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Performance and Simulation of Four Wheel Drive using an Induction Motor

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ABSTRACT: Wide variation in speed from low speed crawling to high speed cruising, maintaining constant power operation is the most desired characteristic of a drive used in Electric Vehicles (EV). The multiphase Induction Motor (IM) drive is capable of extending the constant power operation over very wide range of speed with required torque for electric launch, straight and curved roadway and also hill climbing. In this paper a four three-phase squirrel cage IM drive with common Direct Torque Control (DTC) – Space Vector Moduclation (SVM) scheme applied to drive the four wheels EV is proposed. The variable speed operation can be achieved by the proposed control scheme which eliminates the need of mechanical gear box which saves in weight and size of the EV. Phase number appears to be slightly large, but with the advantages such as reduction in voltage rating of the power switch and dc link supports the selection of large phase number. In addition high number of phases considerably reduces torque ripple and increases efficiency by reducing slot harmonics, the performance of the proposed EV for the case of starting and cruising modes are verified by using MATLAB/Simulink.

KEYWORDS*:* induction machine; direct torque control; space vector PWM; and four wheel drive.

I. INTRODUCTION

Increase in concern over the Green House Gases effect nowadays is becoming very serious. Slowly the Internal Combustion Engine based vehicles are being replaced by Hybrid Electric Vehicle or completely Electric Vehicle. So that by certain means the pollution is reduced or completely eliminated. Interest has been focused on the Two Wheel Drive Electric Drive or Four Wheel Drive Electrical Vehicle; of which Four Wheel Drive Electric Vehicle has more advantageous for any type of roadways. With independent driving motor at the front and the rear wheels it is possible to control the vehicle speed in kind of aspects [1-4]. This kind of drive also gives the possibility to achieve accurate and quick control of the distribution torque. Torque control can be ensured by the Voltage Source Inverter (VSI). Therefore, this kind of vehicle does not require a mechanical differential gear or gearbox but the main disadvantage of these kind of Electric Vehicles is to assume the car stability. During normal driving condition, all drive wheel system requires a symmetrical distribution of torque in the both sides.

The Direct Torque Control strategy (DTC) is one kind of high performance driving technologies for AC motors, due to its simple structure and ability to achieve fast response of flux and torque has attracted growing interest in the recent years. DTC-SVM with PI controller direct torque control without hysteresis band can effectively reduce the torque and flux ripple, DTC-SVM method can improve the system robustness and effectively improve the system dynamical performance. The dc-dc converter is used with wide range in electric vehicles to assure the energy require for the propulsion system.

The aim of this paper is to understand the lithium-ion battery comportment controlled by chopper, each wheels is controlled independently by using DTC based SVM under several topology and speed variation.

Performance and simulation of proposed Four Wheel Drive is presented by using the Matlab/Simulink.

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II. DTC-SVM

In this technique two proportional integral (PI) type con- trollers are used instead of hysteresis band regulating the torque and the magnitude of flux as it shown in Fig. 1, by generating the voltage command for inverter control. Noting that no decoupling mechanism is required as the flux magnitude and the torque can be regulated easily by the PI controllers. Due to the structure of the inverter, the DC bus voltage is fixed, therefore the speed of voltage space vectors are not controllable, but we can adjust the speed by means of inserting the zero voltage vectors to control the electromagnetic torque generated by the Induction Motor. The selection of vectors is also changed. It is not based on the region of the flux linkage, but on the error vector between the expected and the estimated flux linkage [5]. The stator flux and electromagnetic torque are estimated by:

$$|\psi_s| = \sqrt{\psi_{ds}^2 + \psi_{qs}^2}$$

$$T_{em} = \frac{3}{2}p(\psi_{ds}i_{qs} - \psi_{qs}i_{ds})$$

III. PROPOSED ELECTRIC VEHICLE DRIVE

Figures 1 and 2 shows the individual DTC-SVM scheme employed for IM and the complete proposed Four Wheel Drive schematic respectively.

