# OPTIMIZED SOLAR POWERED VEHICLE FOR THE PHYSICALLY CHALLENGED

**A PROJECT REPORT**

***Submitted by***


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***of***

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***in***

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**EASWARI ENGINEERING COLLEGE**
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# BONAFIDE CERTIFICATE

Certified that this project report **“OPTIMIZED SOLAR POWERED VEHICLE FOR THE PHYSICALLY CHALLENGED”** is the bonafide work of “**ANEES AHMED. M. S (310611105009), GANESH RAM. P (310611105027), GIRI PRASASAD. V (310611105028), GOWTHAM. S (310611105029)”** who carried out the project work under my supervision.

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# DECLARATION

We solemnly declare that the entire work contained in this project report entitled "**OPTIMIZED SOLAR POWERED VEHICLE FOR THE PHYSICALLY CHALLENGED**" has been carried out by us at Easwari Engineering College, Chennai, under the guidance of **Dr. K. KALAI SELVI, M.E., Ph.D.,** Head of Department, Electrical and Electronics Engineering.

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# ABSTRACT

The solar powered vehicle is designed, keeping in view the difficulties faced by the physical challenged in the society and also to relieve the ever increasing demand for the conventional sources of fuel. This project focuses on creating an eco-friendly environment as well as to serve as a simpler mode of transportation for the physically challenged in the society. The conventional solar vehicles are purely driven by a single battery. Whereas this design houses two batteries, wherein one will act as an active one that drives the system and the other battery will be used as an auxiliary. The multiple battery charging technique is implemented in this project, which governs the parallel charging of the batteries used. Also, manual hand pedal driving is provisioned so as to run the vehicle even when there is any kind of battery outage. The motor that is used for the model is Permanent Magnet Brushless DC Motor. The torque-speed characteristics, power consumption and load characteristics are feasible enough so as to optimize the overall power consumption.

# CHAPTER 1
# INTRODUCTION

## 1.1 OVERVIEW

This chapter will provide an introduction to our project in terms of its salient features and how it is aimed at making the environment a better place to live in and creating an easier life for the physically handicapped. It also gives an insight into the similar existing systems and their shortcomings [1].

## 1.2 SCOPE

This project envisages a broad scope and are enlisted as follows.

- To convert the solar energy to the electrical energy efficiently by using solar cells.
- To alleviate the problems faced by a handicapped while travelling and enhance their commutability.
- To find an alternative for fuel.
- To maintain the ecological balance.
- To form an economical vehicle.
- To maintain a pollution-free environment.
- To promote awareness of renewable energy resources amongst the society.

The National Sample Survey, sampled some data and made a detailed statistical report in the year 2011, with regard to disabilities and their variations prevailing in India.

The following are the results (with number and percentage statistics) that were disclosed.

| DISABLED POPULATION | | | |
|---|---|---|---|
| **Residence** | **Persons** | **Males** | **Females** |
| **Total** | 26,810,557 | 14,986,202 | 11,824,355 |
| **Rural** | 18,631,921 | 10,408,168 | 8,223,753 |
| **Urban** | 8,178,636 | 4,578,034 | 3,600,602 |

**Table 1.1 Disabled Population by Sex and Residence, India, 2011**

| DISABLED TO TOTAL POPULATION | | | |
|---|---|---|---|
| **Residence** | **Persons** | **Males** | **Females** |
| **Total** | 2.21 | 2.41 | 2.01 |
| **Rural** | 2.24 | 2.43 | 2.03 |
| **Urban** | 2.17 | 2.34 | 1.98 |

**Table 1.2 Percentage of Disabled to Total Population, India, 2011**

| TYPE OF DISABILITY | | | |
|---|---|---|---|
| **Type of Disability** | **Persons** | **Males** | **Females** |
| **In Seeing** | 5,032,463 | 2,638,516 | 2,393,947 |
| **In Hearing** | 5,071,007 | 2,677,544 | 2,393,463 |
| **In Speech** | 1,998,535 | 1,122,896 | 875,639 |
| **In Movement** | 5,436,604 | 3,370,374 | 2,066,230 |

| | | | |
|---|---|---|---|
| **Mental Retardation** | 1,505,624 | 870,708 | 634,916 |
| **Mental Illness** | 722,826 | 415,732 | 307,094 |
| **Any Other** | 4,927,011 | 2,727,828 | 2,199,183 |
| **Multiple Disability** | 2,116,487 | 1,162,604 | 953,883 |
| **Total** | 26,810,557 | 14,986,202 | 11,824,355 |

**Table 1.3 Disabled Population by Type of Disability, India, 2011**

Disability generally has many facets. So, it is important to understand that there are many different types and severities of impairment which lead to disabilities. Some types of impairment are:

a. Visual impairment.
b. Hearing impairment.
c. Movement impairment.
d. Cognitive/language impairment.

Within each of these major types, there are many variations and degrees of impairment. Each of these may present different barriers and need to be addressed with different solution strategies.

The variations in the impairments and their needs are as follows.

- Someone with a moderate visual impairment may need some mechanism to enlarge the image on the screen.

- An individual with a mild hearing impairment may just need a mechanism to increase the volume.

- Someone with a severe visual impairment or who is blind would find screen enlargement to be of no value and would need mechanisms to translate the contents of the screen to speech or braille.

- An individual with a severe hearing impairment or who is deaf may need to have auditory information presented in some visual form.

- An individual with a mild physical impairment may just need to have an efficient working model for them to travel from one place to another.

It is clearly evident that the number of physically challenged people are very high, and the problems they face are very severe.

**1.3 ENVIRONMENT IMPACTS**

Another major problem is the energy crisis. We rely on coal, oil and gas (the fossil fuels) for over 80% of our current energy needs. Energy demand is expected to grow by almost half over the next two decades. Understandably this is causing some fear that our energy resources are starting to run out, with devastating consequences for the global economy and global quality of life. But more than the fear of getting exhausted, the major problem is the impact created on the environment.

Many of the environmental problems our country faces today result from our fossil fuel dependence. These impacts include global warming, air quality deterioration, oil spills, and acid rain.

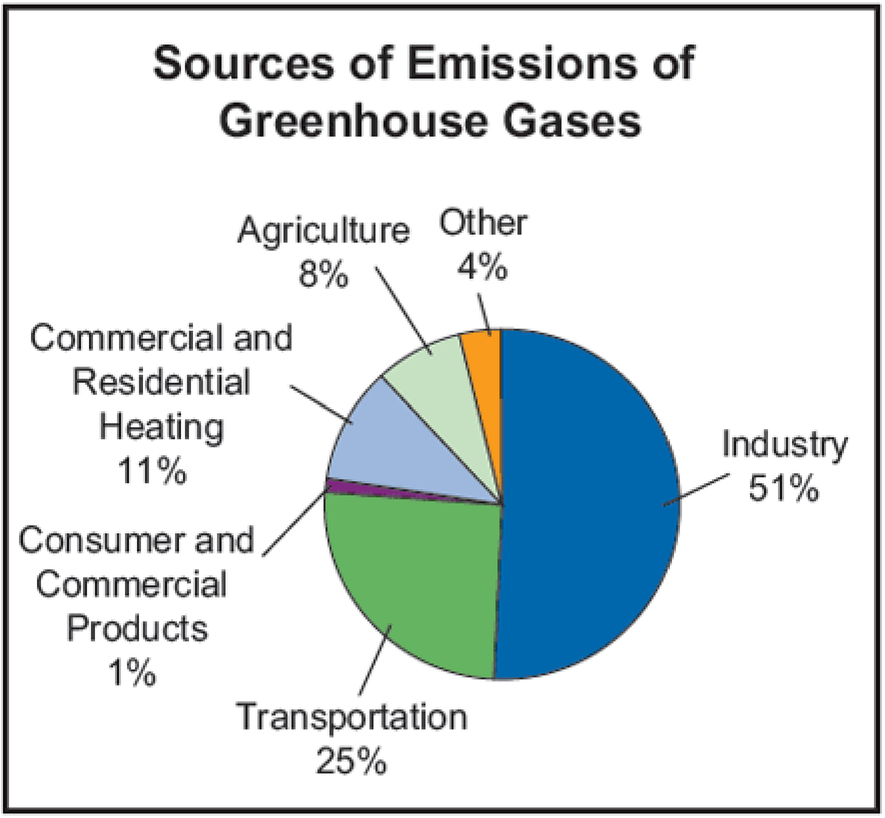


**Fig 1.1 Sources of Emissions of Greenhouse Gases**

The above pie chart shows the sources of emissions of gases. Next to the industrial sector is the transportation sector, which forms a major contribution of up to 25%, which is a staggering amount. Also a chart based on $CO_2$ emissions is shown below.

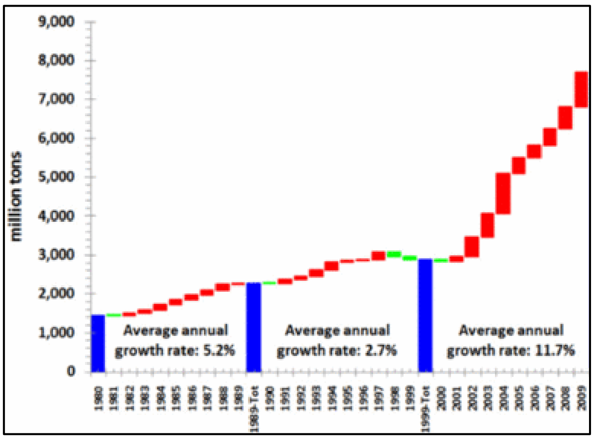


**Fig 1.2 $CO_2$ Emissions**

### 1.3.1 GLOBAL WARMING

Among the gases emitted when fossil fuels are burned, one of the most significant is carbon dioxide, a gas that traps heat in the earth's atmosphere. Over the last 150 years, burning fossil fuels has resulted in more than a 25% increase in the amount of carbon dioxide in our atmosphere. Fossil fuels are also implicated in increased levels of atmospheric methane and nitrous oxide, although they are not the major source of these gases.

Climate scientists predict that if carbon dioxide levels continue to increase, the planet will become warmer in the next century. Projected temperature increases will most likely result in a variety of impacts. In coastal areas, sea-level rise due to the warming of the oceans and the melting of glaciers may lead to the inundation of wetlands, river deltas, and even populated areas. Altered weather patterns may result in more extreme weather events. And inland agricultural zones could suffer an increase in the frequency of droughts.

