

DESIGN AND DEVELOPMENT OF ADVANCED ELECTRIC VEHICLE PROTOTYPE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of engineering degree in Mechanical Engineering

By

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC I 12B

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BONAFIDE CERTIFICATE

This is to certify that this project report is the confide work of SUDHAKAR .T (REG.NO. 3 8 1 5 0 7 1 0) and TITUS RAJ .K (REG.NO. 3 8 1 5 0 1 2 0) who carried out the project entitled “DESIGN AND DEVOLOPMENT OF ADVANCED ELECTRIC VEHICLE PROTOTYPE” Under our supervision from December 2021 to March 2022

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ABSTRACT

Electric cars (EVs), including pure electric vehicles and plug-in hybrid electric vehicles (PHEV), will be the only mode of transportation on the roads of India by 2040, according to this study (PHEVs). A ceteris paribus model was used to assess current data and trends and project the year of 2040. Results indicated that in 2040, the power consumption of all electric cars would account for 80 percent of the total demand expected for the whole state. Changing the country's automotive fleet might cut CO₂ emissions by 40 million metric tonnes.. Approximately 1.1 million public charging stations must be established to meet this transformation and numerous power plants must be built to supply enough energy for the State's demands, although particular amounts rely on a variety of variables detailed in this research. So we have designed an electric vehicle prototype using lead acid battery .we had also implemented electric steering system for efficient turning of our eV car prototype.

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CHAPTER 1

INTRODUCTION

Motorized vehicles (MV), often known as electric drive vehicles, are powered by one or more electric motors. Vehicles that run on electric power include electric cars, electric trains, electric lorries, electric aeroplanes, and even electric boats, motorcycles, and scooters.

Vehicles equipped with an electric motor may either be used to power the vehicle or to help the driver pedal. An automobile, or a hybrid vehicle, may be powered by a number of engine types and power sources. Early electric cars were designed at a period when electricity was one of the most popular methods of power for motor vehicles, providing a level of comfort and simplicity that couldn't be equaled by gasoline autos of the age. The gas powered motor (ICE) overwhelms the impetus of engine vehicles, while electric power is as yet normal in other vehicle types, like trains and more modest vehicles, everything being equal. Petroleum-based transportation infrastructure is having an adverse environmental impact, and since oil reserves are diminishing, people are becoming more interested in switching to an electric transportation system. Fossil fuel-powered automobiles utilise electricity that is generated from a single source, but electric cars may use a range of sources, including tidal and solar power, wind power, and other renewable forms of energy. At the moment, the car has more than 400 watt-hours of energy stored in various battery, flywheel, and super capacitor systems. Non-renewable fossil fuels are the most common source of energy for vehicles powered by engines that operate on the combustion principle. One of the vital benefits of battery-fueled electric vehicles is their capacity to change over the energy ordinarily squandered during slowing down into power that can be put away in the vehicle's battery. Toyota Prius, the main efficiently manufactured gas electric vehicle, was presented globally in 2003, while Going Green in London appeared the G-Wiz electric vehicle, a quadric cycle that proceeded to turn into the world's top of the line EV.

1.1 ELECRICITY SOURCES

Electricity generation may be accomplished in a variety of methods, some more environmentally friendly than others: Full Electric Vehicles (FEVs) are vehicles equipped with an onboard rechargeable energy storage system (RESS) (FEV). The following are some of the ways in which

power may be stored: kinetic energy storage: flywheels Electric trains, trolley buses, and trolley trucks all have a direct link to the power producing units (See also : overhead lines, third rail and conduit), Solar power, for example: a solar-powered car An electric locomotive powered by a diesel engine. Powered by a fuel cell: automobile Nuclear submarines and aircraft carriers generate their own nuclear power on board. Motorized electric vehicles may also be powered by several sources of energy. To recharge the vehicle's on-board rechargeable energy storage system (RESS) and provide an unlimited highway range, the vehicle should be connected directly to land-based power producing facilities through a continuous direct connection. Plug-in Motorized, with an internal combustion engine and a rechargeable electrical storage device on board. Flywheels, batteries, and electric double-layer capacitors are all examples of on-board electrical storage that may be recharged. It is possible to increase the efficiency of the energy conversion process by eliminating an intermediary mechanical step, hence avoiding superfluous energy transformations. Because of this, it is possible to convert electro-chemical batteries back to their original state, enabling the storage of electrical energy in chemical form. Fuel cells, which are expected to be used in the future, are another method of converting chemical energy into electricity. Nuclear reactors may be used to replace the chemical energy used by diesel-electric engines on very large electric vehicles, such as submarines. In most cases, the nuclear reactor generates heat that powers a steam turbine, which in turn drives a generator that powers the ship's propulsion system.

1.2ENERGY TRANSFORMATION

The word "energy" in physics refers to a system's ability to undergo transformations without respect to the entropy-imposed limits on transformation. The first rule of thermodynamics states that energy is a quantity that cannot be created or destroyed, hence any changes to a system's total energy can only be achieved by adding or withdrawing energy. Special relativity predicts that changes in a system's energy will be accompanied by changes in its mass, and the total mass of a system is a measure of its energy. A system's energy may be shifted to a new state by altering its structure.

Energy may be utilised to do a variety of physical tasks in a variety of states. Energy might be used in normal cycles or apparatus, or it very well may be utilized to help society somehow or another (like Heat, light, or movement). For instance, a gas powered motor turns the Potential compound energy in fuel and oxygen into heat, which is along these lines changed into the drive energy (active energy that moves a vehicle.) Light bulbs and computers may both benefit from the electrical energy

generated by a solar cell's conversion of incident solar radiation into electrical current. For a gadget that changes energy starting with one structure then onto the next, transducers are utilized. Hypothetically, all energy sorts aside from nuclear power might be switched over completely to some other type of energy with a transformation proficiency of 100 percent. Only in isolated systems can such efficiency exist in reality, such as when chemical potential energy is totally transformed into kinetic energies and the reverse. Other forms of energy can be converted to heat with great efficiency as well, although achieving a perfect degree of efficiency would need separated systems as well. Accepting there isn't anything beyond the known universe, the main genuinely disconnected framework would be the actual universe. We currently come up short on information and innovation to confine a segment of the universe. Special cases for wonderful productivity (in any event, for segregated frameworks) emerge when energy has been isolated across a few potential quantum states for an assortment of particles, who are allowed to investigate any state all alone own. Entropy, or the even-out of energy appropriation in such states, requests that future conditions of the framework should be of basically comparative equality in energy dissemination in these circumstances. (It is impossible, when considering the cosmos as a whole, to gather energy into a smaller number of states after it has diffused across it).

As need might arise, the productivity with which nuclear power might be switched over completely to different types of energy is restricted, as nuclear power in harmony at a specific temperature as of now mirrors the greatest evening out of energy between every expected state. The expression "corrupted energy" is infrequently used to depict this sort of energy since it isn't absolutely useable. Hence, the second law of thermodynamics expresses that nuclear power must be switched over completely to different sorts of energy with efficiencies moving toward 100 percent, gave that the entropy (uniformity or turmoil) of the universe is raised by different means, to make up for the reduction in entropy related with the vanishing and content of nuclear power in the universe.

CHAPTER-2

LITERATURE REVIEW

It was Gadh who performed the trials on multiplexed electric vehicle charging employing a network-based management system for smart charging algorithms and multiplexing, as well as cloud/IP networking, to solve the concerns mentioned above with current EV charging methods.

C. Chung, P. Chu and R. Gadh, Designed and realized a smart charging infrastructure with various current controlling and multiplexing capabilities. Besides the hardware and firmware implementation, the EV's response time to the pilot signal change command is also measured.

S. Mal, A. Chattopadhyay, A. Yang and R. Gadh, did A comprehensive system leveraging mobile and RFID technologies, aggregation middleware, and an aggregated charge scheduling algorithm, that effectively schedules charging and V2G operations for cost savings and peak load reduction.

M. Majidpour, C. Qiu, C. Y. Chung, P. Chu, R. Gadh and H. R. Pota, We've evaluated four rather quick Machine Learning methods for predicting the energy usage of EV charging stations. To make a mobile phone app work, the algorithm must be fast enough to fit inside the permitted range. A comprehensive system leveraging mobile and RFID

J. Chynoweth, C. Y. Chung, C. Qiu, P. Chu and R. Gadh, did a Smart Electric Vehicle Charging Infrastructure Overview on software based EV charging system has been built. It has the ability to optimally schedule charging in order to safely maximize the use available grid resources for charging EVs and thereby maximizing the number of EVs that can be connected to the grid while enhancing grid stability.

Y. Wang, H. Nazaripouya, C. C. Chu, R. Gadh and H. R. Pota, presents a droop based automatic load sharing with driver preference using V2G capable EVs in a micro grid. For the first time ever, this research examines a situation where communication is restricted and V2G EVs must adapt active and reactive power sharing based on their own knowledge.

Maggetto, G.; Mierlo, J.V. In Delphi research on electric and hybrid cars until 2020, we have summarised the findings. In addition to providing some useful statistics, the research offers some insight into the opinions of experts on important problems. Several cost and market penetration studies have been conducted with the use of this information.

Rakesh Kumar, Sanjeevikumar Padmanaban, According to a study on the issues facing electric technology, a battery eco-system must be developed to accommodate various enterprises and start-ups working on battery pack and cell production. In order to alleviate concerns about battery life, it is necessary to improve the charging infrastructure. Swapping possibilities should also be considered.

CHAPTER-3

WORKING PRINCIPLE

A motor is powered by a lead-acid battery that is located near the rear wheel of the vehicle. The back wheel is propelled by an electric motor housed within the wheel's hub assembly. Using a DC to DC converter, high voltage is converted to low voltage. Here, electrical energy is transformed into rotational energy, which provides the vehicle forward speed. There is an accelerating throttle on the steering wheel that aids in the vehicle's acceleration with the assistance of the speed controller. Despite its size and weight, the vehicle's acceleration is impressive.

CHAPTER-4

DESCRIPTION OF COMPONENT

4.1 CONTROLLERS

Efficient, smooth and quiet management of electric cars is provided by electric vehicle brushless DC motor controller. Brushless motor controllers in electric cars provide high takeoff currents and rigorously restrict battery current in their output. With a tiny battery, a motor speed controller can offer enough acceleration and hill climbing. In order to reach a 99 percent efficiency rate, BLDC motor speed controllers require high-power MOSFETs and PWM. In most situations, BLDC motor controllers benefit from a powerful microprocessor that provides comprehensive and accurate control. This programmable brushless motor controller also enables users to quickly and simply adjust settings, perform tests, and acquire diagnostic information.

