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A Robust Controller for PMSM in the application of a Plug in Electric Vehicles using Modified current control Technique

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ABSTRACT: In the modern era of transportation the contribution of plug-in electric vehicles (pev) is very important to heavy vehicles. Iinpev reviews torque features predominantly as the torque determining the performance of the pev or even the combustion engine powered vehicle. This paper presents the control system for a permanent magnet synchronous (pmsm) motor for fraction application of electric vehicles (evs). The design and development of the proposed system is done on this basis of the requirement of the rotor speed and load torque for pev in a real environment scenario. To obtain the desired amount with closed loop reference a robust controller is proposed in which the torque, stator flux, load angle and rotor speed are measured, observed and calculated. The values obtained are compared with reference value thus a robust controller is obtained throughout the operation the rotor speed of the pev is maintained at a reference speed and the torque output is varied by considering an external force the whole system i.e., the energy source from the battery uptopmsm are being simulated using MATLAB/simulink and the results are verified.

KEYWORDS: pev's,ev's.pmsm, flux controller, torque controller, svpwm, load angle controller.

I. INTRODUCTION

EVs have seen a resurgence in the twenty-first century as a result of technological advancements and a greater emphasis on renewable energy and the potential reduction of transportation's impact on climate change, air pollution, and other environmental issues. Electric cars were not popular at the time due to a lack of electricity grids and the limitations of storage batteries; however, electric trains were extremely popular due to their economies and achievable speeds. Because of advancements in the development of electric locomotives, electric rail transport became commonplace by the twentieth century. Permanent magnet synchronous motors (PMSM) are widely used in electric vehicle drive systems, robots, CNC machines, and other applications due to their efficiency, power density, and reliability. The precise control of PMSM is susceptible to motor parameters, load torque, and unmodeled dynamic, and the traditional proportional-integral (PI) control method cannot guarantee a sufficiently high performance for a PMSM control system.

When the performance of different batteries is compared, the Li-ion battery outperforms other batteries such as Ni-cd batteries, lead-acid batteries, and so on. Because the battery's storage capacity is limited, it will not last as long. Once consumption begins, exhaustion begins and eventually reaches zero. It is conceivable. Because they are mostly used for a short period of time, they require an energy management strategy to achieve peak performance efficiency. The efficiency of rechargeable batteries can be calculated using the battery's conceptual model. The hyperlink to an electric car, also known as a Plug-in Electric vehicle, is now the most efficient. The vehicle is battery-powered. Electric vehicles are classified into two types: plug- in electric vehicles and hybrid electric vehicles.

Dual motor drives fed by a single inverter are purposefully designed to be smaller and less expensive than single motor drives fed by a single inverter. The speed response behaviour of a Dual Permanent Magnet Synchronous Motor (PMSM) driven by a Space Vector Pulse Width Modulation (SVPWM) and Current Controller is presented in this paper.

The motor, controller, power supply, charger, and drivetrain are the main components of an electric vehicle system. The controller is the heart of an electric vehicle, and it is essential for realising a high-performance electric vehicle with an optimal balance of maximum speed, acceleration performance, and travel range per charge.

A permanent magnet synchronous motor uses permanent magnets embedded in a steel Rod to create a constant magnetic field. The stator carries windings connected to an AC supply to produce a rotating magnetic field. At synchronous speed the router Pole locked to the rotating magnetic field. Permanent magnet synchronous Motors are similar to brushless DC motor neodymium magnets, and are the most commonly used Magnet in the motor. Although in the last few years due to Rapid fluctuation in the price of neodymium magnet, a lot of research has been looking at the ferrite magnet as an alternative. Due to the inherent characteristics of ferrite magnets the available magnets the design of a magnetic circuit of the machine needs to be to be able to concentrate the magnetic flux.

II. TOPOLOGY

The transportation industry was replaced with plug -in electric vehicles very drastically. The imposed controller with higher efficiency will be the most predominantly solution for the conventional PeV drive mechanism. In the proposed system two prism motors are often using a single voltage source inverter (VSI). The direct torque control technique is used for controlling the torque of the prism motor by considering the master motor and slave motor. The battery is considered the energy source for the system. Rather than considering the conventional system the proposed system has the advantages that the control system is monitoring the master motor Rotor speed and all other parameters using stator flux, Load angle, and load torque are being calculated using the observed values. So the Rotor speed will be parameter that governing the torque control of master motor and the slave motor will also be change the load torque condition on accordance with the load torque demand. The parameters are monitored throughout the operation so the efficiency of the system will be high. The torque requirement will be as per the load demand through the operation. So that it can vary with demand.

