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Simulation of Switched Reluctance Motor Drive for Electric Vehicle Application

J.Jeffy Felcia Sharon[1], Dr.Nalin Kant Mohanty [2]

Professor, Dept. of EEE, Sri Venkateswara College of Engineering, Chennai, Tamil Nadu, India[1]

PG Student [PED], Dept. of EEE, Sri Venkateswara College of Engineering, Chennai, Tamil Nadu, India[2]

ABSTRACT: The switched reluctance motor drive has evolved as an alternative to conventional motors in variable speed drives because of rugged construction, high speed operations, four quadrant, absence of magnet, adaptability to harsh environment. The concept of this work helps to develop a 4 phase switched reluctance motor (SRM) drive. Through proper control and setting of key parameters good acceleration/deceleration, reversible driving and braking characteristics can be obtained. The established charger consists of Asymmetric bridge converter from replacing H-bridge Switch Mode Rectifier with dc source. This type power circuit with SRM drive concept has been stimulated using the MATLAB/Simulink software with PI and PID controller The output results obtained as speed response drawn by SRM are compared and necessary drive regulation was satisfactory.

KEYWORDS: switched reluctance motor; Torque ripple; Asymmertric bridge converter.

I.INTRODUCTION

To reduce fossil energy consumption, the utilization of green energy sources has increasingly gained attention worldwide. In addition, the use of electric vehicles (EVs) is also effective in achieving this goal. Moreover, an EV can be regarded as a movable energy storage device. An experimental EV SRM drive is established. Its power circuit consists of a bidirectional dc/dc converter and an SRM asymmetric bridge converter. The proper controls are made to possess good acceleration/deceleration, reversible driving, and regenerative braking characteristics. The SRM high-speed driving performance is further enhanced via commutation shift and voltage boosting.

II EXISTING SYSTEM

This paper develops a battery/ powered switched-reluctance motor (SRM) drive for electric vehicle (EV) propulsion. Its on-board integrated charger is formed using the embedded motor drive components. The boosted motor drive DC-link voltage is established by an interleaved DC/DC boost converter from the battery. The super-capacitor (SC) is interfaced to the DC-link via a DC/DC buck converter. And it is connected to the battery bank by a diode to assist the battery in acceleration and deceleration. Good driving and regenerative braking performances are achieved by proper control. In idle condition, with help of formed on-board integrated charger with good line drawn power quality the grid-to-vehicle battery charging is possible. The established charger consists of a full-bridge boost switch-mode rectifier (SMR) and a buck DC/DC converter based charger.

III PROPOSED SYSTEM

The power circuit of the motor drive is formed by a bidirectional two-quadrant front-end dc/dc converter and an SRM asymmetric bridge converter. Through proper control and setting of key parameters, good acceleration/deceleration, reversible driving, and braking characteristics are obtained. A 4 phase switched-reluctance motor (SRM) possesses a doubly salient and singly excited structure, and there is no conductor or permanent magnet on its rotor. Hence, it possesses the following advantages:
Rigid structure, Low cost, High power density, Absence of cogging torque, Highly developed torque and acceleration capabilities, Suitability for high-speed driving and Simple converter schematic with fault tolerance. Hence, SRM is suited to be the EV propulsion actuator.

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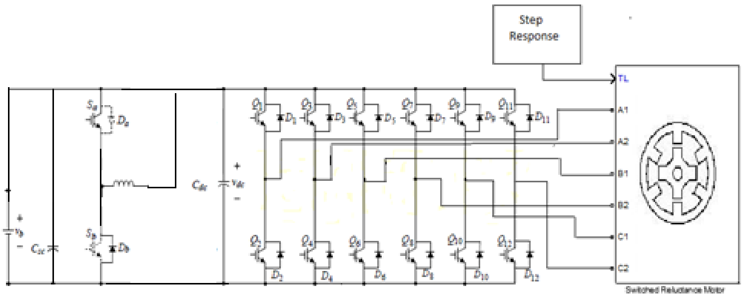

Fig. 1 Power circuits of the developed EV SRM drive powered with Asymmetric Bridge Converter