4.2 FEATURES OF CONTROLLERS:

Designed specifically for use with electric vehicles such as scooters. Microprocessor-powered intelligence. Electronic reversing. Simultaneous amendment, super low drop, quick PWM for incredibly high proficiency. 3 engine stages, transport, and power supply checked for voltage. Voltage checking at 12 and 5 volts from the power supply. On all three motor stages. The current control loop In terms of current protection, hardware is superior. Hardware protection against excessive voltage. Support the operation of torque, speed, and a balanced mode. Battery current and motor current may be set to a predetermined limit. However, there is no effect on takeoff performance from the battery current limitation that is in place. An increase in the amount of startup current might result in a faster start-up time. Low electro-magnetic compatibility. Fault code shown on an LED. At adjustable high and low battery voltages, battery protection includes current cutback, warning, and shutdown. Maximum heat dissipation in an aluminium housing for severe environments. Robust high-current connections as well as small-signal connections using tough aircraft connectors. To guard against overheating: reduced current, a warning or shutdown if it becomes too hot. sensors that are adjustable for either 60 or 120 degrees of hall position Support any number of poles for the motors.. Standard electric RPM is 40,000 RPM. Both 70,000 and 100,000 RPM are available as an option.. Electric RPM is the product of mechanical RPM multiplied by the number of motor poles. Using a brake switch to initiate the

regen process. You may control the regen current by using the braking signal (0-5V).

Brake switch regen, throttle release regen, and 0- 5V analogue signal variable regen are all supported. In the event of a high throttle start-up, the operation is disabled. Multiplying the battery's output current by reducing the amount of current drawn from the battery. The use of a 3-wire potentiometer makes installation a simple.

4.3 CURRENT METER OUTPUT

To programme, use a standard desktop or laptop computer. There are no specific instruments required to do this task. A programme for the user is offered. It's a breeze to get started. Customers won't have to pay anything.

4.5 GENERAL SPECIFICATION OF CONTROLLERS

Operating Frequency: 16.6 kHz. It consumes less than half a milliampere (mA). 40mA is the current draw of a 5V sensor. Power supply range for controllers: 18 to 90 volts. PWR, 150 mA, is the current draw from the power supply. Battery voltage range, B+ may be modified. Operating range: 18 V to 60 V. 0-5 Volts Analog Brake and Throttle Input. A 3-wire potentiometer is used to generate a signal ranging from 0 to 5 volts. Infinite Power 0°C to 50°C operating temperature (controller case temperature). Cold to 90°C operating range, with a maximum shutdown temperature of 100°C (controller case temperature). A 30 second peak phase current of 300A was observed. The continuous phase current limit is 150A. It is possible to customise the maximum battery current.

4.6 BATTERY

When it comes to electric cars, the battery is known as a "EVB" (or, more specifically, a "traction battery") (BEVs). Forklifts, electric trucks, riding floor scrubbers, electric motorbikes, standard size electric cars, trucks, and vans, as well as other electric vehicles, all utilize foothold batteries for drive. 12-15 volt rechargeable batteries, such those used in outboard boat engines, often power electric motors. ' Older or more portable types may need a separate charging station, but most vehicles have an on-board power source that may connect into a conventional wall socket. To put it simply, electric car batteries vary regular SLI batteries because they are meant to provide power over a long period of time, not only while the vehicle is running. Rather of SLI, deep cycle batteries

are employed for these applications instead. A high power-to-weight ratio, energy density and weight ratio are some of the characteristics of electric car batteries; smaller and lighter batteries lower vehicle weight and increase performance. Contrasted with fluid energizes, all current battery advances have considerably lower explicit energy; accordingly the greatest all-electric scope of the vehicles. A BEV's battery pack is often the most costly component. The cost of battery production is high, but the benefits of scale reduce the price. Automobile traction batteries are expected to have a market of over \$37 billion by 2020. Liquid fuel is more expensive to create the same quantity of energy than electricity, but electricity is a quarter of the cost.

4.7 LEAD ACID BATTERY

As the most popular and least expensive kind of lead-acid battery, they are typically drained to around 80%. They are willing to pay a premium for quick payments. Batteries that have been flooded need to be checked for electrolyte levels and refilled with fresh water.



FIG 4.1 LEAD ACID BATTERY PACK

Traditional lead-acid battery technology, availability, and cheap cost have made lead-corrosive batteries the most widely recognized sort of battery in electric vehicles (exemption: a few early EVs, for example, the Detroit Electric, utilized a nickel-iron battery.) as shown in fig 4.1 lead acid battery pack, These batteries, similar to all others, have an ecological impact because of their creation, use, removal, or reusing. However, the United States has one of the highest rates of battery recycling in the world at 95%. The life expectancy of deep-cycle lead batteries, which

are used in many cars, is around three years less than that of the car itself. In electric vehicle (EV) applications, lead-acid batteries account for 25–50 percent of the ultimate vehicle mass. Like other batteries, they have an energy density of 30–40 W/kg, which is much lower than petroleum fuels. While it's not as dramatic as it first looks, indeed, even the best batteries will quite often prompt more mass when applied to vehicles with a normal reach, even if the drive-train is lighter. Hydrogen, oxygen, and sulphur are all common byproducts of battery charging and operation, and they are generally safe if appropriately ventilated. Early Critical owners noticed that sulphur odours leaked into the cabin after charging if not properly ventilated. It was with lead-acid batteries that the first EV1 and RAV4EV were powered.

4.8 INTERNAL COMPONENTS

The battery pack plans for electric vehicles (EVs) are refined and shift incredibly relying upon the maker and individual application. Every one of them, nonetheless, utilize a blend of basic mechanical and electrical part frameworks to satisfy the pack's fundamental tasks. It is possible for different battery pack manufacturers to choose from a variety of battery cell chemistry, physical form, and size. Battery packs will always have several individual cells. Series and parallel connections are used to meet the entire voltage and current needs of the pack. All-electric driving EV battery packs may include as much as several hundred cells. The huge heap of cells is by and large separated into more modest stacks known as modules to help with assembling and gathering. A couple of these modules will be bundled together into a singular pack. The cells in each module are welded together to follow through with the electrical course for stream. Other devices, such as cooling systems and temperature sensors, may be included into modules. Typically, modules enable the Battery Management System (BMS) to keep track of the voltage produced by every battery cell in the stack (BMS). Principle intertwine in battery cell stack forestalls overheating of pack under hamper. A "administration fitting" or "administration disengage" might be utilized to isolate the battery stack into two electrically free areas. There is no great potential electrical threat to service professionals when the help plug is taken out and the uncovered primary terminals of the battery are seen and dealt with by them.

Besides, the battery pack has moves or contactors that control the movement of force from the battery pack to the outcome terminals. These two fundamental exchanges, which interface the battery cell stack to the key positive and adverse outcome terminals of the pack, are commonly utilized by and large. For charging the drive framework before to utilize, a pre-charge resistor or a helper buss with

its own control transfers might be remembered for specific battery pack plans. All of these relays are generally open for obvious safety reasons. Various temperature, voltage, and current sensors are also included within the battery pack. The Battery Monitoring Unit (BMU) or Battery Management System assembles information from the pack sensors and actuates the pack transfers (BMS). The battery the executive's framework (BMS) is likewise answerable for speaking with the remainder of the world external the pack.

4.9 CHARGING

BEVs' batteries need to be recharged on a regular basis. The power grid, which BEVs often use to charge (either at home or at a public charging station), is fueled by a scope of homegrown assets, including coal, hydroelectricity, atomic, and the sky is the limit from there. On account of stresses over a dangerous atmospheric deviation, roof photovoltaic sun oriented cell boards, miniature hydropower, and wind turbines may likewise be used at home. Charging time is for the most part restricted by the framework association's ability. Typical private outlets range from 1.5 kilowatts (in the US and other 110 volt countries) to 3 kilowatts (in different nations with 220 volt supply) (in nations with 240 V stock). Numerous European countries utilize a 3 stage framework intertwined at 16-25 amps with a hypothetical limit of 20-30 kW for home utilization. There are limits to how much of this capacity may be utilised and how much can be sustained "en masse" by the distribution network, however. Indeed, even a small, 7 kilowatt-hour (14-28 miles) battery pack would require an hour to charge at this measure of force. This is minuscule in comparison to a typical fuel pump's effective power delivery rate, which is over 5,000 kilowatts.

One hour to charge a BEV was possible at certain stations in 1995. Ford bought a "Positive Charge" fast-charging system from A climate in November 1997 to test its armadas of Ranger EVs, which charged their lead-corrosive batteries in six to fifteen minutes. The equipment was installed in November 1997. When General Motors launched their "Magne Charge" technology in February 1998, it promised a sixty-to-one hundred-mile driving range for NiMH batteries that could be recharged in as little as 10 minutes. Most individuals don't need quick recharging all the time since they have six to eight hours of free time throughout the day or night to do it. Plugging in and unplugging a car just takes a few seconds thanks to the automatic charging. Recharging their BEVs at home is a common preference among BEV owners who dislike having to stop at a gas station. Parking spaces for electric cars equipped with charging stations are available at certain companies.

4.10 CONNECTORS

It is possible to connect the car's battery to the charging source in two ways. Conductive coupling is the earliest kind of direct electrical connection. Mains power may be routed via specially designed high limit links with associations that shield the client from inordinate voltages to a waterproof socket. For plug-in car charging, the current standard is the SAE 1772 conductor connection (IEC 62196 Type 1) in the United States. When it comes to deployment in Europe, the ACEA has decided on the VDE-AR-E 2623-2-2 (IEC 62196 Type 2).

As a second option, inductive charging may be used. When the automobile is in park, the driver uses one extra "paddle ." While the oar is one twisting of a transformer, one more is coordinated inside the vehicle. The battery pack gets power when the oar is embedded, finishing an attractive circuit. When using an inductive charging system, the car's underbelly is connected to one winding, and that winding is then connected to the garage floor. As there are no exposed conductors, electrocution is not a risk with inductive coupling, but ground fault sensors and interlocks may make conductive coupling almost as safe as inductive. It is possible to minimise the overall vehicle weight by using inductive charging. Simultaneously, conductive charging advocate from Ford said that conductive charging was more financially savvy than inductive charging proponent from Toyota at the time in 1998.

