International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 03 | March - 2022 ISSN: 2582-3930

EV Stability Enhancement: A Review Report

Anant Kumar[1], Dr. Puneet Pahuja[2], Mr. Ashwani Kumar[3]

[1]Student (M.Tech), Department of Electrical Engineering, Hindu College of Engineering, Sonipat, Haryana
[2]Assistant Professor, Department of Electrical Engineering, Hindu College of Engineering, Sonipat, Haryana
[3]Assistant Professor, Department of Electrical Engineering, Hindu College of Engineering, Sonipat, Haryana

---***---

Abstract - There has been a rise in the use of electric cars (EV), including battery electric vehicles, hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and fuel cell electric vehicles (FCEV). Internal combustion engine (ICE) cars are expected to be replaced by this means of transportation in the near future, as the current trend implies. Each of the primary EV components has a variety of technologies that are either presently in use or could be relevant in the future. – Environmental, power systems, and other sectors may be adversely affected by the use of electric vehicles. The research object is an electric vehicle with four in-wheel motors. The criterion of vehicle stability is examined by taking into account parameters such as vehicle speed and road adhesion coefficient. A thorough literature review is provided in this paper on vehicle stability analysis.

Key Words: Electric vehicle, stability, four-wheel drive, review paper

1. INTRODUCTION

Global warming, the depletion of fossil fuels, and air pollution are becoming increasingly major environmental issues. As a result, electric vehicles (EVs) have piqued the public's curiosity due to their claim of zero emissions. The following are some of the benefits of EVs

- Individual control of each wheel is now possible because to the development with in motors.
- The motor current can be used to precisely measure the generated torque.
- There is a very quick response to torque changes.

Many electromechanical systems, such as electric machines and static converters, are needed for some applications in the field of electrical drives. MMSs (multi-machine multi-converter systems) are the technical term for these systems [2]. Extensions of classic drives are what MMSs might be thought of as. But in high-power applications like rail systems, conveyer belts, and steel manufacturing, a single converter feeds multiple units. Lightweight, compact, and low-cost are all advantages of this topology. A multi-machine single-converter system is the name given to this arrangement.

This research focuses on the control of multi-machine single-converter systems. Control of multi-machine single-inverter systems has been proposed in several ways. The electric differential is generated via a master–slave direct torque control (DTC) technique. Benefits accrue from using separate motors for the front and back wheels of a 4WD vehicle, which is a hybridization technique. To begin, the use of independent motors for the front and rear wheels eliminates the need for an additional mechanical device such as a transfer case and propeller shaft for transferring engine power to the wheels. A typical four wheel electric drive system is shown in figure 1.

Second, regenerative braking energy can be captured to increase fuel economy. Last but not least, a more stable vehicle can be achieved by controlling the motor driving torque and the regenerative braking torque properly[1]. In general, torque split and braking technologies have been pursued for vehicle stability in 4WD cars. When using brake-based approaches, the individual wheel brakes are actively controlled through brake-maneuver procedures. Torque-based solutions, on the other hand, provide an offset yaw moment by altering the traction torque split through the power train [2].

Electronic stability programme or vehicle dynamic control systems, which use brake-based approaches to enhance vehicle safety, have recently become extremely popular and their applications have proliferated. There may be a quick increase in tyre slip angles and, therefore, vehicle slip angles when a vehicle faces unexpected road conditions such as a split-road, causing the vehicle to hit its physical limit of adhesion between the tyres and road. If you're a novice driver, you may lose control of your vehicle because you've never had to do it before.

With this brake-based vehicle safety enhancement technology, the driver can quickly regain control of their car by actively controlling each individual wheel brake. Studies into brake-based technologies, such as offset yaw mome and wheel slip control based on estimated tire-road friction coefficient [4]–[6], have examined vehicle safety enhancement systems like these. When it comes to ensuring the safety of your vehicle, brake-based technology has been demonstrated to be efficient.

However, it does have one drawback: It slows down your vehicle too much against your command. When it comes to ensuring a safe vehicle, torque-based technology, such as a viscous coupling [7] and an electromagnetic coupling [8], is employed. However, the torque-based technique has a drawback in that it cannot precisely manage the torque of each particular wheel.

