METHOD AND PROCESS FOR INDEPENDENT POWER SUPPLY OF AN ELECTRIC TRACTION CAR

Dr. Archana Shirbhate[*1], Prof. Dr. Reena Singh[2] & Prof. Dr. B.K Sarkar[3]
[*1]Associate Professor, Anjuman College of Engineering and Technology, Nagpur
[2&3]MES, GEH Research, MH, India

Abstract:
Due to the need for more environmentally friendly transportation and the widespread use of electric and plug-in hybrid cars, the availability of electric vehicle (EV) charging stations has emerged as a significant problem for automakers and a significant research challenge worldwide. In fact, several research projects focusing on advanced power electronics topologies and the optimisation of EV charging stations in terms of power transfer and location are motivated by the high cost of battery energy storage, the limited EV autonomy and battery lifespan, the battery charging time, the deployment cost of a fast charging infrastructure, and the significant impact on the power grid. There are three distinct charging levels that may be identified, each with a different output power and charging time. The charging process moves forward more quickly the higher the charge level, but at the price of power quality problems and disruptions as more power is sent to the car. Inductive recharging (contactless power transmission), conductive charging systems, and battery swapping are the three different types of charging systems that may be recognised. Additionally, EVs include fuel cell (FC) EVs, which use hydrogen as their major source of energy and are now the subject of substantial study in both academia and industry. This review article seeks to provide an up-to-date overview of significant developments in power electronics designs for electric vehicle traction motors and battery-powered EV charging infrastructure.

Keywords: Method, Process, independent, power supply, electric, traction, car.
DOI: 10.24297/j.cims.2023.6.23

1. Introduction

The widespread use of hybrid, plug-in hybrid, and fuel cell (FC) cars [4,5] has been made possible by the growing awareness of global warming, improvements in battery storage systems in power electronics [1,2,3], and electric motor technologies. Electric vehicles (EVs) are becoming more and more prevalent, which may have negative effects on the performance and efficiency of the power grid in the near future [6]. These effects include overloading, decreased efficiency, problems with power quality and disturbances, and voltage regulation, particularly at the distribution level. As a result, the quick adoption of electric cars necessitates the development of a sophisticated infrastructure of both

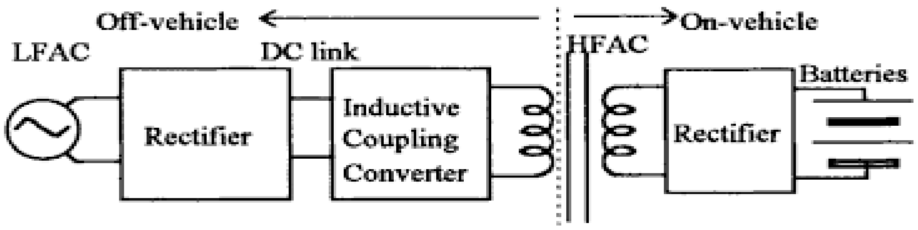

Fig.1: Method and Process for independent power supply of an electric traction car Flow.

Electric cars for use in passenger and light-duty applications are close to becoming commonplace [2,][1][3]. The goal of eliminating fossil fuels from transportation and reducing environmental damage is what motivates this. Compared to conventional internal combustion engine (ICE) cars, electric vehicles have a number of benefits, including fewer moving parts, greater efficiency, increased starting torque, lower maintenance and operating costs, and the capacity to run on locally generated renewable energy [1][4]. Mass EV adoption is not without obstacles, though. For example, EVs are typically more expensive than ICE cars, mining and processing lithium are costly and damaging to the environment, batteries' weight and lifespan are crucial [1][5], and public charging infrastructure is still developing.