### 1.3.2 AIR POLLUTION

Clean air is essential to life and good health. Several important pollutants are produced by fossil fuel combustion: carbon monoxide, nitrogen oxides, sulfur oxides, and hydrocarbons. In addition, total suspended particulates contribute to air pollution, and nitrogen oxides and hydrocarbons can combine in the atmosphere to form tropospheric ozone, the major constituent of smog.

Carbon monoxide is a gas formed as a by-product during the incomplete combustion of all fossil fuels. Exposure to carbon monoxide can cause headaches and place additional stress on people with heart disease. Cars and trucks are the primary source of carbon monoxide emissions.

Two oxides of nitrogen- Nitrogen dioxide and Nitric oxide are formed in combustion. Nitrogen oxides appear as yellowish-brown clouds over many city skylines. They can irritate the lungs, cause bronchitis and pneumonia, and decrease resistance to respiratory infections.

Sulfur oxides are produced by the oxidization of the available sulfur in a fuel. Utilities that use coal to generate electricity produce two-thirds of the nation's sulfur dioxide emissions. Nitrogen oxides and sulfur oxides are important constituents of acid rain. These gases combine with water vapor in clouds to form sulfuric and nitric acids, which become part of rain and snow. As the acids accumulate, lakes and rivers become too acidic for plant and animal life. Acid rain also affects crops and buildings.

Finally, fossil fuel use also produces particulates, including dust, soot, smoke, and other suspended matter, which are respiratory irritants. In addition, particulates may contribute to acid rain formation.

### 1.3.3 WATER AND LAND POLLUTION

Oil and coal form a major part of energy production, but they do have ill-effects on the environment. Production, transportation, and use of oil can cause water pollution. Oil spills, for example, leave waterways and their surrounding shores uninhabitable for some time. Such spills often result in the loss of plant and animal life. Coal mining contributes to water pollution. Coal contains pyrite, a sulfur compound; as water washes through mines, this compound forms a dilute acid, which is then washed into nearby rivers and streams.

### 1.3.4 THERMAL POLLUTION

During the electricity-generation process, burning fossil fuels produce heat energy, some of which is used to generate electricity. Because the process is inefficient, much of the heat is released to the atmosphere or to water that is used as a coolant. Heated air is not a problem, but heated water, once returned to rivers or lakes, can upset the aquatic ecosystem.

## 1.4 ERA OF RENEWABLE ENERGY

It is thus clearly evident that the environment faces severe problems with regard to pollution and degradation and the quality of life and well-being is at stake. This ultimately served as a prime motive for development of a pollution-free renewable energy resources.

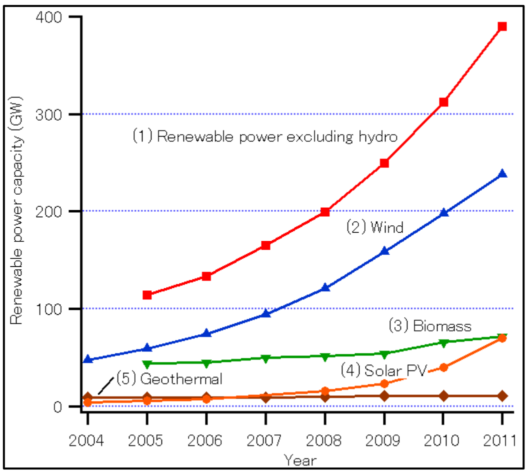


**Fig 1.3 Power Capacity vs. Time Period**

The graph shows us that the commercial implementation of the renewable energy resources started in the year 2004, where the focus was primarily on Wind

Energy, the reason being its abundance in nature. In the end of the decade, the growth of the photovoltaics increased tremendously.


**Fig 1.4 Solar Energy Sector, 2012**

The figure above shows an approximate estimate of how the industrial sector is, for the solar power. It clearly shows that photovoltaic sector has emerged as one of the most rapidly growing renewable sources of electricity. Solar power generation has several advantages over other forms of electricity generation:

### 1.4.1 REDUCED DEPENDENCE ON FOSSIL FUELS

Solar energy production does not require fossil fuels and is therefore less dependent on this limited and expensive natural resource. Although there is variability in the amount and timing of sunlight over the day, season and year, a properly sized and configured system can be designed to be highly reliable while providing long-term, fixed price electricity supply.

### 1.4.2 ENVIRONMENTAL ADVANTAGES

Solar power production generates electricity with a limited impact on the environment as compared to other forms of electricity production.

### 1.4.3 PEAK TIME OUTPUT & PEAK TIME DEMAND

Solar energy can effectively supplement electricity supply from an electricity transmission grid, such as when electricity demand peaks in the summer.

### 1.4.4 MODULARITY AND SCALABILITY

As the size and generating capacity of a solar system are a function of the number of solar modules installed, applications of solar technology are readily scalable and versatile.

### 1.4.5 FLEXIBLE LOCATIONS

Solar power production facilities can be installed at the customer site which reduces required investments in production and transportation infrastructure.

### 1.4.6 GOVERNMENT INCENTIVES

A growing number of countries have established incentive programs for the development of solar and other renewable energy sources, such as:

- Net metering laws that allow on-grid end users to sell electricity back to the grid at retail prices.
- Direct subsidies to end users to offset costs of photovoltaic equipment and installation charges.
- Low interest loans for financing solar power systems and tax incentives.
- Government standards that mandate minimum usage levels of renewable energy sources.

The information stated above evidently portrays the significance of the solar powered generation of energy in the current scenario and its positive effects on the society. This ultimately became the reason behind designing this model.

## 1.5 CONVENTIONAL TRICYCLES

Tricycle drivers work long hours and many are under-nourished and living in extremely poor conditions. The strength and endurance required pedalling over rough roads and uneven terrains take a huge physical toll on the drivers, and the community sees frequent outbreaks of disease and other health effects. The mechanical design of the traditional Tricycles does little to ease the burden on the driver are not the ones purchasing the tricycle, there is little incentive for sellers to improve the design for the better driver comfort and safety.

And there are a number of other problems with the current design Tricycles have poor braking, safety lighting, suspension system, and gearing system. The gear ratio for existing tricycles is very high, making it difficult to pedal uphill or start from a standstill. The difficulty in pedalling takes a physical toll on the drivers, who frequently develop joint and other injuries, or outbreaks of disease. The lack of gearing system and high gear ratio on the existing tricycle models make pedalling passengers incredibly difficult for Tricycle drivers.

## 1.6 CONVENTIONAL ELECTRIC VEHICLES

The solar power was not only used for commercial purposes but was also used to run vehicles. They did have some drawbacks, which didn’t help them flourish into the market. Some of the drawbacks were:

### 1.6.1 BATTERY LIFE

The vehicles that were earlier designed had lesser battery lifetime, thus the vehicle would run only very small distances.

### 1.6.2 BATTERY TYPE

The vehicles generally employed single battery systems that seemed as a very insufficient source of energy. It even failed whenever the battery suffered unavoidable outages.

### 1.6.3 LACK OF PHOTOVOLTAICS

The solar powered systems were a recently emerged field of technology, thus it was completely absent in the previous designs.

### 1.6.4 BULKY AND COMPLEX

The electric vehicles were generally bulky and heavy, and involved complex circuitry system in them.

### 1.6.6 POWER CONSUMPTION

The designs were generally consuming high power, due to absence of highly efficient semiconductor devices and microcontrollers.

### 1.6.6 LOAD CAPACITY

The vehicles had a major drawback of load constraints, which significantly reduced the commercial demand, flexibility and feasibility.

### 1.6.7 PROBLEMS WITH DC MOTOR

The DC motors were generally employed in the vehicles for driving it. But several disadvantages like high power consumption on loading, heating, less speed, less toque etc. reduced its commercial viability.

## 1.7 ORGANIZATIONAL CHART

The organizational chart gives a gist of the structure of the report.

**Chapter 1** gives a brief introduction about the project and includes statistics regarding disabilities and their variations. It also deals about the levels of pollution in the current era.

**Chapter 2** shows information regarding Literature Survey as well as the general components that are implemented in this project.

**Chapter 3** is deals about with the model fabrication by arc welding, mechanical considerations and specifications that are made in this design.

**Chapter 4** gives an insight as to how and where the hardware components are actually implemented in the vehicle.

**Chapter 5** gives information about the design's circuitry and elucidates on the Dual Battery Switchover Technique, which is an optimization feature added in this design.

**Chapter 6** conveys the conclusion of the project.

# CHAPTER 2

# LITERATURE REVIEW AND COMPONENT DESCRIPTION

## 2.1 LITERATURE SURVEY

The paper **"Design of Solar tricycle for Handicapped person by** *Ravikumar Kandasamy, Sachin Ratu, Deep Varma, Ganesh There* **(IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684 Volume 5, Issue 2(Jan-Feb 2013), pp11."** provided us basic idea and procedure as to how to go about with the project.

A paper entitled **"Cost-Benefit Analysis of Plug-In Hybrid Electric Vehicle Technology by** *Tony Markel and Andrew Simpson***, ISSN 2032-6653, The World Electric Vehicle Association Journal, Vol. 1, 2007."** was also a prime motive that instilled us in choosing a project based on electric vehicle.

The journal about **"Implementation of Solar Powered PMBLDC Motor Drive by** *Deepa A. B and Maheshkanth Pawar***, IJSRD - International Journal for Scientific Research & Development | Vol. 2, Issue 08, 2014 | ISSN (online): 2321-0613."** helped us in choosing a PMBLDC motor for our vehicle and also to study more about the motor.

**"Automatic Battery Charging Algorithms for Hybrid Electric Vehicles by** *F.Vijay Amirtha Raj***, International Journal of Emerging Science and Engineering (IJESE), ISSN: 2319–6378, Volume-1, Issue-2, December 2012."** gave us an insight into how batteries are typically charged in an electric vehicles. We have modified their charging algorithm based on our requirement by implementing different charging conditions.

**“Appliance Remote Control Using Arduino by** *D. Anusha, PM.Sarma, M.N. SandhyaRani***, Vol. 2 Issue 4 July 2013, ISSN: 2278-621X.”** helped us in analyzing the working of a relay when integrated with an Arduino.

**“Design and structural analysis of differential gear box at different loads by** *C.Veeranjaneyulu and U. Hari Babu***, International Journal of Advanced Engineering Research and Studies, E-ISSN2249–8974, Vol. I/ Issue II/January-March, 2012/65-69.”** gave us a brief idea about the differential gear system, and instilled us implement the same in our system.

**“Power Assisted Tricycle with Drive-Train Arrangement for Disabled Persons by** *K. Kalyani Radha and K.Sai Kiran***, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 2 Issue XI, November 2014, ISSN: 2321-9653.”** gave us good knowledge about general mechanical framework and about gearing systems.