From the figure it is clear that the, PMSM 1 consider as the master motor and PMSM 2 consider as the slave motor in which the parameters monitored are of PMSM. The stator flux, load angle, load torque are calculated using mathematical formulas with observed values from the analysis.

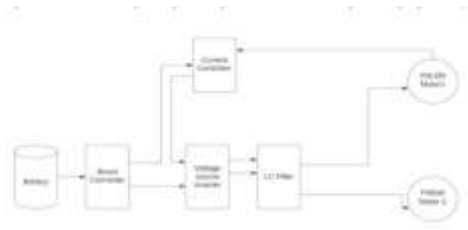

Figure 1: Block diagram of proposed method

III. OPERATING PRINCIPLES OF THE PROPOSED SYSTEM

The system consists of two PMSM motors, battery source and one voltage source inverter battery is the power source for the system. The two PMSM motors connected through one VSI so the power transfer is splitted between the two motors with the same voltage for the operation. During the operation the rotor speed of the master motor is sensed and the rotor speed is converted to the load torque demand using a PI controller. The results will be the error in the torque demand and the proposed control will try to achieve the load torque demand by applying sufficient switching pulse using a space vector PWM.

During the operation the voltage and current motors are also monitored and the stator flux is calculated from the calculated flux value the actual torque value is calculated in which it will be the actual value which is being used to find the torque error for the system. Stator flux control is the operating principle and for the PMSM in which the flux is controlled for varying the load torque with load torque demand. The proposed system is a direct torque control method in which the torque of PMSM 1 and PMSM 2 are controlled directly by controlling stator supply which is given by the result of controlling the stator flux.

The calculation of stator flux, load angle loads to the estimated value, which will compare with the actual value and check with the observed value, check whether it is in the range of values that the system requires.

The master and slave motors considered with same ratings the master is consider for the reference. The rotor speed of the motor is sensored figure 2 shows the control diagram design of the proposed system.

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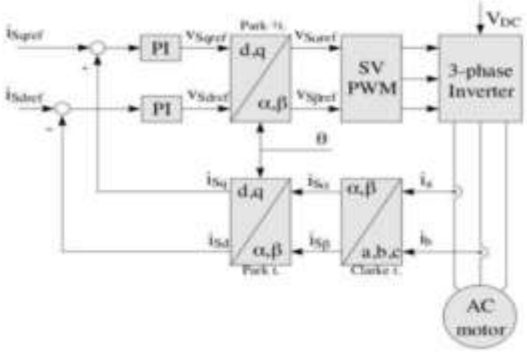

Figure 2: SVPWM Technique

In the proposed diagram the system is modified with a current made controller which is shown in figure 3.

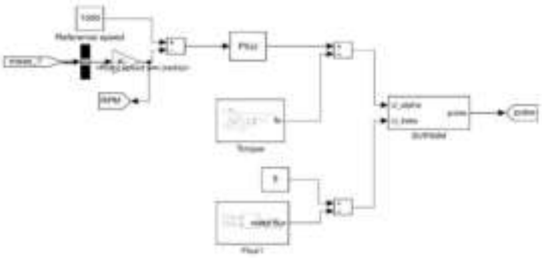

Figure 3: Simulation Circuit of Proposed Controller

From the figure it is clear that the rotor speed of the master motor is considered as the governing input variable or state vector for the system; the rpm is then compared with the reference speed. Then the error signal is generated using the PI controller which will be considered as the torque generated.

By measuring the three phase voltage and three phase current the stator flux is calculated which is given in the figure 4.