As a result, a vehicle safety improvement system is needed that meets the needs of both the driver and the safety community.

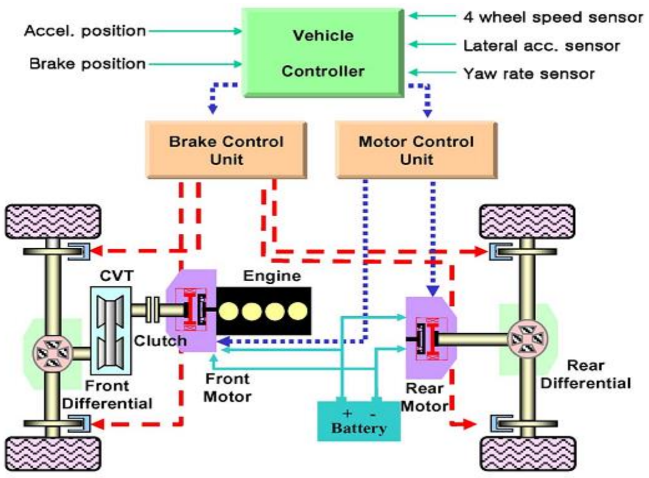

Figure 1: 4WD electric vehicle with separate rear and front wheel control to improve the stability

Some advantages of the motor control algorithm in the 4WD HEV with distinct front and back motors include faster reaction, brake energy recovery, and more [9]. However, because the driving and regenerating torque for both the left and right wheels comes from the same motor, improving stability just by using the rear motor control has limitations in terms of meeting the required offset yaw moment. For the desired offset yaw moment, each wheel must have a different amount of brake force applied.

In this article recent works published on EV modelling and stabilization are analytically discussed in section II and a conclusion is drawn in section III.

2. Related Work

Authors in [1] presented different types of electrical vehicle drive train for synchronous motor based EV model. The model was developed based on optimizing performance and efficiency of the power train. The optimization process considered for the range and performance improvement of the model. This model was used to select the battery technology and parameters as per the requirements [1].
The main system of the drive train has key components where each contains the motor, battery, motor controller; battery controller. The basic parameters like torque and speed condition play important roles in terms of motoring and generating mode. Author [2] provided the simulation model of full electrical vehicle in Matlab/Simulink platform.
Authors in [3] presented the detailed analysis of an optimal configuration of the drive train. The configuration of the drive train depends on the multi-cycles in case of a plug-in electric vehicle. There are four different configurations of drive train modeling were analyzed. The reference driving cycles were FTP-75, HWFET and US06 tested.
A genetic algorithm was used to optimize the efficiency of the electric power train of an EV and a two-speed dual clutch transmission in multi-plate, gear ratio change and gear shift change. After the optimization, the different optimal results were analyzed on the new Europe drive cycle and urban dynamometer driving schedule in [4].
Authors in [5] proposed battery management system (BMS) by using the power performance optimization. The main source of the EV is batteries; all the parameters of a vehicle depend on the life of the battery. The power management system affects the battery condition, so the optimization process provides the optimal condition of the battery management system.
The electric vehicle Mahindra e2o from the popular brand in India was simulated on the Simulink platform of Matlab. The authors in [6] provided the step wise step mathematical calculations of the electric vehicle simulation model. The performance evaluation of the EV model depends on the various speed inputs which provided the better state of charge of battery and vehicle range.
A stable model of the electric vehicle was developed and validated in [7]. The components of the model are motor, controller and wheels. In this model the permanent magnet DC motor was used. A controller provided the control input to the motor for a specific speed and torque condition.
The authors in [8] proposed a new type of electric vehicle drive system in which the front and rear wheels were independently driven. The configuration of the model divides as per the driving and braking torque during running and load conditions. The two motors were implemented while constructing the model on rear wheels induction motor employed and permanent synchronous motor fixed on the front wheels. The dual motors configuration provides the improved steering ability.
The authors [9] proposed a driving control algorithm for four-wheel drive (4WD) EV containing motors on the front and rear wheels. The electric motors were connecting along the wheel shaft which improves the steering stability, vehicle maneuverability, and rollover prevention. The proposed algorithm containing three main parts; 1) supervisory controller, 2) upper-level controller, 3) lower level controller.
The configuration in [10] was obtained by using a BLDC motor with PI control and batteries. Various configurations were designed according to the applications. The electric vehicle configurations performance depend on the size of the battery. By using the electric motor in the electric vehicle structure, the battery size was reduced.
The authors in [11] compared the conventional vehicle with Hybrid Electric Vehicle (HEV) based on dynamic nature and gear shifting scheme in both vehicle configurations. In case of HEV, the gear shifting optimization provide better results than the conventional algorithm. The performance of the HEV vehicle improved with electric motor and batteries.
The authors in [12] proposed the permanent magnet synchronous motor with the bidirectional z-source inverter (ZSI). The function of ZSI is to provide dc link voltage control to the motor at high speed in week field stage. In this research ZSI basic principle provided which further used. The function of ZSI to provided dc link voltage control to the PMSM which operate the motor at high speed in week field stage.
The authors in [13] proposed a torque distribution method to increase the overall motor efficiency for a front and rear wheel control on the NEDC. The efficiency of the NEDC improved by connecting one PM and clutch motor to the second motor. The complete torque required by the model divide equally between the two PM motors which reduced the losses. The induction motor can be used in case of clutch provides the losses when the motor is connected to the clutch. In the case of NEDD low torque region, the improved efficiency achieved.