IV SRM CONVERTER

A main problem in certain application is the selection of converter topology. The SRM Converter has some essential requirements, they are: Minimum one switch is capable to conduct freely in each phase of the motor. The converter would be capable to excite the phase before it enters the generating or demagnetizing region. The converter needs to satisfy several other necessities in order to increase the converter performance; such as fast Demagnetization time, faster excitation time, high power, higher efficiency, and fault acceptance. They are: The converter must be able to allow phase overlap control because the converter energy can be provided to one phase whereas at the same time it is removed from the other phase. The phase voltage should be modulated using Pulse Width Modulation (PWM) technique at low speeds for the controlling of phase current. On each operating point, to inject the sufficient current into the winding at high speed, necessary high driving voltage is essential. This necessary control system can be single pulse or hysteresis current control. Using this device; the demagnetization time can be reduced for avoiding negative torque and or allowing an addition of commutation period (i.e.; dwell angle).The demagnetization energy from the leaving phase must be provided back to the dc source or should use it in the incoming phase. The hysteresis losses and switching losses can be reduced by the converter, because in order to decrease the switching frequency it is capable of freewheeling during the chopping period. In order to decrease the voltage stress through the semiconductor switches, the converter takes to be single rail of power source. Upon the construction of motor, the converter would have to be single rail of power source. The resonant circuit is needed for the converter to apply zero-voltage or zero-current switching for reduction of switching loss. Less number of semiconductor switches is suitable. Power factor correction circuit should be applied for improve the power factor. Little complexity of converter is required. Application and efficiency of this converter is defined by choosing the appropriate dwell angle, switching strategy, and control technique (usually hysteresis current control). Since the torque in SRM drives is independent of the excitation current polarity, the SRM drives require only one switch per phase winding. The SRM drives always have a phase winding in series with a switch. In case of a shoot-through fault, the inductance of the winding limits the rate of rise in current and provides time to initiate protective relaying to isolate the faults. The phases of the SRM are independent and, in case of one winding failure, uninterrupted operation of the motor drive operation is possible, although with reduced power output. Some configurations of converters used in SRM drives are presented and discussed in this chapter. While many of these configurations have been known for some time, the rest are emerging from research laboratories. The torque expression requires a relationship between machine flux linkages or inductance and the rotor position Torque and speed control is achieved with converter control The machine operation in all of its four quadrants of torque vs. speed is derived from the inductance vs. rotor position characteristic of the machine

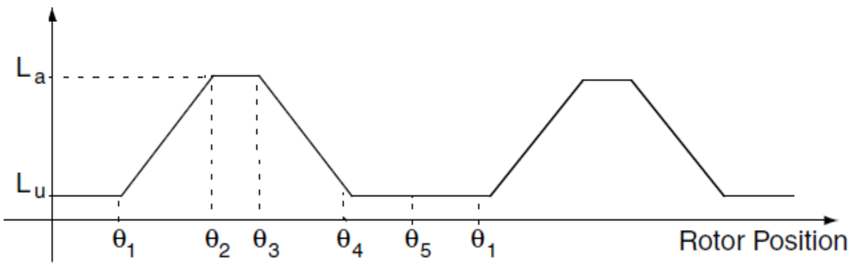

Fig. 2 Motor inductance vs rotor position

SRM is generally controlled by either voltage or current control in the asymmetric converter. Phase current can be controlled accurately that means torque is accurately controlled and the decrease of torque ripple or noise is achieved. This is the main benefit of current control over voltage control. The main demerit is it requires a larger heat sink for cooling because the one switch that is always in the current conduction path increases the losses in the converter so it reduces the efficiency of the system. From this paper, it is found that the asymmetric converter type is suitable for very high speed operation of SRM drive because of the quick rise and fall times of current and moreover it give negligible shoot through faults. Because of the nonappearance of the resistance commutation circuit or any coil that is added to the converter, copper losses is not presented in the asymmetric converter. So, for high power SRM drives, Asymmetric converter is considered as the most suitable converter

