Application of Power Electronics in Hybrid Electric and Plug-in Hybrid Electric Vehicles

Mr. S.S. Kanamadi

Lectuter

Department of Electrical & Electronics Engg.,
Government Polytechnic, Vijayapur

Abstract: Due to the shortage of fossil powers and the expanding got to diminish emanations and progress fuel effectiveness, car companies are effectively creating electric, half breed electric, and plug-in crossover electric vehicles. Power gadgets has risen as a essential innovation within the headway of these ecologically inviting vehicles, empowering the execution of modern electrical models to meet the rising request for expanded electric loads. Thus, noteworthy changes are anticipated in car electrical control frameworks over the following 5-15 years.In the setting of future crossover electric vehicles (HEVs), control hardware converters and related engine drives, capable for controlling the stream of electrical vitality inside the HEV control framework, are expected to play a crucial part in enhancing fuel productivity and decreasing destructive emanations. Control gadgets is additionally instrumental within the advancement of electric vehicles (EVs), plug-in half breed electric vehicles (PHEVs), and fuel cell vehicles (FEVs). This article investigates the basic structure and circuit setup of EVs, PHEVs, HEVs, and FEVs, with a center on the control hardware framework. It dives into control hardware arrangements custom-made for HEVs and looks at potential future patterns in vehicular control hardware.

Key Words: Hybrid Electric vehicles, Fuel cell vehicles, Plugin hybrid electric vehicles, Power electronics system, Future trends.

1. INTRODUCTION

Car companies are progressively centering on creating vehicles that are more naturally inviting and offer higher fuel economy. This has driven to a critical accentuation on Electric Vehicles (EVs), Hybrid-Electric Vehicles (HEVs), Plug-In Half breed Electric Vehicles (PHEVs), and Fuel Cell Vehicles (FCVs). The momentous advance in this field has been made conceivable basically due to headways in control hardware and electric drive innovations. As control gadgets proceed to make strides, the estimate of converters and other electronic gadgets diminishes, driving to noteworthy progressions in electric vehicle technologies.In applications like steer-by-wire and brake-by-wire, the integration of actuators with control hardware is pivotal for guaranteeing quick and solid operation, indeed beneath unfavorable natural conditions. This integration not as it were improves the generally framework unwavering quality but moreover diminishes costs and estimate [1]. Besides, nearby control hardware, the advancement of electric engines plays a crucial part within the flow of the vehicle and the sort of control converter utilized to control its working characteristics.

2. ANALYSIS OF HEVs, PHEVs, FCVs

By the time the next-generation automobiles are made available for purchase, advanced control devices and motor drives will already be firmly established as essential elements of dynamic vehicle drivetrains. These advanced control electronic converters and driving engine drives will have a significant impact on how much fuel the car uses.The automotive industry is now progressing quickly, particularly in the area of half breed electric vehicles (HEVs). Models including the Toyota Prius, Toyota Highlander Crossover, Toyota Camry Crossover, Lexus RX 400h, Honda Knowledge, Honda Civic Crossbreed, Honda Agreement Crossbreed, and Passage Elude Crossbreed are among the commercially available HEVs. Future HEVs are expected to use control electronic converters and associated motor drives, which manage the flow of electrical energy inside the HEV control framework, to significantly improve fuel efficiency and reduce harmful emissions.The 6-V frameworks, which were used for things like starting, working on cars, and a few lighting loads, have changed throughout the course of the last century. However, the requirements for vehicle control have consistently increased. To increase execution and effectiveness, execution loads that are typically driven by mechanical, pneumatic, and water powered frameworks are gradually being replaced with electrically driven frameworks. Additionally, the need for electrical regulation has increased as excessive loads have been taken into account throughout time [2]. It is imperative to note that the rate of car stack increase is anticipated to be around 4% per year.

