Top Level Newsletter: Connected Vehicle

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Vol 25 comprises the following topics:

(1) Overview: Electric and Hybrid Vehicles

(2) State of the Art and Trends in Electric and Hybrid Electric Vehicles

(3) Electric Drive Technology Trends, Challenges and Opportunities for Future Electric Vehicles

(4) Reliability of Power Electronic Systems for EV/HEV Applications

We wish our readers a Connected New Year! This issue will focus on electric and hybrid vehicles, which will definitely become dominant in connected vehicle technology.

General Notes

This series of newsletters is intended to provide the IEEE member with a top level briefing of the many different subjects relevant to the research, development and innovation of the connected vehicle.

A note on the Connected Vehicle Newsletter development: Volume 18 was a top-level synopsis of the 74 most recent entries from the twelve previous volumes (vol 17 to vol 6) since March 2020. Volumes 19 to 22 returned to the usual format. Volume 23 departed from the norm and included a single complete article. We return to the usual format of multiple article summaries here.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 300 to 600 words is usually set for each entry, but not rigorously exercised.

As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise and podcast-friendly. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore (www.ieeexplore.ieee.org) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at kaydas@mac.com. The objective is to provide *top level guidance* on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

1. Electric and Hybrid Vehicles, by Mehrdad Ehsani et al

Published: Proceedings of the IEEE Magazine (June 2021, Volume 109, pp 962- 965)

Land transportation over the past two centuries has experienced astonishing advancement. Up till the 1860s, it took more than six months to get from the East Coast to the West Coast of the United States. Today, it may take only three days by automobile. We are even considering flying cars and there are air-taxi startup companies that have announced going public. Vehicle propulsion electrification is at the core of this modern land vehicle revolution. However, the concept of electric vehicle traction is not new.

For example, in 1897, the Electric Vehicle Company began operating electric traction taxicabs in New York City. In London, Electrical Cab Company also began operation that year.

These electric vehicles offered welcomed advantages over the horse-drawn vehicles. They were clean and quiet and their novelty also appealed to the wealthy and the avant-garde. They paid 30 cents a mile, more than $ 9.75 in today’s money, while horse-drawn cabs charged 50 cents a mile

Back in 1900, a third of all cars on U.S. roads were electric, and there were plenty of electric vehicles driving around in the 1910s. It wasn’t until the 1920s when gasoline had truly won out as the fuel of choice for motorists. However, people of the 1920s would probably be astonished that we are using fossil fuels to power our cars a 100 years later.

Then, the premature technology took its toll. Short battery life proved disastrous for firms in a few years. In 1902, the General Carriage Company collapsed. Most of the other electric taxi services in the United States never made it.

Then, Henry Ford displaced the electric car by changing the definition of what the automobile is. The early electric taxis were the extrapolation of the 19th-century concept of transportation, such as the railroads: centralized services that charged fixed prices to serve fixed routes on fixed schedules. Thus, consumers would rather pay others to drive them than to drive themselves. In contrast, Ford helped consumers to think of the car as a personal transportation product that they could personally own and operate, rather than a service someone else offered. The personal car could offer freedom of travel time and place. This special issue provides a comprehensive overview of the most recent development in electric and hybrid vehicles, and the key components and enabling technologies.

This change of paradigm was made possible by the improvements in the power and range of the gasoline engines, combined with their low price. The Model T, in 1908, was introduced at $850. This was roughly one-third of the price of electric cars at the time. Thus, millions of people could own a vehicle that gave them a sense of control over travel time and place.

Modern introduction of the electric vehicle, EV, faces similar challenges as before. Of course, the technology of the EV has significantly improved. Furthermore, the imperatives of adopting EV, such as tailpipe emissions and global warming carbon emissions, have changed. However, the gasoline engine cars have also had a century of advancements and improvements to become very good products.

This helps explain the market reluctance to dominant adoption of the EV, over the past two decades. For example, less than 2% of the about 17 million cars sold annually in the United States are EVs. This is in contrast with the dominance of other recent products, such as smartphones, that were clearly superior to the existing products, during the same time period.

Among the present handicaps of the EV products, relative to the existing gasoline engine vehicles, are shorter range, higher initial and lifetime costs, larger ratio of charge to discharge times, and limited continental charging facilities. Hybrid electric vehicles, HEVs, have been offered as a compromise between the advantages and disadvantages of the EV and the gasoline vehicles. However, their modest penetration of the vehicle market, over the same two decades, indicates that they too are not yet superior products, compared to the conventional car.