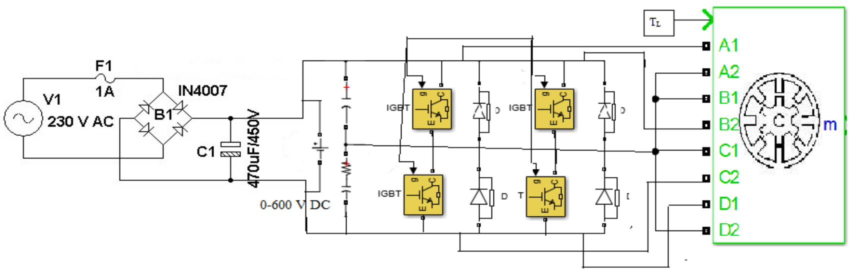

Fig. 3 System configuration of the developed SRM drive on-board charger

(i.e., the control signal). This is identified hereafter as a unipolar switching strategy and is utilized in other drive systems. This switching strategy handles negative current error signals in between the energization and commutation modes of the phases with judicious choice of negative or zero voltage across the winding to obtain a fast current response. Further, it effectively doubles the switching frequency contributing to mitigation of current ripple and hence reduction of the ripple torque. Due to these advantages, this switching strategy is ideal for high-performance current and torque control of SRM drive systems

V. RESULT AND DISCUSSION

Many industrial processes are controlled using conventional controllers like PI, PD, and PID *etc*. The PI controller is very popular because of their robust performance over a wide range of operating conditions and functional simplicity. The basic purpose of process control systems such as is two-fold: To manipulate the final control element in order to bring the process measurement to the set point whenever the set point is changed, and to hold the process measurement at the set point by manipulating the final control element. The control algorithm must be designed to quickly respond to changes in the set point (usually caused by operator action) and to changes in the loads (disturbances). The design of the control algorithm must also prevent the loop from becoming unstable, that is, from oscillating.

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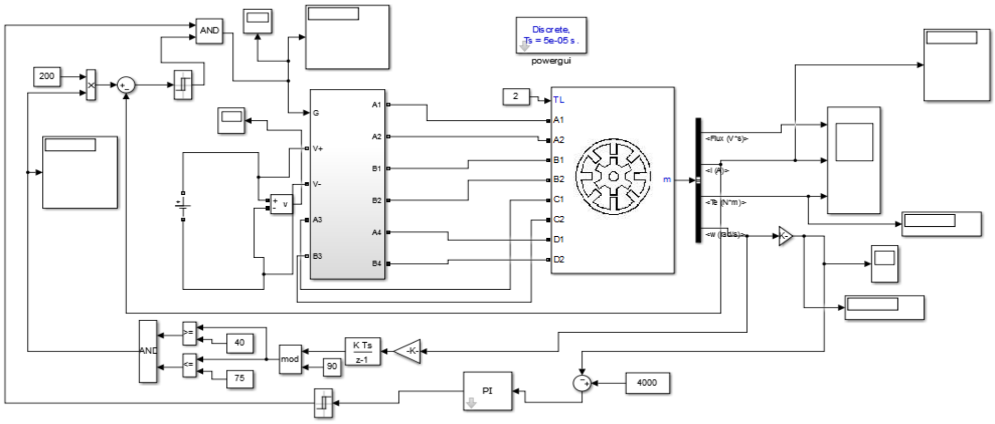

Fig. 4 PI Control SRM drive

There are varieties of control actions that are used, in order to achieve the desired response from the designed process satisfactorily and efficiently The performance of the PI controlled SRM drive is analyzed through simulation. The simulation is performed to obtain a constant speed at 4000rpm. In this simulation, the MATLAB Inbuilt 8/6 SRM model is used. Fig 5 shows .the simulation diagram of SRM drive with PI control. The simulation diagram consists of SRM model, Asymmetrical converter and PI controller.

