NUST COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING

Conversion of SI Engine Powered Commercial Vehicle into Electric Vehicle

Project Report

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Declaration

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Acknowledgements

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Abstract

The world is entering a new technological and scientific era. In an age of abundant technology, fossil fuels won't stack up. Nonrenewable fossil fuels are dwindling; we need an alternative. Electric cars have made fossil fuels obsolete in a crowded technological society. Electric cars are growing quickly as fossil fuels cause an energy and environmental crisis. Electric automobiles have several advantages over combustion engines. In the first stage, nonrenewable fossil fuels are becoming extinct as the world evolves towards technology. Electric alternation is the greatest response to this and the previous concern, which is that fossil fuels are a big cause of pollution and global warming, which has expanded in recent years as more companies started. Electric automobiles solve the biggest problem with autos now. Batteries power electric autos. EVs emit nearly no air pollution. They're 80c/o more efficient than combustion engines. Battery noise isn't audible in electric automobiles [8]. Standard electricity charges electric automobiles, which go farther than gas-powered cars.

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Chapter 1: Literature Review

When it comes to the overall amount of primary energy that is used all over the globe, the transportation sector is responsible for as much as 27 percent of the demand. Because of this, the transportation industry is responsible for a significant amount of the greenhouse gas emissions that are a contributing factor in climate change. Air pollution is becoming worse, which is having a detrimental effect not only on people's health but also on the economy. This is a result of the fast development of the transportation industry. It is very necessary to improve the overall energy efficiency of the many industries that use energy if one wishes to restrain both the rise in the demand for energy and the environmental damage that results from it [18], [20]. Developing countries have the highest rates of increase in their use of energy for transportation [21]. It is crucial to look at the energy efficiency of automobiles, which play a significant position in human society, in order to deal with problems about energy management. These concerns are related to the management of energy. When comparing the fuel economy of different kinds of vehicles, it is important to take into account the WTW efficiency. Using the WTW evaluation, a comprehensive measurement of the energy consumption of vehicles was carried out WTW is concerned with the efficiency of the vehicle's energy chain from the beginning to the end, sometimes known as "cradle to grave." In terms of their WTW efficiencies, conventional internal combustion vehicles (such as gasoline, diesel, and natural gas) are pitted against electric automobiles. The WTW efficiency of the electric vehicle demonstrates that the optimal use of natural gas combined-cycle power plants will result in an increase in the overall efficiency of electric automobiles. [22]. A research compared the energy efficiency of internal combustion engines to that of electric bikes by using actual data from both types of vehicles. According to the findings, electric engines are around 15.2 percentage points more efficient than engines that run on liquid fuel. This represents a threefold increase in efficiency. [23] As a result of this work, a more in-depth evaluation of the entire energy chain was able to be conducted in order to get a better idea of how well energy works. Electric automobiles did not come into existence in the twenty-first century; rather, their origins can be traced back to the early nineteenth century. First, Nikola Tesla and William Morris presented the concept of electric automobiles, and then, as a direct consequence of their work, the field of electric vehicle research was established. William Morris is credited as being the first person to think of a concept for an electric automobile. At the tail end of the 19th century, several nations in Europe, including France and England, were quite passionate about electric automobiles. When they were initially made available to the public in the year 1897, electric taxis quickly became quite popular in the city of New York. In the year 1896, William Morris and a few other individuals conceived up this extraordinary and lavish proposition. At this time, electric vehicles were having a lot of financial troubles since they were highly costly and could only be afforded by the aristocracy or the richest businesses of the time. This caused the electric car industry to have a lot of problems. The law of demand and supply steps in, which drives up the price, since electric vehicles rely on Lithium Ion batteries to power their motors. Lithium-Ion batteries are now rare and expensive, therefore this causes the price to go up. The production of electric cars was suspended and limited since there was not enough demand for them, which resulted in a significant amount of financial loss for the firms. The research on the energy efficiency, CO_2 emissions, and costs of electric vehicles, as well as the effect of EVs on the demand for electricity and the stability of the electricity grid, demonstrated how vital it is to take into consideration all of the processes involved in the energy chain when evaluating the performance of electric vehicles.

Because we are fast running out of resources for fossil fuels, this concept has been brought back into consideration in order to maintain the smooth operation of vehicles while also storing fossil fuels for use in the future, should that become essential in times of extreme struggle. As a consequence of this, the use of electric power to drive vehicles is saving the world from a variety of environmental disasters, including global warming, severe pollution, the average increase in the temperature of the solar system, and a great deal of other environmental issues.

Electric cars are gaining popularity in this day and age because they are much more environmentally friendly than conventional automobiles powered by internal combustion engines. These battery packs and motors may be positioned in close proximity to the tyres of these electric automobiles since they are designed with enough space to accommodate their positioning without taking up an excessive amount of area. Research on electric vehicles has reached new heights as a result of Elon Musk's Tesla company, which is dedicated to supplying people all over the globe with electric autos of the highest possible quality. In order to achieve an even greater level of efficiency, Tesla Model 3 is equipped with IMP Syn-RM brushless DC motors, which are the most cutting-edge kind of electric motor that is presently available. Electric vehicles now have an efficiency of around 80 c/o [8] or even higher, which is much better than the efficiency of regular conventional electric vehicles, which ranges from 20 to 25 percent.

As a direct result of research carried out by current philosophers, the vast majority of vehicles and other linked goods in our modern society run on electricity rather than on fossil fuels. Electric vehicles also have the advantage of being very quiet and smooth, which makes the driver feel more safer and more at ease when they are behind the wheel of the vehicle. The most cutting-edge technology currently accessible is included in today's modern electric automobiles. Incorporating and installing a variety of the most cutting-edge technologies, such as the CV2x 5G technologies and the automatic single-speed transmission, in electric automobiles is among the many features that have been included. The most advanced android systems and electronic control units, in conjunction with sensors, have been used as part of the 5G technology in order to quickly alert and take control of the vehicle in the event that an accident does take place. This has helped to lessen the impact that an accident has on the rider. Electric cars are the wave of the future for humanity, and they are going to bring about a revolution in the way that we travel and interact with technology.

A comparison of the amount of energy being used by conventional vehicles and the corresponding models of electric vehicles while driving on hilly roadways in Andorra. In order to evaluate the diesel and electric cars in terms of their energy efficiency, the simulation model followed a protoplasmic journey. The findings suggest that electric cars have a greater potential to reduce energy use [24], [27], [25] and [28].This study compares the total energy efficiency of vehicles driven by internal combustion engines (ICE) against that of electric vehicles (EV) fueled by a variety of power plants, including gas, coal, and diesel. This evaluation is carried out in accordance with the WTW efficiency approach.

Permanent-magnet synchronous machines, also known as PMSMs, are widely used as an essential component of an electric propulsion system for electric vehicles (EVs) owing to the many benefits that they provide [3–6], including high power density, high torque density, and high efficiency. When compared to surface-mounted PMSMs, internal PMSMs (IPMSMs) are garnering greater attention due to their superior PM usage and larger constant power speed range (CPSR) [24], [25]. It is feasible to increase the performance of an IPMSM by improving the rotor design [26]– [29]. The performance of the IPMSM is significantly impacted by the PM rotor topologies. Some IPMSMs with different configurations and positions of PMs and flux barriers in the rotor core as well as the number of magnet layers are compared in [30]. The results show that as the number of magnet layers increases, the average torque tends to decrease if the PMs are in an arc-shape configuration. . The ratio of magnet torque to reluctance torque has been shown for a variety of IPMSMs with a variety of rotor topologies in reference [31]. According to the findings, IPMSM rotors with square-shaped PMs cost less to manufacture than those with arc-shaped PMs because the square form is more efficient. In [32], a comparison of five rotor topologies is made; the results reveal that the W -shape PM motor has a wider CPSR and a greater rated torque than the others; nevertheless, the complicated rotor structure lowers the mechanical strength and the dependability in the high-speed area. In [33], a unique rotor for IPMSM that has damper bars is presented. Damper bars that are installed correctly have the potential to not only minimize the torque ripple and the cogging torque, but also to raise the average torque. However, the full comparison of IPMSMs with various rotor topologies has only seldom been evaluated, despite the fact that several innovative rotor topologies for electric vehicle applications have been described in a great deal of literatures. IPMSMs designed specifically for use in electric vehicles are anticipated to not only have favorable torque characteristics in the low-speed zone, but also an improved capacity for field-weakening in the high-speed region [34], [35]. The majority of these aspects of the motor are, in direct connection, connected to its geometrical dimensions. When it comes to designing a rotor for IPMSMs, there is a great degree of flexibility in the selection of the geometrical characteristics, and some performance may be considerably increased by enhancing specific geometrical parameters [36]–[39].

According to reports in [40] and [41], the magnetic bridge is a highly critical feature for IPMSMs, and the magnetic torque characteristics may be considerably improved with an appropriate barrier form. [40] and [41] also state that this improvement is possible.