## 2.2 SOLAR PANEL

Solar panel refers either to a photovoltaic module, a solar hot water panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure. A PV module is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts.

**Fig 2.1 Solar Panel**

The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules.

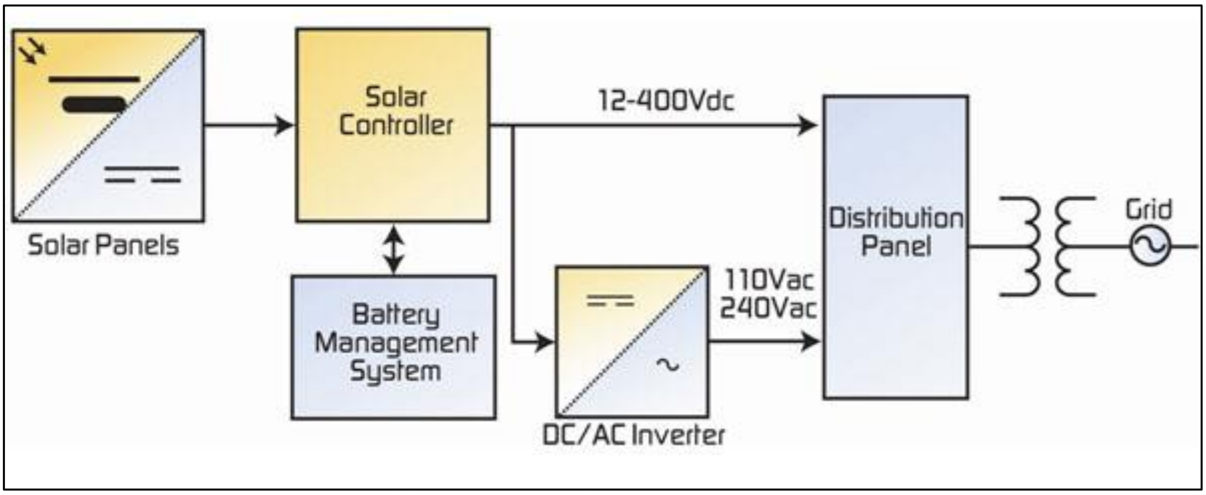


**Fig 2.2 Photovoltaic System**

A photovoltaic system typically includes a panel or an array of solar modules, an inverter (concerted DC to AC). It may include even one or more batteries, to store the energy and use when there is no sufficient solar power. A solar tracker may also be implemented to increase the efficiency of the whole system.

## 2.3 PHOTOVOLTAIC THEORY

Photovoltaics (PV) is a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun.

The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. The phenomenon behind this is the photovoltaic theory.

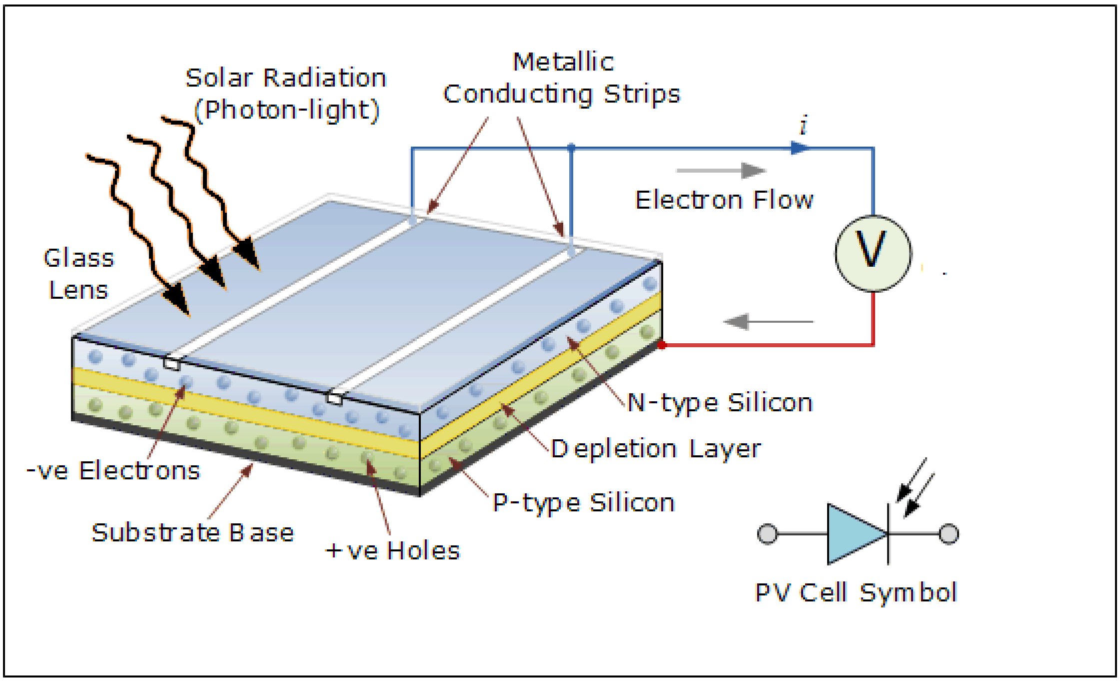


**Fig 2.3 Photovoltaic Phenomenon**

The theory briefly states that when a material (such as Germanium, Silicon etc.) is irradiated by a beam of photons (say sunlight), there is an excitation of the molecules present in the material, thus giving rise to production of electrical energy. Other materials that are used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Copper solar cables connect modules (module cable), arrays (array cable), and sub-fields. Because of the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

## 2.4 BATTERY

An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

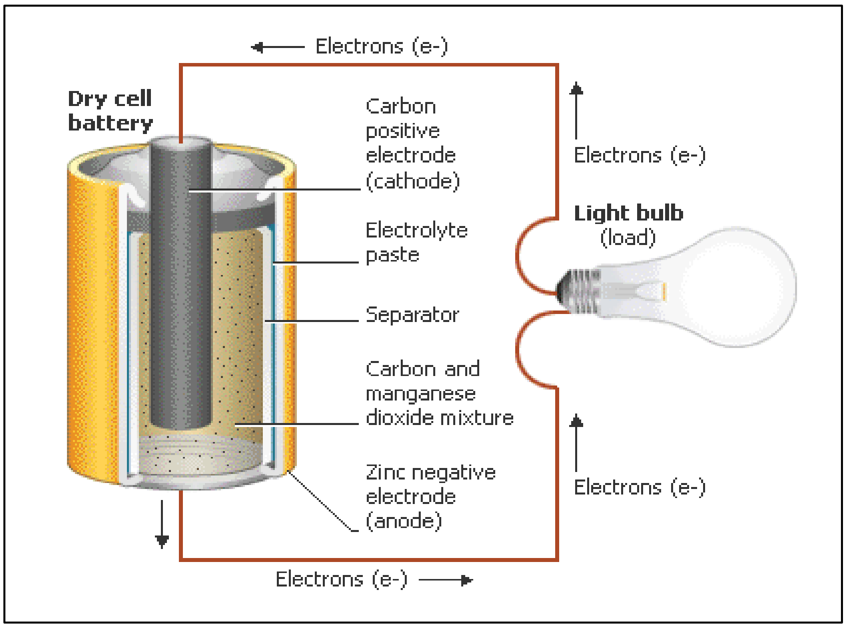


**Fig 2.4 Working Principle**

Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current.


**Fig 2.5 Typical Battery**

Examples include the lead-acid batteries used in vehicles and lithium ion batteries used for portable electronics.

## 2.5 PRINCIPLE OF OPERATION

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate.

Redox reactions power the battery. Cations are reduced (electrons are added) at the cathode during charging, while anions are oxidized (electrons are removed) at the anode during discharge. The electrodes do not touch each other, but are electrically connected by the electrolyte.

Some cells use different electrolytes for each half-cell as shown below. A separator allows ions to flow between half-cells, but prevents mixing of the electrolytes.

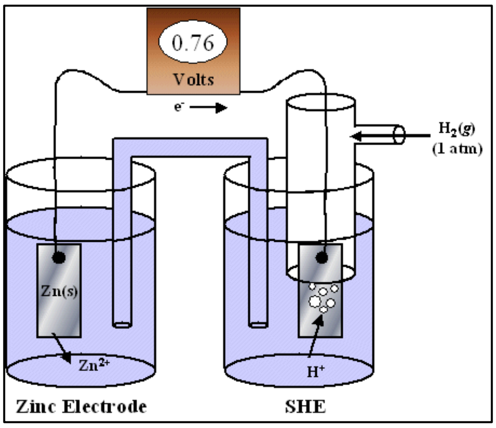


**Fig 2.6 Principle of Operation**

Each half-cell has an electromotive force (or EMF), determined by its ability to drive electric current from the interior to the exterior of the cell.

The net EMF of the cell is the difference between the EMFs of its half-cells. The general half-cell reaction is depicted as follows.

$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$ (Reduction)

$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ (Oxidation)

Net reaction:

$Zn_{(s)} + 2H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

The batteries can be connected in following configurations:

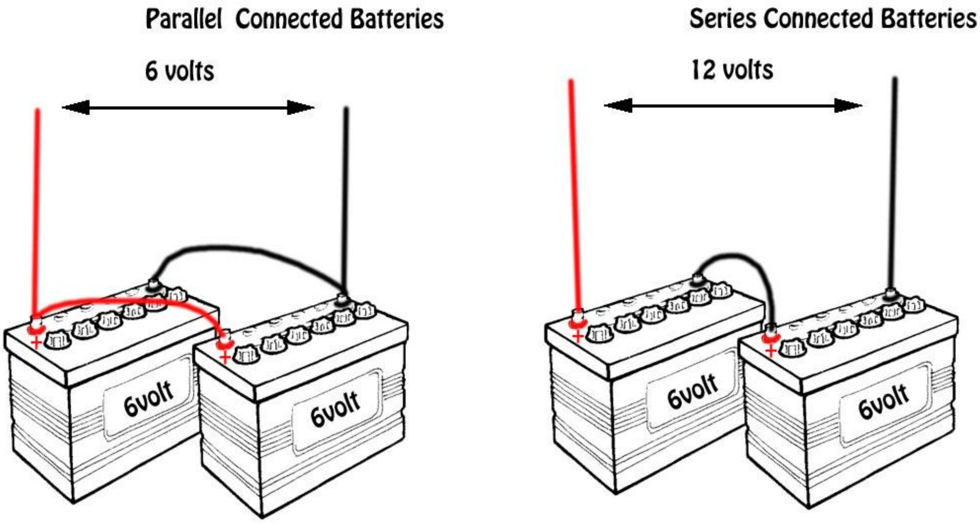


**Fig 2.7 Parallel and Series Connection of Batteries**

Some of the commonly used batteries and their capacities are mentioned below.

| Type | Capacity (mAh) | Density |
|---|---|---|
| Alkaline AA | 2850 | 124 |
| Rechargeable | 1600 | 80 |
| Ni-Cd AA | 750 | 41 |
| NiMH AA | 1100 | 51 |
| Lithium ion | 1200 | 100 |
| Lead acid | 2000 | 30 |

**Table 2.1 Types of Batteries**

Batteries can be broadly classified into two types based on the electrolytic material used. They are:

1. Wet cell.
2. Dry cell.

## 2.6 WET CELL

A wet cell battery operates by means of a liquid electrolyte solution, while in a dry cell battery the solution is in the form of a paste. A higher number of recharge cycles equals a longer-lasting battery, but this often increases the wet cell's price. The components in a wet cell battery are liquid, meaning they can spill and create noxious fumes. A wet-cell battery is the original type of rechargeable battery. It is commonly found in aviation, electric utilities, energy storage and cellphone towers.