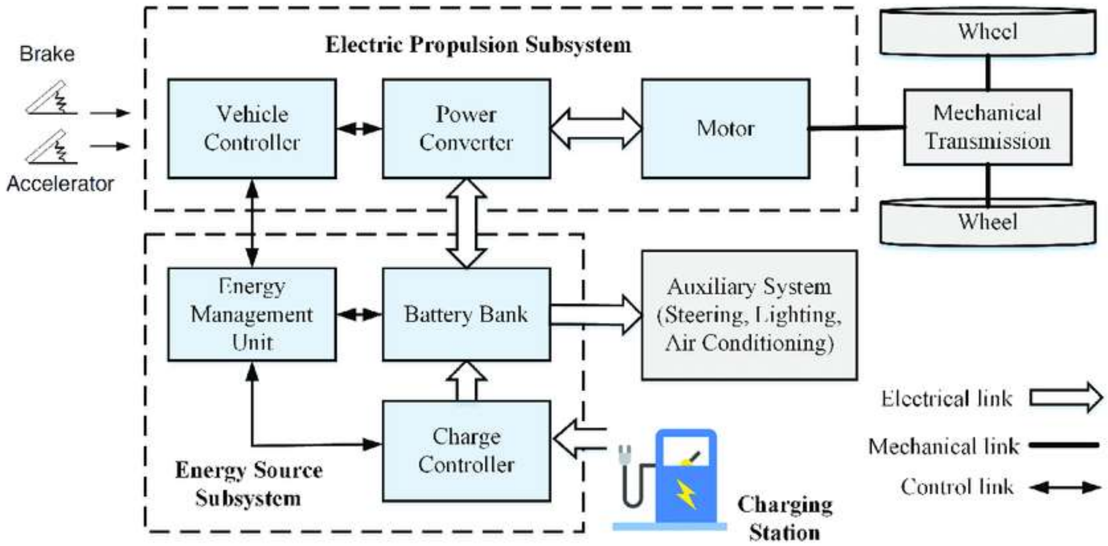

Fig.2: Method and Process for independent power supply of an electric traction car Process

Additionally, uncontrolled bulk charging of EVs has the potential to cause major disruptions in the electrical system [[6,[7],[8]. Customers must wait a long time for electric cars to fully recharge since they take many tens of minutes to several hours, as opposed to the few seconds to a few minutes it takes ICE vehicles to refill [19,20]. It is important to note that the autonomy of medium-range electric vehicles (EVs) is currently relatively constrained and limits their application to urban settings [1,2]. On the financial front, advancements in technology and cost savings associated with increased production capacity in manufacturing facilities will result in a decline in the cost of batteries, which now stands as the most prohibitive expense for electric vehicles.

2. Charging Stations Technologies

This section presents two aspects related to electric vehicles and charging stations infrastructure as follows:

- Departing from a mechanical study and WLTP driving cycle, presenting the requirements in terms of torque, power, and energy of a vehicle. Then, presenting all possible technologies of vehicles: ICE vehicles, hybrid vehicles, and electric vehicles.
- Presenting charging stations technologies for electric vehicles and refueling stations for fuel cell *vehicles.*

Power and Energy Requirements

To evaluate the power and energy requirements for light vehicles, Worldwide harmonized Light vehicles Test Procedures (WLTP) are used [,5][1]. The purpose of these procedures is to ensure that the real-life conditions of use of vehicles and their current technologies are better taken into account during certification.