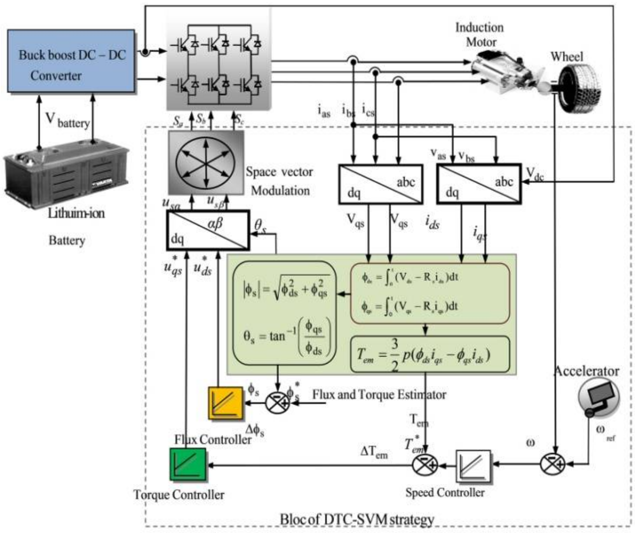

Fig 1. Block diagram of DTC-SVM

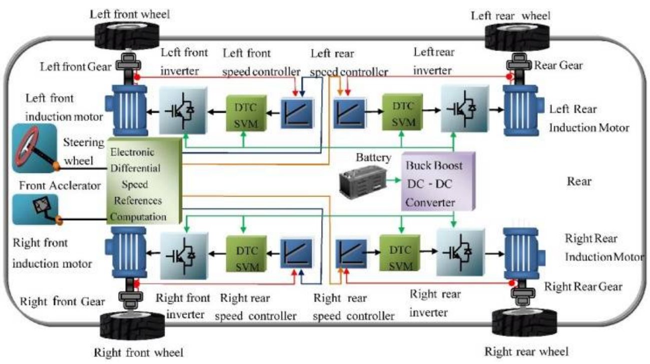

Fig.2. Four Wheel Drive based on DTC-SVM scheme

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IV. RESULTS AND DISCUSSION

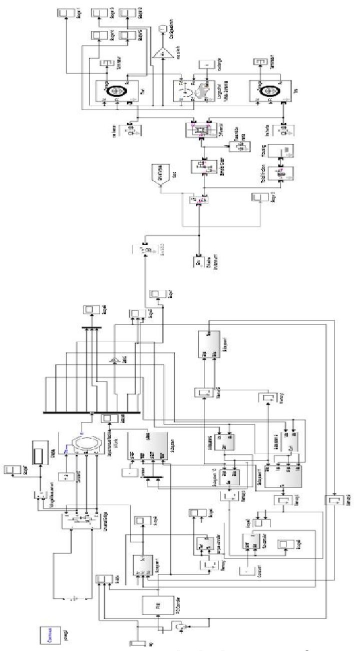

Fig. 3. Simulink diagram of Four Wheel Drive.

As discussed above about the DTC, here the DTC system is extended or connected to simulink diagram of Four Wheel Drive. The main blocks used in wheels system are torque actuator, differential, tire system, vehicle dynamics.
Torque actuator actuates a drive line axis and all connected inertias with the torque specified by the incoming simulink signal. From the differential block the power is divided into tire inertia 1 and tire inertia. From the tire inertia it is fed to the wheels. In this simulink diagram, the upper block represents two wheels in a single block and they are front wheels. The lower block represents two wheels in a single block and they are back wheels. From the front and back wheels the power is fed to vehicle dynamics. The speed is controlled by the pulses given by IGBT.

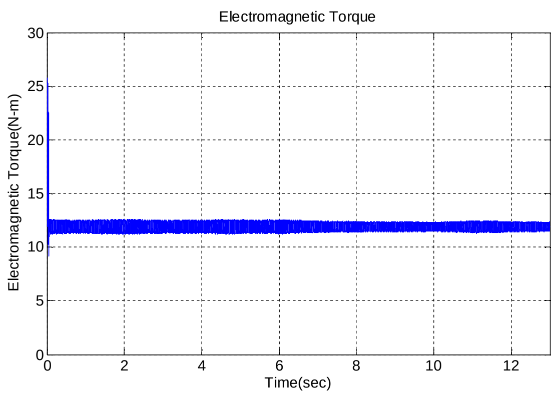

Fig. 4. Torque.