The battery contains a liquid electrolyte such as sulfuric acid, a dangerous corrosive liquid that damages what it comes into contact with.

## 2.7 DRY CELL

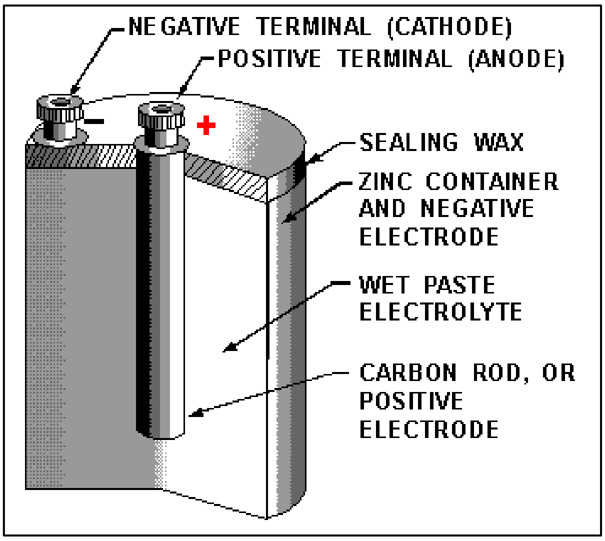


**Fig 2.8 Dry Cell**

A dry cell uses a paste electrolyte, with only enough moisture to allow current to flow. Unlike a wet cell, a dry cell can operate in any orientation without spilling, as it contains no free liquid, making it suitable for portable equipment. By comparison, the first wet cells were typically fragile glass containers with lead rods hanging from the open top and needed careful handling to avoid spillage. Lead-acid battery did not achieve the safety and portability of the dry cell until the development of the gel battery.

A common dry cell is the zinc–carbon battery, sometimes called the dry Leclanché cell, with a nominal voltage of 1.5 volts, the same as the alkaline battery (since both use the same zinc–manganese dioxide combination).

A standard dry cell comprises a zinc anode, usually in the form of a cylindrical pot, with a carbon cathode in the form of a central rod. The electrolyte is ammonium chloride in the form of a paste next to the zinc anode. The remaining space between the electrolyte and carbon cathode is taken up by a second paste consisting of ammonium chloride and manganese dioxide, the latter acting as a depolariser. In some designs, the ammonium chloride is replaced by zinc chloride.

## 2.8 ADVANTAGES

The advantages of dry cell over wet cell are as follows:

### 2.8.1 COMPACT

Manufacturers can make dry cell batteries much smaller and more compact than their wet cell counterparts (which is why the latter are only used for powering large items, such as cars and boats). And, unlike with wet cell technology, we can use dry cells individually as mini-batteries (commonly referred to as button cells), for powering small electronic devices such as watches and calculators.

### 2.8.2 NO LIQUIDS

Dry cells do not contain freely moving liquids. This design feature gives dry cells several advantages over wet cells, including being lighter in weight, easier to transport and easier to contain (or to group together in a series, in order to generate a higher voltage output). Because of their dry design, dry cell batteries are also more durable, particularly in high-vibration situations. This is because the fluid electrolytes in wet cells can slosh around and disrupt proper function, while the electrolytes in dry cells are fixed.

### 2.8.3 SAFE

The chemicals acting as electrolytes in dry cell batteries are all relatively safe, both for human handling and for the environment. These chemicals include manganese oxide, ammonium chloride, powdered carbon and an inactive filler substance (which, oftentimes is starch). In contrast, wet cell batteries utilize a liquid solution (referred to as battery acid) of distilled water and sulfuric acid, the latter of which is an incredibly corrosive substance. If a wet cell battery is damaged and it begins leaking, the battery acid that spills out can cause burns, tissue damage and other severe traumas. Wet cell batteries also release hydrogen, a highly flammable gas, which requires that you pay special attention to keeping them well ventilated. Otherwise, a fire or explosion could result.

### 2.8.4 INEXPENSIVE

Dry cell batteries are less expensive for manufacturers to produce in comparison to their wet cell counterparts.

## 2.9 MICROPROCESSOR

The microprocessor is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. It is an example of sequential digital logic, as it has internal memory.

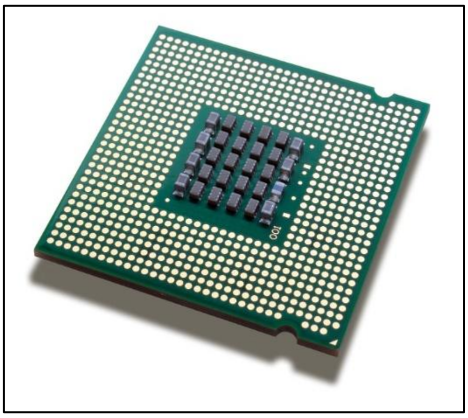

**Fig 2.9 Microprocessor Chip**

Before microprocessors, small computers had been implemented using racks of circuit boards with many medium- and small-scale integrated circuits. Microprocessors integrated this into one or a few large-scale ICs. Continued increases in microprocessor capacity have since rendered other forms of computers almost completely obsolete (see history of computing hardware), with one or more microprocessors used in everything from the smallest embedded systems and handheld devices to the largest mainframes and supercomputers.

## 2.10 MICROCONTROLLER

A microcontroller (sometimes abbreviated µC, µC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of Ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

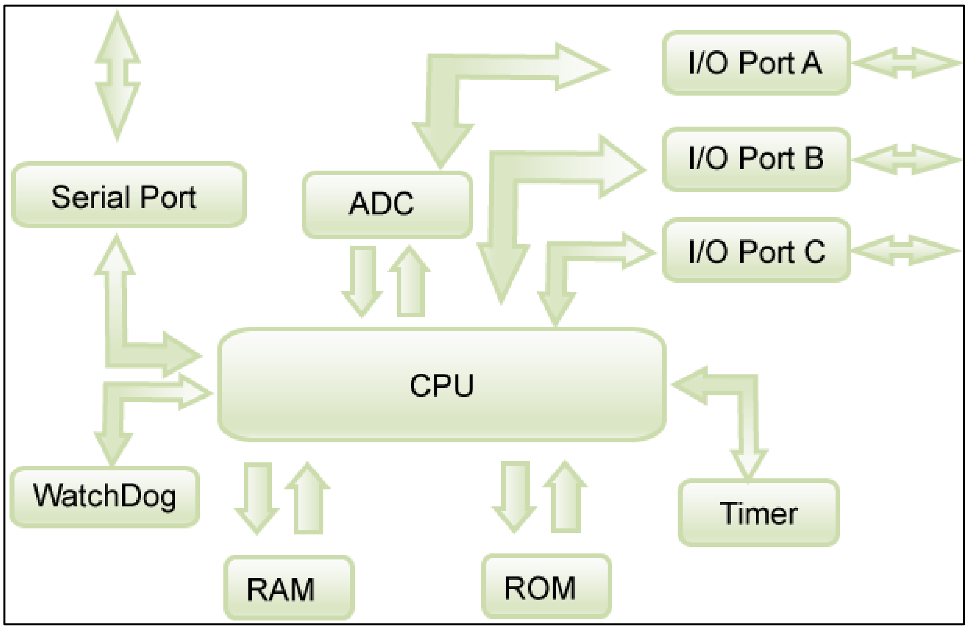


**Fig 2.10 Typical Architecture of Microcontroller**

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.

## 2.11 ARDUINO

Arduino is an open-source electronics platform, based on easy-to-use hardware and software. It's intended for anyone making interactive projects. Arduino basically senses the environment by receiving inputs from sensors and other sources, and affects its surroundings by controlling lights, motors or other actuators. One can command the Arduino according to their will, by dumping an Arduino-based code using Arduino Development Environment (ADE) [2].

## 2.12 ARDUINO UNO R3

One of the Arduino boards includes Arduino UNO R3, which is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

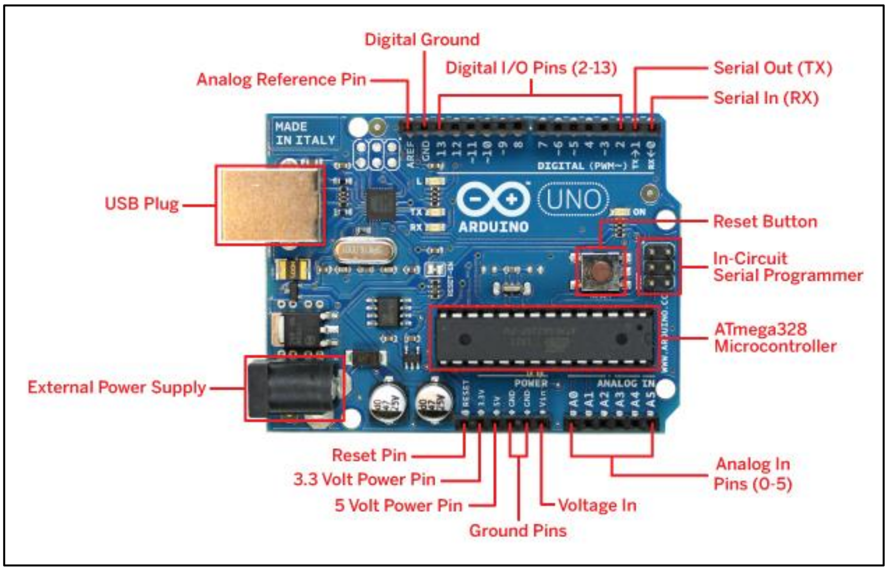


**Fig 2.11 Arduino UNO R3**

It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The specifications are as follows.

| | |
|---|---|
| Microcontroller | ATmega328 |
| Operating Voltage | 5V |
| Input Voltage (recommended) | 7-12V |
| Input Voltage (limit) | 6-20V |
| Digital I/O Pins | 14 |
| PWM Digital I/O Pins | 6 |
| Analog Input Pins | 6 |
| DC Current per I/O Pin | 40 mA |
| DC Current for 3.3V Pin | 50 mA |
| Flash Memory | 32 KB |
| Flash Memory for Bootloader | 0.5 KB |
| SRAM | 2 KB |
| EEPROM | 1 KB |
| Clock Speed | 16 MHz |
| Length | 68.6 mm |
| Width | 53.4 mm |
| Weight | 25 g |

**Table 2.2 Technical Specifications**

## 2.13 BLDC MOTOR

**Brushless DC electric motors** (**BLDC motors**, **BL motors**) also known as **electronically commutated motors** (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor [3].

