International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Hybrid Electric Vehicles, Architecture and Components: A Comprehensive Review

Ganta Yamini[1], Vasupalli Manoj[2], Darla Naga Sai Krishna[3]

[1,3]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

[2]Assistant Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.

ABSTRACT

The substantial rise in greenhouse gas emissions from burning fossil fuels has boosted interest in cutting-edge, pollution-free technological innovations. It paved the way for the development of modern electric cars. The advent of hybrid electric cars is a breakthrough in the history of electric vehicles. In response to the rising cost of gasoline, consumers have shown a growing interest in HEVs due to their many advantageous characteristics. Hybrid electric vehicles (HEVs) get their power from both an engine that burns fuel and batteries. In this work, we will examine the structural components of HEVs. It also includes data on the different motors and inverters that may be used in HEVs. It explains why and how an HEV's sustainability is improved by using a bidirectional converter, ultra-capacitors, and traction engines rather than just one kind of motor or converter. It provides a rundown of the components included in HEVs as well as their benefits, drawbacks, and architectures. In addition, the effect that MPPT algorithms have on the HEV's efficiency was discussed, along with the factors for selecting a hybrid storage system for energy. References are used to compare and contrast the different HESS topologies, actuators, MPPT algorithms, and already existing hybrid electric cars.

Keywords: electric vehicle (EV), photo voltaic hybrid electric vehicle (PVHEV),), hybrid electric vehicle (HEV), hybrid energy storage system (HESS), fault-tolerant controller (FTC), plug-in hybrid electric vehicle (PHEV), Maximum power point tracker (MPPT), ultracapacitor (UC), switched reluctance motor (SRM), brushless dc motor (BLDC), permanent magnet synchronous motor (PMMC).

1. Introduction

Greenhouse gases and fossil fuels are both heavily impacted by the transportation sector, which is mostly a result of human activity. For this reason, in recent years, people have been gravitating toward zero-emission electric automobiles. A switch to electric cars from internal combustion (IC) engines, which emit fossil fuels, occurred for the first time in 1881. However, if the EV's power is limited to the battery alone, it will be useless for travel beyond a short distance. Hybrid electric cars then emerged, with power coming from both the internal combustion engine and the battery. For propulsion, a hybrid electric vehicle draws on both battery power and conventional gasoline. Internal combustion engines, which run on gasoline or diesel, and chemical batteries with electric motors are some of the current power sources. In spite of this, a number of drivetrain configurations and a broad variety of power source management control systems have emerged to accommodate the many power sources in use. PHEVs and PVHEVs are two more advanced forms of EVs. Several different motors, ultracapacitors, and converter topologies exist for EVs, in addition to HEV, PHEV, and PVHEV. How those parts are put to use determines how productively an HEV can function. Critical to the operation of an HEV is the bidirectional inverter, which converts the direct current (DC) from the batteries, fuel cell, and UC, or puts them together to form AC for the motor drive. voltage-source inverters, impedance-source inverters, and current-source inverters are only a few examples of the inverter topologies available. Charging speed, power density, lifespan, cost, mass, and size are just a few of the many factors that go into determining the best energy storage system. It seems that UC and batteries will be the two most popular ESS choices for the foreseeable future. An increase in the quality of motors and generators is essential if HEVs are to meet the stringent standards for efficiency, specific power, and drivetrain cost. Traction motors in EVs and HEVs may be either a switching reluctance motor, a permanent magnet synchronous motor, an induction motor, or a brushless DC motor. The fast development of PV technology is being driven by the need to switch to renewable energy sources. Reasons for its widespread use include its lack of disruptive noise or harmful emissions, its resistance to being responsible for it, and the ease with which it may be used. To get the most juice out of a power converter, a basic charging strategy using P&O MPPT is used. All of these factors taken together will be the subject of the article.

2. Literature review

Electric traction has been identified as one of the key techniques for lowering pollution levels, improving energy efficiency, and enhancing vehicle performance. Due to its superior performance, amazing fuel efficiency, low emissions, and extended operating range, electric hybrid vehicle (HEV) propulsion provide the most practical technology. This paper analyses the state-of-the-art hybrid electric vehicle technology, namely in the places in drivetrain layout, electric motor drives, but also power storage. [1].

Since the conventional test platform for motor drives seen in hybrid electric cars is insufficient in terms of energy utilization, this research suggests a sort of power test with a parallel converter joined to a DC bus. The reliability of the testing platform is shown experimentally by the study and evaluation of energy usage ratio, active power, and extra equipment capacity. An HEV combines electrical and internal combustion engine propulsion.[2].

An array of tests has been conducted on ultrathin batteries. Data suggests that compared to a standard lead-acid battery, the ultra-battery does have a higher drain and recharge power and long cycle life (three times longer). As a bonus, the ultra-battery could be produced in the existing lead-acid factory as flooded electrolyte or nozzle designs, and it can be adapted for use in many potential uses, including standard automobiles, power tools, heavy machinery, high-power backup power, and outlying regions. The first generation of ultra-batteries has been constructed, and they are undergoing testing in both the field and the lab. If the ultra-battery proves effective, more and cheaper HEVs will be on the market. This will lead to less use of valuable fossil fuels and less release of harmful gases in areas with lots of people. [3].