4.11 TRAVEL RANGE BEFORE RECHARGING AND TRAILORS

Batteries utilised, topography, weather, and driver performance all affect the range of a BEV. A vehicle's fuel economy is influenced by its weight and kind, just as it is with more conventional cars. The battery chemistry has an impact on the efficiency of electric vehicle changes. Among the numerous battery types, lead-corrosive batteries are the most well-known and least expensive. Generally speaking, these conversions may go anywhere from 30 to 80 kilometres (20 to 50 mi). Up to 130 kilometres (80 miles) are possible on a single charge of lead-acid batteries in production electric vehicles (PEVs). Energy density is better in NiMH batteries and prototype electric vehicles may go up to 200 kilometres (120 miles) on a single charge. Electric vehicles using lithium-ion batteries can go 320–480 kilometres (200–300 miles) on a single charge. Nickel is more costly, whereas lithium is less so. In terms of cost and weight, nickel-zinc batteries beat nickel-cadmium batteries. Batteries, on the other hand, are more expensive but lighter. It's a struggle for every EV

maker to find the right mix of performance and range, battery size and weight, and battery type and price. Regenerative braking may increase range by up to 50% under harsh traffic circumstances, without the vehicle having to come to a full stop. A 10% to 15% increase may be expected in city driving, but only little so on the open road (depending on the topography). In order to increase the range of BEVs, such as buses and trucks, they may also employ genet trailers and pusher trailers, which do not add weight during regular short-range driving. At a route point, old, depleted beset trailers may be swapped out with new, recharged ones. Maintenance expenditures might be postponed to the rental agency if the property is leased. Based on the energy and powertrain of the vehicle, these BEVs may be converted into motorised vehicles, such as trailers.

4.12 LIFESPAN

There are many different types of batteries that may be combined into huge battery packs to meet a variety of needs. Battery service life should be taken into account when estimating long-term ownership costs, since all batteries ultimately wear out and need to be replaced. Their elapsed time is affected by a variety of variables. Battery cycles may be maximised by discharging the battery to its rated depth of discharge (DOD), which is a percentage of the battery's total energy storage capacity. It is typically recommended not to drain deep cycle lead-acid batteries below 20% capacity. Formulations from the more recent era can withstand cycles that are longer.

4.13 SAFETY

International standard ISO 6469 is mostly responsible for addressing battery electric vehicle safety problems. The three sections of this paper are devoted to a variety of topics: The battery, which stores electrical energy on the vehicle. Means and safeguards to ensure the integrity of the system. Electrical safety. In electric and motorised electric vehicle accidents, firefighters and rescue workers are given additional training to cope with the greater voltages and toxins that may be found. There seems to be no evidence that BEVs are pretty much hurtful than gas or diesel inner burning vehicles, which transport combustible fuels, despite the fact that BEV accidents may offer peculiar challenges such as flames and odours arising from fast battery drain.

4.14 FUTURE

The expense and accessibility of batteries with high energy densities, power densities, and long lives are the most critical factors affecting the future of battery electric vehicles, as any remaining parts, like engines, engine regulators, and chargers, are deep rooted and cost-serious with those found in gas powered motors. Longer range and faster recharge times are now possible using batteries with energy densities equivalent to those used in traditional automobiles, such as lithium-ion, lithium-polymer, and zinc air.

4.15 STEERING SYSTEM

The phrase "steering" refers to a system of parts, linkages, and other mechanisms that allows a ship (or boat) or vehicle (or car, motorbike, or VEHICLE) to follow a predetermined path. Rail transit is an exception, since rail tracks and railroad switches (sometimes known as 'points' in British English) supply the steering function.

4.16 BASIC GEOMETRY

Main goal of steering is to keep wheels pointed in desired directions. A complex of links, rods, pivots, and gears is commonly used to accomplish this.. Each wheel has a pivot point in front of it so that the steering is self-centering in the direction of movement. Caster angle is another important element to understand. Ackermann guiding math is much of the time utilized in directing linkages connecting the controlling box and the wheels to represent the way that the inward wheel voyages a more modest sweep in a turn than the external wheel, consequently the level of toe ideal for driving on a straight course isn't appropriate for turns.

4.17 LEAD-ACID WET CELL

The lead-acid cell is the most frequent form of battery when large currents are required. Sulphuric acid (H_2SO_4) is used as the electrolyte in this procedure. The load current to the starting motor, for example, as shown in fig 4.2 lead acid battery, when using battery power to start an automobile's engine. Is typically somewhere in the range of 200 and 400A. Battery cells are many times utilized in a series mix of three to make a 6-volt battery and six to make a 12-volt battery. One cell's ordinary result is 2.1V. You can recharge the lead corrosive battery, which is a type of optional or store cell. In excellent physical condition, the cell may be recharged and discharged numerous times

to recover the output voltage. An automotive battery's usable life may be reduced to 3 to 5 years if it is overcharged and over discharged. This means that the lead-acid kind of secondary cell can accommodate a smaller number of cells than other types of secondary cells.



FIG 4.2 LEAD ACID BATTERY

4.18 SERVO MOTEOR DRIVER MODULE

Using the A4988 is as simple as plugging it into a USB port and turning it on. The highest output voltage is 35 V and the current draw is less than 2 A. If you want to run a bipolar stepper motor at a fraction of a step, you can. The A4988 Stepper Driver Module has the following capabilities: At 35V, the maximum current per phase may reach 2A; the lowest possible operating voltage is 8V. Full step, 12 step, 14 step, 1/8 step, and 1/16 step micro step resolutions are available Protection against reverse voltage: No, 15.5 x 20.5 mm (0.6 x 0.8 inches) two types of protection: Shorted load and Short to ground. Low RDS outputs (ON) Thermal shutdown circuitry. As shown in Fig 4.3 a4988 driver and fig 4.4 circuit diagram.

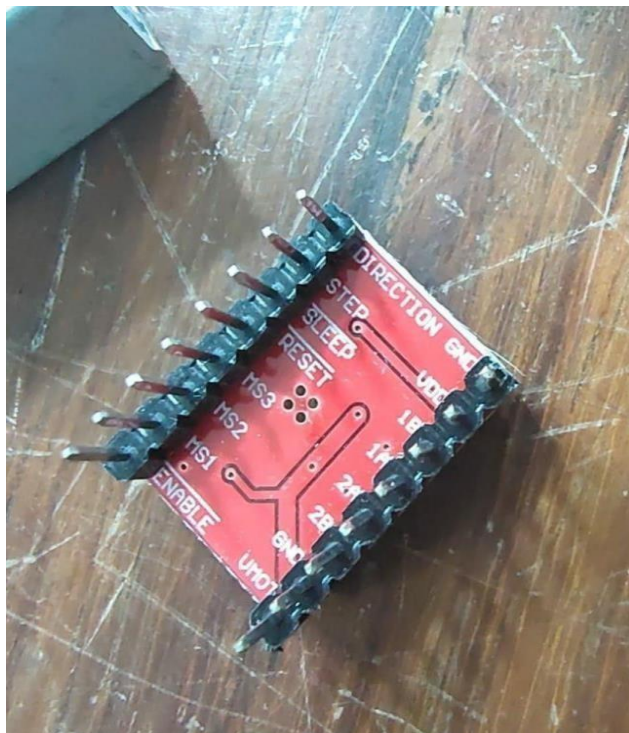


FIG 4.3 A4988 DRIVER.

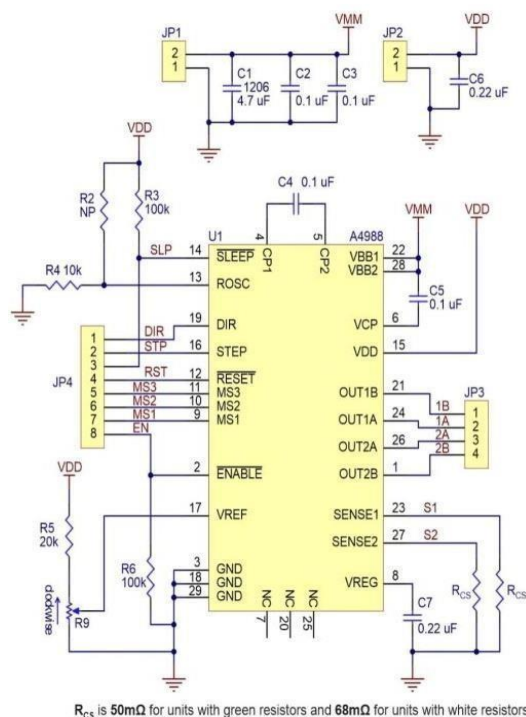


FIG 4.4 CIRCUIT DIAGRAM

SERVO MOTOR-NEMA 17.

The 1.8° step angle of this hybrid bipolar stepping motor in NEMA 17 as shown in fig 4.5 stepper motor- nema. 17 size is impressive (200 steps per revolution). With a torque of 3.7 kg-cm and a current draw of 1.7 A at 2.8 V, each phase may be regarded as autonomous (51 oz. in). Dark and green interface with one curl, while red and blue associate with the other. The engine has four variety coded associations with exposed leads. A bipolar stepper engine driver or one of our Tic Stepper Motor Controllers, or two appropriate H-spans, might be utilized to drive it (one for each curl).

4.18.1 SPECIFICATIONS

Size: without counting the shaft, 42.3 mm square 38 mm (NEMA 17), It weighs 285 g (10 oz.), Five millimeters in "D" Each rotation takes 200 steps. Coils have a current rating of 1.68 A, a voltage value of 2.8 V, and a resistance rating of 1.65. 3.7 kg-cm of holding torque (51 oz.-in), It has an inductance of 32 mH per coil a 30 cm (12 inch) lead Both of the output shaft's ball bearings.



FIG 4.5 STEPPER MOTOR- NEMA. 17

4.19 ARDUINONANO

A breadboard-accommodating microcontroller board planned by Arduino.cc in Italy founded on the ATmega328p (Arduino Nano V3. Atmega168) is the Arduino Nano (Arduino Nano V3.x). As far as usefulness, it's very like the Arduino UNO, despite the fact that it's a lot more modest and lighter in weight. Operating at 5V, it accepts a range of 7 to 12 volt inputs, but the output voltage is just 5V. As shown in fig 4.6 arduinonano, it has a total of twenty-four input/output (I/O) connections: fourteen digital, eight analogue, two reset, and six power. Although they may be used for many other things, the primary purpose of every one of these Digital and Analog Pins is to be utilized as one or the other information or result.