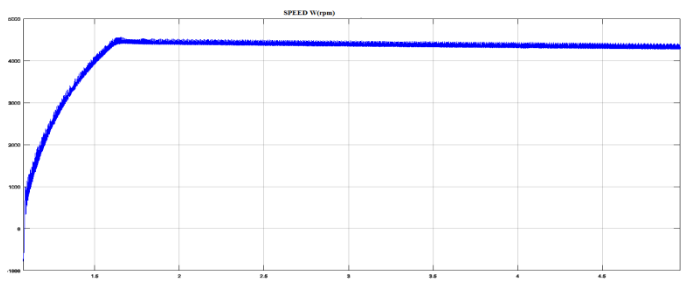

Fig. 5 simulation result of PI control

As we increase the proportional gain, it provides smaller amplitude and phase margin, faster dynamics satisfying wider frequency band and larger sensitivity to the noise. We can use this controller only when our system is tolerable to a constant steady state error. In addition, it can be easily concluded that applying P controller decreases the rise time and after a certain value of reduction on the steady state error, increasing K only leads to overshoot of the system response. P control also causes oscillation if sufficiently aggressive in the presence of lags and/or dead time. The more lags (higher order), the more problem it leads. Plus, it directly amplifies process noise. P-I controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue. Since P-I controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot. The performance of the PID controlled SRM drive is analyzed through simulation. The simulation is performed to obtain a constant speed at 4000rpm. In this simulation, the MATLAB Inbuilt 8/6 SRM model is used. Fig 6 shows .the simulation diagram of SRM drive with PID control. The simulation diagram consists of SRM model, Asymmetrical converter and PID controller.

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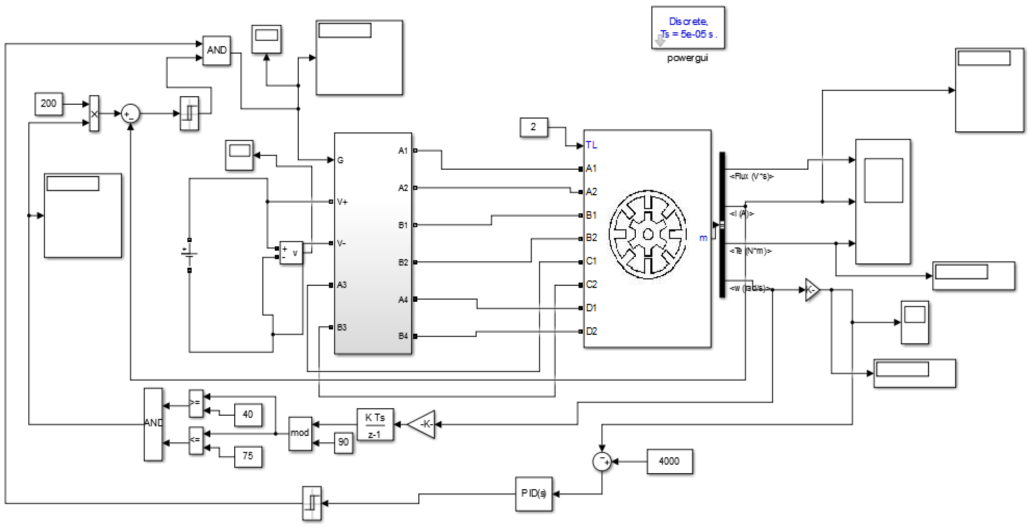

Fig. 6 PID Control SRM drive

P-I-D controller has the optimum control dynamics including zero steady state error, fast response (short rise time), no oscillations and higher stability. The necessity of using a derivative gain component in addition to the PI controller is to eliminate the overshoot and the oscillations occurring in the output response of the system. One of the main advantages of the P-I-D controller is that it can be used with higher order processes including more than single energy storage.