A mathematical model of electric vehicle has been developed by using the batteries and motors with NEDC and FTP-75 platform. The parameters like minimizing the cost of batteries, maximizing the range of anxiety are the main challenges. Authors in [14] discussed the effects of transmission type and parameters on the overall efficiency of the system.
The authors in [15] proposed the hybrid control algorithm with the help of centralized and hierarchical control of electric vehicles. The centralized control algorithm developed for the suspension and steering control provided stability to the steering and braking system. The hierarchical control algorithm distributed the proportion of hydraulic braking and regenerative braking to improve the overall performance braking.
The integrating of EV with the grid help to improve the efficiency of the system and several numbers of EV can be charged at the same time. The peak hour energy was provided to the grid using integrating EV. The proposed model is called Capacity loss (CL) model. An economical financial model was discussed based on different energy loss and grid loss. In this study [16], a mathematical model was developed in which dual process achieved like energy transfer from EV to grid and grid to EV simultaneously.
The authors in [17] proposed the effect of different PEV level penetration on the distribution network costs and their increased energy losses. This type of analysis was proposed on the urban area where overall lines were underground and rural areas had large energy loss compared with the PEV penetration level.
Authors in [18] presented a model of electric vehicle with the optimal design of an electric vehicle is which required minimum energy consumption and provide maximum average speed. An optimal control and linear quadratic regulator managed to minimize the energy consumption of the EV model. Two simulation models were compared to each other on the MATLAB platform.
Authors in [19] provided the advantages of physical, electric vehicle tool while compared with the Matlab software EV model. The physical model of EV has multiple running rates and several solvers configurations. For the heavy uses an Automated Mechanical Transmission (AMT) model developed for an example city bus was used.
Authors in [20] proposed four in wheel electric vehicle called UOT March II. An electric vehicle was driven by the electric motor which has following advantages; motor torque generation is fast and accurate, motors can be installed on two or four wheels, and the motor torque can be recognized very easily.

The critical comparison of the above study is tabulated in table 1.

Table 1 Literature Review analysis

Author	Year	Technique	Advantages	Limitations
NoëlleJaniaud et al.	2010	Synchronous machine based EV model proposed	The battery technology improved and performance efficiency increases	Only Li-ion battery tested
Y Mastanamma et al.	2017	Full electric vehicle model with motor and dc controller	Torque and speed values are estimated which can use for the efficiency calculations	NA
Jony J. Eckert et al.	2016	Four configurations of EV model proposed with motor, battery, and differential on FTP-75 and HWFET platform	The electric motor drive train and power transmission ratio improved the performance efficiency	Experimental setup only for the high-speed drive train
Yu Wang et al.	2016	Proposed two-speed dual clutch transmission system in the electric vehicle	Improved performance efficiency	NA
P. M.W. Salehen et al.	2015	Control of Battery Management System (BMS) of electric vehicle	Reduced electrical losses and performance optimization of Li-ion battery	NA
Aalok Bhatt et al.	2016	Mathematical model calculations of Mahindra e2o	Optimal value SoC of the battery	Only battery capacity analyzed
David McDonald	2012	EV model simulation for the estimation of power flow in motoring and generating phase	Stable model	NA
Mutoh et al.	2006	Simulate an EV model with a battery	Minimize the failure case	NA