This research looks at the feasibility of using a supercapacitor bank in an electric or hybrid vehicle to dampen the rapid power spikes that occur as the battery charges and discharges. This study examines the simplest implementation of something like a DC/DC converter to improve a supercapacitor bank's performance by connecting it to a shunt circuit consisting of batteries and the storage containers it is housed in. vehicle starting and stopping procedures are modeled in a computer simulation. Insights from controlled experiments on A second circuit designed as a prototype is shown. Right hybrid layout Battery health should improve noticeably after implementing an electrical energy storage device.[4].

The article suggests a permanent magnet asynchronous motor with two hydraulic ports for use in hybrid automobiles. To meet the design goals of high starting torque capability, low torque fluctuation, and minimal electromagnetic interaction between the external and internal motors, a new multi-layered design optimization approach is given. [5].

To use a trapezoidal-shaped emf Brushless DC motor, this research evaluates and contrasts several control topologies. Power quality (PQ) indicators such as total harmonic distortion, torque ripple, and power factor must be checked and confirmed to be within the limits prescribed by international standards. the efficiency of the three controllers' performances. When evaluating PI, fuzzy, and hybrid methods, it is important to evaluate the following criteria. Specify the maximum overshoot, peak time, steady flow error, and time[6].

In this paper, we discuss a specific controller architecture for creating a PMSM drive that can withstand malfunctions in mechanical sensors. To address the issue of reliability in transport and industrial implementations (aviation actuators or electric hybrid ground vehicles), a fault-tolerant controller is developed by combining this same real sensor with multiple virtual sensors (a two-long Kalman filter as well as a back emf responsive) and then the highest voting algorithm (FTC). The results from both experiments and simulations are used to evaluate the observers. The effectiveness of the FTC is shown on a 1.1-kW PMSM drive using simulation and experimental data.[7].

This study recommends a more refined direct rotor field control of a 7-phase induction machine for use in HEV systems. To eliminate noise and enhance power usage, a fuzzy controller is also advised, as shown by the dynamic system of the machine. Adding the fuel cell (HEV) and then another energy source to an electric vehicle improves the system's dynamic efficiency and responsiveness. As a form of energy storage, an UC is to enable a lower dynamic FC during rapid power changes, recovers braking energy, and absorbs accidental disturbances of a static converter. As a result, the actuator and onboard power sources may last longer. [8].

The Anti-Directional-Two-Rotary-Motor was put through its paces on the Electric Vehicles (EV) Driving Game (ADTR-motor). acts and drives as if the EV's ADTR-motor was installed and it had been driven under EV conditions. The alternator (outer rotor) of a conventional motor has been changed to rotate in the opposite direction of the rotor (inner rotor), making the Motor ADTR suitable for EV drives (inner rotor). Among the most important motor architectures for ADTR motors are the permanent magnet (PM) and the induction motor (IM) structures. Justifications for a long-term commitment are discussed. Using the EV drive simulator, we computed a magnet-type ADTR-motor and proposed using it for EV traction control.[9].

A solar electric vehicle (SEV) had been a useful mode of transportation for reducing carbon emissions and protecting the natural world because of its silent operation and lack of pollution. Power was lower in SEV. In the study, researchers developed a better strategy for maintaining audience attention during PowerPoint presentations (MPPT). Using MATLAB/Simulink, it is possible to examine how a potential improvement in technique may increase the power output of solar cells (PC). The vehicle industry eases and simplifies our lives.[10].

3. Methodology

The three most common types of electric cars are hybrids, plug-in hybrids, and plug-in electric vehicles. powered by an internal combustion engine and a rechargeable battery. Based on their design, HEVs may be classified as either series HEVs, parallel HEVs, series-parallel HEVs, or complex HEV. An electric motor coupled to an IC engine supplies power to the electric drivetrain and energy storage system of a series HEV. In a parallel HEV, the engine or electric motor is coupled mechanically to the wheels so that torque may be transmitted. In a series-parallel HEV, either the gas engine or even the electric motor, maybe both, may provide propulsion. Parallel HEV represents the most effective configuration overall. The series-parallel architecture incorporates the best features of both parallel and serial drivetrains. One mode of operation for the sophisticated hybrid system uses an electric motor to drive the back wheels, while the other uses the hybrid drive train to move the front wheels. In the second set, the front axle is propelled by an electric motor, and the rear axle is propelled by a hybrid drive system. Drivetrain complexity rises from the necessity of a planetary unit, an auxiliary electric machine, as well as other parts. To keep up with the times, plug-in hybrid electric vehicles (HEVs) were introduced. You may plug any external cable into an HEV socket to charge the battery packs. PHEVs employ a parallel HEV design. There are several HEV designs available; however, the complex hybrid is best due to its bidirectional power flow.