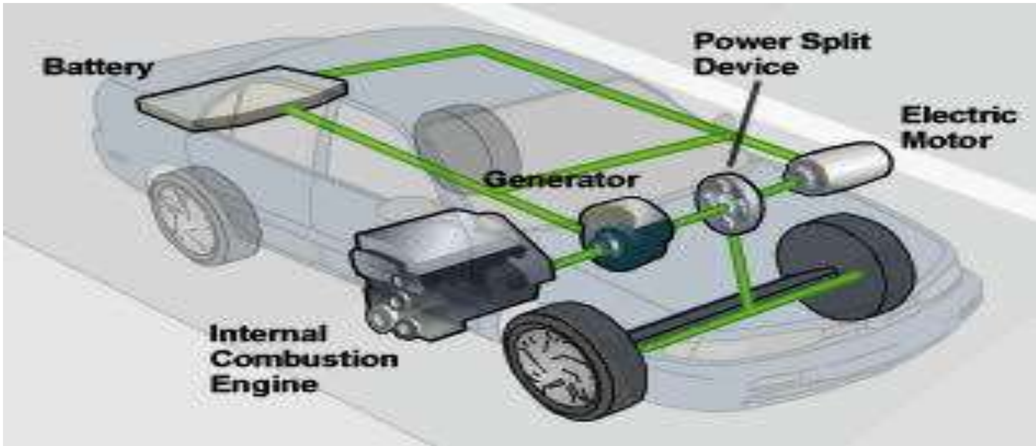

Fig.3: Method and Process for independent power supply of an electric traction car Look.

Worldwide Harmonized Light Vehicles Test Procedures

WLTP is a vehicle testing and certification standard that measures fuel consumption, electric range and CO_2 and pollutant emissions [52]. This test procedure mainly applies to passenger cars and light commercial vehicles while other procedures concern motorcycles and heavy vehicles.

3. Vehicles Technologies

Numerous vehicle technologies can be taken into consideration based on the power and energy needs previously described. In fact, cars may be categorised based on the employed motors as either hybrid vehicles, which combine ICE and electrical motors, or vehicles with 1 motor, which include ICE vehicles, BEVs, and FCEVs [5][7,6][10]. Other than that, it may be divided into three categories based on the energy storage systems employed: a petrol tank for ICE cars, batteries that can be connected to supercapacitors for BEV [61], and a hydrogen tank and battery for FCEV vehicles.

Internal Combustion Engine Vehicles

The vehicle is propelled, moved, or powered by an internal combustion engine, which converts the chemical energy of the fuel into kinetic energy [6][2[6][3]. Natural gas or petroleum-based fuels like petrol, diesel or fuel oil are the most common sources of energy for ICEs [6][4]. Additionally, biofuels like biodiesel and bioethanol, which are frequently combined with fossil fuels, are utilised [6][5,][9]. Rarely utilised hydrogen is now supplied mostly from fossil fuels (grey hydrogen) and infrequently from sources of renewable energy (green hydrogen) [6][7].

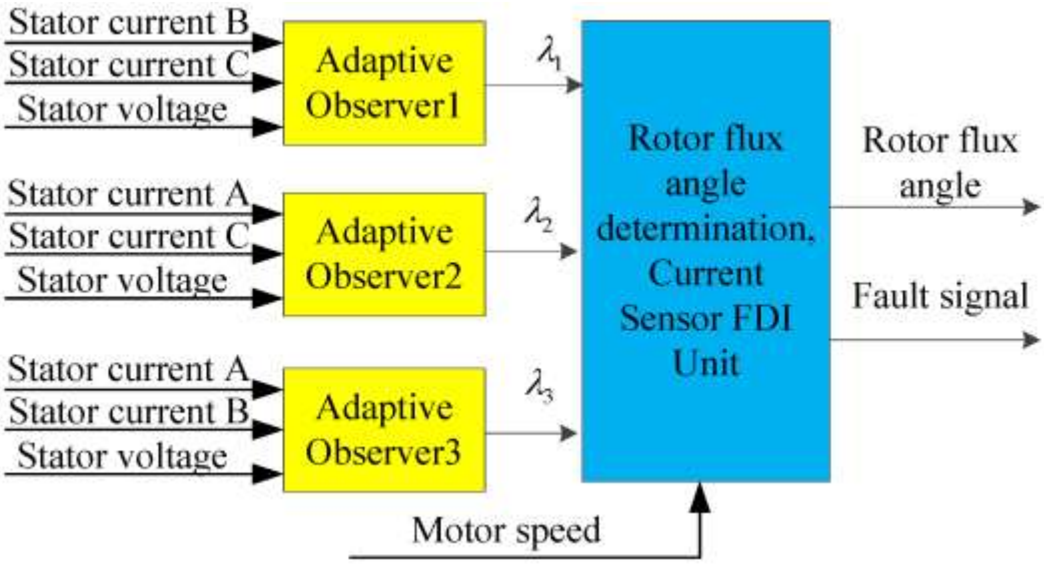

Fig.4: Method and Process for independent power supply of an electric traction car Internal Method.