According to a research that was conducted in 2010 on the many kinds of motors that were used for EVs, a comparison of IPM, IM, and SRM has been made in terms of taken motor sizes, speeds of 1500 and 6000 rpm, and maximum power. TABLE II provides an illustration of the comparison between torque, iron loss, copper loss, efficiency, and current density. At 1500 revolutions per minute, the torques of IPM and IM are greater than those of SRM, as can be shown in Table II. Copper is lost at a greater rate in IM. When we consider how efficient something is, we find that IPM is the most efficient kind of motor. The weight of the battery is affected by the efficiency of the motor and electronics as a whole. Every one percent that the battery's efficiency is reduced demands an additional one percent of battery [42]. It has been determined that SRM offers the highest amount of torque while operating at 6000 revolutions per minute. When operating at a fast speed, IPM functions at their optimal level [43].

The Permanent Magnet Synchronous Motor, or PMSM for short, is a kind of AC synchronous motor that has a sinusoidal back EMF waveform and gets its field excitation from permanent magnets. It is also abbreviated as PMSM. Induction motors and brushless DC motors are the two types of motors that are combined to create the PMSM. It is similar to a brushless DC motor in that it features a rotor with a permanent magnet and a stator with windings. The machine has a stator construction with windings arranged in such a way as to create a sinusoidal flux density in the air gap. This structure is quite similar to that of an induction motor. Due to the fact that there is no stator power being allocated to the formation of a magnetic field, its power density is greater than that of induction motors with the same ratings.

Permanent magnet synchronous motors (PMSMs) are able to create torque even while operating at zero rpm; however, they cannot function without a digitally controlled inverter. PMSM are often used in motor drives because of their great performance and high efficiency. The characteristics of high-performance motor control include smooth rotation throughout the entire speed range of the motor, full torque control at zero speed, and rapid acceleration and deceleration.

Chapter 2: Introduction

The mobility industry is in the midst of a shift that is environmentally friendly. This change is being prompted by the intensification of societal problems like as pollution, as well as by developments in technological enablers such as improvements in battery cell technology. Significant attention has been paid to the topic of transportation in the literature on industrial transition [5]. Transportation is currently responsible for approximately 23 percent of all greenhouse gas (GHG) emissions around the world, with approximately 70 percent of these emissions coming from road transport. Regulation on both the supply side and the demand side has spurred the development of electric cars (EVs), which promise lower greenhouse gas emissions throughout the lifespan of the vehicle. This has led to greater market acceptance of EVs. The increased level of dynamism led to the breakdown of previously established business models and the appearance of new competitors in the market. Since 2010, existing manufacturers have spent over $19 billion on electric vehicles (EVs) and charging infrastructure, in addition to another $14.3 billion on battery technology, which will result in around 300 new EV models by the year 2025 [5]. At the same time, incumbents are seeing a decline in their profitability. The ICE market is not growing and has been stagnant for some time, and there are transitions occurring from more profitable larger automobiles to less profitable smaller automobiles, as well as high investment needs in CASE (Connectivity, Autonomy, Sharing, Electrification) [3]. All of these factors contribute to the pressure that is being felt. Electric vehicle (EV) startups such as Tesla (USA) and Byton, who are acquiring market share, are battling incumbents (China). However, with the exception of Tesla, all of the major electric vehicle (EV) companies, both those already in the market and those wanting to get into it, are always searching for new ways to increase their profits. As a consequence of this, they might perhaps have an interest in researching the opportunities and risks associated with ICE-to-EV retrofitting business models.

Converting internal combustion engines (ICE) to electric motors (EV) is one possible intermediate solution that might speed up the transition to widespread EV usage. It is possible that EV retrofitting will hasten the adoption of electric vehicles (EVs), increase public acceptance of EVs, increasing the amount of resources used by internal combustion engine (ICE) vehicles, and hasten the construction of EV infrastructure. Customers may benefit from decreased operating expenditures, an increase in operational quietness, and an improvement in the overall cleanliness of the environment. In essence, the notion may hasten the shift toward environmentally friendly modes of transportation. Hobbyists and small businesses often convert internal combustion engine (ICE) vehicles to electric drive by exchanging ICE components like the combustion engine, exhaust system, and fuel tank with electric vehicle (EV) components including the electric motor, controller, battery packs, and inverter. The vast majority of conversions make use of an adapter plate [4] to link the electric motor to the conventional gearbox in order to keep power transmission to the wheels intact. [4]. For example, the number of businesses that provide conversion from internal combustion engine (ICE) to electric vehicle (EV) is now quite low in Germany and the United States. In Germany, the cost of retrofitting a smaller vehicle ranges from 8,000 to 13,000 to 15,000 euros, whereas the cost of retrofitting a mid-size passenger car is from 13,000 to 15,000 euros [9]. TÜV inspections in Germany are one example of the regulations and processes that are in place in certain countries to permit modified vehicles to be driven on public roadways.

In order to get answers to the research questions, a study using sequentially mixed methodologies was carried out. Given the dearth of previously done research, the first step in conducting the essential topic inquiry was to carry out seven qualitative interviews with prospective customers and industry professionals. Second, the information gathered from 76 people who filled out an online questionnaire made it possible to quantify the viewpoints gained from the interviews, such as the requirements for the business model. The use of many sources of information provided a more complete and nuanced picture of the perspectives held by prospective consumers about the transition from ICE to EV. A country case study was used because specialized insights, such as national nuances like laws, are required to create an effective approach to a business model in order for the strategy to be successful.

First, the report includes genuine information from prospective customers interested in ICE to EV retrofitting, which is a market that has not yet been exploited in any way. The investigation centers on many points of view, such as connected hazards, opportunities, and offer requirements. Second, the paper provides a synthesis of the data by drawing implications for the business model, putting emphasis on the primary success qualities that must be satisfied from the standpoint of a customer.

Chapter 3: Architecture of Electric Vehicle

The electric vehicle drivetrain permits brand new degrees of architectural flexibility inside electric vehicles but also opens the door to brand new difficulties in terms of satisfying all of the standards.

Because electric cars use an electric motor and a battery rather than an internal combustion engine and a gasoline tank, they are more environmentally friendly. At the component level, the architecture becomes easier to understand and more controlled. These alterations call for considerable adaptations in order to incorporate the battery in a secure manner.

It is required to employ modelling and simulation tools while building the architecture for an electric vehicle (EV), and particular attention must be paid to the electric powertrain. This involves taking into account the battery, power electronics, electric motors, sensors, and control system.

The architecture of an electronic vehicle is mostly made up of five significant components. These are a battery pack, an inverter, a converter, and a DC motor and charger. We are going to have an in-depth conversation about each one of them in turn.

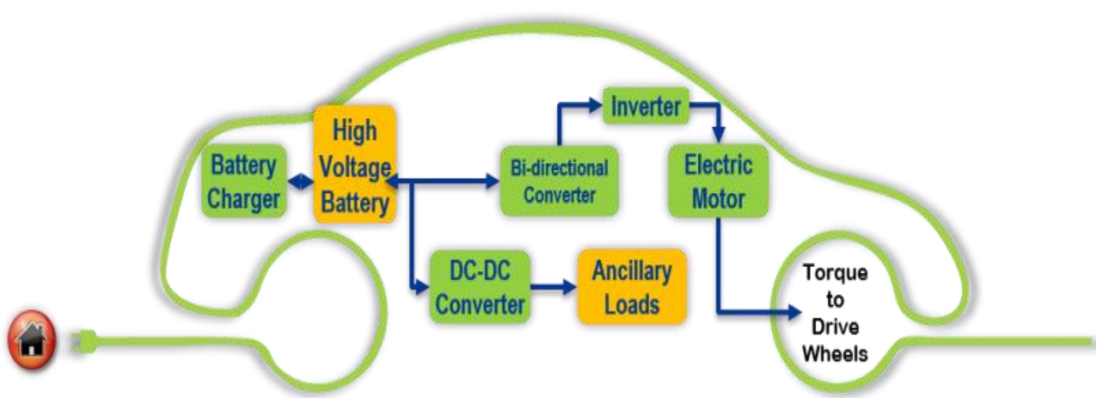

Figure 1: Architecture Design [6]

The schematic diagram of the architecture of the electronic vehicle:

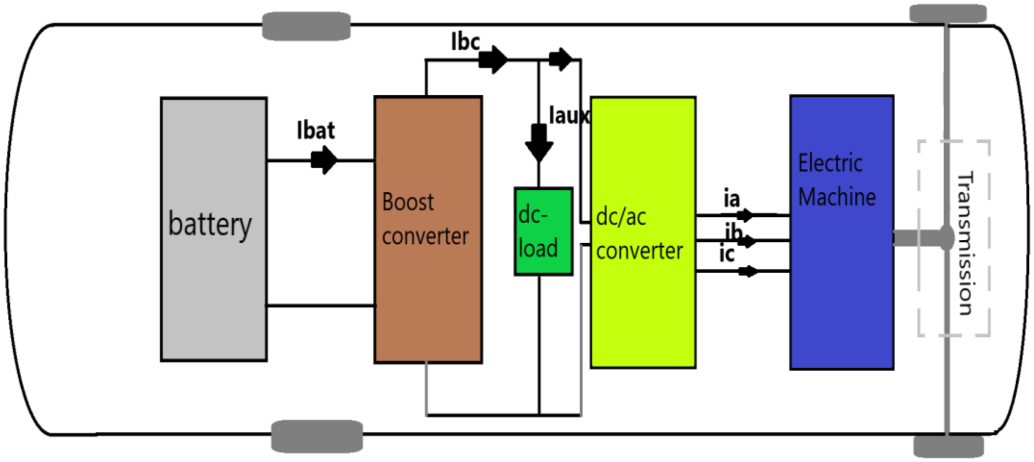

Figure 2: Schematic of Electronic Vehicle

Figure shows a schematic representation of an electric vehicle (EV), which shows that the battery pack serves as the storage unit. A three-phase power inverter and an alternating current machine are both components of the driving system. Not only does a power electronic converter known as a VSC serve as an interface between the on-board storage units and the power grid, but it also facilitates the interchange of active and reactive power.