Automotive applications make extensive use of power converters due to their potential to increase controllability and efficiency. DC/AC converters, particularly single-stage single-phase, and solitary three-phase, including zero-voltage switching inverters, have received much research attention. Traction inverters may use a variety of topologies, such as switching losses, impedance source converters, voltage source inverters, and current source inverters. The inverter's panel determines how fast and in which way the two motors spin. For the accompanying motor to pull the tested motor, the inverter must first start the accompanied motor. Hybrid energy storage systems (HESSs) are superior to batteries, flywheels, supercapacitors, and fuel cells, all of which store energy independently. Current trends indicate that UC and batteries continue to be the two most preferred ESS technologies. High power, long cyclic life, high price per watt, and poor energy content set UCs apart from batteries, which have a cheap cost per watt hour, power density, but short cycle life & low specific power. Blending the two approaches is one way to address the problems with each one taken alone. Vehicle duty cycle, thermal characteristics, and cooling system all have significant impacts on the performance of the machine. Permanent magnet synchronous motors (PMMC), Switched reluctance motors (SRM), induction motors, and brushless DC motors (BLDC), are only a few of the motor types utilized in HEVs. A combination of the engine's axial, stator, and permanent magnetic coils can be used to control the traction motor.

MPPTs, meaning maximum power point tracker, are DC-to-DC converters that improve the compatibility of a PV array (solar panels) with a battery system or the utility grid. Solar panels (and other types of wind generators) provide DC at a greater voltage, but the low current needed to charge batteries requires a special kind of converter. HEV performance is affected by the MPPT algorithm. PVHEV was presented with a straightforward pricing method based on P&O MPPT. Together with a boost converter, this helps extract every little bit of power. The converter is powered by an algorithm that combines constant voltage operation with constant current charging on demand. Many methods are employed in the Maximum PowerPoint Tracker (MPPT). The voltage is tracked at a constant rate, which is the preferred way. The highest power point also happens to be the region of the device where the voltage varies greatly throughout a large temperature range, which is one of its main drawbacks. Poor performance, an increased price, limited range, high maintenance expenses, weak batteries, and a lack of testing are just a few of the issues plaguing EVs. It's clear that more research is needed to solve the problems with batteries, charging infrastructure, charging prices, and people's knowledge of smart charging.

4. Working and operation

The primary components of a hybrid electric vehicle are its converter, control board, internal combustion engine, batteries, fuel tank, and electric motor. We may classify these components into three broad groups.

1. Connecting the electric motor and the internal combustion engine is what we mean when we talk about drivetrains.
2. Batteries and other energy storage technologies are emphasized for their large or modest energy storage and power capacity (ESSs).
3. All ICE, HESS, and electric systems are under the command of the control system.

High-voltage electricity flows through HEVs to satisfy demand. Hybrid electric vehicles (HEVs) have electrical systems that can change the amount of power they put out based on how much power they need.

1. Powertrain 1 is the only source of propulsion for the load.
2. Only Powertrain 2 can handle the workload.
3. Two power sources, powertrains 1 and 2, provide the load at the same time.
4. Essentially, the second powertrain is driven by the weight (regenerative braking)
5. Ppowertrain 1 is the source of power for powertrain 2.
6. Powertrain 1 is the workhorse, bearing the weight while also supplying power to Powertrain 2.
7. Powertrain 1 simultaneously supplies energy to the load and Powertrain 2.
8. Powertrain 1 fuels Powertrain 2, and Powertrain 2 fuels the load
9. Load provides power to powertrain 1, while powertrain 2 receives power from the load.

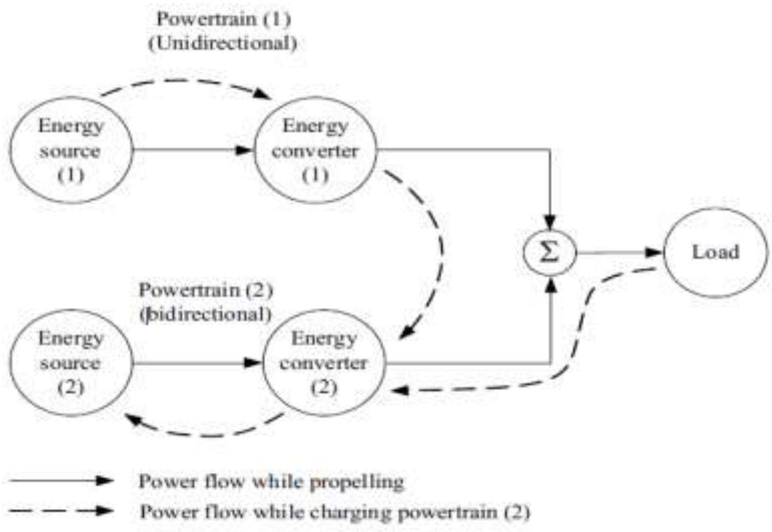

Fig. 1. Conceptual illustration of a hybrid drive train

Different architectures (configurations) can be used to accomplish this hybrid drivetrain idea.