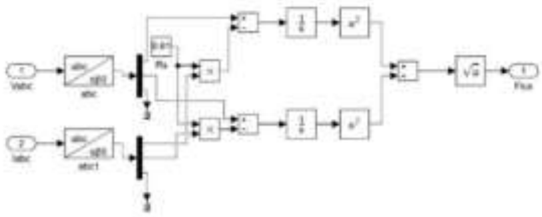

Figure 4: To calculate the flux

The stator flux calculated will be considered as the estimated values and it will be compared with the reference as shown in figure 4. In the meanwhile the torque is also estimated by considering the Ld,Lq and stator flux.

$$T_e = \frac{3}{2}\frac{p}{2}(\lambda_d i_q - \lambda_q i_q) \qquad (1)$$

By calculating the load angle from the estimated value the observed values are compared the figure 5 shows the loaded angle estimation and T_e estimation using mathematical formulation.

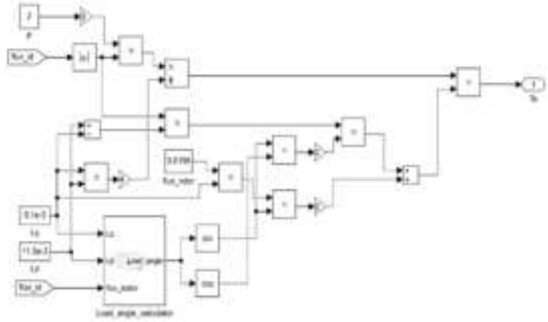

Figure 5: Formula for finding the torque reference

From the figure it is clear that the stator flux estimated is used for calculating the torque reference so the overall efficiency of the system will be high due to the continuous monitoring of the torque estimation

IV. DESIGN OF THE PROPOSED SYSTEM

The master and slave motors are governed by the single voltage source inverter the components of the proposed system will be battery with VSI controller master and slave motor and closed loop direct torque controller.

A. Battery with voltage source inverter

The battery is the main energy source for the system. So by design the system the constrain that has to be keep in mind that the battery system should be suit and enough to supply both master and slave motor table 1 shows the parameter of the battery. From the battery the developed voltage is amplified to a level that is required for the AC voltage generation and it is being maintained at a constant voltage of 400v. The switching pulse for the voltage source inverter is governed by the closed loop DTC controller table 2 given the components used for the boost converter.

Table 1 Li-ion battery properties

Sl.No:	Parameter	Value
1	Capacity	155Ah
2	Operation Voltage range	45-64.5V
3	Electric Energy	8.8kWh

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Table 2: components used for the boost converter

Sl.no	Parameter	Value
1	L	1mH
2	C	1000µf
3	f	1KHz
4	R_1	100Ω

B. **Master and slave motor**

Both master and slave motors used in the proposed system are permanent magnet synchronous motor table 3 gives the parameter for the pmsm.

The concept of current mode controller is the modification in the voltage mode control instead of using the irregular waveforms the inductor current varies with the pwm generated by the controller circuit.

The stator flux is controlled by the three phases voltage and three phase current given to the stator the pmsm motor so as to control the torque generated by the pmsm motor. The stator flux is controlled by the closed loop control system.

V. RESULT AND DISCUSSION

The proposed stem is developed and simulated using MATLAB/simulink. Figure 6 shows the simulation diagram of the proposed system.

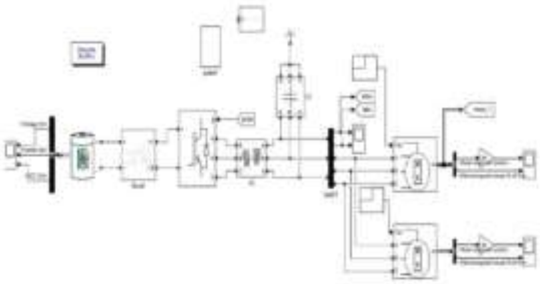

Figure 6: Simulation Circuit Diagram

From the diagram it is clear that the two PMSM motor are driven by the battery source the closed loop controller generator sufficient PWM to dive the voltage source inverter by taking the rpm of the master motor the master and slave motor are connected to same voltage source inverter with same voltage and the current ratings load the load sharing are different figure 8 shows the three phase voltage and three phases current generated by the voltage source inverter.

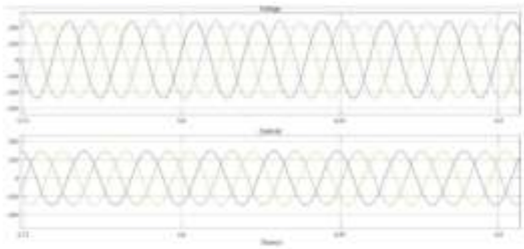

Figure 7: Stator Voltage and Current Waveform

From the graph it is clear that the voltage is at 260v 50Hz and current at 110A. So the overall system will be off 25kw that the power shared by the PMSM motor figure 8 shows the power delivered by the battery.