2.1 Hybrid – Electric Vehicles [HEVs]

Hybrid vehicles incorporate two or more sources of energy and/or power onboard the vehicle. These energy sources can include batteries, flywheels, and more, while the power sources encompass motors, fuel cells, batteries, ultracapacitors, and others. Depending on the vehicle's configuration, two or more of these power or energy sources are utilized to operate the vehicle.Hybrid vehicles aim to conserve energy and reduce pollution by combining the advantages of an electric motor and an internal combustion engine (ICE). This combination allows the vehicle to leverage the most desirable characteristics of each power source. Hybrid vehicles are generally categorized into two main types: series hybrids and parallel hybrids. Moreover, they can be further divided into mild hybrids, power hybrids, and energy hybrids based on the specific roles played by the engine and the electric motor, as well as the mission the system is designed to accomplish [1].

2.1.1 Series Hybrid Vehicles

Electric vehicles having an inbuilt source of control for battery charging are referred to as arrangement half breed vehicles. Typically, an engine and generator are connected to give control for charging the batteries. It is also possible to set up the system so that the generator looks to function as a load-leveling device that controls thrust. In this situation, the size of the batteries can be reduced, but the generator and engine sizes must be increased. The following are the control

electronic parts of a half-breed vehicle system with a standard configuration:

1) A converter to convert alternator output to direct current (dc) for battery charging; and
2) An inverter to convert dc to ac for drive engine control.
Also needed is a dcdc converter to charge the vehicle's 12-volt battery. An inverter and accompanying control frameworks are necessary during creation of an electric air conditioning unit.

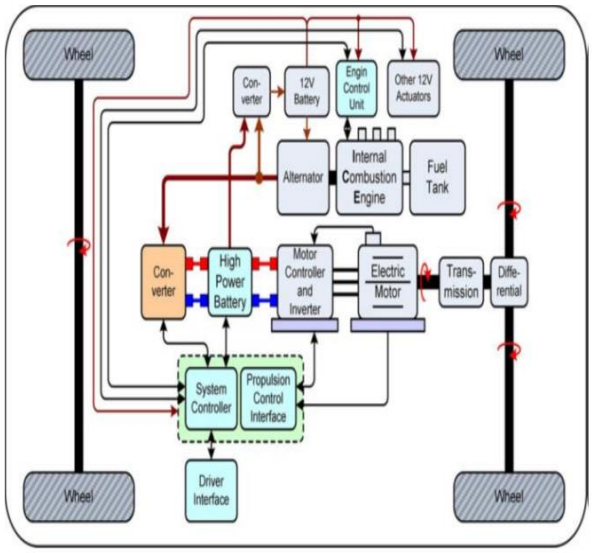

Fig-1: Series hybrid vehicle propulsion system

2.1.2 Parallel Hybrid Vehicles

Parallel crossbreeds can provide the most reduced taken a toll and the option of using the current engine, battery, and engine manufacturing capacity. Whatever the case, a parallel half-breed vehicle requires a sophisticated control system. Different parallel cross-breed vehicle configurations exist based on the motor and electric motor/generator components. The motor and electric engine can be used independently or in tandem to induce a vehicle in a parallel half-breed vehicle. One example of a parallel half breed framework that is commercially accessible is the Honda Knowledge. Fig. 2 shows a typical configuration for a parallel cross breed driving system.