FIG 4.6 ARDUINONANO

4.19.1 SPECIFICATION

The ATmega328 is a microcontroller. To operate at logic level, the input voltage should be between 7 and 12 volts. 6-20 V is the input voltage range. Digitized I/O Pins: 14 (of which 6 provide PWM output) The following pins are used for analogue input: 8DC The amount of current flowing via each input 40 mA is the maximum current that may be applied to this pin. 32 KB (ATmega328) flash memory, of which bootloaders use 2 KB This computer has 2 KB of RAM (ATmega328) 1 KB of EEPROM (ATmega328) 16 MHz is the clock frequency. The dimensions are 0.73" x 1.70"

4.20 HEAT SINK

To regulate the temperature of an electrical or mechanical component by transferring its heat to a fluid medium, such as air or coolant, is the function of a heat sink, as shown in fig 4.7 heat sink, which acts as a passive heat exchanger. We'll be using a tiny sink for this project.



FIG 4.7 HEAT SINK

4.21 BEVEL GEAR

In this project, the steering wheel action is transmitted to the front and back wheels using two bevel gears. By way of a connecting rod, the steering wheel is linked to the vertical bevel gear. One of these horizontal bevel gears will be linked to the front pinion and the other to the rear pinion through this vertical bevel gear's transmission of motion to those two components. It is up to the gear ratio to determine how much input the front pinion receives from the gear and how much motion is sent to the front wheels. Similar to the front pinion, the rear pinion's position is determined by the vehicle's speed, which is regulated by a sensor and a hydraulic pump and telescopic shaft.

4.21.1 ADVANTAGE

The steering wheel and front pinion work together to move the rear pinions to the right when the gear ratio is one to one.

CHAPTER-5

COMPONENTS REQUIRED

Three sets of rack and pinion steering gearbox and column, a 25.4 mm diameter pipe with a 2 mm thick wall. A single steering wheel is connected to two tie rods through two bevel gears. 19-millimeter-diameter steel rod of 1.5-meter-long length, 400-by-400-millimeter square steel sheet of 2mm thickness Arduinos, Heat sink for the smallA4988-driver circuit in a NEMA nano servomotor a Capacitor of 13.100 f

5.1 OPERATION DONE BY THE MACHINES

5.1.1 DRILLING

An object's hole may be widened by pushing a drill, which is a spinning instrument, to turn faster. Holding the drill in place and rotating the job might achieve the same thing in a different machine.

5.1.2 BORING

It is the process of enlarging a hole that has already drilled or cored. Principally, it is an operation of turning a hole that has been drilled previously, with a single point tool.

5.1.5 REAMING

A reamer is a cutting instrument used to enlarge or refine a previously produced hole to its exact proportions. The flutes on the body of the reamer are both cutting teeth and grooves for storing the chips that are removed during the cutting process.

5.1.6 GRINDING

It is the process in which the metal cutting or removal take place comparatively in smallervolume through friction for accuracy. It is also used for sharpening the tool.

5.1.7 TURNING

It is the process which is performed on lathe machine in which remove the excess of material from the work piece to produce crown shaped.

5.1.8 TAPPING

Taping and threading is a process of making threads, are being made on adjustable rod, for fixing steering column.

5.1.9 SHAPING

It is used principally to machine flat or plane surface in horizontal, vertical and angular.

5.1.10 CUTTING

It is used principally to cut the material for making structure other parts.

5.1.11 WELDING

It is the process of joining different material with help of heat and with or without the application of filler material. In the manufacturing of chassis, battery cabin.

5.2 HAND TOOL AND EQUIPMENTSUSED

These are the hand tools required: Single point cutting tool, Drills, Vernier Caliper, Hacksaw, Files, Measuring Tap, Hammers, Punch, Screw Driver, Hand grinding machine, Hand drilling machine, T joint, Oxy-Acetylene gas welding system, Grease and oil, Paint.

CHAPTER 6 COST ESTIMATION

TABLE 6.1 COST ESTIMATION

SR. NO.	COMPONENT NAME	MATERIAL	NO.OF COMPONENT	COST RS.
1.	flat rod (150 * 2.5)	Mild Steel	2	1500
2.	Square Pipe(120 * 1.5)	Mild Steel	2	3000
3.	Cover sheet (75*120)	Mild Steel	1	1500
4.	Batteries(12 volt)	Lead acid	2	4000
5.	Wheels		3	2000
6.	Motorized wheel	Mild steel	1	2000
	Steering Handle			250
7.	Controller accelerator		1	1500
8.	battery System		1	100
9.	Wires		1	200
10.	Balancing Rod	Plastic	1	150
11.	Coupling	Mild steel	1	500
12.	Joints	Cast Iron	4	100
13.	Bearing	Cast Iron	4	1850
14.	Nut & Bolt	Cast Iron	1	300
15.	WELDING	Mild steel	15	2000

CHAPTER-7

PROPERTIES OF MOTORIZED VEHICLE

7.1 ENERGY SOURCES

However, despite the fact that electric cars don't produce any direct emissions, they all depend on electricity supplied by power plants, which in turn cause pollution and trash. Electric cars may be made more or less efficient, polluting, and costly to operate by altering the electrical producing stations that provide the power to the grid. Under a government energy strategy, this would be carried out by an electrical utility on a timeline agreed upon by the utilities and government.. A nation's fleet of fossil-fuel cars may take years to adapt to new efficiency and emission regulations. New productivity and contamination prerequisites require the acquisition of new vehicles, which is many times set off by the deterioration of more seasoned vehicles currently out and about. A couple of nations, like Japan and Singapore, have a retirement age for old cars, which powers all vehicles at present making a course for be updated consistently. At the point when another environmentally friendly power delivering station goes on the web, or a petroleum product power station is decommissioned or modernized, electric vehicles might exploit the natural advantages. Government strategy or monetary conditions that force generators to use seriously dirtying petroleum derivatives and inside vehicles (ICEVs) or other wasteful sources could make the contrary difference. Indeed, even for this situation, electric vehicles are even more effective than a comparable number of petroleum derivative vehicles. Assuming an electrical vehicle proprietor lives in a space with a liberated electrical energy market, the person has the choice of running their vehicle on traditional electrical energy sources or totally on inexhaustible electrical energy sources (probably at an extra expense), which would compel different customers to utilize customary electrical energy.

7.2 EFFICIENCY

Due to the different techniques for charging, the outflows have been estimated in an assortment of ways. There are additional differences in the consumption patterns of plug-in hybrids and plug-in all-electric automobiles.

7.3 ELECTROMAGNETIC RADIATION

However, except for the most severe exposures, no evidence has been found to link electromagnetic radiation from high-performance electrical motors to any human illness or disease in particular. Faraday cages may be used to shelter electric motors, although this adds weight to the vehicle, reducing efficiency, and it is not definitive that all electromagnetic radiation is contained.

7.4 CHARGING (Grid Capacity)

For example, if more people drove electric cars, the demand for power production and transmission would grow and so would emissions as a result. Because electric cars are more efficient over their entire life cycle, they will consume less energy and produce fewer emissions in the long run. In the US, it has been projected that there is presently basically adequate existing power plant and transmission establishment, expecting that most charging will occur around evening time, using the most effective off-peak base load wellsprings of energy. Things are quite different in the United Kingdom. According to CEO Steve Holliday, "penetration up and over" 1 million electric vehicles is a "serious issue" for public network's high-voltage power transmission framework. Urban communities like London might battle to adjust their lattices to connect their cars simultaneously."

7.5 CHARGING STATIONS

Charging an electric car using a standard wall socket or a specialist charging station normally takes hours, although it may be done overnight and frequently provides enough juice for regular day-to-day use. POD Point's network in the UK and Europe allows electric vehicle owners to charge their vehicles while they are at work. This allows trips to be longer and eliminates commuters' fear of running out of battery power. This may be finished by utilizing a typical inductive charging innovation like Evatran's Plugless Power. The simplicity of stopping over the charging station and the decreased cabling and associated hardware are the principle benefits. While long distance driving is less common, "fast charging" is another option that has been suggested. Examples of these are the A environment Charge line (up to 250 kW) and the Norvik MinitCharge line (up to 300 kW). As a charger maker, Ecotality has worked with Nissan on many projects. No OEMs, including Nissan/Renault, have any manufacturing plans for battery replacement, which is a possible option. Exchange calls for a uniformity of standards across various platforms, models, and manufacturers. In

order to do a battery swap, the system needs many more battery packs than usual. While the ongoing form of vanadium redox battery offers an energy thickness practically indistinguishable from lead-destructive, the charge is kept totally in a vanadium-based electrolyte, which can be directed out and re-energized with charged fluid. The vanadium battery structure is also an appropriate decision for moderate energy storing in quick charging stations because of its strong thickness and particularly extensive future. In any case, the system's cost is at this point outrageous. A battery that can give 100 purchasers to 24 hours at 50 kWh a charge.

According to a study by the Department of Energy, 84 percent of current cars can be converted to plug-in Motorized without the need for additional grid infrastructure. Net decreases in ozone depleting substance discharges from transport would be 27%, a 31% decrease in nitrogen oxide outflows, a 2% diminishing in nitrous oxide transmissions, a 3% extension in particulate matter surges, a comparative sulfur dioxide radiation levels, and a nearby complete removal of carbon monoxide and temperamental regular compound outpourings (a 98 percent decrease in carbon monoxide and a 93 percent decrease in eccentric normal combinations). The "solid human-wellbeing impacts" of the toxins would be moved away from the road level.

7.6 BATTERY SWAPPING

There is an alternative method of "refuelling" electric cars. It is possible to change batteries manually in a matter of minutes rather than recharging them from an electrical outlet (battery swapping). A clean electric recharge is typically not possible for batteries with the highest energy density, such as metal-air fuel cells. Some form of metalworking process, such as aluminium smelting or anything like that, is required. For battery swapping, it seems that metal air fuel cells such as those made of silicon or aluminium are strong contenders. Redoing old metal-air power modules with sensibly high productivity might be finished with any wellspring of energy, inexhaustible or non-sustainable. Infrastructure investment will be required. However, the expense of such batteries may be a concern, even if they are constructed with interchangeable anodes and electrolyte.

7.7 OTHER IN-DEVELOPMENT TECHNOLOGIES

Lithium ion batteries, with their near-infinite lifespans and lack of environmental impact, are now being developed using conventional electric twofold layer capacitors with an end goal to match their energy thickness. If high-K electric twofold layer capacitors, like Ester's EESU, can be created, they could increment lithium particle energy thickness many times over. Lithium-

Sulfur batteries provide 250Wh/kg of power. When charged and discharged, sodium-ion batteries have a very large surface area and are expected to provide 400Wh/kg of power. Scientists from a Ukrainian state college guarantee to have delivered tests of super capacitors in view of intercalation strategy with 318 W-h/kg explicit energy, which they express is no less than twice better than ordinary Li-particle batteries.