Electric Motor

Electric engines provide power to the vehicle by using electromagnetic fields. The energy required to run the engine comes from the vehicle's battery, and the amount of force that can be generated is limited by varying the flow stream. The electric engine is more efficient than ICE by more than 90 percent [4], and since it generates force at zero speed, it enables the vehicle to have a single stuff ratio between the engine and the tire rather than many gear transmissions.

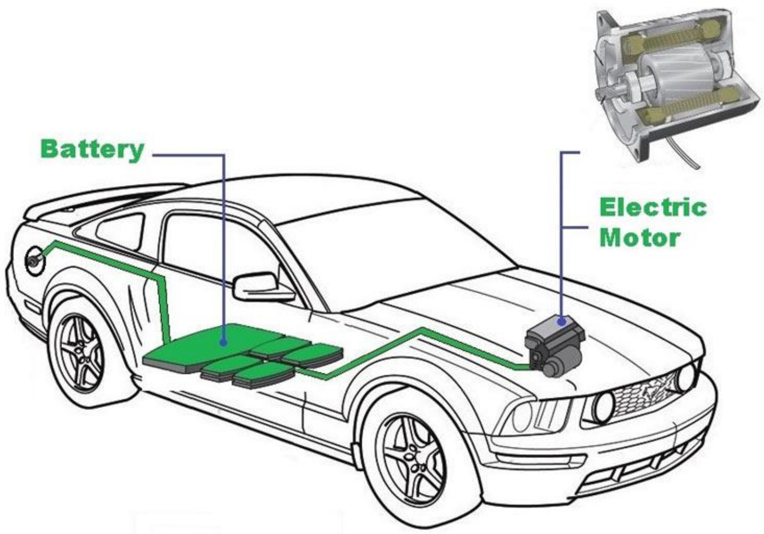

Figure 3: Working of an Electric Motor [11]

PMSM is used in our electric vehicle. Permanent Magnetic Synchronous Motors are very efficient and reliable and have higher torque on smaller frame size and no rotor current [16]. This is due to their high power-to-size ratio. The rotation of the motor is very smooth over the entire speed range. It gives the maximum torque control even at zero speed and provides fast acceleration and deceleration. The working of this motor is such that the magnetic flux produced by permanent magnets locks at a synchronous speed. This type is quite similar to brushless DC motor. PMSM has a higher power density [, hence the size of the motor is reduced. These motors are not only used in vehicular propulsions but also in industrial drives. This motor is an AC synchronous motor.

Battery Pack

The battery pack is the device that stores energy; in order to function properly, it must take in and send out current to the electric machine. The battery is the component of an electric car's energy storage system that stores electrical energy. The kind of battery a vehicle uses may change depending on whether it is an all-electric vehicle (AEV) or a plug-in hybrid electric car (PHEV). The existing technology for batteries is built for a longer service life (typically about 8 years or 100,000 miles). Some batteries have a lifespan of between 8 and 12 years in harsh regions and between twelve and fifteen years in mild settings. Ultracapacitors, lithium-ion batteries, nickel-metal hydride batteries, and lead-acid batteries are the most common types of batteries used in electric vehicles. At the terminals where the current is output, battery packs provide direct current (DC). Altering the waveform of a rotating current (AC) may limit the capabilities of electric machinery [8]. The lithium-ion battery is the kind of battery that is used in electric automobiles more often than any other type.

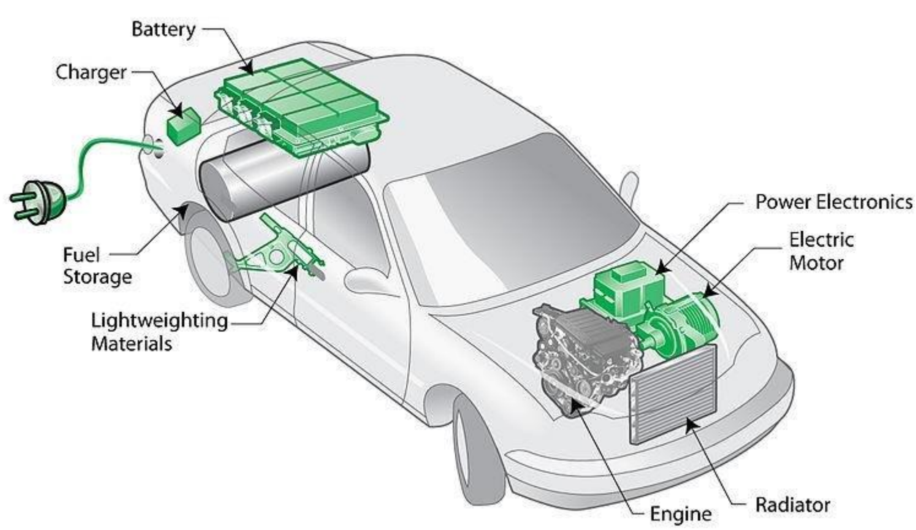

Figure 4: Representation of a Battery Pack [11]

Lithium-Ion Battery

Lithium-ion battery is a rechargeable battery and is used in many other portable electrical appliances.The lithium-ion battery is the kind of battery that is used in electric automobiles more often than any other type. You've probably heard of this kind of battery before since it's used in the vast majority of portable electronic devices, such as cellular telephones and personal computers. Batteries that use lithium ions offer a high power-to-weight ratio [51], great energy efficiency, and good performance when exposed to high temperatures. In application, this indicates that the batteries are capable of storing a significant amount of energy despite their relatively low weight, which is essential for electric vehicles since a lighter vehicle can drive longer on a single charge [52],[54] and [56]. In addition, lithium-ion batteries have a low "self-discharge" rate, which indicates that they are superior to other types of batteries in terms of their capacity to retain a full charge even after a significant amount of time has passed [53].

In addition, the majority of the components that make up lithium-ion batteries can be recycled, which makes these batteries a fantastic option for those who are concerned about the environment. Although the specific chemistry of these batteries differs from that which is found in consumer devices, it is employed in both alternative and plug-in hybrid electric vehicles (AEVs and PHEVs) [57].

An electric traction motor, as opposed to a gasoline-powered vehicle's internal combustion engine, is found in all-electric vehicles. Gasoline-powered vehicles employ an internal combustion engine. A traction battery pack, which is often a lithium-ion battery, is what is used in AEVs to store the power that is utilized by the motor to propel the wheels of the vehicle [58]. The effectiveness of the traction battery pack, which is the component of the automobile that needs be plugged in and recharged, plays a role in determining the total distance that the vehicle is capable of travelling [59], [60].

The pace at which many rechargeable batteries self-discharge is a problem with these batteries. One advantage that lithium-ion cells have over other types of rechargeable batteries, such as Ni-Cad and NiMH versions, is that their rate of self-discharge is far lower. It is normally somewhere about 5 percent during the first four hours after being charged, but then it drops to a level that is around 1 or 2 percent every month after that.

There is no need for any kind of upkeep or maintenance with lithium-ion batteries, which is one of the most significant benefits of these types of batteries. To prevent the memory effect from manifesting in their operation, Ni-Cad batteries needed to be discharged at regular intervals since this has no effect on lithium-ion batteries or cells. This operation, along with other maintenance procedures that are quite similar, are not necessary. In a similar vein, lead acid batteries need regular maintenance, with certain models requiring the acid in the battery to be regularly replenished. To our good fortune, one of the benefits of using lithium-ion batteries is that they do not need any kind of active maintenance.

Each lithium-ion battery has a voltage output of around 3.6 volts when it is fully charged. This offers a wide variety of benefits. The voltage of each lithium-ion cell is higher than that of standard nickel cadmium, nickel metal hydride, and even standard alkaline cells, which are all around 1.5 volts per cell, and lead acid cells, which are all around 2 volts per cell. Since the voltage of each lithium-ion cell is higher, many battery applications require fewer cells. The fact that just one cell is required for smartphones makes the process of managing the power supply much more straightforward.

We will also briefly discuss the other batteries available for this task.

Nickel-metal hydride batteries

Nickel-metal hydride batteries are employed in hybrid-electric cars on a far larger scale than in all-electric vehicles, although they are also utilized effectively in some of the latter. Because hybrid-electric vehicles do not get their electricity from an external source that they plug into, but instead use gasoline to replenish their batteries, we do not consider them to be electric cars because they do not meet the criteria of an electric car.