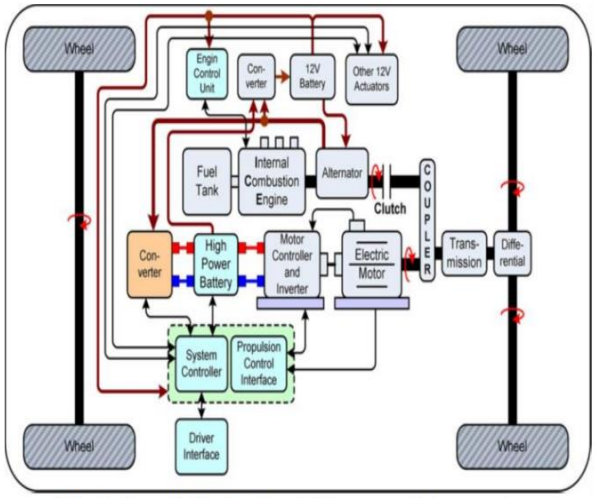

Fig-2: Parallel hybrid vehicle propulsion system

2.2 Plug – in Hybrid Electric Vehicles [PHEVs]

PHEVs have been considered as a vital development of the half breed vehicle development in both the industry and the shrewd world and without a question by unmistakable government organizations around the world. PHEVs have a battery pack of tall essentialness thickness that can be remotely charged and, subsequently, can run as it were on electric control for a run longer than conventional HEVs. The battery pack can be restored by a neighborhood ac outlet charger or interior the carport. PHEVs progress the utilization of utility control since the charging of the batteries is done in the midst of night time. A operator building of a plug-in parallel cross breed vehicle building is showed up in Fig-3. The modify of schedule HEVs into PHEVs is being endeavored as a transitory development in different companies to create strides the capability of HEVs. Additionally, auto creators are considering and orchestrating for the introduction of PHEVs into the commercial show off. The modify is wrapped up either by tallying a high-energy battery pack or by supplanting the existing battery pack of HEVs to develop the all-electric increase. In either case, the high-energy battery pack must be able to store satisfactory electrical imperativeness from outside charging as well as from regenerative braking and must be able to supply the put absent electrical essentialness to a balance motor framework.AC outlet charging got to require a battery charger composed of an ac–dc converter with control calculate correction (PFC) and a programmable advanced controller with an appropriate voltage–current profile for high-energy battery packs[2]. A bidirectional dc-dc converter and charge–discharge profile to boot significant to exchange vitality between the battery and the balance motor framework. To form PHEVs accessible to clients, there are a handful of issues to be tended to. For case, the consistent quality of utility control to utilizing a exceptional number of high-power battery chargers with PFC at the same time and the choice, security, thermal management, and cell-balancing of high-energy batteries such as NiMH and lithium batteries for car applications are a number of of the essential issues[3].

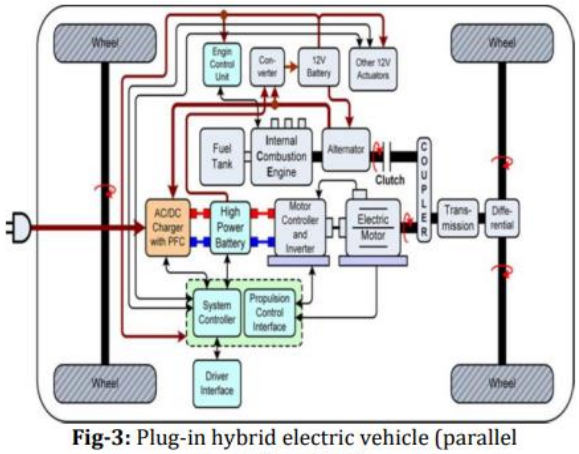

Fig-3: Plug-in hybrid electric vehicle (parallel configuration)

2.3 Fuel-Cell Vehicles (FCVs)

Be that because it may, correct endeavors to realize the viability and radiations benefits of fuel cells interior the transportation division have materialized as they were interior the extreme 10 a long time. The common objective of ceaseless fuel cell examine and development programs is to create a fuel cell engine that will permit vehicles the extend of schedule cars, in spite of the fact that satisfying common benefits comparable to those of battery-powered electric