If the electrified vehicles are to be considered as the stepping stone to carbon emission-free land transportation, then clearly, the best approach for EV and HEV dominance is a technical improvement. The EV must become a better product than the conventional gasoline vehicle, with the HEV as a transitional product. Top-down government mandates that are in contrast to better products and prices cannot be a successful strategy for this transition in long term. (730 words)

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2. State of the Art and Trends in Electric and Hybrid Electric Vehicles, by Mehrdad Ehsani et al

Published: Proceedings of the IEEE (February 2020 Volume 8, Issue 2, pp 967-984)

Electric and hybrid electric vehicles (EV/HEV) are promising solutions for fossil fuel conservation and pollution reduction for a safe environment and sustainable transportation. The design of these energy-efficient powertrains requires optimization of components, systems, and controls. Controls entail battery management, fuel consumption, driver performance demand emissions, and management strategy. The hardware optimization entails powertrain architecture, transmission type, power electronic converters, and energy storage systems. In this overview, all these factors are addressed and reviewed. Major challenges and future technologies for EV/HEV are also discussed. Published suggestions and recommendations are surveyed and evaluated in this review. The outcomes of detailed studies are presented in tabular form to compare the strengths and weaknesses of various methods. Furthermore, issues in the current research are discussed, and suggestions toward further advancement of the technology are offered. This article analyzes current research and suggests challenges and scope of future research in EV/HEV and can serve as a reference for those working in this field.

Excerpt: Architecture of EV: The EV powertrain mainly consists of an electric traction motor, its associated power electronic converters, an Energy Storage System (ESS), and the powertrain controller. In EVs, the power electronic converters are of two types, i.e., the dc–dc converters and the dc–ac converters. The energy storage can be of one or a combination of electrochemical battery, fuel cell, and flywheel. The control system is an essential part of the EV and controls the various energy resources at various driving conditions. The battery is usually charged from the utility grid using a battery charging unit that can be placed onboard or at the charging station.

Excerpt: Architectures of HEV: The HEV powertrain consists of two or more power plants. The (Internal Combustion Engine) ICE is the primary source of energy, responsible for producing most of the vehicle energy and long driving range, while the Energy Management (EM) is the auxiliary source, responsible for high-vehicle-power demands and fuel economy of the ICE. The EM charges the batteries from the excess power from ICE when not needed by the vehicle and also from the regeneration of vehicle kinetic energy. The design and control of such powertrains require advanced control algorithms and strategies, which optimizes many objectives, such as the ICE fuel economy and the state of charge (SoC) of the batteries, with the system and driving constraints. The HEV system architecture consists of a drive train, ESS, and a controller unit. Integration of these components gives rise to various HEV configurations. (413 words)

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3. Electric Drive Technology Trends, Challenges and Opportunities for Future Electric Vehicles, Iqbal Husain by et al

Published: Proceedings of the IEEE (February 2020 Volume 8, Issue 2, pp 1039 - 1059)

Abstract: The transition to electric road transport technologies requires electric traction drive systems to offer improved performances and capabilities, such as fuel efficiency (in terms of MPGe, i.e., miles per gallon of gasoline-equivalent), extended range, and fast-charging options. The enhanced electrification and transformed mobility are translating to a demand for higher power and more efficient electric traction drive systems that lead to better fuel economy for a given battery charge. To accelerate the mass-market adoption of electrified transportation, the U.S. Department of Energy (DOE), in collaboration with the automotive industry, has announced the technical targets for light-duty electric vehicles (EVs) for 2025. This article discusses the electric drive technology trends for passenger electric and hybrid EVs with commercially available solutions in terms of materials, electric machine and inverter designs, maximum speed, component cooling, power density, and performance. The emerging materials and technologies for power electronics and electric motors are presented, identifying the challenges and opportunities for even more aggressive designs to meet the need for next-generation EVs. Some innovative drive and motor designs with the potential to meet the DOE 2025 targets are also discussed. (184 words)

DOI: https://doi.org/10.1109/JPROC.2020.3046112

4. Reliability of Power Electronic Systems for EV/HEV Applications, by Frede Blabjerg et al

Published: Proceedings of the IEEE (February 2020 Volume 8, Issue 2, pp 1060 - 1076)

Abstract: The electrification of the transportation sector is moving at a fast pace. All car manufacturers have strong programs to electrify their car fleet to fulfill the demands of society and customers by offering carbon-neutral technologies to bring goods and persons from one location to another. Power electronics technology is, in this evolution, essential and also in a rapid development technology-wise. Some of the introduced technologies are quite mature, and the systems designed must have high reliability as they can be quite complicated from an electrical perspective. Therefore, this article focuses on the reliability of the used power electronic systems applied in electric vehicles (EVs) and hybrid EVs (HEVs). It introduces the reliability requirements and challenges given for the power electronics applied in EV/HEV applications. Then, the advances in power electronic components to address the reliability challenges are introduced as they individually contribute to the overall system reliability. The reliability-oriented design methodology is also discussed, including two examples: an EV onboard charger and the drive train inverter. Finally, an outlook in terms of research opportunities in power electronics reliability related to EV/HEVs is provided. It can be concluded that many topics are already well handled in terms of reliability, but issues related to new technology introduction are important to keep the focus on. (213 words)

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