Brushed DC motors develop a maximum torque when stationary, linearly decreasing as velocity increases. Some limitations of brushed motors can be overcome by brushless motors; they include higher efficiency and a lower susceptibility to mechanical wear. These benefits come at the cost of potentially less rugged, more complex, and more expensive control electronics.

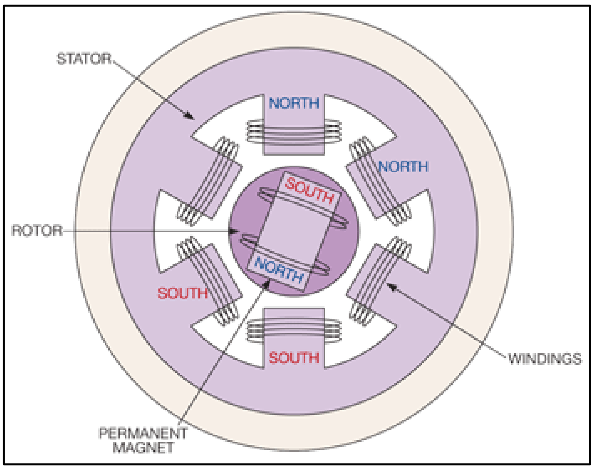


**Fig 2.12 BLDC Motor**

### 2.13.1 ADVANTAGES

Some of the advantages of PMBLDC motors are as follows:

- BLDC motors do not experience "slip" as in the case of IM (Induction motor)
- The BLDC motor uses feedback directly of the rotor angular position so that the input armature current can be switched among the motor phases in exact synchronization with rotor motion.
- A permanent magnet BLDC motor has a wide speed range.
- High efficiency.
- Rugged construction.
- Ease of control.

# CHAPTER 3

# MECHANICAL FABRICATION AND FRAMEWORK

## 3.1 INTRODUCTION

Electric motive power started with a small drifter operated by a miniature electric motor, built by Thomas Davenport in 1835. In 1838, a Scotsman named Robert Davidson built an electric locomotive that attained a speed of four miles per hour (6 km/h). In England a patent was granted in 1840 for the use of rails as conductors of electric current, and similar American patents were issued to Lilley and Colten in 1847.

As the years passed, the world is directing towards implementing modern technologies, for a better, convenient and an efficient lifestyle of the people. Almost everything turned automated and electricity-based.

## 3.2 FABRICATION LAYOUT

The model is fabricated keeping in mind all the features of the vehicle. As mentioned earlier, the model can be both mechanically as well as electrically driven. The mechanical modelling will aid during the situations where there is any kind of emergency situations. This is done using a crank derailleur with a crank arm, which gives the front wheel control (i.e. steering and acceleration) [5].

The model is fabricated using 1”, 1.6 mm square metal pipe for rigidness, stability, endurance and proper balance of the vehicle. The layout of the proposed design is as follows.

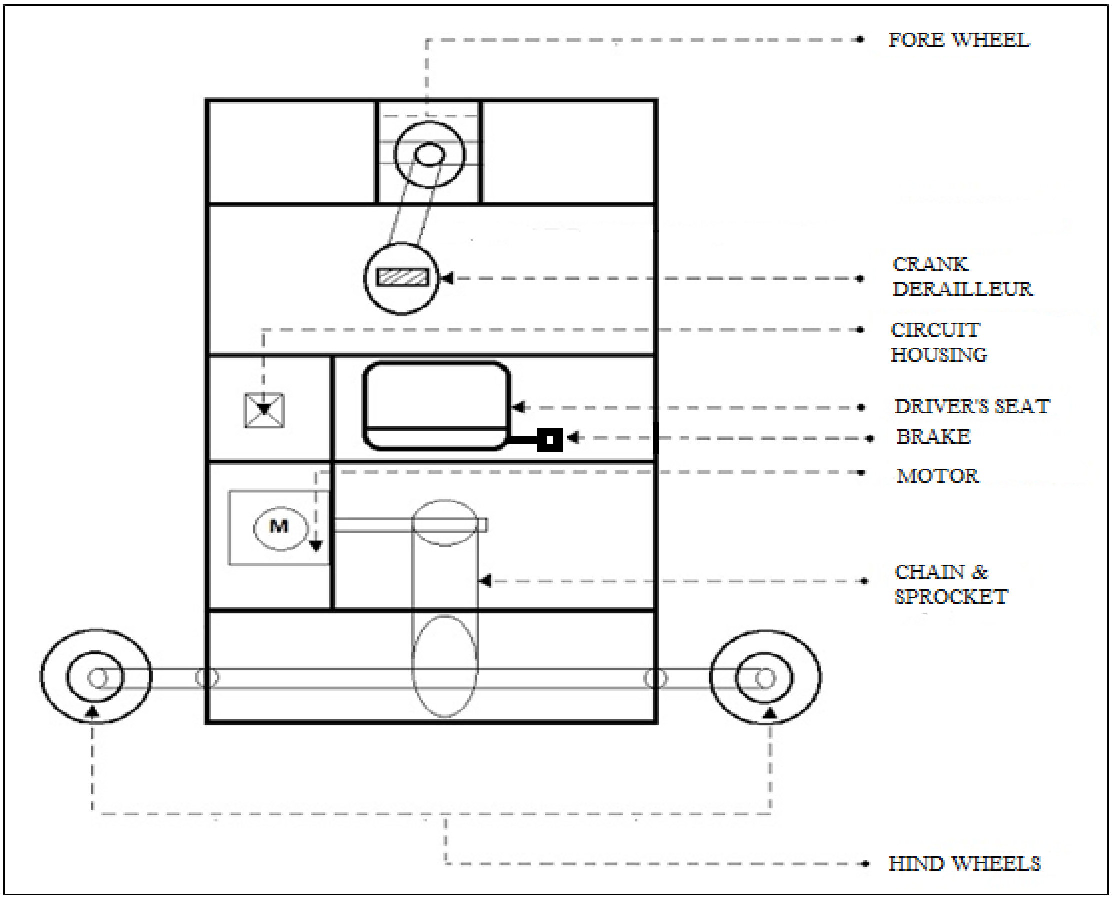


**Fig 3.1 Fabrication Layout**

The design is fitted with 3 wheels (i.e. 1 fore wheel and 2 hind wheels) for a smooth movement. The fore and the hind wheels involve independent movement mechanisms.

### 3.2.1 WHEEL DESIGN

The fore wheel movement involves a crank derailleur with a chain, which can be used as a hand paddle to manually drive the vehicle. A good turning radius is provided for the fore wheel to enable easier and quicker manoeuver.

### 3.2.2 MOTOR HOUSING

The motor is fitted with a freewheel coupling which is in turn coupled with the main hind axle through another freewheel. The hind wheels involve differential gearing mechanism (i.e. it receives one input and provides two outputs), which enables the two hind wheels to revolve independently as well as to get better momentum and speed [4] [6].

### 3.2.3 SHAFT

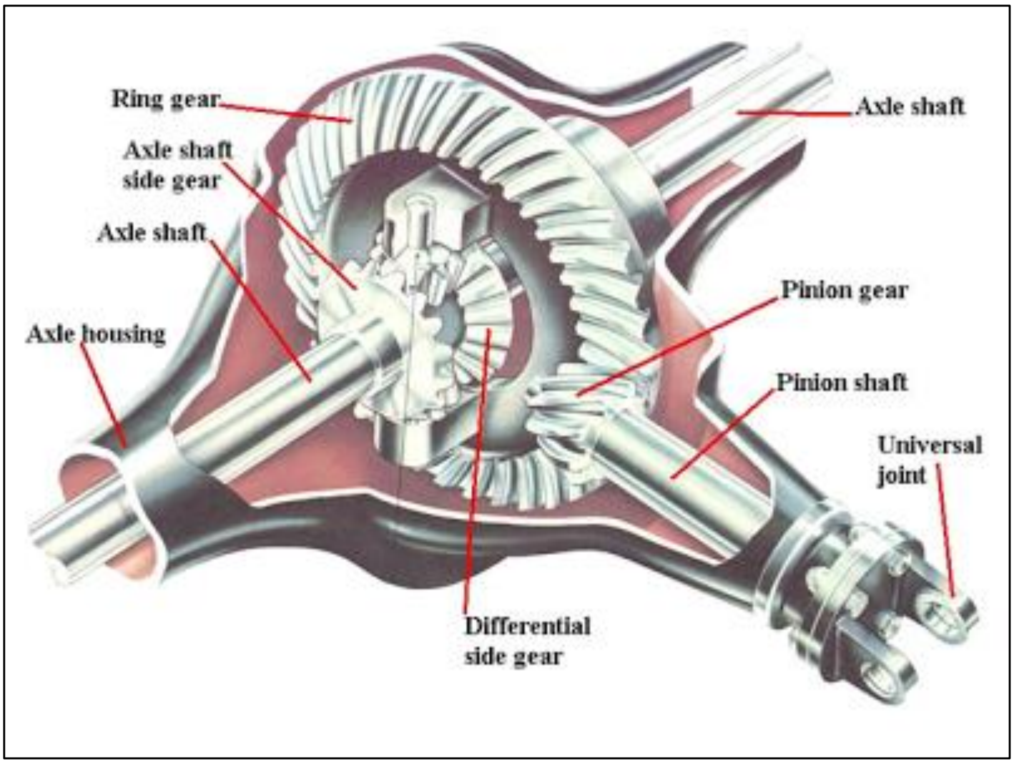


**Fig 3.2 Differential Shaft**

The differential has three jobs:

1. To have good power at the wheels.
2. To act as the final gear reduction in the vehicle.
3. To transmit the power to the wheels while allowing them to rotate at different speeds.