vehicles. In fact in show disdain toward of the truth that the development is right directly outstandingly costly, fuel cells offer benefits counting tall for the most part efficiency and calm operation due to few moving parts. Hydrocarbon fuel such as gasoline, characteristic gas, methanol, or ethanol is, to begin with, changed to actuate the specified hydrogen utilizing a reformer (or fuel processor). This hydrogen-rich gas from the reformer is reinforced to the anode of the fuel cell. It to boot conceivable to store the hydrogen on-board the vehicle utilizing a pressurized barrel, rather than utilizing the reformer for changing over the fuel to Hydrogenrich gas. The oxygen is bolstered into the cathode fuel cell[5]. Hydrocarbon fuel such as gasoline, characteristic gas, methanol, or ethanol is, to begin with, changed to encourage the desired hydrogen utilizing a reformer (or fuel processor). This hydrogen-rich gas from the reformer is supported to the anode of the fuel cell[5]. It in expansion conceivable to store the hydrogen on-board the vehicle utilizing a pressurized barrel, or possibly than utilizing the reformer for changing over the fuel to Hydrogen-rich gas. The oxygen is bolstered into the cathode fuel cell. Depending on the fuel cell stack setup, and the stream of hydrogen and oxygen, the fuel cell stack produces the dc abdicate voltage. The fuel cell stack surrender is energized to the control conditioner (control electronic converter) to initiate the required abdicate voltage and current. In a culminate world, the control conditioner must have insignificant hardships driving to predominant viability. Control conditioning efficiencies can commonly be higher than 90%.

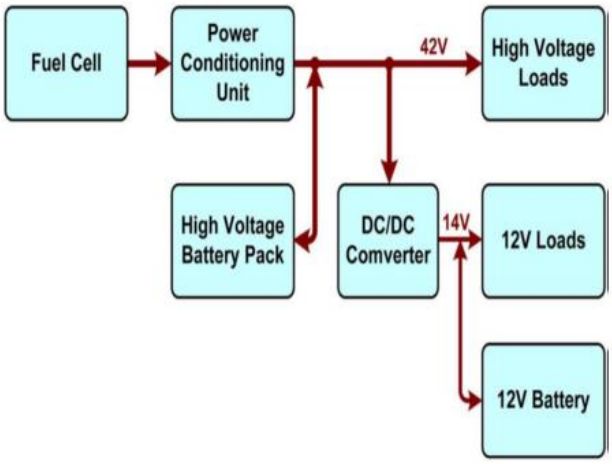

Fig-4: Typical fuel-cell vehicle system

3. POWER ELECTRONICS SYSTEM

Control hardware plays a pivotal part in progressing electric and crossover vehicle drive frameworks. The control hardware framework comprises of control exchanging gadgets, control converter topology with its exchanging procedure, and the closed-loop control system of the engine. To create proficient and high-performance vehicles, the choice of control semiconductor gadgets, converters/inverters, control, and exchanging techniques, as well as the integration of person units into the framework, are of most extreme significance.Right now, all-electric and cross breed vehicles utilize a three-phase bridge inverter topology to change over the DC voltage from the battery into variable voltage and recurrence to control a three-phase AC engine. This topology, including three-phase difficult exchanged bridge inverters, is commonly utilized due to its effortlessness, unwavering quality, and flexibility. Within the advertise, different sorts of control gadgets with diverse levels of execution are accessible, with IGBT gadgets being broadly utilized in commercially open EVs, HEVs, and PHEVs.Silicon carbide (SiC) is picking up notoriety as the next-generation control semiconductor fabric due to its radiation resistance, high-temperature working capacity, tall voltage, control dealing with capacity, and effectiveness. SiC gadgets offer higher control thickness and current thickness than conventional silicon gadgets. Be that as it may, SiC innovation for EVs and HEVs isn't however as dependable as silicon gadgets. GaN gadgets, on the other hand, are anticipated to offer indeed higher execution than SiC, with lower conduction and exchanging misfortunes. GaN-on-Si innovation is congruous with high-volume silicon fabs, making it reasonable for large-scale fabricating and down to earth for future electric and crossover vehicles.Overall, control hardware progressions, especially in SiC and GaN gadgets, hold the potential to altogether upgrade electric and cross breed vehicle frameworks, coming about in diminished measure and weight, diminished EMI era, and lower framework costs.Fig-6 illustrates a ordinary impetus framework with components of an EV powertrain.