1. *Propulsion System* with a Hybrid Battery Linked in Series: A small internal combustion (IC) engine/generator was installed in series with the EV's battery to make up for the EV's energy shortfall. Components of series hybrid drivetrains are often found in big cars because they are easy to build, easy to control, and small. These vehicles include major commercial trucks, military vehicles, buses, and even trains. Mechanically isolating the internal combustion engine from the driven wheels keeps the IC engine within its small optimum operating range. The easy speed regulation is made possible by having just one torque source for the driven wheels. When you use an electric motor, you don't need a lot of gears in the transmission because the torque-speed relationship is almost perfect.

2. *Propulsion System* with a Hybrid Battery Linked in Parallel: Because of the mechanical linkage between the engine and the electric motor in the parallel hybrid configuration, torque can be sent directly to the driven wheels. It is also possible to employ a single axle, pulley-belt device, sprocket-chain component, gearbox, or other basic mechanical connection. There are several advantages to a parallel hybrid powertrain, which comprises an electric motor as well as an engine that transmits torques precisely to the driven wheels. Because energy form conversion eliminates the need for a large generator, traction motors can be made more compact.

3. *Propulsion System* with a Hybrid Battery Linked in Series- Parallel: In a series-parallel powertrain, the engine speed is disconnected from wheel speed by using a planetary gear unit. Due to the planetary gear as well as the speed-torque connection, the attempt speed profile just on the driven wheel is almost identical to this optimal profile. With a series-parallel setup, you get the best of both worlds: faster speeds and more efficiency. There are a lot of moving parts in the drivetrain because of the requirement of a planetary unit, an extra electric machine, and some other mechanisms.

4.1 BIDIRECTIONAL POWER CONVERTER

Vehicle-to-Grid describes the two-way exchange of energy between an electric vehicle and the electricity grid. For the vehicle-to-grid system to work, the AC-DC converter must provide bidirectional power flow. A bidirectional power converter in a car-to-grid system normally consists of two stages: an alternating current to the direct current stage and a direct current to the alternating current stage. The bidirectional converter was critical in hybrid vehicles because it changes the direct current (DC) from a battery, UC, fuel cell (FC), and any combination into alternating current (AC) for the motor drive. Its many advantages include its low cost, broad output voltage range, great power density, compact size, and excellent dynamic performance. Various power inverter topologies exist, including those that rely on voltage sources, current sources, impedance converters, including soft switching.

1. *The converter of a voltage source (VSI):* Single-phase and three-phase setups are both viable use cases for the VSI in practice. Single-phase half-bridge converters, single-phase full-bridge inverters, and even three-phase VSIs, are all distinct varieties of this inverter type. VSI's benefits include excellent energy efficiency (up to 90%), low power consumption, high handling capacity, resistance to age- and temperature-related linearity degradation, and easy implementation and regulation. The main part of the waveform gets weaker, the stress on the switching device goes up, and harmonic components are made.

2. *The converter of a current source (CSI):* Current source inverters can be used in place of DC/DC converters in traction drives for EV and HEV applications, therefore removing the volume, longevity, and cost challenges that arise with VSI implementations. The CSI may be used to regulate the velocity of AC motors and induction motors with highly variable load torque. Single-phase CSI, three-phase CSI, conventional CSI, and auto-sequential shunt connected mode single-phase inverters are all examples of CSI. As a consequence of output ac filter capacitors, the voltages supplied to the motor are sinusoidal, and alternatively, spliced diodes aren't required in the switches. The output voltage may be raised above the input voltage, allowing the motor to run at higher speeds. However, CSI has a few drawbacks, including a low working frequency that prevents it from being used in UPS systems, poor performance and stability concerns under light loads with high frequency,

and the difficulty of CSI integration with batteries.

3. *The converter of an impedance source:* Impendence source inverters (also called Z-source inverters, or ZSI for short) are widely considered a reliable option in automotive applications, including drive system dependability, due to their ability to broaden the inverter's output range. The ZSI is a potential topology of converters for power electronics that could be employed in motor driving applications. To utilize the shoot-through condition in either buck or boost mode, a novel Z network is linked to the standard three-phase inverter bridge. Both capacitors and inductors are included in this circuit. The benefits of ZSI include its ability to work no matter what the input voltage is, its ability to make the necessary AC voltage output, its ability to get rid of sags without adding more circuits, and its ability to reduce motor ratings to deliver the needed power.