Figure 8: Voltage, current and soc of the battery

From which it is clear that the voltage at which the battery delivers power is 490v and average current is 50A. Ao as the system is highly efficient.

When considering the boost convertor it magnitude the battery voltage upto a constant level that is sufficient for generating three phase AC voltage figure 9 shows the input and output voltage of the boost converter.

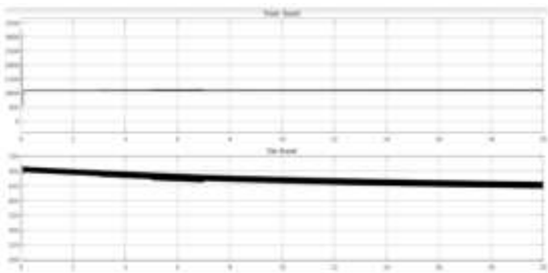

Figure 9: Input and output voltage of Boost Converter

The spwm technique is used for governing the torque controller. The pulse generated by the closed loop controller is such a way that the output three phase voltage is maintained to obtain the direct torque controller.

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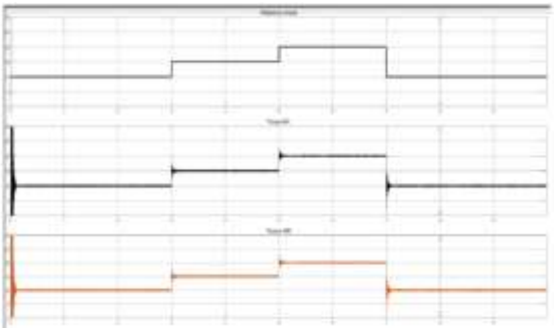

Figure 10: Output torque of motor M1 and M2 with reference torque

Figure 10 shows the torque response of the master motor slave motor with load torque reference. It is clear that from the analysis the controller has high efficiency on responding the torque variation of the loaded torque from the graph during (0-3)s the torque reference is 10 NM and the master and the master motor and slave motor has the load torque of 10Nm in the benign there is some asymmetric instability that will coverage with in a few second after 3s the load torque is varied to 15Nm and the load torque of master and slave motor becomes 15Nm but at the transition status these is some asymmetric instability of observation in micro seconds range after (3-7)sec a laid change is introduced even if the load change introduced in the system the master and slave motor are retraced the path and converge into the reference value. In all conditions the load torque refers to the path without only derivation but switching from one point to another there is some asymmetric instability for a small interval of time but it doesn't disturb the stability of the system. The closed loop controller neglects the system asymmetric instability.

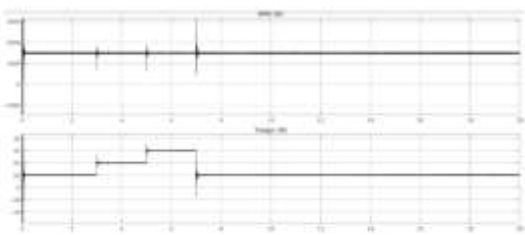

Figure 11:Torque vs rpm of motor M2

Figure 11 shows the rotor speed and load torque of master motor from the figure it is clear that the rotor speed is constant through and the operation 1500 rpm on switching the load torque from (15-20-30-15)NM during the time interval (3,5,7) second the rotor speed does not change even the asymmetric stability which is clearly shows the efficiency of the system.

VI. CONCLUSION

The direct torque control of pmsm motor has very much importance in the plug electric vehicle due to improve the stability and efficiency of the vehicle system dynamics many methods are available for direct torque control technique in which the flux control is adopted in this proposed method the proposed system has the modified part that the flux control is governed by mathematical calculation of vehicle obtained from measuring the three phase voltage three phases current. The flux estimator circuit then compares the result with the reference value and shows that the closed loop controller performs well enough to get high efficiency. Through the operation the rotor speed of the pmsm motor is maintained at constant value if the torque requirement is getting from the load torque side the reference torque is changed so the switching pulse and hence the flux control.

