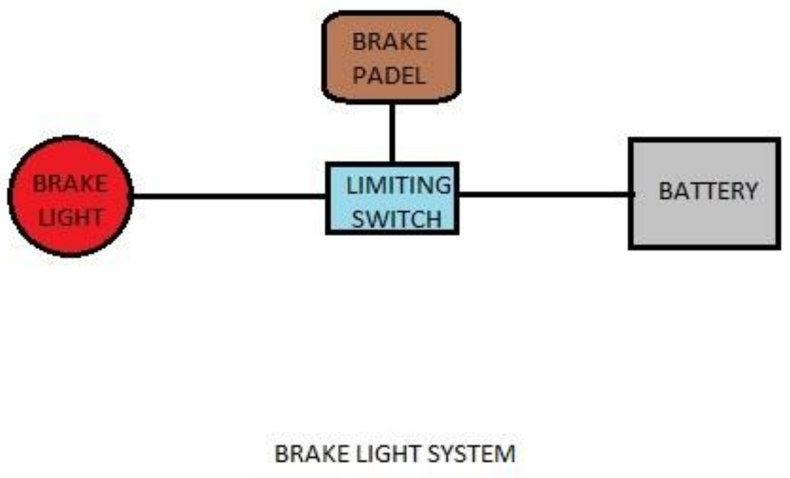


Fig. 12.a

LED Connected parallel with each other.

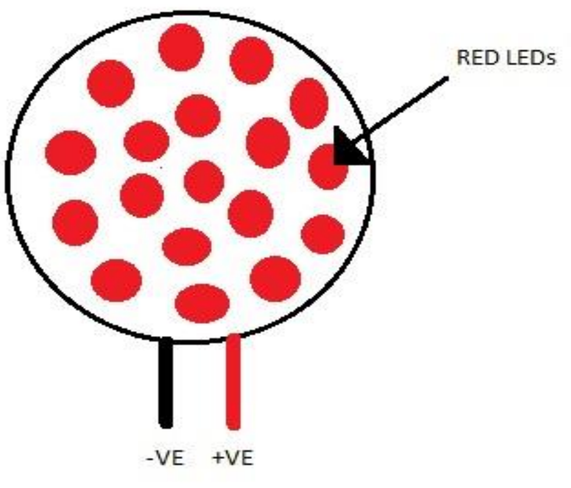


Fig. 12.b

Working of Brake Light:

Limiting switch is connected with battery and brake pedal. As soon as the pedal is pressed the limiting switch will be turned on and hence LEDs will glow. Limiting switch will complete the circuit when the pedal will come in contact with the driver's feet. It activate the switch at some angle.

LEDs Circuits schematic diagram:

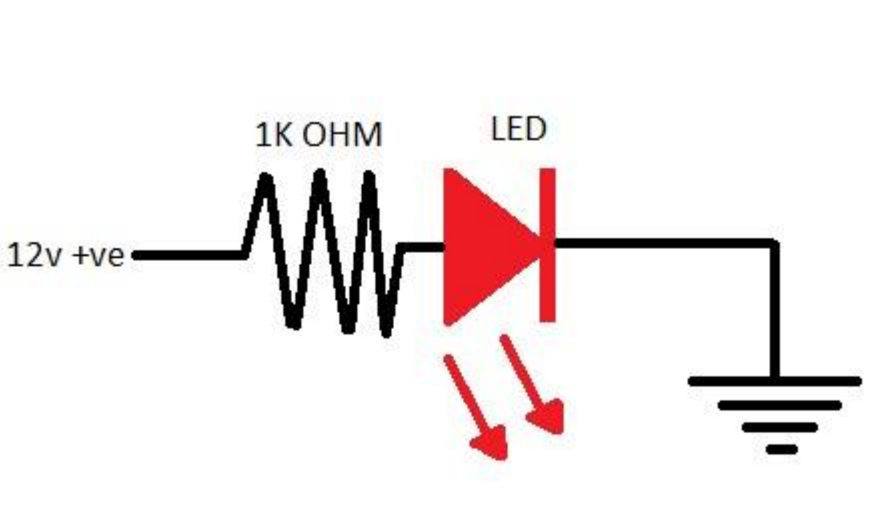


Fig. 12.c

Specification:

PCB Radius = 5cm
No of LEDs=25
Resistor=1k ohm
Limiting Switch=3A,25v, NO Type

Cost:

LED=Rs25
Resistor=Re1
Zero Size PCB=Rs7
Limiting Switch=Rs60

CHAPTER 13 : KILL SWITCH

A kill switch, also known as an emergency stop or e-stop, is a safety mechanism used to shut off a device in an emergency situation in which it cannot be shut down in the usual manner. Unlike a normal shut-down switch/procedure, which shuts down all systems in an orderly fashion and turns the machine off without damaging it, a kill switch is designed and configured to completely and as quickly as possible abort the operation, even if this damages equipment.