7.8 SAFETY

First worldwide law on safety of both completely electric and motorised electric cars has been enacted by the United Nations in Geneva (UNECE) in order to guarantee that electric automobiles, for example, mechanized and completely electric vehicles are just about as protected as ignition vehicles. The EU and Japan have previously said that they need to incorporate the new UNECE Regulation into their particular principles for auto innovation.

7.9 ENERGY RESILIENCE

Electricity is a sort of energy that may be derived from a variety of places, including the nation or location in which it was created. Thus, the highest level of energy resilience is achieved.

7.10 ENERGY EFFICIENCY

Internal combustion engine cars have a "tank-to-wheels" efficiency that is around three times greater than that of electric vehicles. Unlike internal combustion engines, which continue to use energy even while idling, it consumes no energy when it is not moving. As long as we're talking about well-to-wheel efficiency, electric cars' emissions are on par with those of a gasoline or diesel car in the vast majority of nations.

7.11COST OF RECHARGE

Recharging the GM Volt will be as cheap as "buying a cup of your favourite coffee," according to the company. In contrast with gas at \$3.60 a gallon, driving the Volt on power ought to cost something like 2 pennies for each mile, contrasted with 12 pennies for every mile on fuel. An excursion from Los Angeles to New York would cost \$56 on power and \$336 whenever finished with fuel. Paying 60 cents a gallon of petrol would be the equivalent of this.

7.12 STABILIZATION OF THE GRID

Battery-fueled vehicles might have the option to adjust the interest for energy by conveying power into the lattice from their batteries during intense usage hours, (for example, midafternoon cooling use) while charging around evening time, when there is unused delivering limit. This vehicle-to-network (V2G) interface can possibly kill the prerequisite for new power plants. As sustainable power sources like breeze turbines and photovoltaic sunlight based chargers (PV) become progressively ordinary, our present electrical framework might be extended as far as possible. EV batteries might be charged or drained at a different rate to overcome this problem. Some theories envision battery swap and charging facilities, similar to the ones that exist now at gas stations and elsewhere. Capacity and charging possibilities are plainly required, which may be used to alter the charge rate and result power during seasons of lack, much how diesel generators are utilized to balance out specific public matrix frameworks.

7.13 RANGE

Batteries have a lower energy density than gasoline, which means that many electric designs have a restricted range. Recharging an electric car takes longer than refilling a gas tank, which is comparatively rapid. This is made more difficult by the lack of public charging facilities currently available. Consumers' worry over the range of electric vehicles is dubbed "range anxiety."

7.14 HEATING OF ELECTRIC VEHICLES

Vehicles must be heated and defrosted in colder areas, which consumes a large amount of energy to do so. On account of gas-powered motors, this hotness is now present in view of the ignition cycle from the waste hotness produced by the motor cooling framework. On account of battery electric vehicles, this will require a lot of battery power. There is some hotness that might be caught from the motor(s) and battery, but since to their expanded proficiency, there is less waste hotness available than in an ignition motor. Batteries may be pre-heated or cooled in battery electric cars that are linked to the grid, so they don't require much or any battery power for short excursions.

More up to date plans stress the utilization of super-protected lodges that can warm the vehicle with the body hotness of its inhabitants. Be that as it may, in colder locales, a driver can supply around 100 W of warming power, which is deficient . An AC system that can cool and heat the EV's cabin at the same time seems to be the most feasible and promising solution to EV thermal

management. Ricardo Arold (2008) developed a novel approach based on the premise of employing a reversible AC-framework to join the warm administration of the EV battery with the warm administration of the lodge. It's finished by adding a third hotness exchanger, thermally connected to the battery center, to the commonplace hotness siphon/cooling framework used in earlier EV vehicles like the GM EV1 and Toyota RAV4 EV. One of the principle benefits of the thought is that it might assist with expanding the battery's duration cycle, as well as further develop the general energy effectiveness of the vehicle.

7.15 ELECTRIC PUBLIC TRANSIT EFFICIENCY

Taking public transportation (train, trolleybus, or tram) instead of driving has the potential to save a significant amount of energy each individual mile. People, according to studies, prefer trams over other modes of public transportation because they are quieter, more comfortable, and seen as denoting a better social position. As a result, electric trams provide the potential to reduce city-wide use of liquid fossil fuels. With elastic wheel vehicles requiring 2/3 additional energy than the comparing cable car and running on power as opposed to petroleum products, cable cars might be the most energy-proficient method of public transportation. When it comes to net present value, Blackpool is cheaper than combustion buses, which only last 15 years on average.

CHAPTER-8

ADVANTAGES AND DISADVANTAGES OF MOTORIZED VEHICLES

8.1 ENVIRONMENTAL

Regardless of whether the energy expected to charge electric vehicles starts from a CO₂ transmitting source, for example, a coal or gas fuelled controlled plant, the net CO₂ age from an electric vehicle is for the most part one half to 33% of that from a comparable ignition vehicle. Nearly no air pollutants are released from the location where electric cars are operating while they are powered up. To worsen retrofitting countless vehicles, it is frequently easier to introduce contamination control frameworks into brought together power plants as opposed to retrofitting a huge armada. Whether or not the vehicle is very still or moving, electric vehicles generally produce less commotion contamination than vehicles fueled by gas powered motors. There is no tailpipe CO₂ or poisons like NO_x, NMHC, CO and PM at the mark of utilization for electric vehicles.

Unlike internal combustion engines, which need oxygen, electric motors do not. This is beneficial for submarines. Despite the fact that electric and powered vehicles have decreased carbon emissions from their tailpipes, the energy they require may be generated in ways that are harmful to the environment. It is not carbon neutral to drive an electric vehicle in America since the bulk of power is generated from fossil fuels (coal and natural gas). When it comes to reducing energy consumption and pollution, electric and motorised vehicles can help, as they produce zero pollution locally and may eventually only use renewable resources. However, changing one's lifestyle to include more walking, biking, taking public transportation, or telecommuting would have the lowest negative environmental impact. Governments may engage in research and development of electric cars with the goal of lowering the environmental effect when they may instead construct pedestrian-friendly cities or electric mass transportation.

8.2 FUTURE ASPECTS

Survey respondents in the United States prepared to spend an additional \$4,000 for a plug-in electric vehicle jumped from 17 percent in 2005 to 26 percent in 2006. The chairman of the Center for Automotive Research at the Gelsenkirchen University of Applied Sciences in Germany, Ferdinand Dudenhoeffer, has predicted that "by 2025, all passengers old in Europe will be electric or powered". Tesla Motors, Commuter Cars, and Miles Electric Cars are just a few of the start-ups that plan to make electric vehicles readily accessible to the general public in 2008.

There is a tremendous advancement in the field of battery and energy storage technologies. About 80 percent of American people travel at least 50 miles a day in their cars, which is within the current range of electric vehicles. Battery swapping, quick charging stations for electric cars, better energy density batteries, flow batteries, and Plug-in Motorized Electric Vehicles (PMEVs) all have the potential to extend the range of these vehicles. A lithium-ion battery-powered plug-in hybrid vehicle was first mooted by General Motors in 2006. The Chevrolet Volt was formerly referred to as the Car. North American International Auto Show (NAIAS) was where the basic concept was originally shown in January 2007. General Motors expects this electric vehicle to be available to the public in the second half of 2010. A 40-mile (64 km) range is planned for the vehicle. Battery limit dips under 30% and a small gas powered motor is initiated to charge the battery while driving. This, basically, works on the vehicle's reach, empowering it to be driven until it very well may be totally charged by connecting it to a traditional AC power source. The Nissan Leaf was sent off in Japan and the United States in December 2010.

One of Nissan's most famous electric vehicles is the Nissan Leaf, a five-entryway, fair size hatchback model. With an expected scope of 117 kilometers (73 miles), and an energy use of 765 kJ/km, not set in stone by the US Environmental Protection Agency (34 kWh per 100 miles). While the Nissan Leaf has been respected with a few awards for its harmless to the ecosystem plan, it has additionally been hailed as EPA's most effective ensured vehicle for all fills ever. When Shai Agassi founded Project Better Place on October 29, 2007, the goal was to develop enormous scale Electric Recharge Grids to facilitate the worldwide adoption of electric cars (including plug-in Motorized). Renault-Nissan signed a memorandum of understanding with PBP on January 21 to supply the battery recharging and swapping infrastructure, and PBP would mass-produce the cars.

8.3 IMPROVED LONG TERM ENERGY STORAGE AND NONO BATTERY

There have been various advances that might move electric vehicles outside of their present areas of use, such as scooters, golf cars, neighbourhood vehicles, industrial operative yards, and interior operation. They could also. When it comes to electric vehicles that can go long distances on one charge, the consumer electronics sector is a major factor in the development of lithium-based battery technology . Lithium batteries have been made safe, can be re-energized in minutes instead of hours, and presently outlive the typical auto. The expense of delivering these lighter, higher-limit lithium batteries is lessening as the innovation improves and fabricating amounts develop. It's possible that Lithium-air batteries might outperform other kinds of batteries in terms of range, which is why they're now being researched.

8.4 INTRODUCTION OF BATTERY MANAGEMENT AND INTERMEDIAT STORAGE

The use of ultra-capacitors to store short-term but high-volume power needs as well as energy from regenerative braking is another way to enhance the system. In addition to the introduction of novel cell types, an intelligent cell management system corrected both of these weaknesses. In addition to keeping tabs on the health of the cells, the management of cells necessitates the establishment of backup cells (one more cell than needed). It is feasible to regulate one cell while the others are in use thanks to smart switched wiring.

8.5 FASTER BATTERY RECHARGING

Lithium ion batteries were said to be 100 times quicker to recharge when the material in normal batteries was soaked in a specific solution. However, this test was carried out using a battery with a very low capacity. Recharging a battery with a larger capacity is 40 times quicker. MIT's Youngwood Kang and Gerrard Cedar were the authors of the study. The remedy is expected to be on sale in 2011, according to the experts. Adding an extra oscillating electric field may speed up battery charging even more.. Ibrahim from the university came up with this idea. Epsom is a company that specialises in charging electric automobiles at a quicker rate.