The lifespan of nickel-metal hydride batteries is much greater than that of lithium-ion and lead-acid batteries. They are not only harmless but also tolerant to being abused. The expensive cost of nickel-metal hydride batteries, their high rate of internal self-discharge, and the fact that they produce a substantial amount of heat when exposed to high temperatures are the three primary drawbacks associated with these types of batteries. Due to these limitations, the effectiveness of these batteries is reduced when used in rechargeable electric cars; as a result, hybrid electric vehicles are the primary application for their utilization.

Lead-acid batteries

At this time, lead-acid batteries are exclusively used in electric cars in order to augment the loads of other types of batteries. These batteries have a high power output, are relatively affordable, safe, and dependable; but, because to their short calendar life and subpar performance at low temperatures, it is challenging to utilize them in electric cars. Even though high-power lead-acid batteries are now in the process of being developed, the batteries are currently only employed as secondary storage in commercial vehicles.

Ultracapacitors

Ultracapacitors are not batteries in the same sense that we typically understand the term. In its place, a polarized liquid is stored between an electrode and an electrolyte. When there is a greater amount of liquid surface area, there is also a greater amount of energy that can be stored. Ultracapacitors, much like lead-acid batteries, are most effective as backup storage devices in electric cars. This is due to the fact that ultracapacitors assist electrochemical batteries in maintaining a consistent load. In addition, ultracapacitors are able to provide additional power to electric cars throughout the acceleration process as well as the regenerative braking process.

Inverter

Inverters are sometimes known as AC Drives or Variable Frequency Drives (VFD) (variable frequency drive). They are electrical devices that are able to convert direct current (DC) to alternating current (AC) (Alternating Current). Additionally, it is in charge of regulating the amount of speed and torque that electric motors produce. The output of direct current (DC) is "inverted" into alternating current (AC) as the primary function of an inverter (AC). Because alternating current (AC) is the industry standard for all commercial appliances, many people consider inverters to be the "gateway" between photovoltaic (PV) systems and the energy off-taker. The motor in your electric vehicle runs on alternating current (AC), but the battery must be charged using direct current (DC). Therefore, it is necessary to have a conversion from alternating current to direct current, either onboard the vehicle or outside the vehicle. The power that comes from the grid is always AC. The engine inverter is responsible for the transition between DC and AC as well as the capability of torque control. The frequency of the alternating current may be altered by the inverter, which allows for the rotational speed of the motor to be altered as a result. An inverter is a piece of electrical equipment that, in the broadest sense, transforms the electric current that is produced by a DC (direct current) source into an AC (alternating current) of the kind that can be used to power a machine or an appliance. In a solar power system, for example, the power that is stored in batteries and supplied by solar panels is charged by the solar panels and then converted to standard AC power by the inverter, which then supplies the power to plug-in outlets and other devices that operate on a standard voltage of 120 volts.

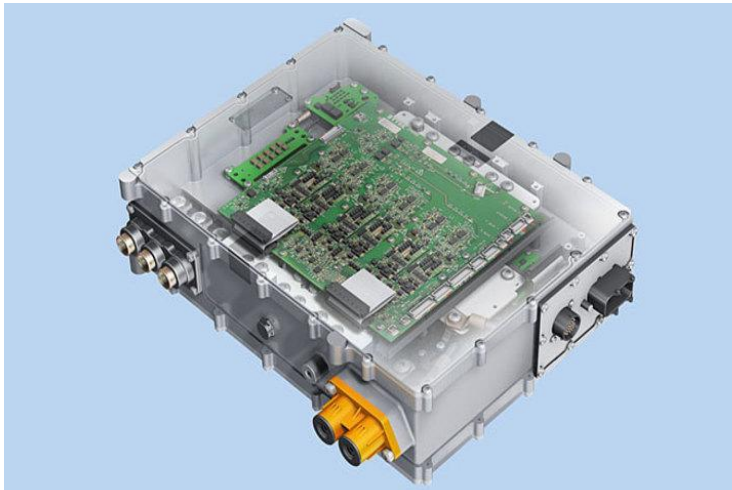

Figure 5: Inverter

DC/DC converter

A DC/DC converter is used to convert power from battery pack voltage down to 12 volts. They are used in wipers, infotainment system, mirror control. This electrical device, which should more accurately be referred to as a voltage converter, has the capability of altering the voltage (either AC or DC) of a source of electrical power. 2 There are step up converters, which raise the voltage, and step down converters, which lower the voltage. Both kinds of voltage converters are available (which decreases voltage). The most common application for a converter is to take a source of voltage that is relatively low and raise it to a higher voltage for use in heavy-duty work that requires a high-power consumption load.

Stepping down the voltage requires the use of the buck converter, whereas stepping up the voltage requires the use of the boost converter. Both the buck-boost and the Cuk converters have the ability to step either down or raise the voltage. The charge-pump converter may be used for either voltage step-up or voltage inversion, however it can only be utilized in applications that need a relatively modest amount of power.

However, converters can also be used in the opposite direction to lower the voltage for a source that is used for a light load.

Figure 6: DC Converter [17]

Charger

The charger performs three functions:

- Rectifies AC voltage from the grid to DC voltage.
- Controls the current flowing in the battery pack by controlling the DC output voltage.
- Communicates with the vehicle itself and the off-vehicle equipment.

In order to provide support to the initiative taken by the government, Pakistan State Oil has installed a charging station for electric vehicles at the Capri petrol station (F-7, Islamabad). PSO, being the largest OMC in Pakistan, is in support of the change, and the company will increase its footprint by installing charging stations as the number of vehicles increases. This will serve as an enlightenment to the automotive industry of Pakistan, which will be the result of this initiative.

Battery Management System (BMS) performs cell adjusting to deliver the best output from a battery pack, and an ECU is used in this for correspondence with different parts.

Figure 7 Charging Ports [12]

An invention in the charger has just been prototyped by Tesla, which after reaching home, automatically senses the battery power and gets inserted in it.

Snake bot type charger under test by the Tesla and shall be launched real soon [15] , another which is another advancement in this immaculate beauty of technology.

Figure 8 Snake-bot Charger by Tesla [1]

Chapter 4: PSMS Motor Selection

Because of the high torque and high-power density provided by high-energy-density PMs (neodymium Fe boron (NdFeB) and samarium cobalt (SmCo)), PMSM has been the primary option of EV manufacturers [61]. The PMSM may be broken down into two sections: the surface PMSM and the inside PMSM. Since the overload capacity of the internal-PMSM is higher compared to that of the external-PMSM [62], the internal-PMSM is often seen in electric vehicles. The price of high-energy-density PM is at least twice as expensive as the overall cost of other raw materials used in electric motors . This is due to the fact that PM has a poor yield, is not a renewable resource, and is geopolitically sensitive. Therefore, it is vital and important for the EV sector to develop methods that may cut PM costs without considerably losing performance. Both the spoke-type motor and the permanent magnet assisted synchronous reluctance motor (PMasyRM) are examples of low-cost solutions for permanent magnet (PM) motors.

Among PM-free motors, the IM has effectively broken into the market for electric vehicles because to its well-established manufacturing processes and competitive pricing. On the other hand, because of the constraints imposed by its design, the efficiency performance of the IM is worse than that of other motors [61], [63], which is not beneficial to the EV mileage. It is predictable that when more advanced motor methods are developed, the cost advantage of mature IM technology will eventually diminish due to competition from these other approaches. For instance, the SRM that has the lowest total cost of materials is attracting a growing lot of attention [64]. In order to produce the same amount of output power (30 kW), the material cost of SRM is roughly one-half of that of PMSM (NdFeB), and it is significantly less than 80 percent of that of IM. Despite this, few electric vehicles (EVs) now make use of SRM because to its poor torque density, high torque ripple, and high noise levels.

Additionally, since the method of regenerative braking can recover electrical energy for extended miles, this method is becoming an increasingly significant component of electric vehicles (EVs). The performance of electric vehicle (EV) motors has to be improved in order to maximize the amount of energy that can be reclaimed via the use of regenerative braking.

According to the research [65],[66] and [67], the amount of energy that may be reclaimed by braking is related to the torque and the efficiency of the motor, and the impact of regenerative braking is at its peak in the constant power area that is near to the base speed. In order to maximize the amount of energy that may be reclaimed via the use of regenerative braking, the electric vehicle's motor has to have the best possible efficiency as well as the widest feasible constant power range. Because of its great efficiency and large constant power range, the permanent magnet synchronous motor, or PMSM, is the electric vehicle motor that is best suited for regenerative braking, according to studies on motor design. A poor efficiency affects the energy recovery rate of the IM, which also results in a decrease in output power and a shorter constant power range. Even though the SRM is resistant to high temperatures and has a mechanical construction that is dependable, it only has a limited speed range because of its inadequate torque capacity. This makes the energy recovery effect less effective.