The proposed design the current mode control over the direct torque control is perform well the results obtained from the simulation shows that the estimated value calculated value and observed values are same for the DTC of the pmsm motor so by the considering the rotor speed of master motor and sensing the three phase voltage and current led to the PMSM the DTC can be controlled easily. The stator flux load angle torque reference is calculated mathematically during simulation. The results show that the proposed system is efficient and can be implemented in real time conditions like cars, ships and industries.

REFERENCES

[1]. T. -I. Yeam and D. -C. Lee, "Design of Sliding-Mode Speed Controller WithActiveDamping Control for Single-Inverter Dual-PMSM Drive Systems," in IEEE Transactions on Power Electronics, vol. 36, no. 5, pp. 5794-5801, May 2021, doi:10.1109/TPEL.2020.3028601

[2]. X. Wang, Z. Wang, Z. Xu, M. Cheng and Y. Hu, "Optimization of Torque Tracking Performance for Direct-Torque-Controlled PMSM Drives With Composite TorqueRegulator," in IEEE Transactions on Industrial Electronics, vol. 67, no. 12, pp. 10095-10108,Dec. 2020, doi: 10.1109/TIE.2019.2962451.

[3]. TJ. M. Lazi, Z. Ibrahim, M. Sulaiman, I. W. Jamaludin and M. Y. Lada, "Performancecomparison of SVPWM and

Hysteresis current Control for Dual motor drives," 2011 IEEEApplied Power Electronics Colloquium (IAPEC), 2011, pp. 75-80, doi:10.1109/IAPEC.2011.5779854.

[4]. K. Li, X. Liu, J. Sun and C. Zhang, "Robust current control of PMSM based on PCHand disturbance observer," Proceedings of the 33rd Chinese Control Conference, 2014, pp. 7938-7942, doi: 10.1109/ChiCC.2014.6896326.

[5]. Y. Inoue, S. Morimoto and M. Sanada, "Comparative study of PMSM Drive systemsbased on current control and direct torque control in flux-weakening control region,"2011 IEEE International Electric Machines &Drives Conference (IEMDC),2011, pp. 094-1099, doi: 10.1109/IEMDC.2011.5994754.

[6]. F. Chen, S. Chen and Y. Huang, "Model Predictive Current Control with VariableControl Period for PMSM," 2020 Chinese Automation Congress (CAC), 2020, pp. 6282-6287, doi: 10.1109/CAC51589.2020.9327580.

[7]. J. Kang, X. Li, Y. Liu, S. Mu and S. Wang, "Predictive Current Control with Torque Ripple Minimization for PMSM of Electric Vehicles," 2018 IEEE International Power Electronics and Application Conference and Exposition (PEAC), 2018, pp. 1-6, doi: 10.1109/PEAC.2018.8590256.

[8]. D. Hind, C. Li, M. Sumner and C. Gerada, "Realising robust low speed sensorlessPMSM control using current derivatives obtained from standard current sensors," 2017 IEEE International Electric Machines and Drives Conference (IEMDC), 2017,pp. 1-6, doi: 10.1109/IEMDC.2017.8002075.

[9]. T. Yeam and D. Lee, "Speed Control of Single Inverter Dual PMSM Drives UsingSliding Mode Control," 2019 IEEE Vehicle Power and Propulsion Conference (VPPC), 2019, pp. 1-6, doi: 10.1109/VPPC46532.2019.8952492.

[10]. D. Hind, C. Li, M. Sumner and C. Gerada, "Realising robust low speed sensorlessPMSM control using current derivatives obtained from standard current sensors," 2017 IEEE International Electric Machines and Drives Conference (IEMDC), 2017,pp. 1-6, doi: 10.1109/IEMDC.2017.8002075.

[11]. A textbook of Electric motor drives by R.KrishnanR. Morales-Caporal, M. E. Leal-López, J. de vehicle applications," 2018 International Conference on Electronics,Communicationsand Computers (CONIELECOMP), 2018, pp. 232-237, doi: 10.1109/CONIELECOMP.2018.8327204.

[12]. L. Tang and G. Su, "High-Performance Control of Two Three-Phase Permanent-Magnet Synchronous Machines in an Integrated Drive for Automotive Applications," in IEEE Transactions on Power Electronics, vol. 23, no. 6, pp. 3047-3055, Nov. 2008, doi: 10.1109/TPEL.2008.2005374.