CHAPTER-9

ENVIRONMENTAL IMPACT OF MOTORIZED VEHICLE

Motorized automobiles use less petroleum, but the environmental harm caused by the battery of the vehicle is still a concern. Nickel metal hydride and lithium ion batteries now account for the vast majority of motorised vehicle batteries, and both are considered more ecologically benign than lead-based batteries, which formerly accounted for the vast majority of vehicle batteries. Batteries come in a wide variety of shapes and sizes. It's clear that some people are significantly more poisonous than others. Nickel metal hydride batteries, which are now used in Motorized, are much less harmful to the environment than lead acid or nickel cadmium batteries. Nickel-based batteries are well-documented carcinogens that have also been demonstrated to have a number of developmental ramifications in laboratory animals. The Lithium-ion battery has drawn interest because of its potential for usage in electric cars. Hitachi is a pioneer in the field of innovation.

There is a developing requirement for Lithium-particle batteries as a choice to nickel-metal hydride batteries, which have been utilized in the mechanized area up to this point. Further developed charge effectiveness without memory impact is only one of the natural advantages given by lithium-particle batteries, notwithstanding their more modest size and lighter weight. There will be an ascent in the viable utilization of mechanized, electric, and energy component vehicles in a climate where engine vehicle principles, including decreased fumes discharges and further developed eco-friendliness, are far and wide. The lithium-particle batteries have the best energy thickness of any battery-powered battery and can produce a voltage multiple times that of a nickel-metal hydride battery cell while at the same time putting away critical measures of force. Worked on yield (expanded vehicle power), higher proficiency (keeping away from pointless utilization of energy), and extraordinary strength, contrasted with the battery duration being about equivalent to the vehicle's life, are generally benefits of utilizing batteries. Because of the lower weight and superior fuel economy that lithium-ion batteries provide compared to gasoline-powered cars, as well as the resulting decrease in CO₂ emissions, this technology aids in the fight against global warming. There are a variety of uses for Hitachi's lithium-ion batteries, from automobiles to buses to commercial vehicles and even trains. More and more countries throughout the world are now offering electric automobiles that can be recharged using the home's primary power source. It costs around one-ninth of the cost of filling a gasoline-powered car when these vehicles are charged overnight, which is less expensive than charging the vehicle during the day in Japan.

9.1 MOTORIZED VEHICLE EMISSIONS

Emission levels from today's vehicles are near to or even lower than those mandated by the Environmental Protection Agency. A typical passenger vehicle's acceptable carbon dioxide emissions should be equivalent to 5.5 tonnes. The Honda Civic, Honda Insight, and Toyota Prius pushed the bar even higher by emitting 4.1, 3.5, and 3.5 tonnes of carbon dioxide emissions, respectively. Up to 90 percent of smog-forming pollutants and half of carbon dioxide emissions may be reduced by the use of motorised vehicles.

9.2PRESENT SCENERIO IN INDIA

The Indian REVA has been the sole Electric Vehicle on the market for some years now. It is made in Bangalore, India by REVA Electric Car Company Private Ltd. (RECC), a joint venture between the Maini Group India and AEV LLC, California, USA, which was created in 1994. When the first REVA automobile was released in June 2001, they had spent seven years developing it.

The REVAI is the most recent version of the REVA, which was originally designed for the Indian market but is now available in several European countries, including the United Kingdom (via Green under the name G-Wiz), Cyprus and Greece (via REVA Phaedra Electricity Mobility Ltd.), Belgium (via Green Mobil), Norway (via Ole Chr. Bye AS), Iceland (via Perlukafarinn EHF), Spain (via Movement), and Germany (via Electro PKW). The REVA is also An export licence is required for it to be used in the US as a Neighborhood Electric Vehicle (NEV). Electric vehicle manufacturer Bovina Cars India was given property in Ramie, Tamil Nadu, by the state government in July 2010. By the end of 2011, the facility is expected to be operating. In addition to Bangalore-based Reva, which is presently the sole EV manufacturer in India, electric automobiles manufactured in India include: By 2010, Mahindra & Mahindra will have a four-seater model. Clockmaker Ajanta Group has plans for a low-cost electric vehicle, Tara is a low-cost EV less expensive than a Tata Nano, and Hero is an electric automobile that will be released in 2013. Low-cost automobiles are being discussed by Ajanta, Tara, and Tata. CONCLUSION.

9.3 COMPARED OF 4WS SYSTEM WITH 2WS CONVENTIONAL SYSTEM

On the corners, the car is more efficient and steady. Enhanced responsiveness and accuracy of the steering. Stability on a straight path at high speeds. The ability to change lanes quickly, easily, and safely has significantly improved. Tighter space mobility at low speed with a smaller turning radius. Relative Wheel Angles and their Management. The likelihood of running into a roadblock is significantly decreased. And a detailed comparison chart is shown in Fig 9.1 comparison of 4ws system with 2ws ev.

Private vs Commercial Cars

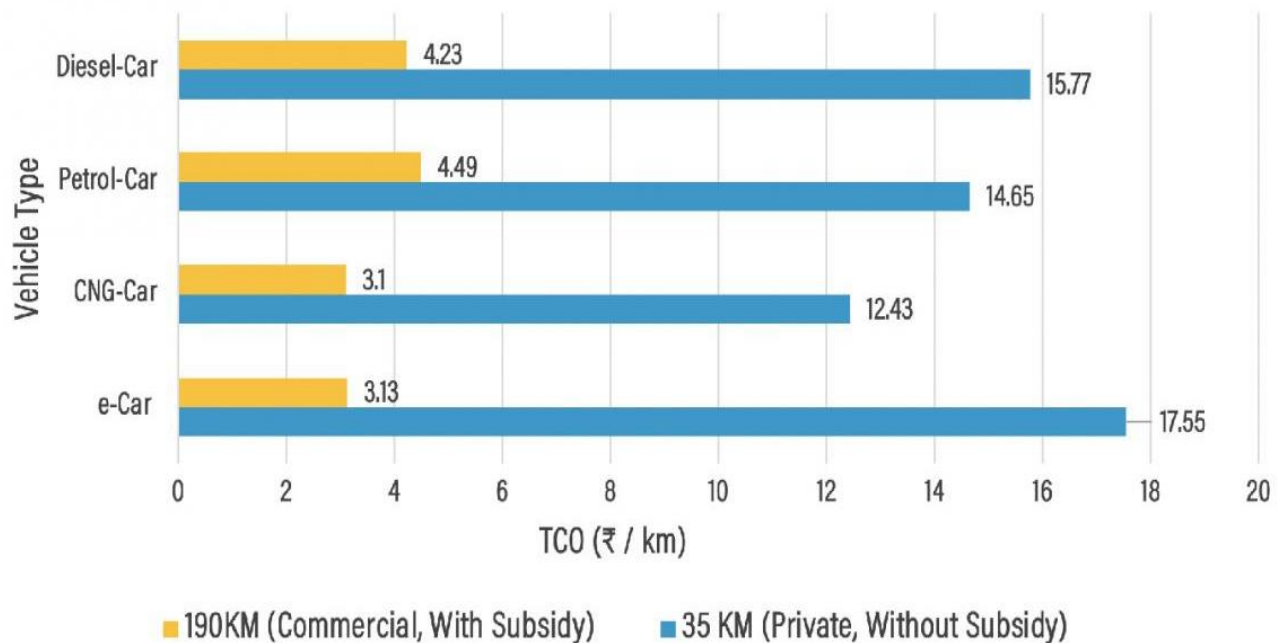


FIG 9.1 COMPARISON OF 4WS SYSTEM WITH 2WS EV

CHAPTER 10

RESULT & DISCESSION

In terms of mechanics, electric motors are really simple. Over the complete range of speeds and power output, electric motors often approach 90% energy conversion efficiency and may be accurately regulated. With regenerative brake systems, they may also be used to convert movement energy into stored power. As a result of this, a trip's overall energy consumption may be reduced, as well as a vehicle's braking system wear. When driving in cities with many stops and starts, regenerative braking comes in handy. Like internal combustion engines, they can be precisely regulated and generate tremendous torque from rest without the need for several gears. Gearboxes and converters are no longer required. Electric cars are quieter and smoother to operate than internal combustion engines, thus they produce less noise and vibration.

Excess solar energy is stored in batteries in systems that are separated from the main grid. Solar-powered irrigation pumps and water storage tanks are the only exceptions to this rule. This is especially true of devices with a power output of under a kilowatt. The only storage option that is both technically feasible and economically viable is the use of batteries. As a result in fig 10.2 output of the project. The substantial initial investment in the photovoltaic system and batteries. The whole system has to be optimized in terms of energy availability and local demand patterns. Storage of solar power needs a battery with a certain mix of attributes in order to be economically attractive: low cost, long life, high reliability, high overall efficiency, low discharge, little maintenance, amp hour efficiency and watt hour efficiency. The solar panel's energy is stored in a lead acid battery for use in street lighting, and the lead acid cells are detailed in fig 10.1 design of advanced electric vehicle prototype in auto cad in detail below.