4.2 HYBRID ENERGY STORAGE SYSTEM:

Hybrid energy storage systems (HESSs) are superior to batteries, flywheels, supercapacitors, and even fuel cells, all of which store energy independently. Charging speed, energy density, longevity, cost, portability, and size are all important considerations when choosing an ESS. The batteries in EVs can be protected and have their lifespans extended when connected with a UC. Because the UC smooths down the fluctuating power requirements, the batteries may last longer between charges. Both UC, as well as battery parameters, may be evaluated with curve-fitting methods to get the required cell responses. It is critical to consider cell balance and redistribution when designing ESS mechanisms such as high temperature, overcharge, and discharge, but also under- and overvoltage protection systems. Its electric traction motor with HESS can be connected in several different ways.

The power in a series HEV should be transferred between the battery as well as the UC in a way that minimizes the equivalent consumption of both components. At least three significant advantages may be gained by installing HESS: the battery costs less, has greater range, and lasts longer. There are at least three major advantages to installing a HESS, and they include reduced battery costs, increased range, and increased battery life. Connecting a battery to UC might be accomplished using a bidirectional DC/DC converter. Unlike the battery, which is connected to the inverter through a DC/DC converter, the UC in an active cascaded battery/UC architecture is connected directly to the inverter terminal. Energy control is applied to a single storage component using a bidirectional quasi-DC/DC converter. With this kind of control, the battery bank supplements the UC's rapid dynamic power.

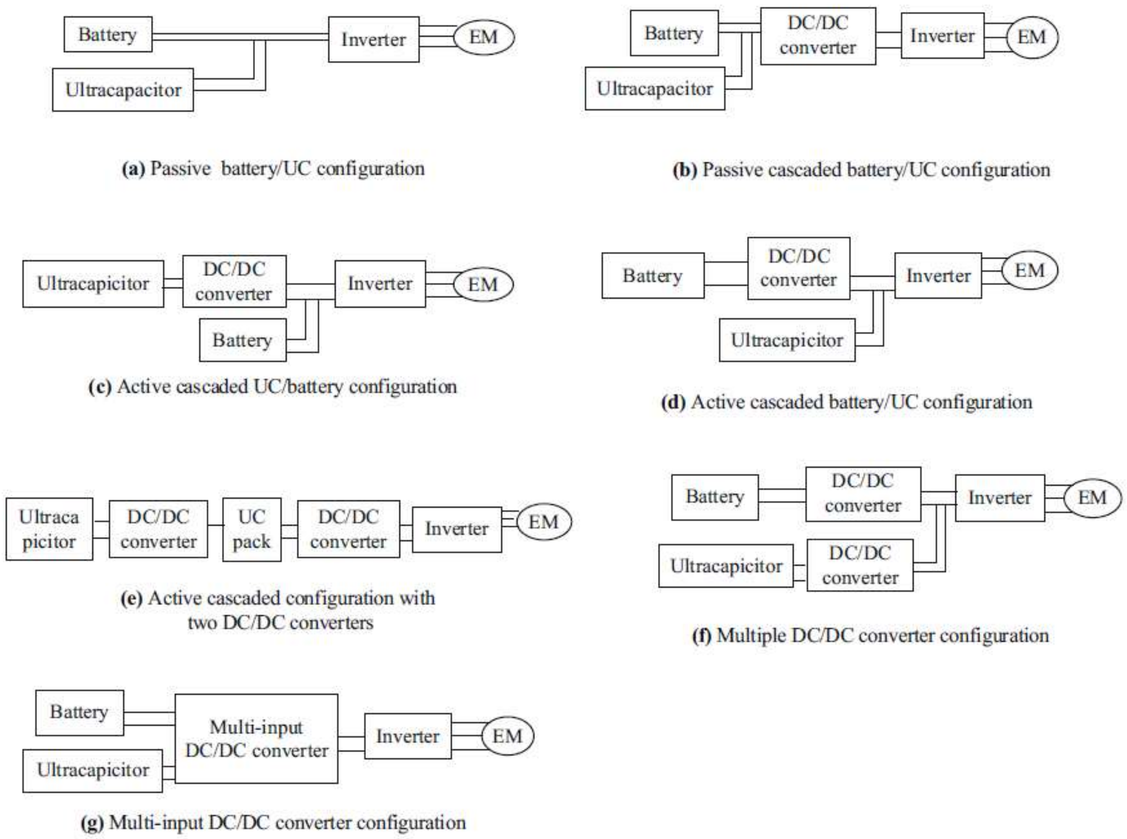

Fig 2: various UC and battery configurations that might be used.

4.3 MOTORS:

New motors and generators were desperately needed for HEVs to reach the ambitious targets set on efficiency, power density, or drivetrain cost. Light, medium, and heavy-duty vehicles, off-road vehicles, and on-highway vehicles, including locomotives, all have different motor and generator requirements. Vehicle duty cycle, thermal characteristics, and cooling system all have significant impacts on the performance of the machine. EV traction systems have come a long way since the development of new power converter topologies that allow drive control.