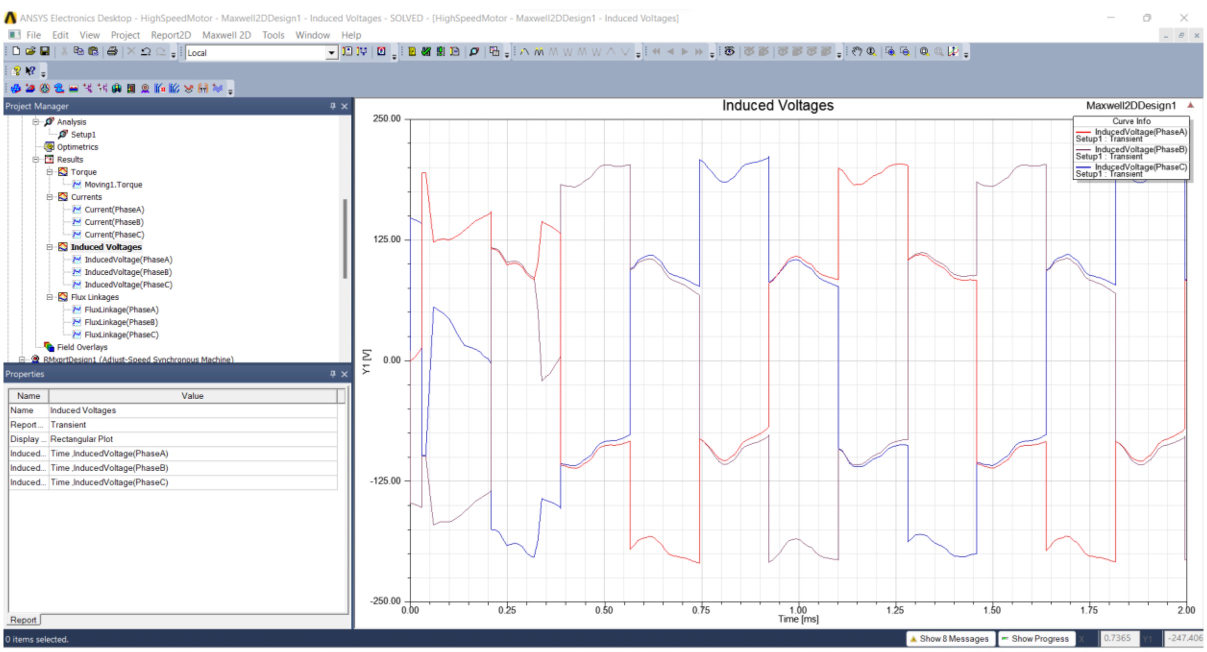

Figure 9: Induced Voltages of PSMS Motor

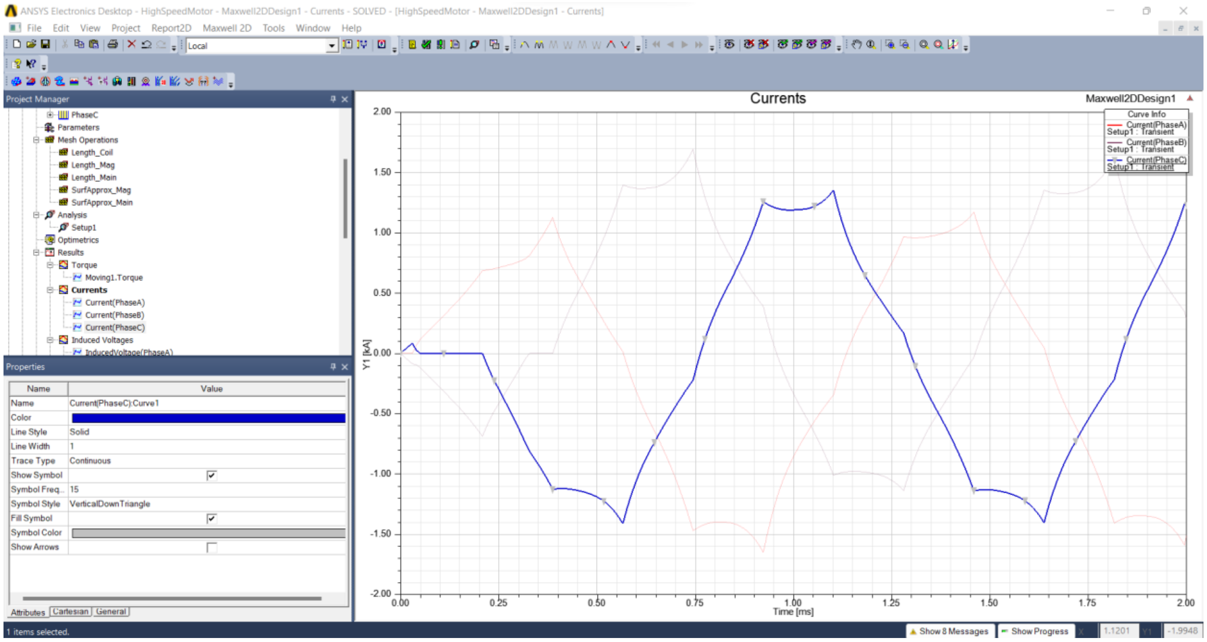

Figure 10: Three Phase Current

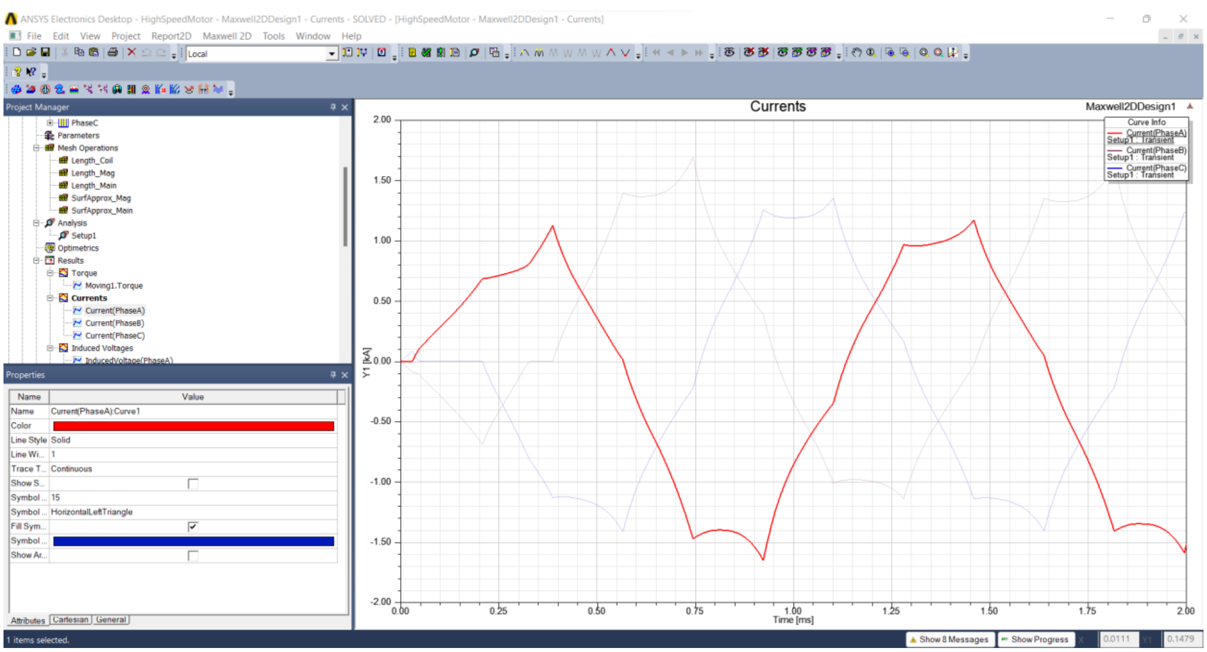

Figure 11: Current Analysis Obtained from Ansys

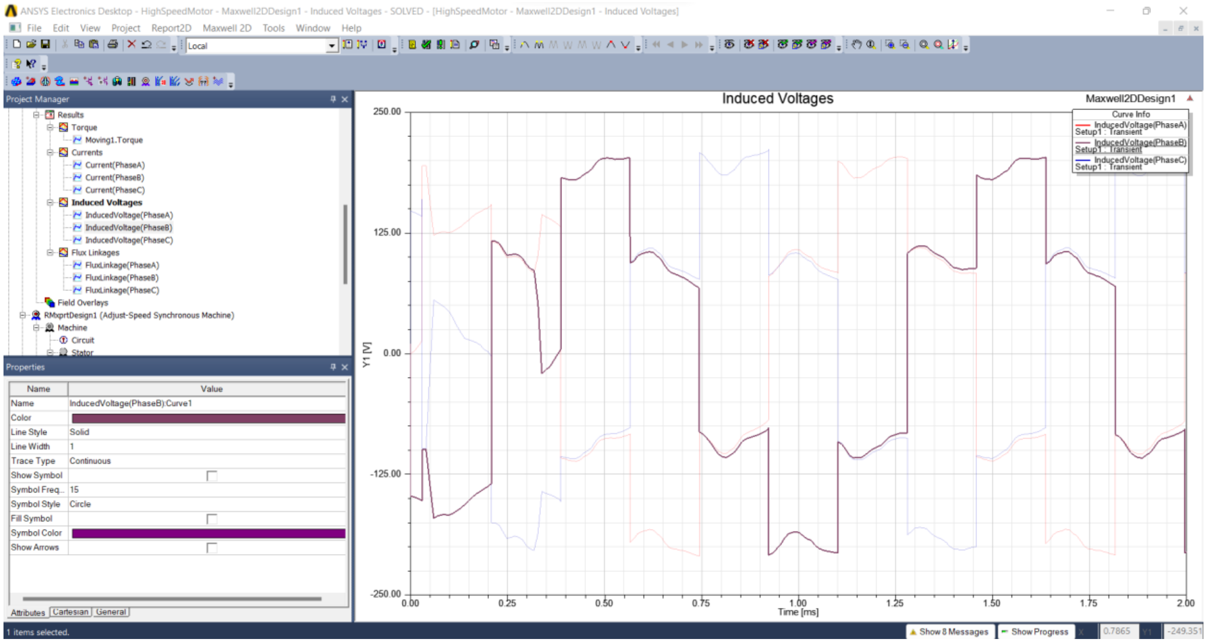

Figure 12: induced Voltage Analysis Obtained from Ansys

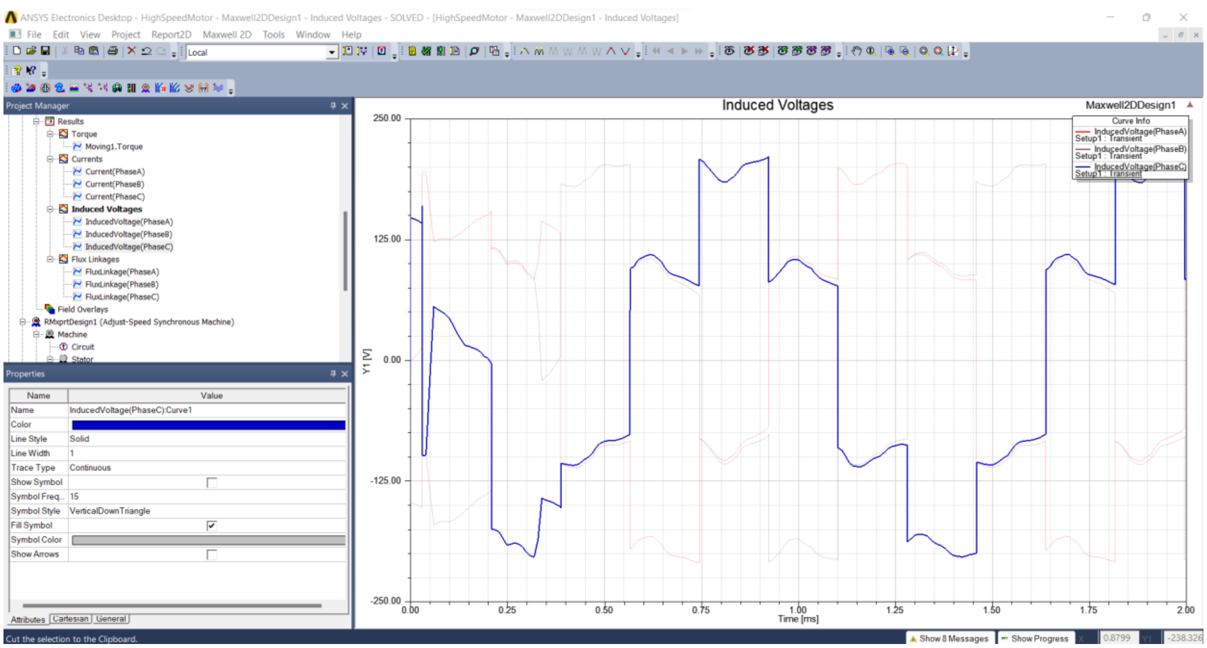

Figure 13: Voltage Input for the PSMS Battery

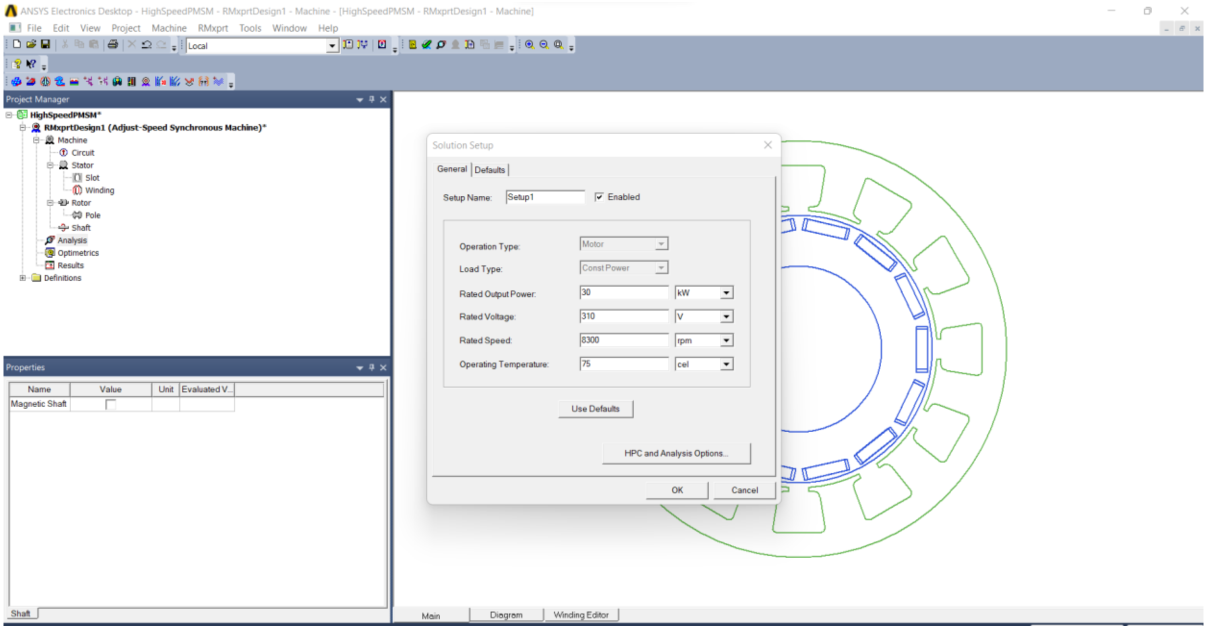

Figure 14: Parametric Model of PSMS Motor

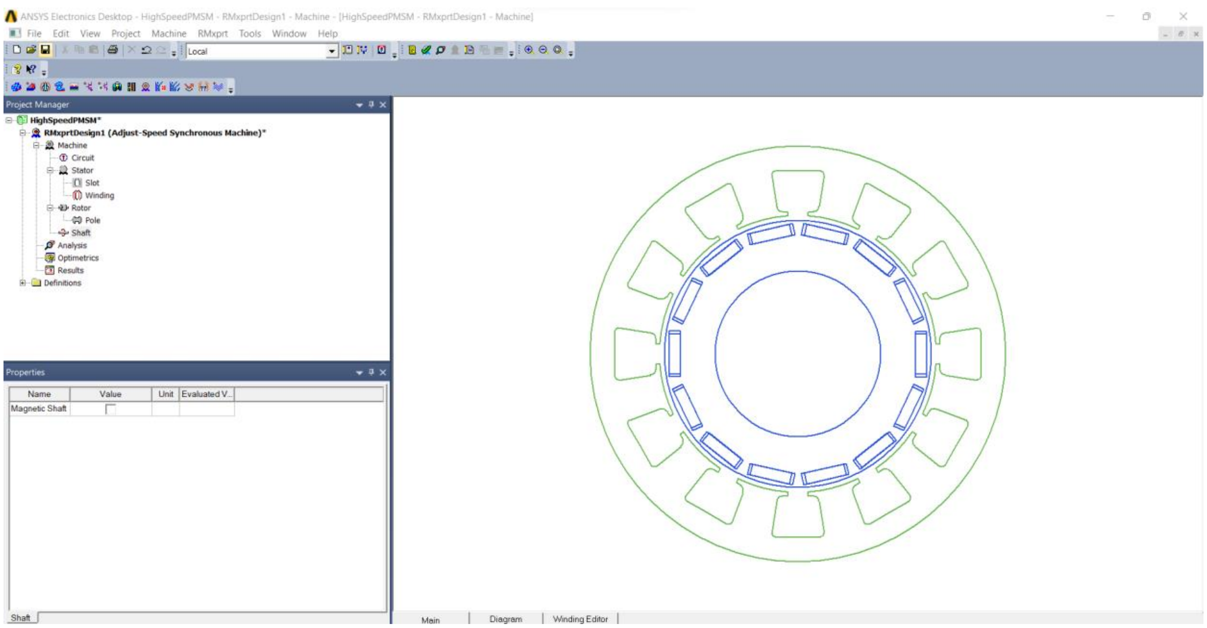

Figure 15: 2d Model of PSMS

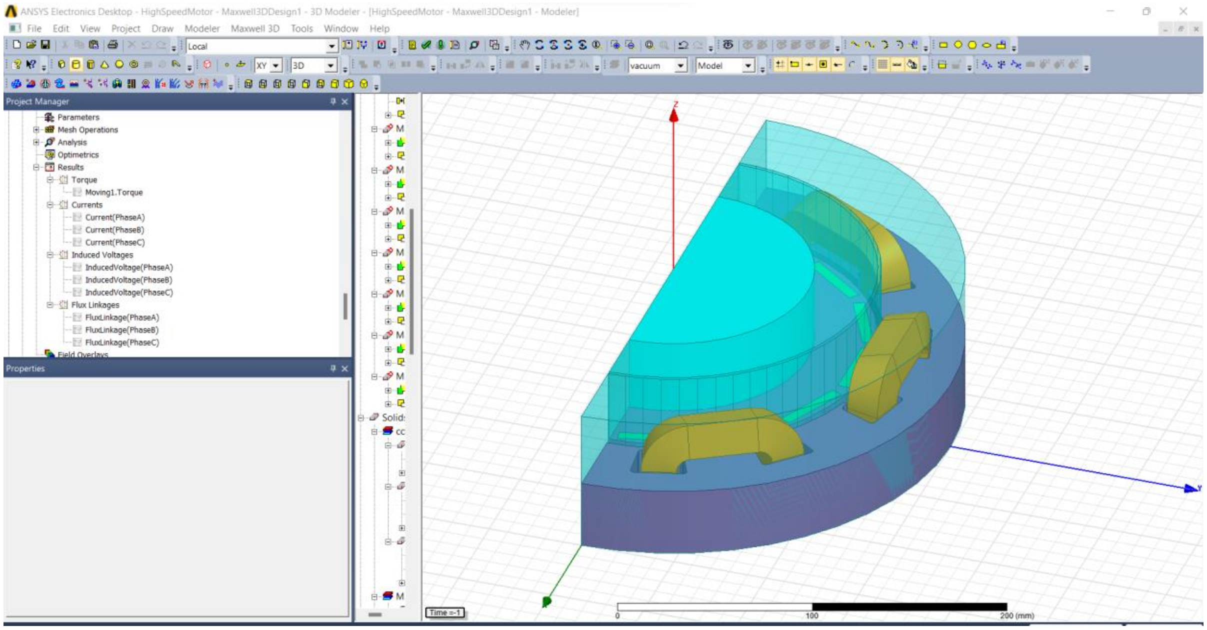

Figure 16: 3D Model of PSMS

PM motors are useful for several reasons, including their high efficiency, high torque density, and their appropriateness for long-range electric vehicles. Conquering the prohibitively costly price of the PM is a difficult task. Both the cost of the IM and its torque density are around average in PM-free motors; nevertheless, the poor efficiency of these motors is a significant drawback. The SRM clearly has a cost advantage, but it has a poor torque density, and it has problems with torque ripple and noise, both of which are detrimental to the use of electric vehicles. Following that, we will discuss and evaluate the most recent approaches that have been developed to make up for the deficiencies of these motors.

Chapter 5: Electronic Control Unit/ Module

An electronic control unit is a very small component that may be found inside a vehicle and is responsible for the regulation of one or more of its electrical systems (ECU). It gives instructions to electrical systems on what to do and how to operate properly. A microcontroller that is run by embedded software is at the heart of an electronic control unit (ECU). An electronic control unit is responsible for receiving input from one or more components of a vehicle and