The above fig is the electromagnetic torque generated from induction machine. This torque is fed to the four wheel drive. Initially the torque is high and after that it remains constant.

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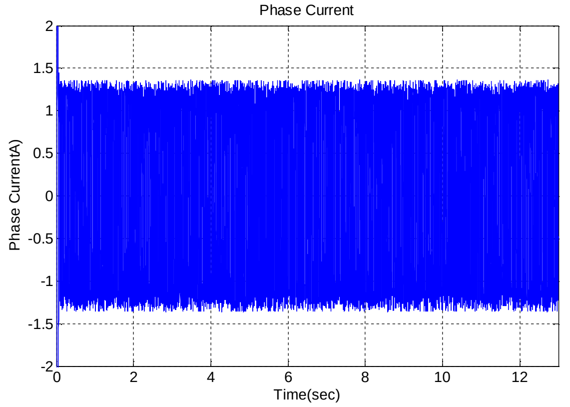

Fig. 5. Phase Current.

In the above current waveform no over currents existed because required current is generated from induction machine.

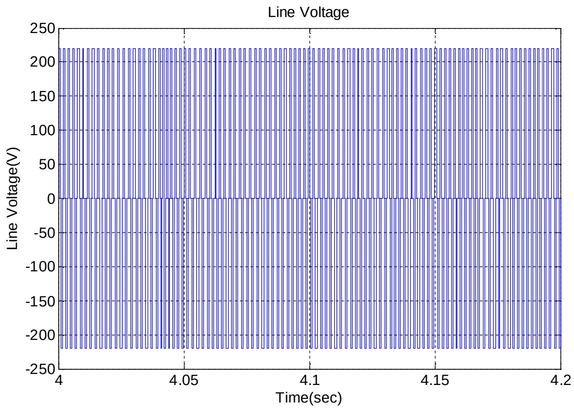

Fig. 6. Line Voltage.

Figure above shows the line voltage fed to the Induction motor drive.

Fig. 7. Force on Wheel.

The above fig represents the force on wheel of the vehicle. Initially the friction is high and after it is constant.

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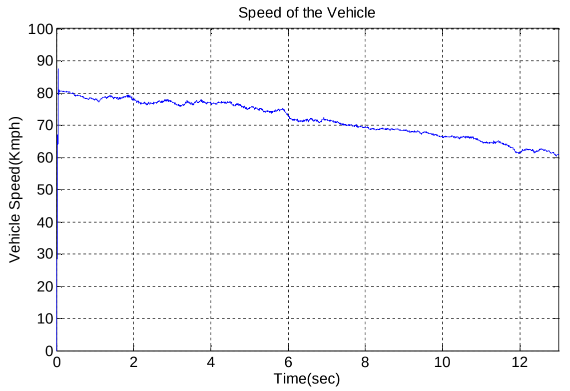

Fig. 8. Vehicle Speed.

The above graph represents the vehicle speed with induction machine of 3HP with three-phase, 60 Hz frequency. As it is the Electric Vehicle and not the IC Engine Vehicle, the speed is achieved instantaneously as it is observed from the Fig. the vehicle behaves in acceleration mode until 0.2s, from 0.2s to 6s it is in constant acceleration mode and then from 6s it works in deceleration mode.

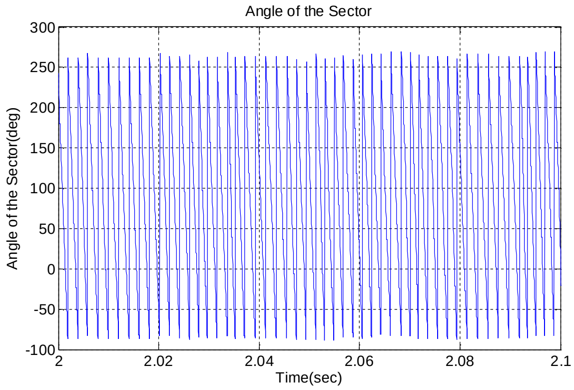

Fig. 9. Angle of Sector.