SWITCHED RELUCTANCE MOTOR: There has been a recent uptick in the use of switching reluctance motors (SRMs) for electric and hybrid vehicles. The advantages of these motors include superior fault tolerance, simplified control, increased durability, and remarkable torque-speed characteristics. An SRM is well suited for applications that need constant power throughout a wide operating area. It has been argued that SRM has several drawbacks, such as the need for a specific converter design, high levels of noise and torque ripple, and electromagnetic field interference. To fix the problems with SRM, like its low torque/power density and high torque ripple, a new modular (M)-SRM with hybrid magnetic paths has been made for use in EVs. It is easy to build, inexpensive, and has improved dynamic performance. To improve upon the drawbacks of using PI controllers for SRM speed control—namely, high overshoot and prolonged settling times—a fuzzy backstepping controller was designed. SRM appears to be the best choice for HEV applications, based on its highest torque capabilities and highest power density. As a way to make the system more reliable, a dual-converter-fed, four-phase SRM motor has been put in place to allow flexible, integrated charging from both DC and AC sources.

BRUSHLESS DC MOTOR: In theory, BLDC motors may be made from PM DC motors by switching the locations of the stator and rotor. Its efficiency, portability, and compactness are three of its most appealing features. A hybrid-excitation motor with five phases and brushless excitation was proposed for use in electric vehicle applications. Both the complexity and the cost of flux-weakening control methods make them impractical for general use. To address these concerns, a multispeed wrapping that can be controlled without the use of sensors is developed. Using the reverse electromotive force (EMF) signal, brushless in-wheel hubs may have their antilock braking system (ABS) streamlined. For a BLDC drive, digital PWM control is simple, dependable, current sensor-free, and computationally less demanding both in motoring and generating modes of operation. field of magnetism. After studying the BLDC motor, it was determined that post-assembly magnetization is the best method for dealing with the magnetic field problem caused by ferrous debris and forces. It alters the intensity of the magnetism. The stator and the PM, as well as the modulating ring rotor HEVs, are the parts that make up the brushless double-rotor machine (MFM-BDRM).

PERMANENT MAGNET SYNCHRONOUS MOTOR: PMSMs seem to be strong competitors to IM in HEV contexts. As compared to conventional methods, it generates less heat and has a higher power density and better efficiency. Despite this, demagnetization caused by armature reaction is a major drawback of PMSMs. Using the ADVISOR advanced vehicle simulator, we compared the PM motor and IM for HEV applications and found that the PM motor outperformed the IM on key performance measures like traction and fuel efficiency. The performance of an HEV is much improved when a PMSM is paired with a HESS. A unique PMSM drive system utilizing a bidirectional ZSI was introduced and tested with the viability and efficiency of the EV system in mind. The implementation of a bidirectional ZSI improves reliability in a PMSM drive system due to the elimination of shoot-through states, which may otherwise cause damage to the inverter in a single-stage design.

INDUCTION MOTOR: Because of their durability, economy, and minimal maintenance needs, IMs are widely employed as the driving force for EVs. In the event of an inverter failure, these motors automatically de-excite, adding an extra layer of safety. Power density and efficiency are both improved when using an IM as opposed to a DC machine. Instant messaging provides a wide variety of speeds and efficiency levels. Copper mouse cage rotor motors are shown to be more efficient than aluminium rotor motors. For IM drives to work as well as possible, the main control strategy is paired with a technique for reducing losses.

It has been found that there is a sizable audience interested in high-tech traction motors driving hybrid vehicles and that there is a multitude of traction motors available. Permanent magnet AC motors, however, are often used when trade-offs involving performance, robustness, durability, as well as cost are considered. Several approaches have been offered for monitoring this MPP, with the most well-known one being constant voltage tracking; however, this approach has limitations when the temperature fluctuates. Both disturbed and observing (P&O) and control algorithm are common methods for getting around them (IC).

4.4 MPPT ALGORITHMS IN HEV:

In light of the growing need to transition to renewable energy sources, PV technology is rapidly exceeding competing alternatives. Reasons for its widespread use include its lack of disruptive noise or harmful emissions, its resistance to being responsible for it, and the ease with which it may be used. Connecting electronic and electrical devices to the MPP controller has the potential to increase the PV system's efficiency. However, in IC, MPP is determined by monitoring dip/DV, where p is the energy and v are indeed the voltage, rather than by the load impedance, which varies periodically in P&O and catches changes in the direction. The system's inefficiency stems from the fact that it often approaches the minimum power point (MPP) in P&O. Adaptability to changing climatic conditions is an advantage of IC, while ease of installation is a plus for P&O. To control the ever-changing levels of solar irradiation, P&O, and IC-based methods may be used. They provide the most applicable scenario and optimal solution when driving. Effective output control is very helpful in a dispersed MPPT because it lets each MPPT have its power source.