10.1 DESIGN OF ADVANCED ELECTRIC VEHICLE PROTOTYPE IN AUTOCAD

DESIGNE AND FABRICATION ADVANCED EV CAR PROTOTYPE

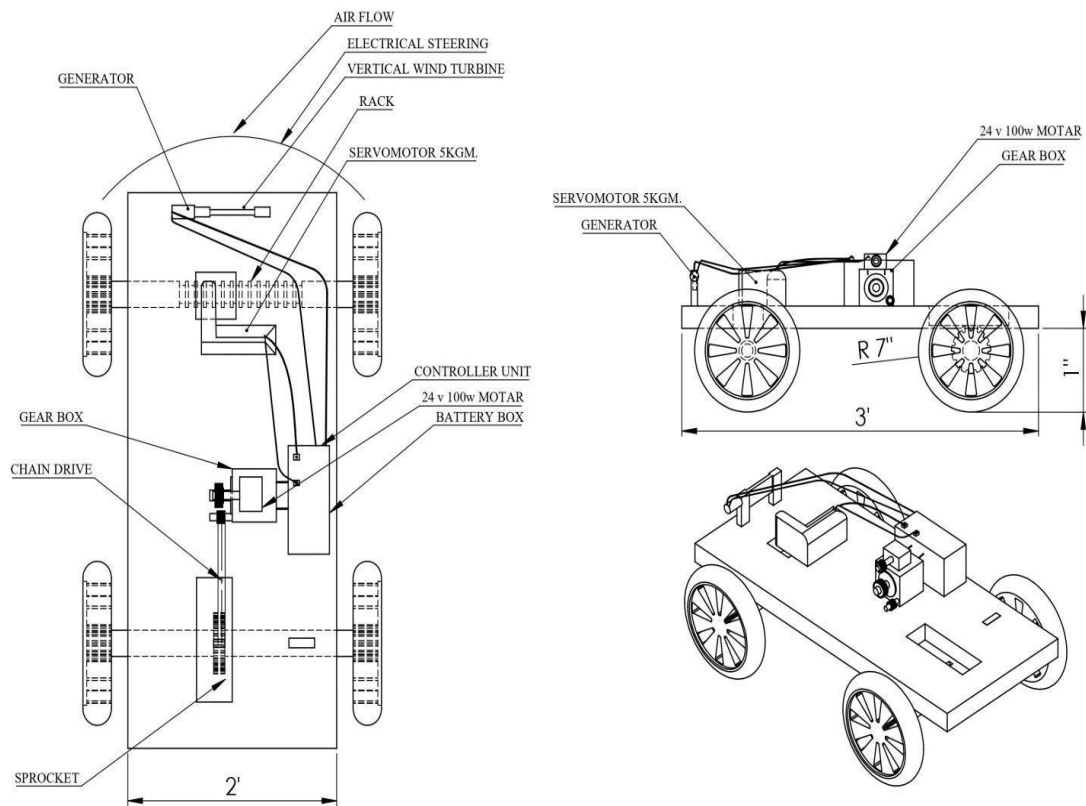


FIG 10.1 DESIGN OF EV IN AUTO CAD

10.2 OUTPUT OF THE PROJECT

According to our auto cad design, the output of our project have came very well. We did some trail runs. The vehicle movement increases gradually after pickup. Servo motor produces the power to the vehicle continuously which helps in maintain the speed. When testing the battery, lead acid battery produces the power roughly around 10 hours and Stepper motor works perfectly that the steering system is turning as calculated. Even the control unit distribute the power supply evenly during the trail run, the gear shifters also function accordingly. As shown in the fig 10.2 output of the project. The project completed successfully on scheduled time.

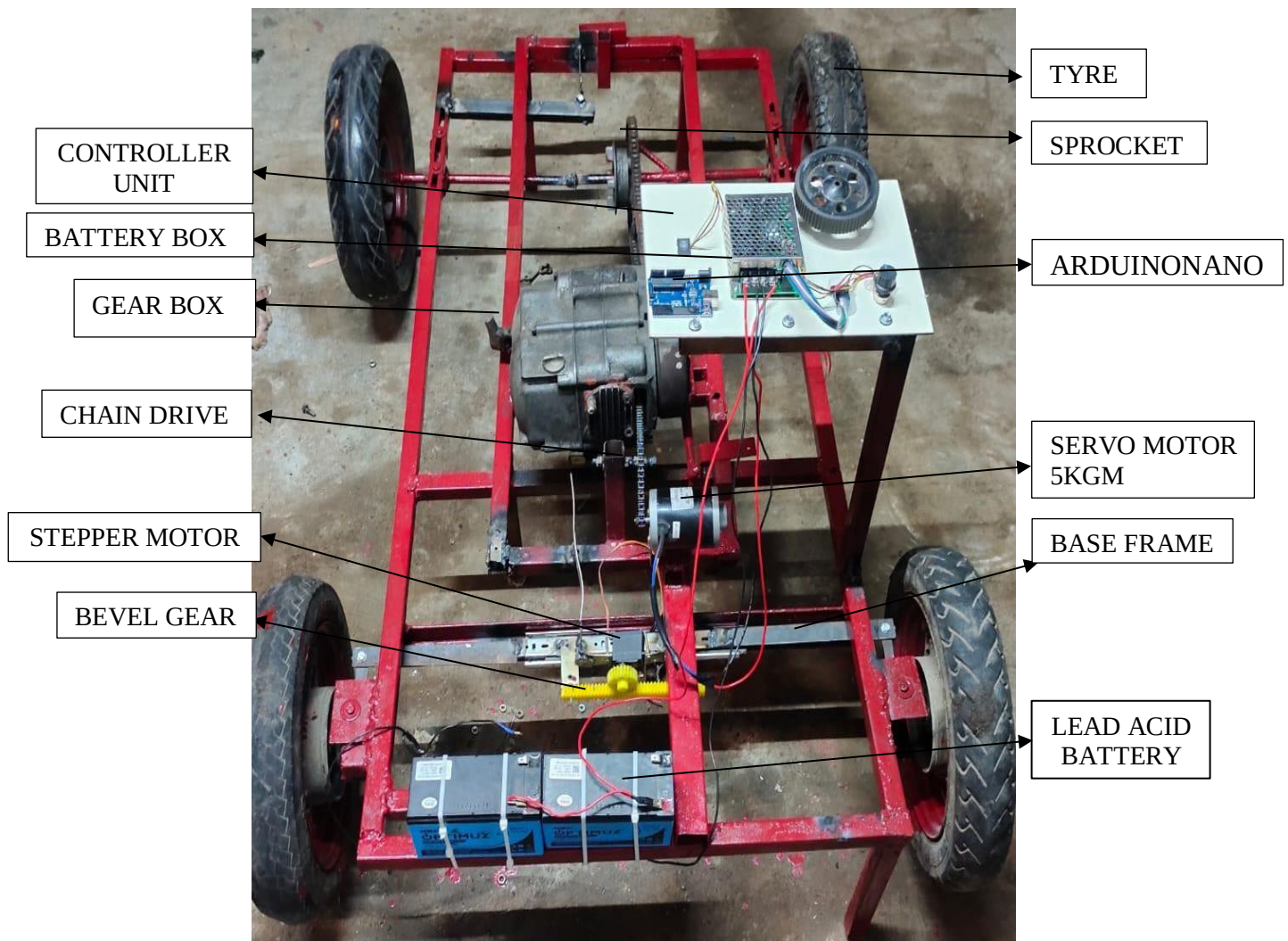


FIG 10.2 OUTPUT OF THE PROJECT

10.3 DRAWING DETAILS OF COMPONENT

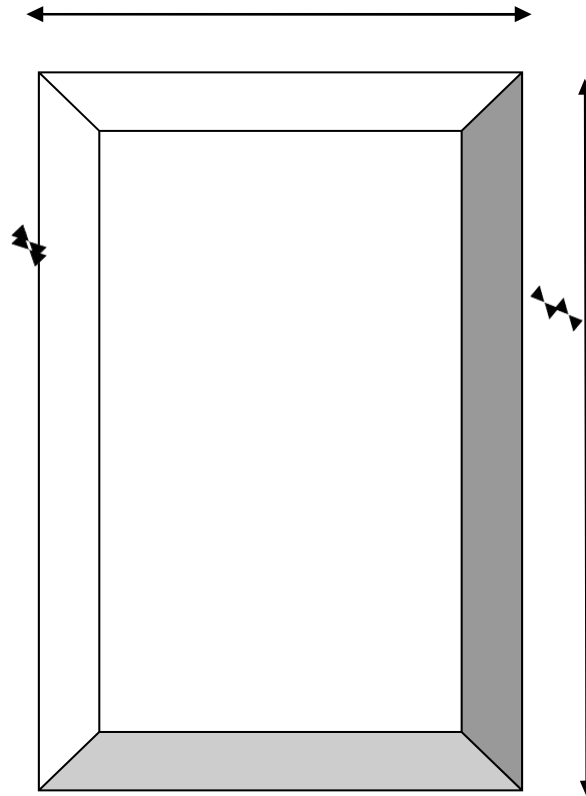


FIG 10.1 DESIGN OF VEHICLE

10.3.1 DESIGN OF VEHICLE

Assume

Load on vehicle= 100 kgLoad (P) = 1000 N

Let Area cross section = Stress = load / area

$$= 1000/160 \times 100 \times 10^{-4}$$

$$\sigma = 625.55 \text{ n/m}^2$$

From tensile testing, $\sigma' = 650 \text{ N/m}^2$

Thus, $\sigma' > \sigma$ theoretical

Hence design of the vehicle is safe

Capability of Motor

Specification of motor Power (P) = 1.5

KW No. Of revolution per min (N) = 500RPM

$$P = 2 \pi r t / 60 \times 1000$$

Torque Transmitted $T = 28.62 \text{ N-m}$ Shear Stress $\tau = 16T / \pi d t$

Where $D =$ dia of

$$\text{Wheel } D = 40 \text{ cm } \tau = 16 \times 28.62 / \pi (0.4) t$$

$$\tau = 2278.66 \text{ N/m}^2$$

Load carried by motor = shear stress $\times$ area of crosssection =

$$2278.66 \times 160 \times 100 \times 10^{-4}$$

$$P = 3645.5 \text{ N}$$

$$\text{Or } P = 364 \text{ kg}$$

Therefore the load on vehicle is easily carried by this motor.
Hence Design is safe

10.3.2 DESIGN CALCULATION

Nomenclature

L Wheelbase (mm)

R Turning radius (mm)

A2 Distance of CG from rear axle (mm)

If Inner angle of front tire (degree) of Outer angle of front tire (degree) i_r

Inner angle of rear tire (degree) if Outer angle of rear tire (degree)

R1. Distance between instantaneous Centre and the axis of the vehicle (mm)

Wf Load on front axle (kg) W

Total weight of car (kg)

C1. Distance of instantaneous center from front axle axis (mm) C2 Distance of instantaneous center from rear axle axis (mm) Wf Front track width (mm)

Wr Rear track width (mm) Total l steering angle of the vehicle (degree) =Total inner angle of the vehicle(degree) Total outer angle of the vehicle (degree)

10.3.3 DESIGN OF RACK AND PINION

$$D_{min} > \{ (0.59 / \sigma_{cmax}) \times [[Mt] / ((1/E1) + (1/E2))]^2 \}^{1/3} \text{_____} (1)$$

Where,

N/m²

Σ_{cmax} = maximum contact compressive stress

E1, E2 = Young's modulus N/m² Mt =Torque N-m

E1 = E2 = 1.1x10⁶ N/m²

Calculation of coax Where,

$$\Sigma_{cmax} = HB \times CB \times K_{cl} \text{_____} (2)$$

HB = Brignell hardness number

CB = coefficient depends on hardness

K_{cl} = life factor

Where

$$K_{cl} = \{ [1 \times 10^7] / N \}^{1/6}$$

$$N = 60 \times n \times T$$

$$N = \text{rpm}$$

$$N = \text{life in no. Of cycles } T$$

$$= \text{life in hours.}$$

$$= 8000 \text{ hours.}$$

From P.S.G design data book (page no.2.4)

CB = 20

HB = 200

Substituting the values of N, n, T in the equation [3],

the value of kcl is obtained as 1.139.

$$K_{cl} = 1.139.$$

Substituting the values in equation [2]

$$\begin{aligned}\Sigma c_{\max} &= 20 \times 200 \times 1.1309 \\ &= 4520 \times 10^5 \text{ N/m}^2\end{aligned}$$

Calculation of M_t

$$M_t = 97420 \times (K_w/n) \dots \dots \dots (4)$$

For power calculation

$$\text{Centrifugal force, } f_c = m \omega^2 r \dots \dots \dots (5)$$

$$M = 0.2 \text{ Kg}$$

$$W = m \times g$$

$$= 2\pi n/60$$

$$R = 1 \text{ m}$$

Substituting the values of m, ω , r in

$$\text{equation [4] } F = 0.216 \text{ N.}$$

$$\begin{aligned}\text{Downward force, } F_D &= m \times g \\ &= 1.962 \text{ N.}\end{aligned}$$

$$\begin{aligned}\text{Centrifugal force, } f &= f_c + F \\ &= 0.216 + 1.962\end{aligned}$$

$$= 2.178 \text{ N}$$

$$\text{Torque} = f \times r = 2.178 \times 1$$

$$= 2.178 \text{ Nm.}$$

Power = Torque x angular velocity.

$$= 2.178 \times 1.0$$

$$= 2.28 \text{ w}$$

Substituting the value of kW and n in equation in [4],

$$M_t = 22.21 \text{ [Mt]} =$$

$$\begin{aligned}
 &1.4 \times M_t \\
 &= 1.4 \times 22.21 \\
 &= 31.1 \text{ N-m}
 \end{aligned}$$

Substituting the values of σ_{cmax} , $[M_t]$, E_1 , E_2 in equation [1],

the minimum diameter of the pinion is calculated to be 23.07mm.