Figure shows the angle of the sector that is it is the angle between the stator flux and the rotor flux.

VII. CONCLUSION

In this paper, torque distribution control system for four-wheel-independent-drive electric vehicle is outlined. The system is based on applying a differential torque between the right and left front wheels to minimize the difference between the actual steering torque and the reference steering torque, which is mapped by the vehicle speed and steering wheel position. The simulation results prove that the direct torque control based space vector modulations improve the driving wheels speeds control with high accuracy in curved road or in slopped ones. The road topology disturbances, the driver decisions do not affect the performances of the driving motors in the other hand the proposed control gives good dynamic characteristics of the traction chain. It can be concluded that this novel power control DTC-SVM strategy, which is based on the characteristics of independent drive of electric vehicle, may be applied to four-wheel- independent-drive EV in the future.

REFERENCES

[1] A Novel 4WD Electric Vehicle Control Strategy Based on Direct Torque Control Space Vector Modulation Technique (scientific Research)

[2] Independent Wheel Torque Control of 4WD Electric Vehicle for Differential Drive Assisted Steering. (Scientific Research).

[3] F. Wu and T. J. Yeh, “A Control Strategy for an Electri- cal Vehicle Using Two In-Wheel Motors and Steering Mechanism,” *Proceedings of AVEC*’08, Kobe, 6-9 Octo- ber 2008, pp. 796-801.

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[4] S. Shin-Ichiro, S. Hideo and H. Yoichi, "Motion Control in an Electric Vehicle with Four Independently Driven In-Wheel Motors," *IEEE Transactions on Mechatronics*, Vol. 4, No. 1, 1999, pp. 9-16. doi:10.1109/3516.752079
[6] T. G. Habetler, F. Profumo, M. Pastorelli and L. Tolbert, "Direct Torque Control of Induction Machines Using Space Vector Modulation," *IEEE Transaction on Industry Applications*, Vol. 28, No. 5, 1992, pp. 1045-1053. doi:10.1109/28.158828.

BIOGRAPHY

G. Venu Madhav received his B.Tech. degree in Electrical and Electronics Engineering from Jawaharlal Nehru Technological University, Hyderabad in 2002. M.Tech. degree in Power and Industrial Drives from Jawaharlal Nehru Technological University, Anantapur in 2005. He was awarded Doctorate in 2016 from Jawaharlal Nehru Technological University, Hyderabad. He also completed Master of Business Administration (MBA) from Annamalai University in 2013. Currently he is working as Associate Professor, Dept. of EEE, Matrusri Engg. College, Saidabad. Right now, he has around 12 years of teaching experience.He has published several National and International Journals and Conferences. His area of interest is Advanced Control strategies of Electric Drives, Microprocessors and Microcontrollers, Fuzzy logic & ANN applications, and Network Analysis. Have professional society memberships in IEEE (M), IETE (M), ISTE (LM), IE (AM), SESI (LM), IAENG (M), NIQR (M), SSI (LM), SPE (LM), IAENG (LM), IACSIT (LM), and C.Eng.

Kothuri Ramakrishna completed his Bachelor of Engineering (B.E.) from Gulbarga University in the year 1998 and Master of Technology (M.Tech.) from J.N.T.U Hyderabad in 2001. He also completed Master of Business Administration (MBA) from Annamalai University in 2013. Presently, he is pursuing Ph.D from J.N.T.U. Hyderabad. Right now, he has around 16 years of teaching experience. His research interest includes Power Electronics, Power Quality, Power System Analysis, Power System Dynamics, etc. He has published several National and International Journals and Conferences. Have professional society memberships in IEEE (M), IETE (M), ISTE (LM), IE (AM), SESI (LM), IAENG (M), NIQR (M), SSI (LM), SPE (LM), IAENG (LM), IACSIT (LM), and C.Eng.