Energy use for class 3 cars is around 250 Wh/km, which equals 25 kWh to reach a range of 100 km. The amount of thermal energy needed to go 100 km is 83.33 kWh, assuming a thermal engine efficiency of 30%30%. Diesel has a 9.7 kWh/L energy density, therefore a class 3 car uses around 8.59 L and generates about 22.3 kg to travel 100 km (223 g/km). The overall range of this kind of vehicle is 814 km if the tank has a capacity of 70 L.

Hybrid and Plug-In Hybrid Vehicles

A hybrid electric vehicle (HEV) is a vehicle that contains a second source of reversible energy storage in the form of hydraulic, pressure, kinetic, or electrochemical energy in addition to its primary energy source (chemical energy of the fuel) [,7][1]. Typically, HEVs power the wheels with an ICE and an electric motor connected to a battery energy storage system. By doing so, the ICE is run at its highest level of efficiency, and the electric motor enables the achievement of acceleration stage [7][2]. In fact, an electric motor is better at creating torque while an internal combustion engine is better at maintaining high speed. HEV includes plug-in hybrids, complete hybrids, mild hybrids, and micro hybrids [7][3,7][4].

Battery Electric Vehicles

The power needed for the traction/propulsion in a BEV is provided by the battery energy storage system (BESS) [][2[4,]. The battery capacity and driving style of the EV determine its range. These days, batteries having a DC voltage between 360 and 400 volts are utilised to increase the voltage to 800 volts [8][4,[5]. EVs are propelled by a variety of electric motor technologies, including wound rotor synchronous motors, induction motors, permanent magnet synchronous motors, and internal permanent magnet synchronous reluctance motors (IPMSynRM). the standard power conversion unit for a BEV. BEV can operate in two different operating modes: battery mode and regenerative braking mode. In battery mode, the power is transferred to the motor that drives the wheels through a boost DC/DC converter followed by DC/AC converter. In regenerative braking mode, EV kinetic energy is converted to electricity and stored in the battery.