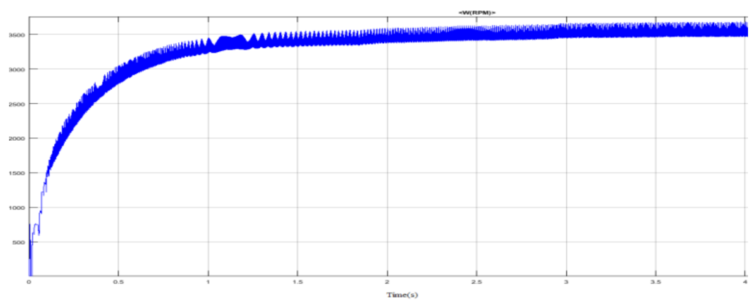

Fig. 7 Simulation result of PID control

In order to observe the basic impacts, described above, of the proportional, integrative and derivative gain to the system response, see the simulations above prepared on MATLAB in continuous time with a transfer function and unit step input. The results will lead to tuning methods.

VI.CONCLUSION

The above proposed concept initially compares the output response of the four phase SRM drive with two types of controller. The main reason behind considering four phases with 8 stator and 6 rotor poles is to minimize the torque ripple. Generally ripple constraints will be less in going for increasing poles in the motor construction.. As a result the SRM dynamic performance is forecasted and by using the MATLAB/Simulink the model is simulated. The conclusion from this simulation results that when compared with PI controller, the PID controller meets the required output. It gives excellent reference tracking of speed and enhances the regulation.

VII.ACKNOWLEDGEMENT

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REFERENCES

[1] Hu Y, Song X, Cao W, and Ji B. (Oct 2014), 'New SR drive with integrated charging capacity for plug-in hybrid electric vehicles (PHEVs)' IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5722–5731.

[2] Omekanda A. M. (2013), 'Switched reluctance machines for EV and HEV propulsion: State-of-the-art' in Proc. IEEE DEMDCD, vol. 9, no. 12, pp. 70–74.

[3] Pei-Hsun Yi and Chang-Ming Liaw (Aug.-2015), 'An EV SRM Drive Powered by Battery/Supercapacitor With G2V and V2H/V2G Capabilities' IEEE Transactions On Industrial Electronics, vol. 62, no. 8, pp. 4714-4727.

[4] Pinto J. G. (2013), 'Bidirectional battery charger with grid-to-vehicle, vehicle-to-grid and vehicle-to-home technologies' in Proc. IEEE IECON, pp. 5934–5939.

[5] Tina A, M. Camara B., Dakyo B., and Azzouz Y. (May 2013), 'DC/DC and dc/ac converters control for hybrid electric vehicles energy management ultra-capacitors and fuel cell," IEEE Transactions Industrial Informat., vol. 9, no. 2, pp.686–696.

[6] Jr-Jia He, Kai-Wei Hu and Chang-Ming Liaw (2015), 'On a Battery/Supercapacitor Powered SRM Drive for EV with Integrated On-board Charger' IEEE Industrial Technology (ICIT), Vol. 12, no. 10 pp. 2667-2672.

[7] Kramer B, Chakraborty B and Kroposki B. (2008), 'A review of plug-in vehicles and vehicle-to-grid capability' in Proc. IEEE IECON, pp. 2278–2283.

[8] Khan M. A, Husain I, and Sozer Y. (Sep 2013), 'Integrated electric motor drive and power electronics for bidirectional power flow between the electric vehicle and dc or ac grid' IEEE Trans. Power Electron., vol. 28, no. 12, pp. 5774–5783.

[9] Kesler M, Kisacikoglu M. C, and Tolbert L. M. (Dec 2014),'Vehicle-to-grid reactive power operation using plug-in electric vehicle bidirectional offboard charger' IEEE Trans. Ind. Electron., vol. 61, no. 12, pp. 6788–6784.

[10] Krishnan R. (2001), 'Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, Applications'. New York, NY, USA: CRC Press.

[11] Lee Y. J., Khaligh A., and Emadi A. (2009), 'Advanced integrated bidirectional ac/dc and dc/dc converter for plug-in hybrid electric vehicles,' IEEE Trans. Veh. Technol., vol. 58, no. 8, pp. 3970–3980.

[12] Mohan N., Undeland T. M, and Robbins W. P. (2003), 'Power Electronics: Converters, Applications, and Design' 1st Ed. New York, NY, USA: Wiley.

[13] Miller T. J. E (1993), 'Switched Reluctance Motors and Their Control'. Oxford, U.K.: Clarendon.