### 3.2.4 SEATING & PANEL POSITIONING

The driver's seat is provided with a manual braking system, which is just under the hand's reach. It enables easy and quick braking of the vehicle.

The solar panel is mounted atop the whole model, which serves as a roof as well. A provision is provided in such a way that the panel can be detached from the model, if preferred to do so.

## 3.3 SPECIFICATIONS

The specifications for the model is mentioned below:

| COMPONENT | DIMENSION | VALUE |
|---|---|---|
| Front wheels | Diameter | 21 in |
| Fork stem | Length<br>Diameter | 12 in<br>1 in |
| Frame | Length<br>Breadth<br>Thickness | 100 cm<br>75 cm<br>1 inch |
| Seat support | Length<br>Breadth<br>Thickness | 30 cm<br>30 cm<br>1 cm |
| Back wheel | Diameter | 14 in |
| Back freewheel | Number of teeth | 24 |
| Front wheel | Diameter | 21 in |
| Front freewheel | Number of teeth | 24 |
| Motor freewheel | Number of teeth | 16 |
| Panel | Length<br>Width | 80 cm<br>60 cm |

**Table 3.1 Specifications of the Model**

## 3.4 BLDC MOTOR

The PMBLDC motor is used to drive the vehicle without any hassles. Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply.

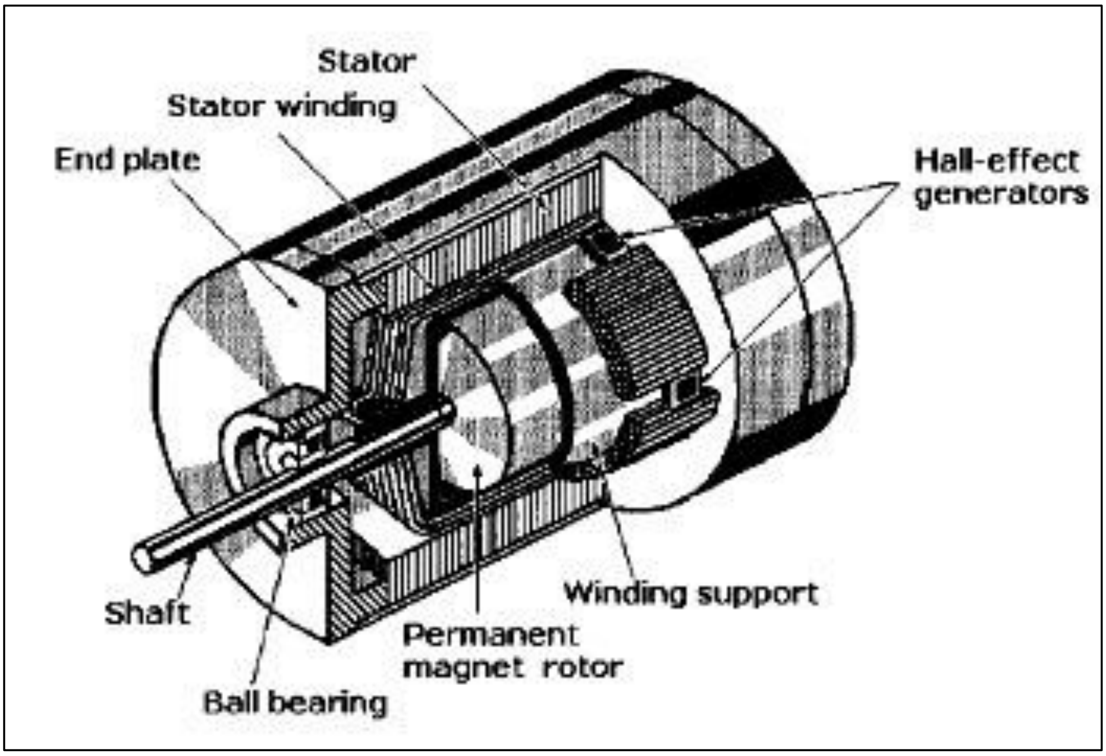


**Fig 3.3 PMBLDC Motor**

It produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).

### 3.5 FREEWHEELING MECHANISM

In mechanical or automotive engineering, a freewheel or overrunning clutch is a device in a transmission that disengages the driveshaft from the driven shaft when the driven shaft rotates faster than the driveshaft.

The condition of a driven shaft spinning faster than its driveshaft exists in most bicycles when the rider holds his or her feet still, no longer pushing the pedals. In a fixed-gear bicycle, if there is no freewheel, then the rear wheel would drive the pedals around. The freewheel, along with gears are incorporated in the model for better manoeuvrability and stability.

### 3.6 GEARING

The gearing mechanism of the whole vehicle (along with the wheel, sprocket, and coupling) is as follows.

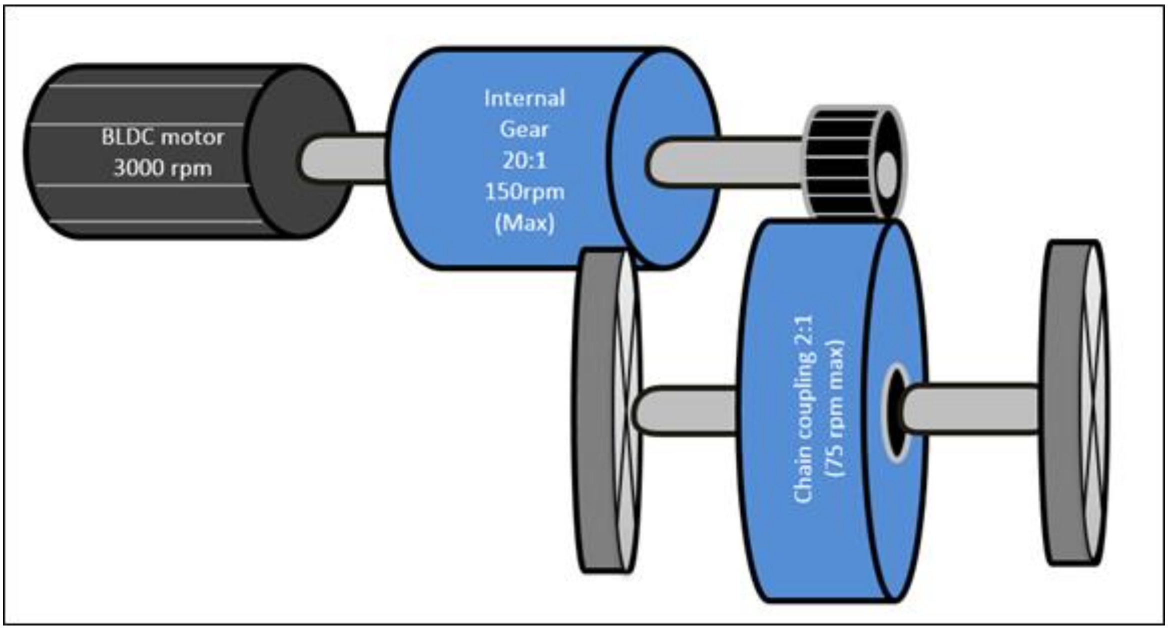


**Fig 3.4 Gearing Mechanism**

# CHAPTER 4

# HARDWARE IMPLEMENTATION

## 4.1 MOTOR

- A 12v 25W BLDC, geared, totally enclosed motor is used.
- It has the torque of 200gf.cm to 8.0kgf.cm.It has the continuous current rating of 0.2 to 2A.
- This motor is driven directly by a 12v battery through a MOSFET drive for better speed control.
- Rotor position is feed backed through the inbuilt Hall Effect sensors to sense the actual speed of the motor by the microcontroller.
- This motor is housed at the rear end of the vehicle and chain coupled to the common rear shaft driving the two rear wheels.
- A 16 Sprocket free wheel is connected to the motor shaft to do this operation.

**Fig 4.1 Motor with Drive Freewheel**

## 4.2 BATTERIES

- Two EXIDE CHLORIDE SAFEPOWER Dry cell batteries with 12v 7Ah rating are used.
- Each can deliver 84VA power.
- On full loaded condition, each of these batteries can drive the motor up to 3hours continuously.
- The batteries will be operated in two modes namely Charging and driving modes.


**Fig 4.2 Lead Acid Battery**

- They will either drive the motor independently or will be charged by the solar panel.
- This switchover is made possible by the use of relays actuated by the microcontroller.
- These batteries are housed below the seat of the driver.
- Short circuit protection is given by help of fuses.
- Battery levels are continuously monitored by the microcontroller.

## 4.3 SOLAR PANEL

- 12v, 75w polycrystalline Solar panel is used.
- This panel is of type Class A.
- Panel is supported by Aluminium frame on four sides.
- It acts as a roofing which provides shade to the driver and better efficiency.
- Panel is attached to the frame with help of wooden strips to absorb vibrations.

**Fig 4.3 Solar Panel with Wooden Support**

**Fig 4.4 Housing of Solar Panel**

- It is positioned at an inclined angle of 15° to avoid dust sedimentations.
- The dimension of the panel is 90 x 65 cm.
- Weight of the panel is concentrated to front end of the vehicle for better balancing.

## 4.4 CONTROLLER

- Controller is chosen in such a manner that is consumes negligible power from the available source.
- Battery Level, Acceleration, Brake and Obstacle Sensor values are given as inputs to the controller.