Results and Discussion:

Table 1: Comparison of the HEV-specific MPPT algorithms:

Sensed parameters	Periodic tuning	Convergence speed	Implementation complexity	MPPT technique
Varies	Yes	Fast	High	Neural network
Varies	Yes	Fast	High	IC

Voltage	Yes	Medium	Medium	Fractional Isc
Current	Yes	Medium	Low	Fractional Voc
Voltage and current	No	Varies	Medium	FLC
Voltage	No	Varies	Low	P&O

Table 2: Analysing and contrasting the several presently available HEVS Contrasting different HESS topologies:

Vehicle	Driving mode	Driving range	Structure	Efficiency	Fuel type	Disadvantage	Advantage	Overall cost	ESS
PVHEV	City and highway	High	Complex	High	Gasoline + Electric	1. very high initial cost 2.extra component	1. High efficient 2. Low emission and large size 3. Quiet and smooth operation 4. reliable	Low	The fuel tank, PV panel, battery, and, ultracapacitor can be charged from an outlet.
PHEV	City	High	Complex	High	Gasoline + Electric	1. High initial cost 2. Impact on the grid	1. High fuel efficient 2. Low emission 3.V2G OR G2V capability 4. Quiet and smooth operation	Medium	The fuel tank, battery, and ultracapacitor can be charged from an outlet.
ICV	City and highway	High	Simple	Medium	Gasoline	1. Harmful emission 2. Poor fuel economy	1. Matured technology 2. Better performance 3. Simple and reliable 4. Commercialized	High	Fuel tank
BEV	City	Low	Simple	High	Electric	1.Poor dynamic response 2. Recharge time is high	1. Pollution free 2. Efficient	Low	battery, and ultracapacitor
HEV	Highway	Medium	Medium	Low	Gasoline + Electric	1. Bulky 2. number of components	1. Low emission 2. High fuel economy 3. Reliable and durable	Medium	fuel tank, battery, and ultracapacitor

Table 3:Contrasting different HESS topologies:

Disadvantages	Topologies	Advantages
Discontinuous output current	Non-isolated topology in Fig. 2g	One small inductor no transfer capacitor voltage, lower switch/diode voltage ratings, lower switching/ conduction losses
Having two large inductors higher transfer capacitor voltage ratings	Non-isolated topology in Fig. 2f	Reduced input/output current ripples
Two large inductors, discontinuous output current, a larger output capacitor, and a higher switch/diode voltage rating	Non-isolated topology in Fig. 2e	Lower transfer capacitor voltage rating
Bulky, heavy, costly magnetic core, higher EMI, higher-voltage stress across switches	Isolated topology in Fig. 2b Isolated topology in Fig. 2c Isolated topology in Fig. 2d	Higher galvanic isolation, higher-voltage conversion ratios

Table 4: Analyzing the performance of different HEV motors:

	PM	Brushless dc motor	Polyphase induction	Switched reluctance
Examples	Nissan/Tino, Honda/Insight (Japan), Toyota Prius (Japan), etc.	Peugeot Citroen/Berlingo (psa) (France)	Renault/Kangoo (France), Chevrolet/ Silverado (USA), etc	Holden/ECOmmodore (Australia)
Efficiency with motor and power electronic devices (%)	90	78	84	85
Efficiency with power electronic devices only (%)	93	98	93	90
Efficiency with motor only (%)	97	80	90	94
Cons	Susceptible to damage if dropped, requires maintenance, bulky and limited rotation speed	Very expensive, limited economy to small-sized motors	Expensive controller	Not very powerful full, ripple in torque and requires position sensing
Pros	High starting torque	Outstanding torque and speed, fast responses, tremendous power, and long life	High efficiency	Low inertia can be tailored for specific applications and runs cool
Controller cost	Medium	Very high	High	High
Commutation method	Mechanical commutation	Internal electronic	External electronic	External electronic
Weight	Medium	Low	Medium	Medium
Overall cost	Medium	High	Medium	Medium
Application	HEVs, EVs, and ICVs	HEVs, EVs, and ICVs	HEVs, EVs, and ICVs	ICVs
Efficiency	High	High	High	Less than PMDC
Speed range	Limited by brushes, easy control	Excellent	Controllable	Controllable
Starting torque	>200% of rated torque	>175% of rated torque	High	Up to 200% of rated torque
Speed control method	PWM	Frequency-dependent	Frequency-dependent	Frequency-dependent
Maintenance Requirement	Brushes wear	Low	Low	Low
Power to stator	PM	Pulsed DC	AC	Pulsed DC
Power to rotor	DC	PM	Induced	Induced
Family	Separately excited	Synchronous excited PM	Induction slip ring squirrel cage	Synchronous unexcited
Type	DC	AC	AC	AC