then using that data to take appropriate action, if necessary. For instance, an airbag electronic control unit (ECU) receives data from impact sensors as well as seat sensors. The Electronic Control Unit (ECU) is responsible for determining which passenger airbags should deploy in the event of a collision by taking into account where passengers are seated. After that, it instructs the actuators to move them into position. The electrical signal is then converted into the necessary physical value by the actuators, which may use relays, injectors, or valves. It is possible for a vehicle to contain over one hundred electronic control units (ECUs), each of which performs an essential function such as regulating the performance of the engine or the power steering, in addition to controlling various convenience and safety features such as parking assistance, memory seats, and the deployment of airbags.

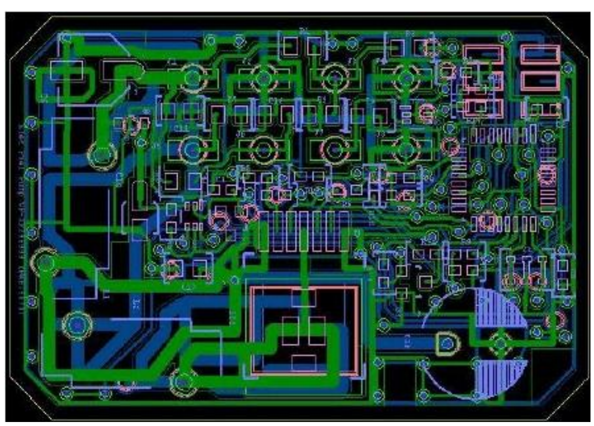

Figure 17: Electronic Control Unit [13]

The electronic control units (ECU) for electric drive and battery are the components of the on-board electronics of electric cars that have undergone the most significant transformation in recent years. An electric drive controller is installed in lieu of the engine electronic control unit, and a battery management system takes the role of the engine ECU.

Although the entirety of an electric vehicle's powertrain is significantly less complicated than that of a typical modern automobile with an internal combustion engine, the number and level of sophistication of the electronic control units (ECUs) that are distributed around road-going electric vehicles in particular continues to increase. This is due to the fact that more functions within an electric vehicle's powertrain, chassis systems, driver aids, and automation require computer control. Additionally, a greater number of them need to be certified to comply with safety requirements, notably ISO 26262, which is the regulation that oversees the safety of electrical and electronic components in motor vehicles.