Kill switches are featured especially often as part of mechanisms whose normal operation or foreseeable misuse may cause injury or death; designers who include such switches consider damage to or destruction of the mechanism to be an acceptable cost of preventing that injury or death.

NASCAR (National Association for Stock Car Auto Racing) requires all their stock cars to be equipped with a steering wheel-mounted kill switch, in case the accelerator pedal sticks and the driver needs to shut down the engine.

Kill switches are used on land vehicles as an anti-theft system and as an emergency power off. Such devices are often placed in bait cars and configured so that observing police can trigger the switch remotely.

A related concept is the dead man's switch, where the operator must be holding a button or lever any time the vehicle is operating.

Specification:-

Capacity: 100 AMPS
1x Battery Disconnect

Cost:

Kill Switch=Rs200

Connection of Kill Switch:

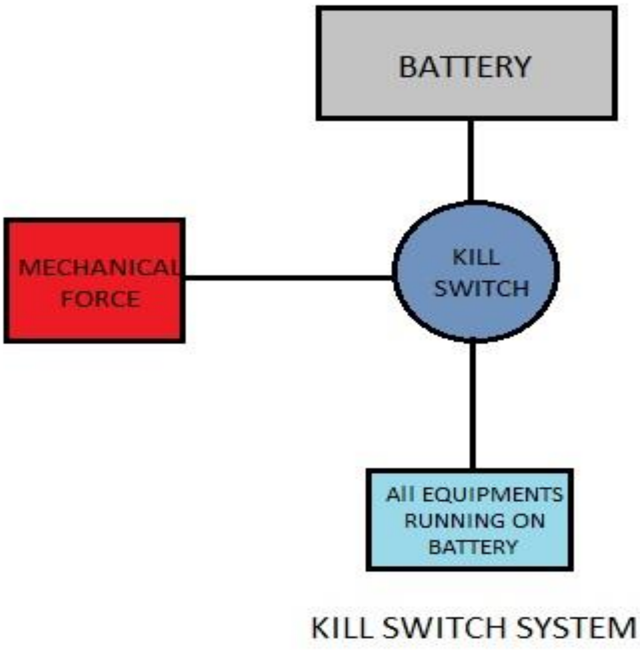


Fig. 13.a

Working Principle of Kill Switch:

Kill switch is directly connected to the battery and with other circuit components . When mechanical force is applied to the switch it disconnects the entire circuits and hence protects from any damage that may occur due to over current or short circuits. It can be manually operated by the driver during emergency.

Image:

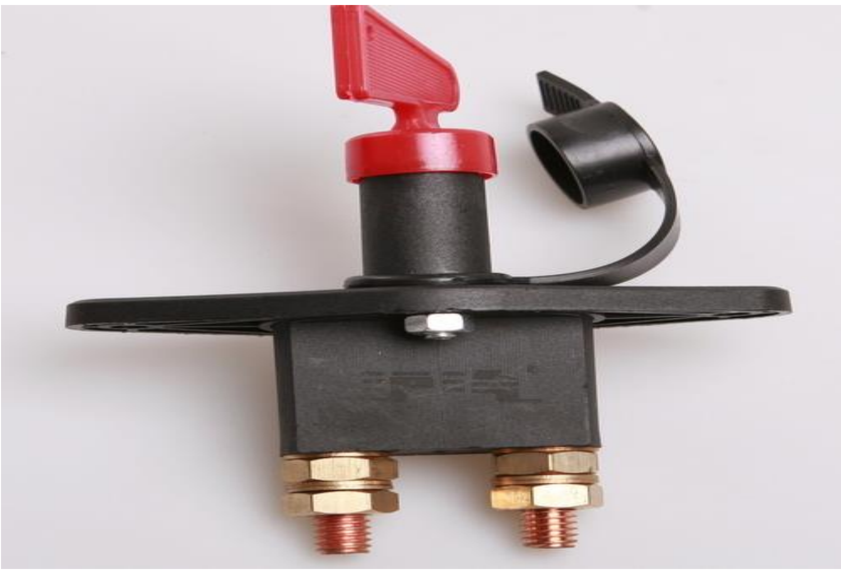


Fig. 13.b

CHAPTER 14 : BATTERY CHARGER:

Basic:-

A battery charger is a device used to put energy into a secondary cell or rechargeable battery by forcing an electric current through it. The charging protocol depends on the size and type of the battery being charged. Some battery types have high tolerance for overcharging and can be recharged by connection to a constant voltage source or a constant current source; simple chargers of this type require manual disconnection at the end of the charge cycle, or may have a timer to cut off charging current at a fixed time. Other battery types cannot withstand long high-rate over-charging; the charger may have temperature or voltage sensing circuits and a microprocessor controller to adjust the charging current, and cut off at the end of charge. A trickle charger provides a relatively small amount of current, only enough to counteract self-discharge of a battery that is idle for a long time. Slow battery chargers may take several hours to complete a charge; high-rate chargers may restore most capacity within minutes or less than an hour, but generally require monitoring of the battery to protect it from overcharge. Electric vehicles need high-rate chargers for public access installation of such chargers and the distribution support for them is an issue in the proposed adoption of electric cars.

Type of Battery Charger:-

Simple:- A simple charger works by supplying a constant DC or pulsed DC power source to a battery being charged. The simple charger does not alter its output based on time or the charge on the battery. This simplicity means that a simple charger is inexpensive, but there is a tradeoff in quality. Typically, a simple charger takes longer to charge a battery to prevent severe over-charging. Even so, a battery left in a simple charger for too long will be weakened or destroyed due to over-charging. These chargers can supply either a constant voltage or a constant current to the battery.
Simple AC-powered battery chargers have much higher ripple current and ripple voltage than other kinds of battery supplies. When the ripple current is within the battery-manufacturer-recommended level, the ripple voltage will also be well within the recommended level. The maximum ripple current for a typical 12 V 100 Ah VRLA battery is 5 amps. As long as the ripple current is not excessive (more than 3 to 4 times the battery-manufacturer-recommended level), the expected life of a ripple-charged VRLA battery is within 3% of the life of a constant DC-charged battery.

Pulse:- Some chargers use pulse technology in which a series of voltage or current pulses is fed to the battery. The DC pulses have a strictly controlled rise time, pulse width, pulse repetition rate (frequency) and amplitude. This technology is said to work with any size, voltage, capacity or chemistry of batteries, including automotive and valve-regulated batteries. With pulse charging, high instantaneous voltages can be applied without

overheating the battery. In a Lead–acid battery, this breaks down lead-sulfate crystals, thus greatly extending the battery service life.
Several kinds of pulse charging are patented. Others are open source hardware.
Some chargers use pulses to check the current battery state when the charger is first connected, then use constant current charging during fast charging, then use pulse charging as a kind of trickle charging to maintain the charge. Some chargers use "negative pulse charging", also called "reflex charging" or "burp charging". Such chargers use both positive and brief negative current pulses. There is no significant evidence, however, that negative pulse charging is more effective than ordinary pulse charging.

Solar Charger:- Solar chargers convert light energy into DC current. They are generally portable, but can also be fixed mount. Fixed mount solar chargers are also known as solar panels. Solar panels are often connected to the electrical grid, whereas portable solar chargers are used off-the-grid (i.e. cars, boats, or RVs). Although portable solar chargers obtain energy from the sun only, they still can (depending on the technology) be used in low light (i.e. cloudy) applications. Portable solar chargers are typically used for trickle charging, although some solar chargers (depending on the wattage), can completely recharge batteries. Other devices may exist, which combine this with other sources of energy for added recharging efficacy.