6. Conclusion:

With their reduced harmful emissions and petroleum consumption, HEVs are soon becoming a viable alternative to the present form of transportation. The test station has a much lower energy consumption ratio compared to conventional test platforms. For this reason, the motor test consumes less power throughout the evaluation. The power factor may also be adjusted to suit the power grid's requirements. The asymmetric supercapacitor and lead-acid battery are combined in a single unit cell to create a hybrid device for energy storage that incorporates the best features of both technologies. It just takes two dynamic power switches, two power, to create the controller required to get the most out of the supercapacitor. To effectively achieve the trading layout between both the design objectives of torques, harmonic distortion, and magnetic coupling, the quasi level, mild-sensitive tier, and strong-sensitive level of primarily due to the high method, the response surface technique, and the MOGA method are used. filters, inductors, and diodes. However, due to challenging control challenges, the optimal control method has not been completely achieved. when an absolute decoder failure (complete outage) occurs in a PMSM drive, recovery may take place at low or medium speeds without any load. A seven-phase transformer is used to power the HEV, and it is under control methods using fuzzy controllers. By modeling it, we can see that the seven-phase induction generator consists of three parts. To begin, components are the primary source of electromagnetic torque. However, voltage harmonics are a real problem with mechanical and electrical power, since they are not engaged in the formation of torque. Suggestions for traction control that boost acceleration are as useful as maintaining steady traction. It is possible to get a PC's output power very near to its maximum point using MPPT management. This may help the computer make better use of its resources. Adding this feature may extend the range of the SEV. Perhaps the battery's lifespan will be increased. Listed below are the prerequisites, and you'll find all the information you need in this article.

References

1. Gao Yimin, Ehsani M, Miller J (2005) Hybrid electric vehicle: overview and state of the art. Proc IEEE Int Symp Ind Electron (ISIE) 2005:307–316.
2. Liwei S, Zijian L, Qianfan Z, et al (2007) Research of an energy-fed induction motor driving test platform with double inverters for HEV. In: VPPC - Proc IEEE Veh Power Propuls Conf, pp 531–535.
3. Lam LT, Louey R (2006) Development of ultra-battery for hybrid-electric vehicle applications. J Power Sources 158:1140–1148
4. Pay S, Baghzouz Y (2003) Effectiveness of battery-supercapacitor combination in electric vehicles. In: 2003 IEEE Bol powertech—conf proc vol, 3, pp 728–733.
5. Xiang Z, Member S, Zhu X et al. (2016) Multilevel design optimization and operation of a brushless double mechanical ports flux—switching permanent magnet motor.0046:6042–6054
6. Ashok RB, Kumar BM (2017) Comparative Analysis of BLDC motor for different control topology. Energy Procedia 117:314–320.
7. Akrad A, Hilairet M, Diallo D (2011) Design of a fault-tolerant controller based on observers for a PMSM drive. IEEE Trans Ind Electron 58:1416–1427.
8. Iffouzar K, Amrouche B, Otmane Cherif T, et al (2017) Improved direct field-oriented control of multiphase induction motor used in hybrid electric vehicle application. Int J Hydrogen Energy 42:19296–19308.
9. Yoshimoto K, Kawamura A, Hoshi N (1998) Traction control of anti-directional-twin-rotary motor drive based on electric vehicle driving simulator. In: PESC 98 Rec 29th Annu IEEE power electron spec conf (Cat No98CH36196), vol 1, pp 578–582.
10. Shuang DU (2013) Algorithm research on maximum power point tracking of a solar electric vehicle. In: Proceedings 2013 international conference on mechatronic sciences, electric engineering, and computer (MEC), pp 74–78
11. Al-Sheikh H, Bennouna O, Hoblos G, Moubayed N (2014)Power electronics interface configurations for hybrid energy storage in hybrid electric vehicles. In: 17th IEEE mediterr electrotech conf (MELECON), pp 122–126. https://doi.org/10.1109/melcon.2014.6820518
12. Groen BC (2011) Investigation of DC motors for electric and hybrid electric motor vehicle applications using an infinitely variable transmission. Brigham Young University, Provo.:https://scholarsarchive.byu.edu/etd. Accessed 15 Feb 2018
13. Manoj, V., Sravani, V., Swathi, A. 2020. A multi criteria decision making approach for the selection of optimum location for wind power project in India. EAI Endorsed Transactions on Energy Web, 8(32), e4
14. Dinesh, L., Sesham, H., & Manoj, V. (2012, December). Simulation of D-Statcom with hysteresis current controller for harmonic reduction. In 2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM) (pp. 104-108). IEEE
15. Manoj, V. (2016). Sensorless Control of Induction Motor Based on Model Reference Adaptive System (MRAS). International Journal For Research In Electronics & Electrical Engineering, 2(5), 01-06.
16. V. B. Venkateswaran and V. Manoj, "State estimation of power system containing FACTS Controller and PMU," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282281
17. Manohar, K., Durga, B., Manoj, V., & Chaitanya, D. K. (2011). Design Of Fuzzy Logic Controller In DC Link To Reduce Switching Losses In VSC Using MATLAB-SIMULINK. Journal Of Research in Recent Trends.
18. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of switching losses in VSC using DC link fuzzy logic controller Innovative Systems Design and Engineering ISSN, 2222-1727
19. Dinesh, L., Harish, S., & Manoj, V. (2015). Simulation of UPQC-IG with adaptive neuro fuzzy controller (ANFIS) for power quality improvement. Int J Electr Eng, 10, 249-268.