ECUs in modern electric vehicles have a tendency to follow functional division patterns that are comparable to their counterparts in internal combustion vehicles. However, ECUs that are concerned with the powertrain naturally need to reflect the fundamentally different nature of systems that are based on batteries, inverters, and electric motor/generator units. According to the opinion of one industry professional, the majority of electric vehicle manufacturers use high-level architectures that share a significant amount of similarity between vehicles. Despite this, specific applications have distinct requirements for the kinds of functions and features that must be included, and distinctive selling points are given a high priority.

This is the generic layout of electronic control module, showing the programmed links and simulations.

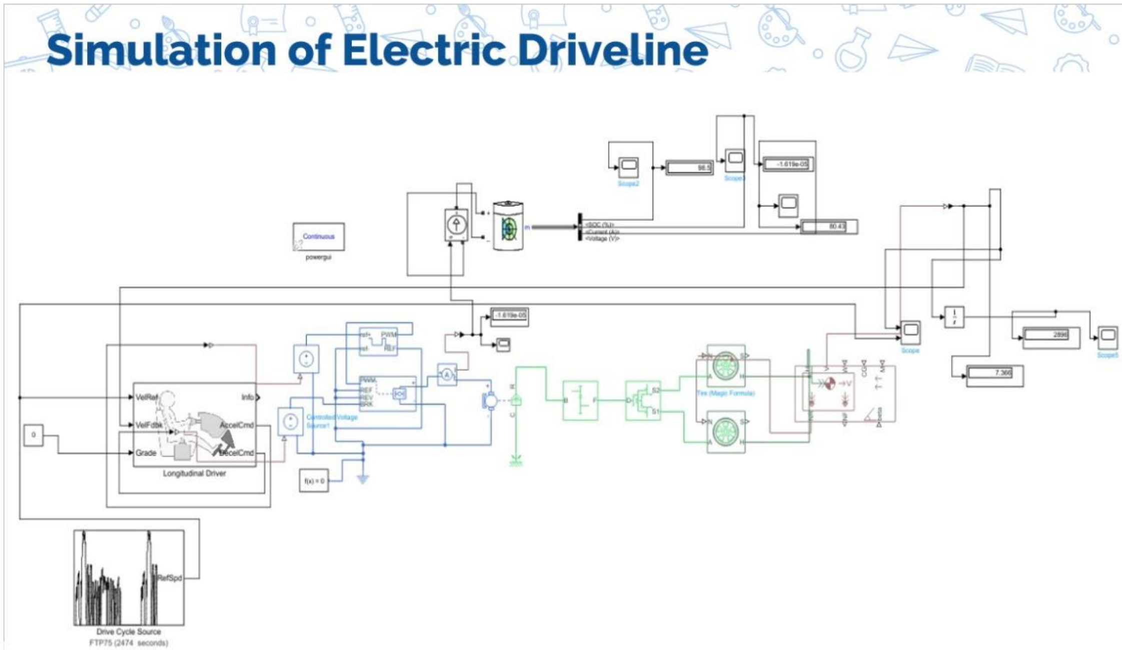

Figure 18: Electric Driveline

It is more common to classify ECUs according to the kinds of systems that they manage than by the types of vehicles they are installed in. For instance, the electronic control units (ECUs) for the lighting systems of different classes of vehicles share more features with one another than they do with the supervisory vehicle control unit (VCU) in the same vehicle. While lighting electronic control units may be found in many types of vehicles, vehicle control units are often only found in electric vehicles and hybrids. Another industry professional explains that VCUs are responsible for interpreting the intentions of the driver, whether that driver is a human person or an autonomous system, and then putting those intentions into action. As a result, it has a stringent requirement for its functional safety.