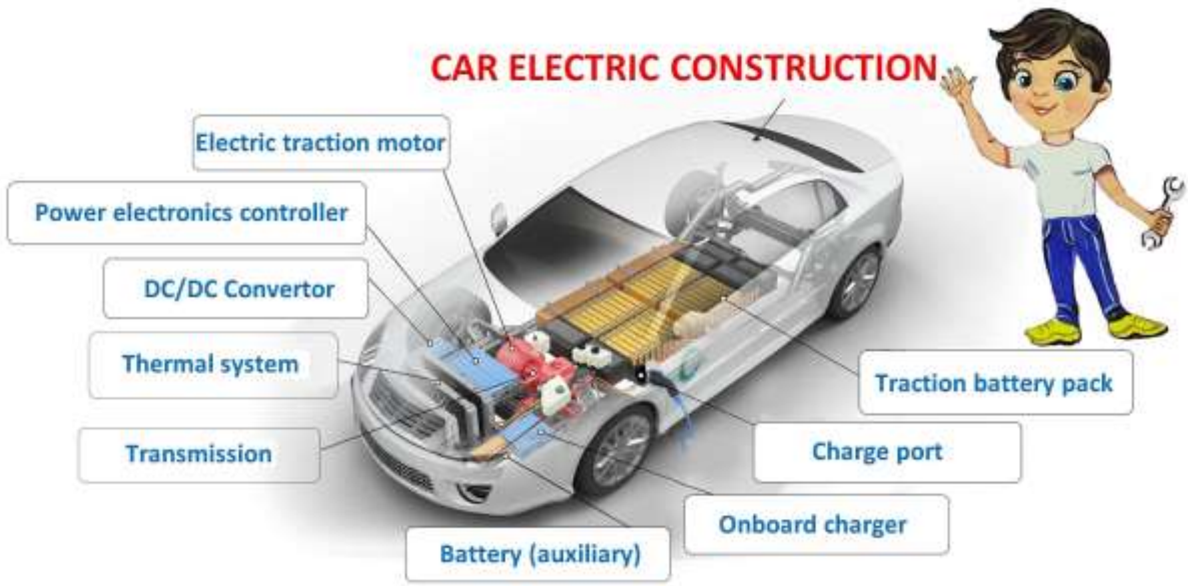

Fig.5: Method and Process for independent power supply of an electric traction car

Fuel Cell Electric Vehicles

As shown in Figure 7b, a fuel cell electric vehicle (FCEV) is an electric vehicle that powers its onboard electric motor using a fuel cell in conjunction with a tiny battery or supercapacitor]. The fuel cell, which produces energy using compressed hydrogen held in unique kind of tanks at 350 bars or 700 bars (10,000 PSI), is the main part of the FCEV]. FCEVs are regarded as zero-emission cars since they only release heat and water. While high temperature fuel (160 °C) is the subject of substantial research in academia and industry, low temperature fuel cells (80 °C) are readily accessible on the market. Fuel cells come in a variety of forms, including those with polymer electrolyte membranes, direct methanol fuel cells, alkaline fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells, and reversible fuel cells [1][3][4],[5]. Five modes of operation can be distinguished in FCEV.

Electric Vehicle Supply Equipment

Electricity is delivered to the electric car batteries via electric vehicle supply equipment (EVSE). In order to efficiently and securely provide electric power to recharge EV batteries and to ensure communication between the EV and the charging station [10][1], on the one hand, and to manage the charging station and electric grid interactions [2][[3], on the other hand, EVSE includes electrical power conductors, charge ports, protection equipment, software and communication devices and protocols. the types and requirements for EVSE. The interface between the EV, EVSE, and other devices is primarily defined by these standards and codes. Interface between the EV and power grid. The most common standards include SAE J1772 in North America and IEC 61851/6219661851/62196 in Europe and emerging markets. These EVSE can be either AC or DC,. AC charging uses power directly from the electric grid with the EVSE simply monitoring the flow of power and ensuring safe operating environment,

Grid Impact Mitigation

More electrical energy is required as the fleet of electric vehicles expands, especially during on-peak hours. The stability of the electricity system will be significantly impacted by the charging of electric vehicles. In order to satisfy the demands of a sizable and expanding client base, it will also be required to fulfil their charging needs (start time, power, and desired SOC) []2. The influence of EV chargers on electricity systems is covered in the sections that follow. Then, three charging methods—non-controllable EV charging, dual pricing EV charging, and smart EV charging—are described and evaluated.. This critical review highlights the relevance of adaptive control and smart energy management of charging stations that may integrate distributed energy resources (DER) and energy storage systems (ESS).

4. Conclusions

The present state of electric vehicle technologies, including HEV, PHEV, BEV, and FCEV, as well as the related power electronics and energy conversion system components, has been examined in this study. The power and energy needs for a particular vehicle have been calculated using WLTP driving cycles. The presentation and discussion of conventional ICE, hybrid, and fully electric automobiles follows. Different on-board and off-board battery chargers have been briefly shown and discussed based on the standards for EV chargers. In particular, integrated on-board chargers provide the opportunity to maximize the usage of motor windings and traction/propulsion power converters, but they have a slow rate of EV battery recharging.

On the other hand, off-board chargers are high power chargers that require few minutes to recharge the EV batteries up to 80%80% state of charge (SOC). Unfortunately, the massive usage of such equipment could have a negative impact on the utility grid and may cause PQ disturbances. To overcome this issues, one solution relies on the integration of distributed energy resources and energy storage systems on the charging stations level. Moreover, coordinated and well-planned EV fleets charging is required to mitigate the impact on the distribution grid without upgrading the utility grid. Finally, the implementation of V2G and V2V technologies are required to take benefit of such distributed energy storage systems.