Safety:-

A car battery contains chemicals that produce hydrogen gas during use. Hydrogen gas is volatile and has been known to explode under certain conditions, causing serious injuries. For example, a car battery may explode while starting the car, while jump starting or by carelessly shorting the terminals with a screwdriver. In fact, under certain conditions a car battery may explode while just sitting in a parked car or on a table.
Keeping this mind, here's how to safely use a car battery charger:

1. Use the correct charger for your particular car battery. Check the car owner's manual for information (or ask your car dealer or trusted auto mechanic).
2. Read the charger manual and make sure you understand how the charger works and what precautions are necessary. Pay close attention to all the warnings.
3. Remove both battery cables from the battery terminals. First remove the negative (black) cable and then the positive (red) cable.
4. Check that the charger is **not** plugged in to an electric outlet and that the power switch is off.
5. Connect the positive (usually red) charger cable to the positive (+) battery terminal and the negative (usually black) cable to the negative (-) battery terminal.
6. Decide whether you want to charge the battery slowly (trickle charge) or quickly. Select a lower charging voltage and current for a trickle charge and a higher setting for a quicker charge. Check the charger manual for the proper settings. Note that trickle charging gives the best results.
7. Select whether the charger will run for a specific amount of time or automatically shut off when the battery is charged. Not all chargers have this feature.

8. Leave the charger or cables in one place while the battery is charging.
9. Turn off and unplug the charger when the battery is fully charged.
10. Disconnect the cables, starting with the negative cable, and then moving on to the positive cable.

36V Automatic Golf Car Battery Charger:-

Fig. 14.a

Technical specification:-

Input-110V-220V AC
Output- 36V/48V DC
Power- 1KW

Cost:- 3575Rs

Manufacture:- Johan, S.A

CHAPTER 15: BATTERY:

Basic:- All lead acid batteries consist of flat lead plates immersed in a pool of electrolyte. Regular water addition is required for most types of lead acid batteries although low-maintenance types come with excess electrolyte calculated to compensate for water loss during a normal lifetime. Lead acid batteries used in the RV and Marine Industries usually consist of two 6-volt batteries in series, or a single 12-volt battery. These batteries are constructed of several single cells connected in series each cell produces approximately 2.1 volts. A six-volt battery has three single cells, which when fully charged produce an output voltage of 6.3 volts. A twelve-volt battery has six single cells in series producing a fully charged output voltage of 12.6 volts.

Lead Acid Battery Recharge Cycle:- The most important thing to understand about recharging lead acid batteries is that a converter/charger with a single fixed output voltage will not properly recharge or maintain your battery. Proper recharging and maintenance requires an intelligent charging system that can vary the charging voltage based on the state of charge and use of your RV or Marine battery. Progressive Dynamics has developed intelligent charging systems that solve battery problems and reduce battery maintenance.

The discharged battery is connected to a converter/charger with its output voltage set at 13.6-volts. In order to recharge a 12-volt lead acid battery with a fully charged terminal voltage of 12.6-volts, the charger voltage must be set at a higher voltage. Most converter/chargers on the market are set at approximately 13.6-volts. During the battery recharge cycle **lead sulfate (sulfation)** begins to reconvert to lead and sulfuric acid.

During the recharging process as electricity flows through the water portion of the electrolyte and water, (H_2O) is converted into its original elements, hydrogen and oxygen. These gasses are very flammable and the reason your RV or Marine batteries must be vented outside. Gassing causes water loss and therefore lead acid batteries need to have water added periodically. Sealed lead acid batteries contain most of these gasses allowing them to recombine into the electrolyte. If the battery is overcharged pressure from these gasses will cause relief caps to open and vent, resulting in some water loss. Most sealed batteries have extra electrolyte added during the manufacturing process to compensate for some water loss.

Picture of Exide Max Battery:-

Specification of Battery:-

TECHNICAL SPECIFICATIONS OF EXIDE MAX RANGE OF BATTERIES												
BATTERY TYPE	PART NUMBER	C_{20} CAPACITY (AH) 20HR (REF)	MAXIMUM OVERALL DIMENSIONS (MM)			NOMINAL FILLED WEIGHT (KG)	ELECTROLYTE VOLUME (LTS)	CHARGING CURRENT (AMPS)	CCA AT -18°C AS PER		ACID LEVEL INDICATOR	BATTERY LAYOUT
			L	W	H				IEC	SAE		
EM32R(MF)	FEM0-EM32R(MF)	32	197	129	227	9.7	2.5	2.0	230	280	Not Present	RIGHT LAYOUT

Fig. 15.b

Manufacturer:- Exide Battery

Cost:- 3000Rs per

Total Cost:- 12000Rs (approx.)