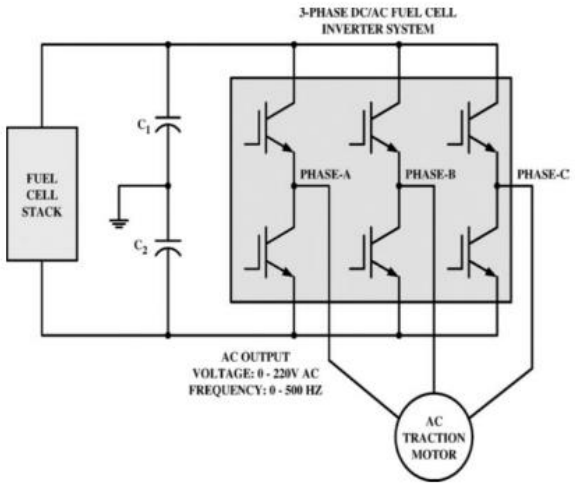

Fig-5: Fuel cell based single-stage power conversion system

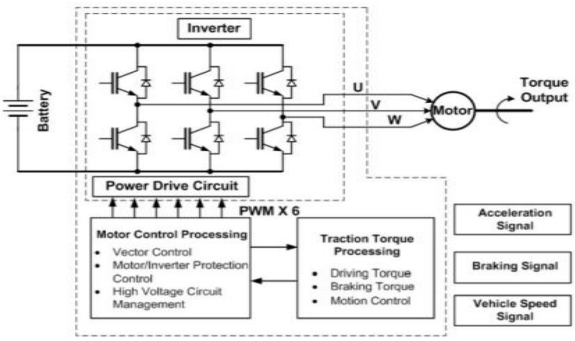

Fig-6: Typical propulsion system components of EV powertrain

4.EMERGING DIRECTIONS IN AUTOMOTIVE POWER ELECTRONICS

The request for progressions in consolation, excitement, security, communication, and natural concerns requires changes in vehicle electrical frameworks. This has gotten to be a driving constrain for a total update of the control framework in vehicles. There are various openings for upgrade in different ranges of car control frameworks, counting made strides beginning, facilitated administration of control era and request, higher framework keenness, expanded productivity, and a diminishment in component costs. Accomplishing these objectives can be fulfilled through half breed multilevel control electronic frameworks, the usage of a dispersion framework with a divided communication transport, and the substitution of a few routine, engine-driven, mechanical, and

pressure driven loads with electric loads to move forward productivity and bundling flexibility.Another outstanding move to expect is the advancement of clean diesel, diesel half breeds, diesel engine-based plug-in half breeds, and vehicles fueled by fluid characteristic gas. Clean diesel base crossovers may empower automakers to approach the 100mpg check within the coming a long time. Whereas major automakers have not however presented diesel half breeds for traveler cars, these frameworks have been broadly utilized in traveler buses and railroad trains for over a decade. In spite of fuel cell innovation appearing extraordinary guarantee, fuel cell vehicles proceed to be restricted to exhibit vehicles or restricted-use vehicles, primarily due to challenges related to fabricating, innovation vigor, hydrogen era, and the hydrogen framework. In any case, progresses in polymer electrolyte film (PEM) and strong oxide fuel cell (SOFC) innovations seem empower the utilization of fuel cells as extend extenders rather than inner combustion engine-driven generators in arrangement half breed vehicles.Right now, most EVs and HEVs don't actualize prognostics and wellbeing administration.By coordination prognostics into the in general control system, it gets to be conceivable to foresee the longer term execution of the machine by evaluating the degree of its deviation from its anticipated ordinary working conditions.