		pack and two motors IM and SM		
Kang et al.	2011	Four-wheel drive EV with synchronizer controller, upper and lower level controller	Rollover performance and lateral stability improved	NA
Ludmila et al.	2015	An electrical vehicle simulation model with BLDC motor, a rule-based method control the power	Reduced the battery size and improved the output	Tested on NBR6601platform
Eckert et al.	2007	EV model based on longitudinal vehicle dynamics methodology	Maximum power was achieved	NA
P. Liu et al.	2012	Bi-directional PMSM used in EV with ZSI inverter	Maximum dc voltage obtained which provide better performance o high speed	NA
Yuan et al.	2012	Torque distribution scheme on the EV over NEDC	Improved the efficiency of the system	Wheel torque distribution
Hofman et al.	2010	Optimizing shifting scheme (Dynamic Programming) for the manual transmission of EV	Improve drive ration and transmission efficiency	NA
Peng et al.	2013	Collaborative control using the center control and hierarchical control	Steering stability and braking control	NA
Das et al.	2014	Mathematical model of EV integrating with the grid	The economic analysis of EV model estimated	Only affect the battery capacity
Fernández et al.	2011	Large scale distribution model of EV	Two real distribution area were analyzed	NA
Roscher et al.	2009	Two-phase transition in the Li-ion compound	The equivalent electrical circuit of battery developed	SoC range affected
Zhou et al.	2014	Review of the dynamic simulation model (AMT control)	The model used for heavy duty applications	NA
Hori et al.	2004	The advance motion control scheme for Electric Vehicle using TCS, DYC, SRC, etc.	Motor torque and speed estimated easily	NA

3. CONCLUSIONS

EVs have great potential of becoming the future of transport while saving this planet from imminent calamities caused by global warming. They are a viable alternative to conventional vehicles that depend directly on diminishing fossil fuel reserves. With the EV advancement, a few design challenges are still to be addressed. The vehicle stability in a four-wheel drive system on slanting roads, straight and slippery roads is challenging for even experienced drivers. So, researchers have worked to stabilize the vehicle by regulating the speed deflection from the reference speed. Researchers have previously studied drive train optimization, which is linked to soft computing controlling techniques. This article reviewed those methods and visualized the EV designing/stabilizing problem for further development.

REFERENCES

1. N. Janiaud, F. Vallet, M. Petit and G. Sandou, "Electric vehicle powertrain simulation to optimize battery and vehicle performances," *2010 IEEE Vehicle Power and Propulsion Conference*, Lille, 2010, pp. 1-5.
2. YMastanamma ,Dr M ArunaBharathi, "Electric Vehicle Mathematical Modelling and Simulation Using MATLAB-Simulink" IOSR Journal of Electrical and

Electronics Engineering (IOSR-JEEE), Volume 12, Issue 4 Ver. I (Jul. – Aug. 2017), PP 47-53.