CHAPTER 16: SOLAR CONTROLLER:

Basic:- A solar controller is an electronic device that controls the circulating pump in a solar hot water system to harvest as much heat as possible from the solar panels and protect the system from overheating. The basic job of the controller is to turn the circulating pump on when there is heat available in the panels, moving the working fluid through the panels to the heat exchanger at the thermal store. Heat is available whenever the temperature of the solar panel is greater than the temperature of the water in the heat exchanger. Overheat protection is achieved by turning the pump off when the store reaches its maximum temperature and sometimes cooling the store by turning the pump on when the store is hotter than the panels. The simplest solar controller circuit uses a comparator with two temperature inputs, one at the solar panel and one at the thermal store's heat exchanger, and an output to control the pump. Commercial controllers use a microprocessor usually with a LCD display and simple user interface with a few pushbuttons. Power for the controller and the pump can come from a mains electric supply or from a photovoltaic (PV) module.

Working:- The controller's main function is to switch the circulating pump on or off. The pump is usually switched on when the solar panel is hotter than the water in the store's heat exchanger and off when the panel is colder. Switching the pump on transfers the heat in the panel to the store. Switching it off when the panels cool prevents a reversal of the process and loss of heat from the store. The controller measures and compares the temperatures in the panel and the heat exchanger every few seconds. Commercial controllers do not turn on the pump until the difference in temperature between the panels and the water in the heat exchanger is sufficient to provide significantly more energy than is consumed by the pump. This temperature difference is called the on differential (usually 4–15 °C. They turn off the

pump when the panels no longer are hot enough to provide significant heat to the store (the off differential). The wider the difference between these differentials, the fewer pump on-off cycles will take place. These factors are usually set by the solar installer in relation to the particular installation, especially dependent on the efficiency of the heat exchanger and production capacity of the panels.
Controllers provide an overrun time to extract some of the heat energy left in interconnecting pipes after the panels cool off. They may also implement certain safety features such as cooling the store when it exceeds a preset temperature such as 65 °C, by sending excess heat back to the panels to be given off to the environment.

Function:-

1. Always keep the battery on full voltage condition.
2. Prevent the battery from over-charging.
3. Prevent the battery from over-discharging.
4. Prevent the battery from reverse charging to solar panels during nights.
5. Reverse polarity protection for battery.
6. Reverse polarity protection for solar panels.
7. When the battery voltage is low, the controller will automatically cut off the load from the system. If the voltage of battery is back to normal and the load will restart working.
8. Thunder protection
9. According to the battery voltage grade, the controller can automatically set charge-off voltage, the load-off voltage, the load-restore voltage. (The parameter is default under 25°C condition, locked by the CPU procedure, cannot adjust.)
10. The controller will automatically compensate the temperature of the charging voltage according to the changes of ambient temperature.

Connection of Solar Controller:-

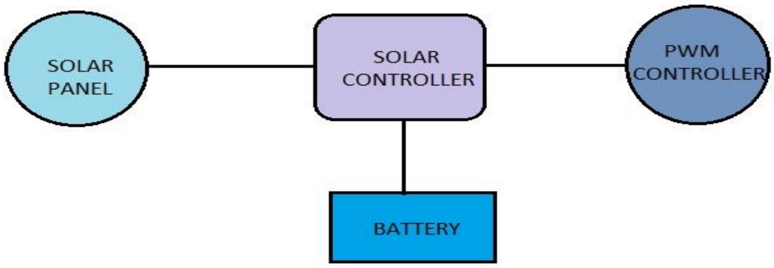


Fig. 16.a

Picture of Solar Controller:-

Fig. 16.b

Specification:-

Rated Voltage: 48V
Max Load current: 30A
Input current range: 48V - 110V
Over voltage protection: 68V
Full charge cut: 54.8V
Low voltage cut: 42 - 44V

Manufacturer:-

2011toplexus

Cost:- 3650Rs

CHAPTER 17: CONCLUSION:

The project report is prepared in such a manner that every layman can understand the details pertaining to the project. The report is prepared in simple language and described well. The report give adequate idea and design guideline for making suitable report is expected to prove valuable to the successor students of both mechanical and electrical engineers to know the essentials of the project and project report.

The matter discussed in the early pages just give a broad outline of small scale industries. We have tried to cover all the aspects concerned with our project.

CHAPTER 18: REFERENCES:

a.) Automobile engineering, volume 2, by- Dr. Kripal Singh
b.) http://en.wikipedia.org/wiki/Solar_vehicle
c.) http://www.scribd.com/doc/20373516/Go-Kart-Project
d.) https://www.facebook.com/groups/ESVC2014/
e.) Automobile engineering by Austin and cruise