We have taken the standard diameter of pinion as 34mm.

10.3.4 SPECIFICATION OF PINION

TABLE 10.1 SPECIFICATION OF PINION

SPECIFICATION OF PINION	
Material	: cast-iron
Outside diameter	: 34mm
Circular pitch	: 4.7mm
Tooth depth	: 3.375mm
Module	: 1.5mm
Pressure angle	: 21°
Pitch circle diameter	: 31mm
Addendum	: 1.5mm
Addendum	: 1.875mm
Circular tooth Thickness	: 2.355mm
Fillet radius	: 0.45mm
Clearance	: 0.375mm

10.3.5 DESIGN OF RACK

$$\begin{aligned}
 \text{Pitch circle diameter of the gear is} &= 31\text{mm} \\
 \text{Circumference of the gear is} &= \pi \times \text{pitch circle diameter} \\
 &= \pi \times 31 \\
 &= 97.38\text{mm}
 \end{aligned}$$

The dimension is for 360° for one rotation
 For two rotations (Approx.) the rack minimum length is
 194.76 mm

10.3.6 SPECIFICATION OF RACK

TABLE 10.2 SPECIFICATION OF RACK

Minimum length of the teeth:	194.76mm. Here
Material	cast iron
Module	1.5 mm
Cross-section	20×15mm

Teeth on the rack is adjusted for 215mm

10.3.7 BEVEL GEAR CALCULATIONS

TABLE 10.3 BEVEL GEAR CALCULATIONS

No of Teeth	20
Pressure Angle	20°
Tooth form	Straight
Module	2.5mm
Pitch Circle Diameter (PCD)	50mm
Outer Diameter (OD)	55.22mm
Face Width	15mm
Overall Width	31.06mm
Bore Diameter	12mm

10.3.8 STEERING ANGLE CALCULATION

Calculation for steering angles for the turning radius of 4.4m.

From the benchmark vehicle we know that turning radius is 4.4m. Where R = Turning radius of the

vehicle. $A_2 =$

Distance of CG from rear axle.

R_1 = Distance between instantaneous center and the axis of the vehicle. To find a_2

$$W_f = (W * a_2) / L \dots (2)$$

Where W_f = Load on front axle. W = Total weight of car.

L = Wheelbase.

So from equation 2 and 1

$$A_2 = 1305 \text{ mm. } R_1 = 4202 \text{ mm.}$$

To find steering angles;

From test we found that the inner angle of front tire is, $\delta_{if} = 25.60$. $\tan \delta_{if} = C_1 / (R_1 - w_f / 2) \dots (3)$

$$C_1 + C_2 = L \dots (4)$$

Where C_1 = Distance of instantaneous Centre from front axle axis.

C_2 = Distance of instantaneous center from rear axle axis. w_f = Front track width.

From equation 3 and 4

$$C_1 = 1722.19 \text{ mm. } C_2 = 452.80 \text{ mm.}$$

To find δ_{of} = outer angle of front tire. $\tan \delta_{of} = C_1 / (R_1 + w_f / 2) \dots (5)$

$$\delta_{of} = 19.700$$

To find δ_{ir} = inner angle of rear tire. $\tan \delta_{ir} = C_2 / (R_1 - w_r / 2) \dots (6)$

$$\delta_{ir} = 7.1640$$

To find δ_{or} = outer angle of rear tire. $\tan \delta_{or} = C_2 / (R_1 + w_r / 2) \dots (7)$ $\delta_{or} = 5.3860$

Calculation for turning radius for same steering angles. To find turning radius, $R_R = a^2 + L^2 \cot^2 \delta$
.....(8)

Where δ = Total steering angle of the vehicle. To find δ $\cot \delta = (\cot \delta_i + \cot \delta_o) / 2$ (9)

Where δ_i = total inner angle of the vehicle.

Δ_o = total outer angle of the vehicle. $\cot \delta = 1.032$. From equation 8 $R = 2596$ mm.

Further calculation for C_1 and C_2 from equation 3 and 4 considering turning Radius as 2596 mm.

$C_1 = 780.82$ mm. $C_2 = 1394.17$ mm. the fig10.2 turning radius calculation shows the final steering radius

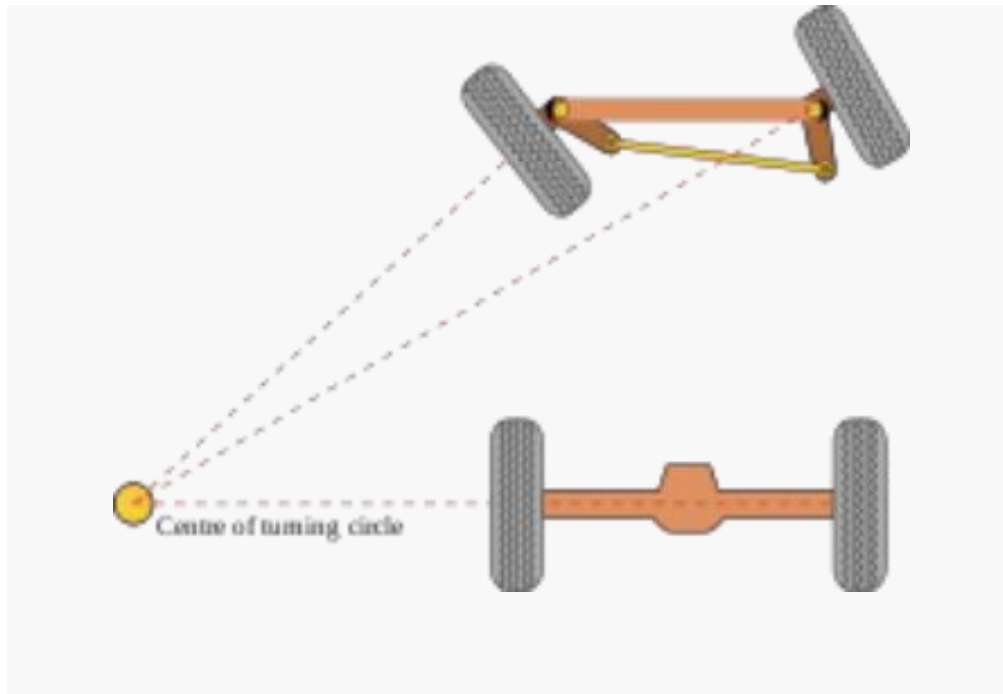


FIG 10.1 TURNING RADIUS

10.3.9 TURNING RADIUS CALCULATION MACHINES USE

Radius turning	Four wheel Steering	Two wheel Steering
By Calculation	2.59m	4.4m

10.2 TURNING RADIUS CALCULATION

CHAPTER 11

CONCLUSION

There are a multitude of uses for electric motors in all kinds of engine-driven vehicles, including cars, planes, aircraft carriers, and agricultural machinery. Electric motors are used in electric cars, diesel-electric vehicles, and hybrid automobiles to move the vehicle. The motor controllers used in automobiles are built within the car itself. The machine is very much advance and simple to construct. The working of machine is easy and ecofriendly. It is the most economical vehicle as there is no fuel consumption. The cost of all the component is less and the components should be easily available in the market .so presently it is common to use in developing countries.

CHAPTER 12

REFERENCES

- [1] R. Gadh, "Network based management for multiplexed electric vehicle charging". United State of America Patent US20130154561A1, US13/691,709, and 30 November 2011.
- [2] C. Chung, P. Chu and R. Gadh, "Design of Smart Charging Infrastructure Hardware and Firmware Design of the Various Current Multiplexing Charging System," in Seventh Global Conference on Power Control & Optimization PCO 2013, Prague, 2013.
- [3] S. Mal, A. Chattopadhyay, A. Yang and R. Gadh, "Electric vehicle smart charging and vehicle to-grid operation," International Journal of Parallel, Emergent and Distributed Systems, vol. 27, no. 3, pp. 249-265, 2012.
- [4] M. Majidpour, C. Qiu, C. Y. Chung, P. Chu, R. Gadh and H. R. Pota, "Fast Demand Forecast of Electric Vehicle Charging Stations for Cell Phone Application," in 2014 IEEE PES General Meeting, National Harbor, 2014.
- [5] J. Chynoweth, C. Y. Chung, C. Qiu, P. Chu and R. Gadh, "Smart Electric Vehicle Charging Infrastructure Overview," in ISGT-2014, Washington, DC, 2014.
- [6] Y. Wang, H. Nazaripouya, C. C. Chu, R. Gadh and H. R. Pota, "Vehicle-to-Grid Automatic Load Sharing with Driver Preference in Micro-Grids," in ISGT Europe 14, Istanbul, 2014.
- [7] Maggetto, G.; Mierlo, J.V. Electric and electric hybrid vehicle technology: A survey. In Proceedings of the IEE Seminar Electric, Hybrid and Fuel Cell Vehicles (Ref. No. 2000/050), Durham, UK, 11 April 2000.
- [8] Rakesh Kumar, Sanjeevikumar Padmanaban, "The National Electric Mobility Mission Plan 2020 (NEMMP 2020) has come with a detailed report on the EV"