References

[1] Piasecki, S.; Zaleski, J.; Jasinski, M.; Bachman, S.; Turzyński, M. Analysis of AC/DC/DC Converter Modules for Direct Current Fast-Charging Applications. Energies 2021, 14, 6369.

[2] Maroti, P.K.; Padmanaban, S.; Bhaskar, M.S.; Ramachandaramurthy, V.K.; Blaabjerg, F. The State-of-The-Art of Power Electronics Converters Configurations in Electric Vehicle Technologies. Power Electron. Devices Components 2021, 1, 100001Tahir, Y.; Khan, I.; Rahman, S.; Nadeem, M.F.; Iqbal, A.; Xu, Y.; Rafi, M. A state-of-the-art review on topologies and control techniques of solid-state transformers for electric vehicle extreme fast charging. IET Power Electron. 2021, 14, 1560–1576

[3] Sun, X.; Li, Z.; Wang, X.; Li, C. Technology development of electric vehicles: A review. Energies 2019, 13, 90. [Wahid, M.R.; Budiman, B.A.; Joelianto, E.; Aziz, M. A Review on Drive Train Technologies for Passenger Electric Vehicles. Energies 2022, 14, 6742.

[4] Khalid, M.R.; Khan, I.A.; Hameed, S.; Asghar, M.J.; Ro, J.S. A comprehensive review on structural topologies, power levels, energy storage systems, and standards for electric vehicle charging stations and their impacts on grid. IEEE Access 2022, 9, 128069–128094. Elbouchikhi, E.; Zia, M.F.; Benbouzid, M.; El Hani, S. Overview of Signal Processing and Machine Learning for Smart Grid Condition Monitoring. Electronics 2022, 10, 2725.

[5] Ronanki, D.; Kelkar, A.; Williamson, S.S. Extreme fast charging technology—Prospects to enhance sustainable electric transportation. Energies 2019, 12, 3721. Shin, M.; Kim, H.; Kim, H.; Jang, H. Building an interoperability test system for electric vehicle chargers based on ISO/IEC 15118 and IEC 61850 standards. Appl. Sci. 2016, 6, 165.

[6] Savio Abraham, D.; Verma, R.; Kanagaraj, L.; Giri Thulasi Raman, S.R.; Rajamanickam, N.; Chokkalingam, B.; Marimuthu Sekar, K.; Mihet-Popa, L. Electric vehicles charging stations' architectures, criteria, power converters, and control strategies in microgrids. Electronics 2021, 10, 1895. [Kumar K, J.; Kumar, S.; VS, N. Standards for electric vehicle charging stations in India: A review. Energy Storage 2022, 4, e261.

[7] Bonsu, N.O. Towards a circular and low-carbon economy: Insights from the transitioning to electric vehicles and net zero economy. J. Clean. Prod. 2020, 256, 120659. [Google Scholar] [CrossRef]

[8] Cano, Z.P.; Banham, D.; Ye, S.; Hintennach, A.; Lu, J.; Fowler, M.; Chen, Z. Batteries and fuel cells for emerging electric vehicle markets. Nat. Energy 2018, 3, 279–289.

[9] Sanguesa, J.A.; Torres-Sanz, V.; Garrido, P.; Martinez, F.J.; Marquez-Barja, J.M. A

review on electric vehicles: Technologies and challenges. Smart Cities 2021, 4, 372–404.

[10]Lai, X.; Chen, Q.; Tang, X.; Zhou, Y.; Gao, F.; Guo, Y.; Bhagat, R.; Zheng, Y. Critical review of life cycle assessment of lithium-ion batteries for electric vehicles: A lifespan perspective. eTransportation 2022, 12, 100169.