3. J. J. Eckert, L. C. A. Silva, E. S. Costa, F. M. Santiciolli, F. G. Dedini and F. C. Corrêa, "Electric vehicle drivetrain optimisation," in *IET Electrical Systems in Transportation*, vol. 7, no. 1, pp. 32-40, 3 2017.
4. Wang, Y., Lü, E., Lu, H., Zhang, N., & Zhou, X., " Comprehensive design and optimization of an electric vehicle powertrain equipped with a two-speed dual-clutch transmission" Advances in Mechanical Engineering, vol-9, no.-1,2017, pp 1-13.
5. M. W. Salehen, P &Su'ait, Mohd&Razali, H &Sopian, Kamaruzzaman, "Battery management systems (BMS) optimization for electric vehicles (EVs) in Malaysia" AIP Conference Proceedings, 2017, pp 1-7.
6. A. Bhatt, "Planning and application of Electric Vehicle with MATLAB®/Simulink®," *IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES)*, Trivandrum, 2016, pp. 1-6.
7. David McDonald, "Electric Vehicle Drive Simulation with MATLAB/Simulink" Proceedings of North-Central Section Conference Copyright © American Society for Engineering Education,2012, pp. 1-24.
8. N. Mutoh, Y. Miyamoto, T. Horigome and K. Takita, "Driving characteristics of an electric vehicle system with independently driven front and rear wheels," *IECON'03.29th Annual Conference of the IEEE Industrial Electronics Society (IEEE Cat.No.03CH37468)*, Roanoke, VA, USA, 2003, pp. 931-938 vol.1.
9. J. Kang, J. Yoo and K. Yi, "Driving Control Algorithm for Maneuverability, Lateral Stability, and Rollover Prevention of 4WD Electric Vehicles With Independently Driven Front and Rear Wheels," in *IEEE Transactions on Vehicular Technology*, vol. 60, no. 7, pp. 2987-3001, Sept. 2011.
10. L. C. A. Silva, J. J. Eckert, F. M. Santiciolli, E. S. Costa, F. G. Dedini and F. C. Corrêa, "A study of battery power for a different electric vehicle propulsion system," *2015 International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles (ESARS)*, Aachen, 2015, pp. 1-6.
11. Eckert, Jony&Santiciolli, Fabio & Silva, Ludmila& S. Costa, Eduardo &Corrêa, Fernanda & G. Dedini, Franco, "Co-simulation to evaluate acceleration performance and fuel consumption of hybrid vehicles" Journal of the Brazilian Society of Mechanical Sciences and Engineering, 2014, pp-1-14.
12. P. Liu and H. P. Liu, "Permanent-magnet synchronous motor drive system for electric vehicles using bidirectional z-source inverter," in *IET Electrical Systems in Transportation*, vol. 2, no. 4, pp. 178-185, December 2012.
13. X. Yuan and J. Wang, "Torque Distribution Strategy for a Front- and Rear-Wheel-Driven Electric Vehicle," in *IEEE Transactions on Vehicular Technology*, vol. 61, no. 8, pp. 3365-3374, Oct. 2012.
14. T. Hofman and C. H. Dai, "Energy efficiency analysis and comparison of transmission technologies for an electric vehicle," *2010 IEEE Vehicle Power and Propulsion Conference*, Lille, 2010, pp. 1-6.
15. JiankunPeng, HongwenHe andNenglianFeng, "Simulation Research on an Electric Vehicle Chassis System Based on a Collaborative Control System" *Energies* 2013, *6*, 312-328.
16. R. Das, K. Thirugnanam, P. Kumar, R. Lavudiya and M. Singh, "Mathematical Modeling for Economic Evaluation of Electric Vehicle to Smart Grid Interaction," in *IEEE Transactions on Smart Grid*, vol. 5, no. 2, pp. 712-721, March 2014.
17. L. Pieltain Fernandez, T. Gomez San Roman, R. Cossent, C. Mateo Domingo and P. Frias, "Assessment of the Impact of Plug-in Electric Vehicles on Distribution Networks," in *IEEE Transactions on Power Systems*, vol. 26, no. 1, pp. 206-213, Feb. 2011.
18. Michael A. Roscher, Jens Vetter, Dirk UweSauer,Characterisation of charge and discharge behaviour of lithium ion batteries with olivine based cathode active material, Journal of Power Sources, Volume 191, Issue 2, 2009, Pages 582-590.
19. Jian Zhou, XiangmingShen and Dong Liu, "Modeling and simulation for electric vehicle powertrain controls," *2014 IEEE Conference and Expo Transportation Electrification Asia-Pacific (ITEC Asia-Pacific)*, Beijing, 2014, pp. 1-4.
20. Y. Hori, "Future vehicle driven by electricity and Control-research on four-wheel-motored "UOT electric march II"," in *IEEE Transactions on Industrial Electronics*, vol. 51, no. 5, pp. 954-962, Oct. 2004.