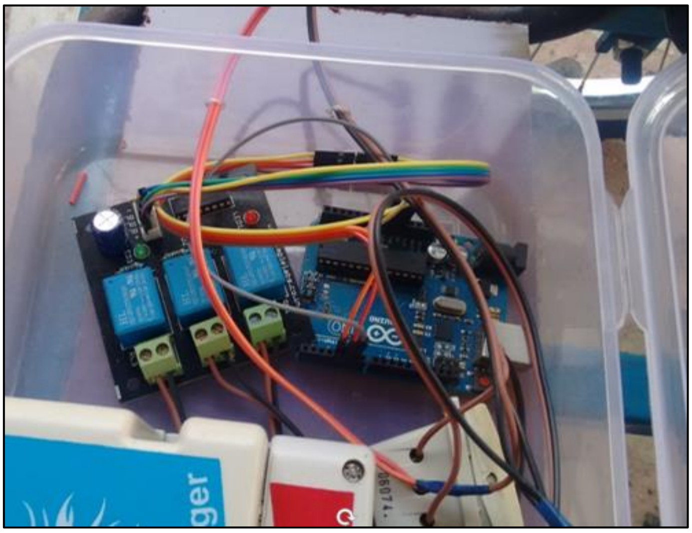

**Fig 4.5 Controller Box with Relay & Microcontroller**

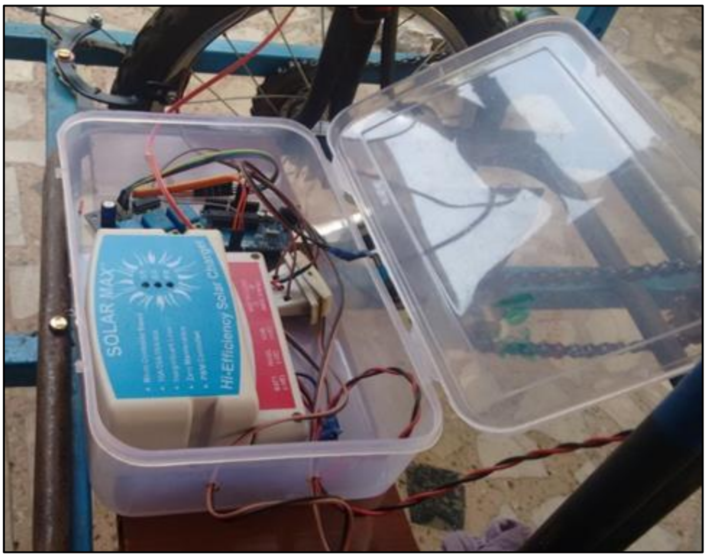


**Fig 4.6 Controller Box housed below the seat**

- Motor drive and relay switches are activated by the controller.
- Battery Levels are monitored throughout the operation with help of resistive network.
- Readings are calibrated with use of high sensitive digital multimeter to know about its charge state.
- 5v relays are used to trip batteries from charge to drive state.

- Battery 1 is connected in normally closed state with the solar panel and in normally open state with the motor.
- Battery 2 is connected in normally open state with the solar panel and in normally closed state with the motor.
- Charge levels are maintained to ensure no power outages.

## 4.5 FRAME

- Frame of the vehicle is built using 1 inch square tubular MS pipe of 1.6mm thickness.
- Appropriate design is made to eliminate useless limbs.
- The limbs are welded carefully to give good strength to the vehicle.
- Support limbs are placed at appropriate positions to enhance frame strength.

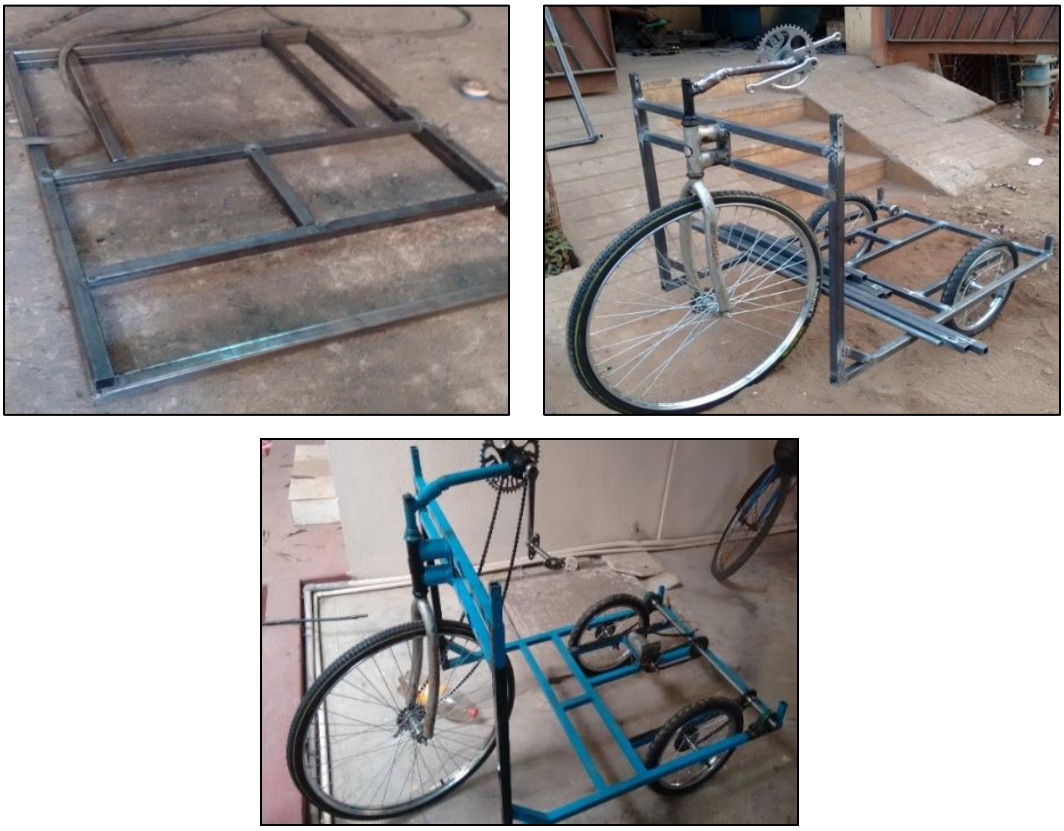

**Fig 4.7 Mechanical Framework**

- Shaft holders, forks, motor slots and panel holders are positioned precisely.
- Roof can be detached during winter seasons and maintenance.
- Chair height and front pedals are positioned precisely based on case study.

## 4.6 SHAFT COUPLING

- Common shaft is placed on the rear most end of the vehicle to deliver the power of the motor to the two rear wheels with minimal loses.
- Motor speed is reduced and torque is improved using different sized freewheels.
- Motor shaft has 16 sprocket free wheel.
- It drives a 24 sprocket freewheel on the common shaft.
- Two 16 sprocket freewheels are placed on both ends of the common shaft.
- 24 sprocket freewheels are attached to the two rear wheels.
- This whole assembly will give a gearing ratio of 2:1.

### 4.6.1 SPEED CALCULATIONS

Diameter of the rear wheel = 14 inches = 0.356m

Circumference of the wheel = 1.118m

Maximum speed of the motor including internal gear = 125 RPM

Distance covered at maximum speed = 125*1.118 = 139 m per minute

= 0.139 km/min

= 8.385 km/hr

So the maximum speed of the vehicle will be approximately 8 km/hr.

## 4.7 MANUAL PEDALLING MECHANISM

- Manual front wheel pedalling mechanism is included considering safety of the individual.
- It is included with the steering hubs.
- A 40 sprocket wheel drives a 21 inch front wheel through a 24 sprocket freewheel.
- Over steering protection is added to avoid steering lock.
- Stability to the vehicle is provided using 17° inclined fork.

**Fig 4.8 Manual Hand Pedal**

## 4.8 BRAKING AND ACCELERATION

- Rear wheel breaking systems is provided to the right hand side rear wheel.
- Brake forks are placed at precise position on the frame.
- Brake and acceleration levers are positioned according to the convenience of the driver.

- Electronic throttle is mimicked using potentiometer.
- Driver will have to steer with the left hand and simultaneously accelerate and brake with the right hand.

**Fig 4.9 Braking**

# CHAPTER 5
# DUAL BATTERY SWITCHOVER TECHNIQUE

The vehicle's charging system is entirely enhanced and optimized to a great extent by implementing **Dual Battery Switchover Technique**.

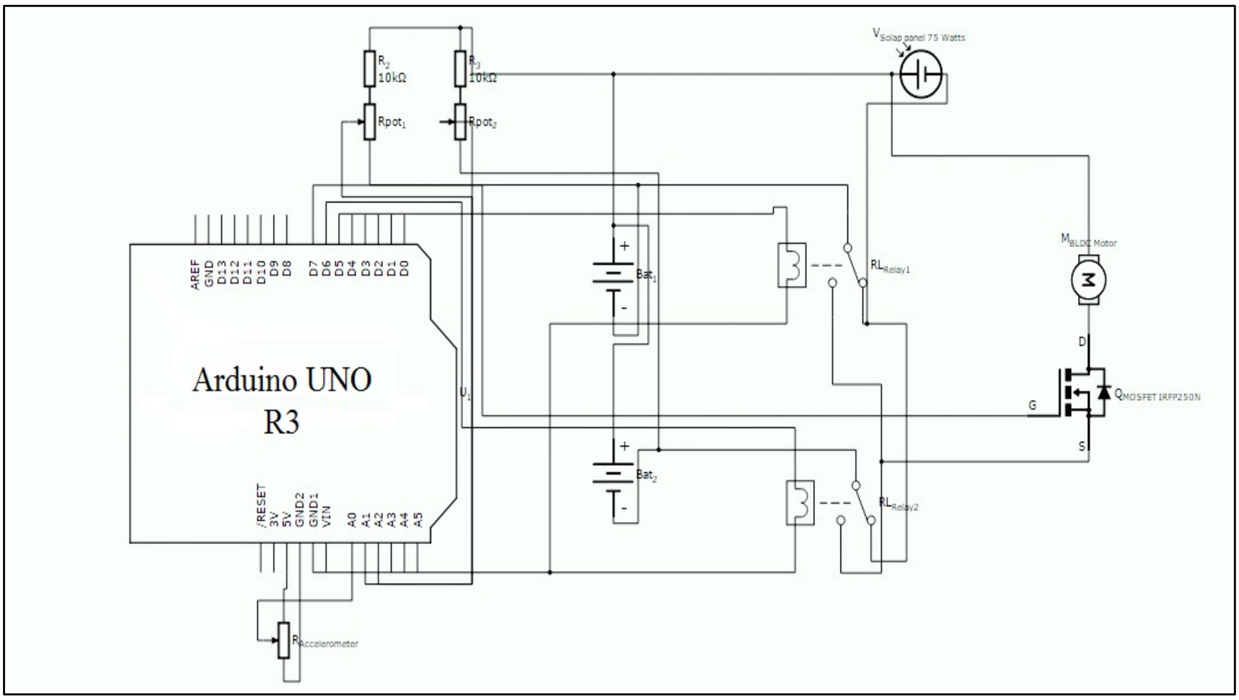


**Fig 5.1 Circuit Diagram**

The above figure shows the overall circuit diagram of the implemented technique. The major components of the circuit are:

| NAME OF THE COMPONENT | QUNANTITY USED |
|---|---|
| ARDUINO UNO R3 MICROCONTROLLER | 1 |
| 10 kΩ POTENTIOMETER | 2 |
| 10 kΩ POT (ACCELEROMETER) | 1 |
| 12v 7Ah LEAD ACID BATTERIES | 2 |

| | |
|---|---|
| 25W PMBLDC MOTOR | 1 |
| 75W SOLAR PANEL | 1 |
| IRF250n MOSFETS | 4 |
| 5v RELAY | 2 |

- **BATTERY LEVEL MONITORING**

The two 10kΩ potentiometers are used for battery level monitoring. The nominal voltage of the fully charged battery was found to be around 14v. But Arduino can only support a range of 0-5v. Thus the function of the potentiometer is to correspondingly reduce it down to this suitable range, so that the voltage levels are readable by the Arduino in order to perform battery level monitoring via relays [7].