ECUs that are utilized in vehicle conversions and some other specialized markets carry out their functions in a manner that is distinct from how ECUs used in production electric vehicles do so. For instance, a vehicle control unit (VCU) designed for an electric vehicle that is intended for use on public roads would not be equipped with the necessary programming to carry out a burnout for a drag racer, or to carry out transmission shift strategies and control torque delivery in order to prevent wheelspin in the highest performance EV applications.

A fuel cell car's electric drive system is analogous to that of a battery electric vehicle or series hybrid, with the traction motor and power electronics scaled to suit the vehicle's total power requirements.

Chapter 6 : Calculations

Now we shall be calculating the tractive forces necessary to find the parameters required to select the motor with specific rpm and power:

Parameters:

$U_m = 0.0109$

Mass = 1150 kg

g = 9.81 m/s^2

Q = 5% - 20%

Density = 1.2 kg/m^3 (air)

$C_d = 0.4792$ (aerodynamic drag coefficient)

$V_a = 2m/s$ (air speed)

V_c = 60 km/hr. = 16.67 m/s (vehicle speed)

$t = 12$ s (for 0 to 60 km/hr.)

Frontal area = 2.41 m^2

Tyre size = 145/50/R12

Tyre radius = 0.1592 m

$G_k = 10$ (gear ratio)

$\eta_a = 80\%$

Tractive Force Calculations:

1. **Aerodynamic drag force** = $\frac{1}{2} \rho C_D A (V + V_A)^2$

   $F_{AD} = 864.91$ N

2. **Rolling resistance force:**

   $F_{RR} = \mu\, mg \cos \Theta$

   $\mu = 0.02$, $\Theta = 0^o$

   $F_{RR} = 122.96$ N

   Now for $\Theta = 20^o$

   $F_{RR} = 115.55$ N

3. **Linear acceleration force:**

   F=ma;

   a =0.67 (Max.)

   F = 1150 x 0.67

$F = 770.5$ N

4. **Angular acceleration force:**

$F_{AA} = (l_{axle} / r^2) \times a$

($l_{axle} = mr^2$, m = weight on axle , r = spindle radius)

$F_{AA} = 37.77$ N

5. **$F_G = 0$**

Now, we will be calculating the total force,

$\mathbf{F_{T£}} = F_{\Theta} + F_G + F_{RR} + F_A + F_{AA}$

$\mathbf{F_{T£}} = 1796.14$

Power and Torque Calculations

Now we shall be calculating the power and torque to select the motor on the basis of these further calculations:

$\mu_{rr} = 0.0109$

$C_d = 0.4792$

Mass = 1150 kg

V_a(air) = 3 m/s

g = 9.81 m/s^2

V_e(max) = 25 km/h = 6.94 m/s

Frontal area = 2.41 m^2

R (tire) = 0.1592 m

Gear efficiency = 80% = η

Gear ratio = G = 10

Elope = 5% to 20%

Density of air = ρ_a = 1.2 kg/m^3

- **Linear Distance = L.D**

L.D = 2πr = 2π (0.1592)

L.D = 1.0008 m

- **(RPM) N = (Total distance/hour)/L.D**

N = 50000/(1.0008x60)

N = 832.66 RPM

- **Angular velocity;**

ω = 2πN/60

ω = 2π(832.66)/60

ω = 67.19 rad/s

- **Torque (on wheel) = F_T(r)**

$= 1796.14 \times 0.1597$

$\tau_\omega = 285.94$ Nm

⇨ **Torque (on motor) = 1/ G(η) xτ_ω**

$= 1/10 \times 0.8 \quad \times 285.94$

$\tau_m = 34.74$ Nm

⇨ **Speed (of motor) = G(ω)**

$= 10(87.19)$

$\Omega_m = 871.9$ rad/s

⇨ **N (RPM of motor) = ω_m x 60 / 2π**

$= 871.9 \times 60 / 2\pi$

N = 8326.03 rpm

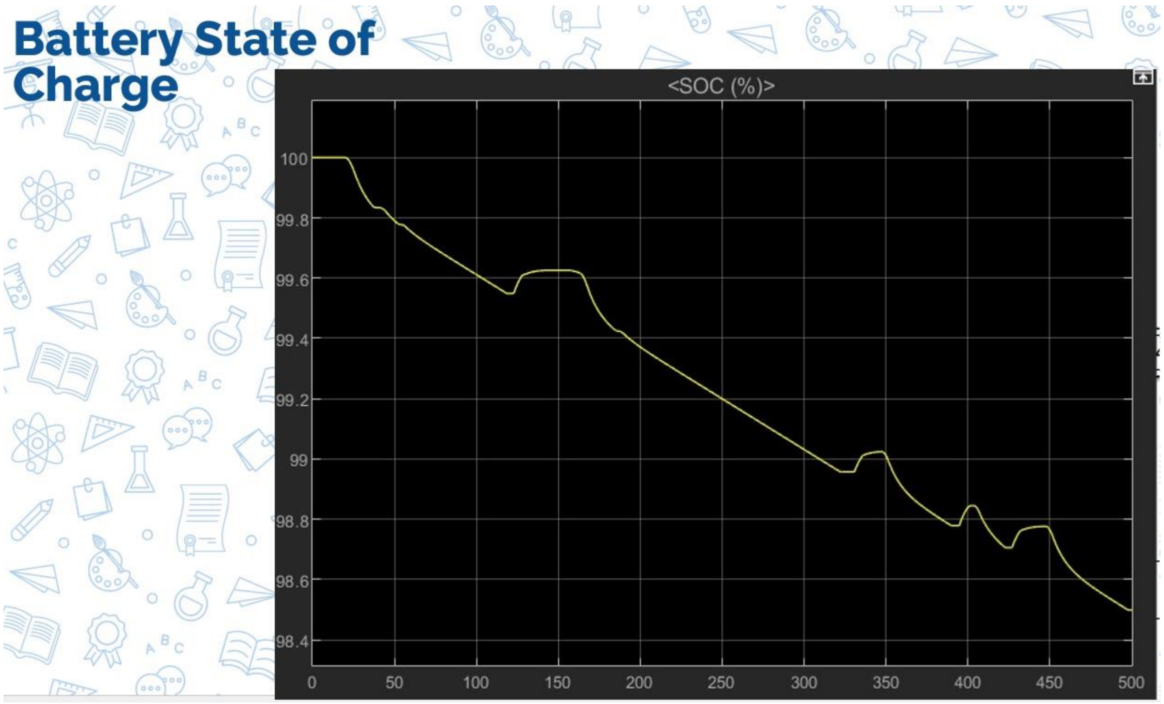

Figure 19: State of charge graph

Operation Principle

Users and potential users are provided with a variety of options thanks to the ongoing development and change of various types of electric cars. The acronyms BEV, HEV, PHEV, and FCEV are becoming more commonplace in today's world. The operation of a certain kind of electric vehicle is determined by its name. In this section, we will have a quick discussion on the many kinds of electric automobiles or vehicles that are now on the market in the world. In contrast to the very straightforward working principle of electric cars, which compels us to start by taking the Mechanical Parts apart, which includes the Engine, Gearbox, and a number of other components, After that, we have to position the electrical components.

An electric vehicle's mode of operation is based on the idea that it stores energy in lithium ion batteries, which then provide power to the electric motor, after which the power is transmitted to all four wheels of the vehicle. After installation, the electronic control unit makes the necessary measurements and distributes power to the various components in accordance with those readings.

Motivation

The motivation and precepts behind this project are listed below:

1) To reduce the cost of EVs by already converting them from previous combustion engine vehicles
2) Monetizing the disassembled parts of the ICE and related components
3) Inculcate a potential in the market to start an industry of convert SI powered vehicles into electric vehicles
4) To increase the efficacy of vehicles
5) To enhance the efficiency of vehicles by many folds
6) To reduce the pollution caused by emissions from combustions engine vehicles
7) To reduce the noise pollution
8) To use a safer and more effective way of generating energy for wheels

Conclusion:

It has been shown via research that the use of electric cars is one of the potential strategies to reduce the negative impacts of climate change on a global scale. They are much more efficient in terms of energy use than traditional automobiles. Batteries in electric automobiles convert between 59 and 62 percent of the energy needed to power the vehicle, while the conversion rate for gas-powered cars is only between 17 and 21 percent. Electric vehicles, in comparison to traditional automobiles, have a significantly reduced number of moving components. When compared to traditional gasoline-powered vehicles, electric automobiles are superior in terms of their energy economy, performance, ease of use, low maintenance requirements, and availability of tax incentives. [5] They also have a smaller environmental footprint and much less emissions. Because they lack exhaust pipes, pure electric vehicles don't release any carbon dioxide while they're being driven. This has a significant impact on lowering levels of air pollution. Electric vehicles have the potential to reduce noise pollution, which is particularly beneficial in urban areas where speeds are often modest. If you charge your electric vehicle during the day and have a solar photovoltaic system, you can reduce the amount of greenhouse gases you contribute to the atmosphere even further.

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