5. CONCLUSION

A few promising innovations are on the skyline for usage within the following eras of automobiles. In any case, there stay significant innovation challenges, especially within the field of fuel-cell vehicles. Overcoming major deterrents related to weight, volume, and taken a toll is basic to realize the anticipated productivity and execution in fuel-cell vehicles. Furthermore, contemplations of manufacturability, unwavering quality, security, toughness, and, most critically, cost-effectiveness are pivotal variables in assembly client desires.The far reaching appropriation of "More Electric Vehicles" to a great extent depends on money related contemplations instead of mechanical impediments. For cross breed or plug-in cross breed vehicles to pick up footing, their esteem must exceed their taken a toll. This esteem recommendation envelops different viewpoints, counting fuel fetched reserve funds, corporate normal fuel economy, vehicle execution and improvements, onboard electric power for consolation highlights, outflows lessening, and the manufacturer's brand picture.Critical advance has been made within the domain of control hardware and turning machines, driving to diminished costs and progressed productivity of the frameworks. The challenges related with control change and pivoting machines are comparative for electric, half breed, and plug-in half breed vehicles.

The persistent decrease within the taken a toll of control gadgets and engine drive frameworks is bringing crossover and plug-in cross breed vehicles closer to the level of conventional ICE-based vehicles.As the request for electrically controlled vehicular functions increments, the number of semiconductors introduced in vehicles is rising, along with the require for higher electrical vitality for progressed electrical loads. This has made a solid request for the improvement of progressed control framework models to improve the vitality utilization proficiency of future EVs, HEVs, and FCVs. The nonstop endeavors in these zones point to clear the way for more economical and productive transportation arrangements within the car industry.

REFERENCES

[1] Ali Emadi, Young Joo Lee, Kaushik Rajashekara, “Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles”, IEEE Trans. On industrial electronics, Vol. 55, 2008, pp. 2237-2245.

[2] Ali Emadi, Sheldon S. Willamson, Alireza Khaligh, “Power electronics intensive solutions for advanced electric, hybrid electric, and fuel cell vehicular power system”, IEEE trans. On power electronics, Vol. 21, 2006, pp. 567-576.

[3] Alexander Stipplich, Chistoph H. Van der Broeck, Alexander Sewergin, “Key components of modular propulsion system for next generation electric vehicle”, CPSS Trans. On power electronics, Vol.4, Dec. 2017, pp. 250-254.

[4] Kaushik Rajashekara, “Present status and future trends in electric vehicle propulsion technologies”, IEEE Journal of Emerging and selected topics in power electronics, Vol.1, 2013, pp. 4-9.

[5] H. Huang, J. M. Miller, and P. R. Nicastri, “Automotive electrical system in the new millennium,” presented at the SAE International Truck and Bus Meeting and Expo., Detroit, MI, Nov. 1999, pp. 608-615.

[6] J. G. Kassakian, “The future of power electronics in advanced automotive electrical systems,” in Proc. 27th IEEE Power Electron. Spec. Conf., Baveno, Italy, Jun. 1996, pp. 7–14. [7] J. M. Miller, “Power electronics in hybrid electric vehicle applications,” in Proc. 18th IEEE Appl. Power Electron. Conf. Expo., Feb. 2003, vol. 1, pp. 23–29.

[8] J. Shen, A. Masrur, V. K. Garg, and J. Monroe, “Automotive electric power and energy management—a system approach,” in Proc. Bus. Briefing: Global Autom. Manufact. Technol., Apr. 2003, pp. 1–5.

[9] M. Kanechika, T. Uesugi, and T. Kachi, “Advanced SiC and GaN power electronics for automotive systems,” in Proc. IEEE Int. Electron Devices Meeting, Dec. 2010, pp. 1–4.

[10] J. Biela, M. Schweizer, S. Waffler, and J. W. Kolar, “SiC versus Si—Evaluation of potentials for performance improvement of inverter and DC–DC converter systems by SiC power semiconductors,” IEEE Trans. Ind. Electron., vol. 58, no. 7, pp. 2872–2882, Jul. 2011. [11] H. Naik, T. Marron, and T. P. Chow, “High-low temperature performance of GaN 600 V schottky rectifiers,” Phys. Status Solidi (C), vol. 8, nos. 7–8, pp. 2219–2222, Jul. 2011.