- **RELAY OPERATION**

There are 2 relays $R_1$ and $R_2$ correspondingly for batteries $B_1$ and $B_2$. Each of the relay is connected in the configuration shown below. The relay is by default in NC-state, wherein it is connected with the panel. Thus the battery gets charged via panel.

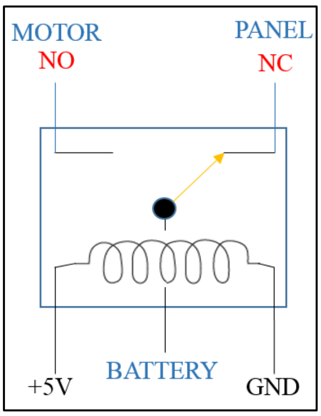


**Fig 5.2 NC/Charging State**

The charge controller makes sure that whenever the battery is fully charged, it stops the supply from the panel to the battery. The role of microcontroller is to switch the relay from NC-state to NO-state (i.e. governs the discharging processes).

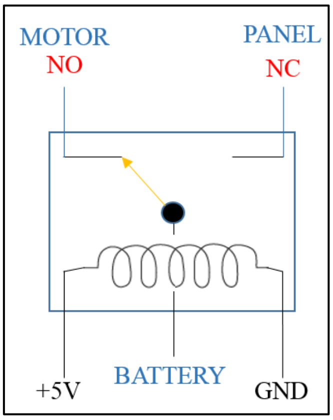


**Fig 5.3 NO/Discharging State**

- **MOSFET DRIVE**

The IRF250n MOSFET can withstand voltages up to 200v. The basic operation of the drive is to govern the motor speed variation with the help of Arduino.

**Fig 5.4 IRF250n**

The Drain-Source Voltage is varied by the Arduino in order to vary the width of the conduction path. Accordingly, conductivity varies. If the width is high, then the conductivity is less and so, only less electrons are allowed to pass through the path to the motor. Thus the motor's speed is lowered. Vice versa is also possible.

- **POTENTIOMETER**

The Accelerometer for the vehicle is mimicked by a POT connected with A0 of the Arduino where 0-5v is equivalent to 0-1023. The potential value can be varied via the POT and this variation is treated as the variation between 0 (throttle minimum position) and 1023 (throttle maximum position).

The other set of 2 POTs which are connected with the 2 batteries are used in battery level monitoring, as mentioned earlier.

- **ARDUINO MICROCONTROLLER**

This is used in battery level monitoring as well as in actuating the relay by establishing contact between battery and motor.

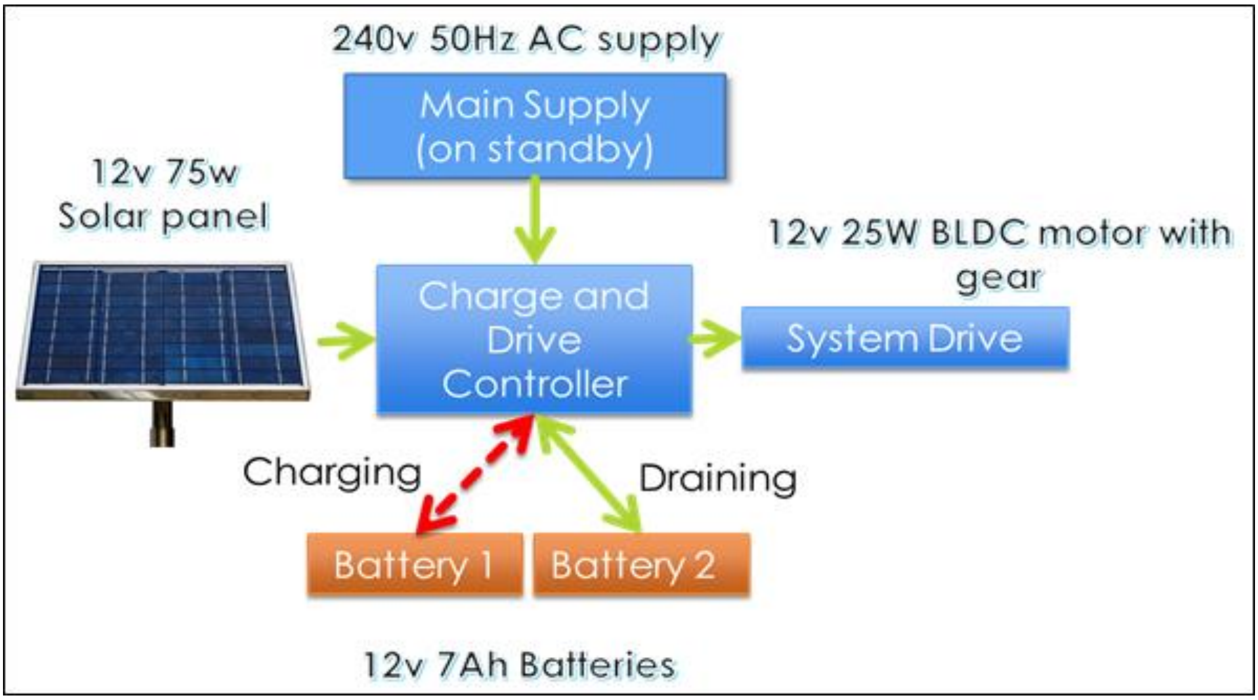


**Fig 5.5 Working Mechanism**

- When the vehicle is at standby state, AC mains can be used to charge the batteries. Both the batteries will be charged simultaneously in such a condition.
- Provisions are made such that typical laptop chargers can also be used to charge the vehicle.
- On running state, Battery 1 will be individually connected to the load (motor) through MOSFET drive. This battery will continue to supply the vehicle till it reaches 30% of its charge state.
- Then, the load will be switched over to the Battery 2 through the same drive, while the Battery 1 gets charged by the solar panel through a charge controller.
- This charge controller is designed in such a way that the Battery 1 gets charged more than 90%, before Battery 2 reaches 30% of its charge state.
- When Battery 2 reaches 30% of its charge state, load will be automatically tripped back to Battery 1.
- This cycle continues till there is sufficient light source incident on the solar panel to charge the batteries.
- In case of insufficient light source, batteries are programmed to get drained one after the other.

## 5.1 ADVANTAGES

### 5.1.1 REDUCED STRESS

Two batteries share the load due to the switching mechanism, which evidently shows that the electrical stress on the battery is reduced significantly.

### 5.1.2 OPERATING TIME PERIOD

If just one battery is used for the entire vehicle, then the vehicle may run out of energy source in quick time.

### 5.1.3 INCREASED LIFETIME

If the whole circuitry and operation solely depends on a single battery, it may cause the battery to reduce its lifetime at a faster rate.

### 5.1.4 SELF-SUSTAINABLE

The whole model is considered self-sustainable since it is driven by an abundantly available renewable source of energy (solar energy).

### 5.1.5 ENHANCED EFFICIENCY

Usage of dual batteries involves less stress on them, which eventually makes sure that the batteries don’t wear out faster or work with less efficiency.

As an added feature a special provision is implemented, such that the vehicle can be charged from household AC supply mains via a normal socket. In terms of mechanical aspects, a provision is made for the user such that they can also manually hand-pedal the vehicle.

It can be done without any stress, since the vehicle is weightless and stable enough to provide maximum manoeuvrability to the user. This feature comes handy in case of insufficient sunlight or power outage.

# CHAPTER 6
# CONCLUSION

A successful prototype model of an Optimized Solar Powered Vehicle for the Physically Handicapped is designed primarily to serve the needy, for a better living. It not only solely aims for the latter, but also to stress the importance of renewable sources of energy and promote its importance amongst the public. Projects of such kinds will definitely instill the society to work towards a cleaner and a greener environment.

The features of the model such as the charging mechanism, gearing, mechanical assembly, dual battery system etc. are elucidated briefly in our thesis, so that it can even serve as a good purpose for upcoming prototypes. The model is ultimately designed with a broader perspective and a positive hope to alleviate the energy crisis in the near future.

**Fig 6.1 Final Model (Front & Side Views)**

| S.NO. | NAME | RATING/VALUE |
|---|---|---|
| 1. | SOLAR PANEL | 75W, $V_{OC}$ = 21.4v |
| 2. | PMBLDC MOTOR | 25W, 12V, 2A |
| 3. | DIMENSIONS<br>a) HEIGHT<br>b) LENGTH<br>c) WIDTH | <br>1.83m<br>1.00m<br>0.75m |
| 4. | DESIGN WEIGHT | 33 Kg |
| 5. | BATTERY | 12V, 7Ah |

**Table 6.1 Design Specifications**

## 6.1 FUTURE SCOPE

The model can serve as an efficient prototype for future models of the same type. The future scope of this design is immense and some of them are as follows.

- Obstacle avoidance sensors such as proximity sensor or ultrasonic sensors can be integrated with the microcontroller.
- Vehicle speed can be increased further by augmenting the number of MOSFETs.
- The whole system can be designed to control and manipulate even with more number of batteries.
- Disc braking can be implemented in terms of mechanical aspect.
- Battery level indicator using LCD display can be implemented.
- Mobile phone (DTMF) based vehicle control can be incorporated.
- For better UI, android interfacing can be implemented.

# APPENDIX

## ARDUINO CODING

```
int r1 = 5;
int r2 = 6;
int sensorValue = 0;
int sensorValue2 = 0;
void setup() {
pinMode(r1,OUTPUT);
pinMode(r2,OUTPUT);
// initialize serial communication at 9600 bits per second:
 Serial.begin(9600);
}
// the loop routine runs over and over again forever:
void loop() {
 // read the input on analog pin 0:
  int Bat1 = analogRead(A0);
  // Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V):
  int Bat2 = analogRead(A1);
  sensorValue = analogRead(A2);
 sensorValue2 = map(sensorValue,0,500,0,249);
  // print out the value you read:
  if(Bat1>Bat2)
  {
   Serial.println(Bat1);
   Serial.println(Bat2);
  Serial.println("Bat1");
  digitalWrite(r1,HIGH);
  digitalWrite(r2,LOW);
```

```
  }
  else
  {
   Serial.println(Bat1);
   Serial.println(Bat2);
  Serial.println("Bat2");
  digitalWrite(r2,HIGH);
  digitalWrite(r1,LOW);
  }
   analogWrite(3,sensorValue2);
 Serial.println(sensorValue2);
 delay(500);
}
```

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