IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 7, July 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.18

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

Performance Evaluation of IM and PMSM with Multilevel Inverter for Electric Vehicle Application

Yogita Sakhare[1], S. S. Kulkarni[2]

PG Student, Dept. of EE, Government College of Engineering, Aurangabad, Maharashtra, India[1]

Associate Professor, Dept. of EE, Government College of Engineering, Aurangabad, Maharashtra, India[2]

ABSTRACT: The varieties of concepts are available worldwide when designing Electric vehicles (EV). The main parts that need to be assembled in power train of electric vehicles are the motor, controller, battery storage and supporting system. The widely used motors for electric vehicle are BLDC motor, AC Induction motor, Brushed DC motor and Permanent Magnet Synchronous Motor. So the objective of this paper is to evaluate the performance of Induction Motor (IM) and Permanent Magnet Synchronous Motor (PMSM) fed by multilevel inverter. To obtain higher levels of voltage different types of multilevel inverters are used. Cascaded H-bridge (CHB) multilevel inverter is mostly used due to its advantages over other multilevel inverter. Multilevel inverter is modelled using sinusoidal pulse width modulation (SPWM) and simulations are carried out in MATLAB Simulink to analyze the performance of IM and PMSM.

KEYWORDS: Multilevel Inverter, Induction Motor (IM), Permanent Magnet Synchronous Motor, Total Harmonic Distortion (THD).

I.INTRODUCTION

In electric vehicles, the main source of power for propulsion of a vehicle is electrical energy. In EV's, electrical energy is converted into mechanical energy by using electric motors. This mechanical (rotational) energy is given to wheels of a vehicle through an appropriate transmission system which causes propulsion. Electric vehicle can be represented as shown in fig.1. The basic components of EV are battery, electric motor and controller. Results and scores were included in all studies presented obtained from design and simulation of the performance of various electric motors. Investigations of the performance of electric motors in the EV systems have never been emphasized in the literature. Because of this, to acquire quantitatively and well-founded results there is a need to check the performance of electric motors as parts of electric vehicle. The most widely used motors for electric vehicle are Induction motor, BLDC motor, Brushed DC motor and Permanent magnet synchronous motor.

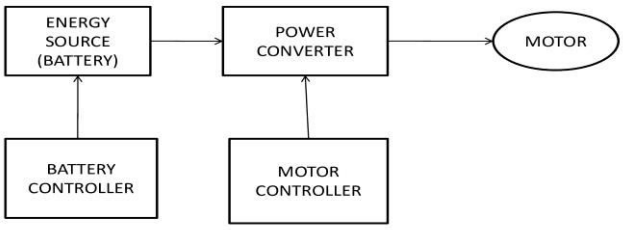


Fig. 1. Basic Components of EV

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

Smoother voltage level can be provided to the motor by using multilevel inverter. As we know the term multilevel is introduced by three level inverter, a staircase voltage waveform is obtained with the multilevel inverter concept by using chain of power semiconductor switching devices with number of lower level dc voltage sources. Compare to typical two level inverters multilevel inverters are more advantageous. They can operate at fundamental and higher frequencies. Multilevel inverters give low harmonic distortion as compare to two level inverter. The main multilevel inverters are cascaded H-bridge inverter, flying capacitor clamped, neutral point clamped inverter. Cascaded H-bridge multilevel inverter gives minimum distortion and least THD as compared with other multilevel inverter. This paper describes the performance of PMSM and IM as two candidates for use in EVs are investigated with cascaded H-bridge (CHB) multilevel inverter in terms of torque, speed, stator current and THD.

II.PROPOSED INVERTER

If the voltage level of voltage increases, the synthesized output waveform becomes smoother and desirable which decreases harmonic content in the waveform. Therefore, multilevel inverters are used for motor drives industries because of the limitations of two level inverters as harmonics, voltage stress, low power rating. The cascaded H-bridge multilevel inverter circuit consists of individual H-bridge cell which is supplied by individual supply. Each H-bridge cell contains four MOSFET switches. Each H-bridge generates three different output voltages +Vdc, 0 and –Vdc using different switching combinations with the four switches. For 5-level CHB multilevel inverter, each leg consists of two bridge cells. Fig.2 shows the one leg of three phase 5-level CHB multilevel inverter.

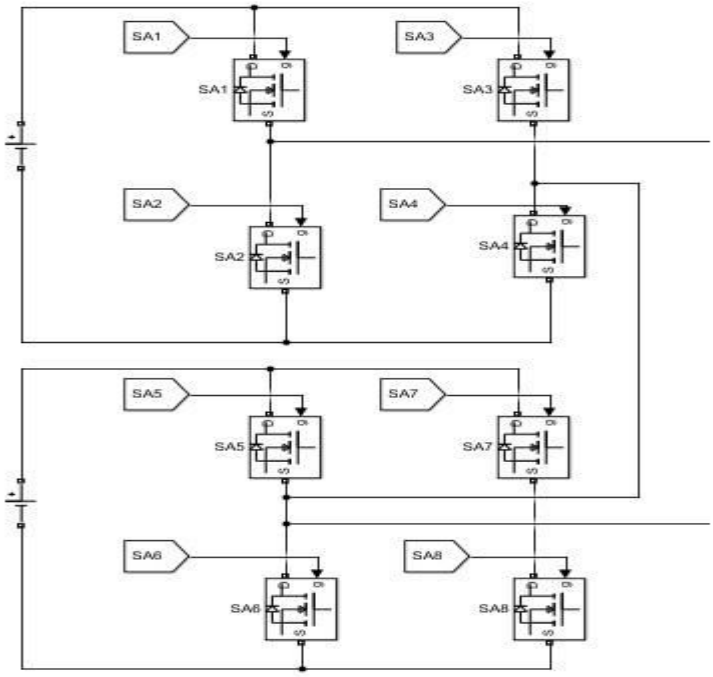


Fig.2. Single leg of three phase 5-level Cascaded H-Bridge Inverter

Since an inverter consists of power electronic switches, by multiple switching within the inverter with constant DC input voltage Vdc, the output voltage can be controlled and harmonically optimized. PWM is one of the techniques to control the switching of multilevel inverter. In the power electronic inverter circuit, Sinusoidal pulse width modulation (SPWM) is very popular control method. SPWM is widely used because it has many benefits easy to understand, easy to implementation, lower switching losses and output has fewer harmonics. Basically, SPWM is divided into two types, one is modulating signal based and other is carrier signal based. Here carrier signal based SPWM method is used. This method gives different output levels; all carrier waves of the same frequency, same amplitude and same phase but with different DC offset compared to single sinusoidal waveform.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

At the points where the sine wave intersects triangular waves for specific period it generates gating signal for the switches to generate the respective ones levels. Fig.3 shows the arrangement to generate the gating signal for the one leg of three phase 5-level CHB multilevel inverter.Fig.4 shows the waveforms of carrier signal based SPWM method for arrangement shown in fig.3.

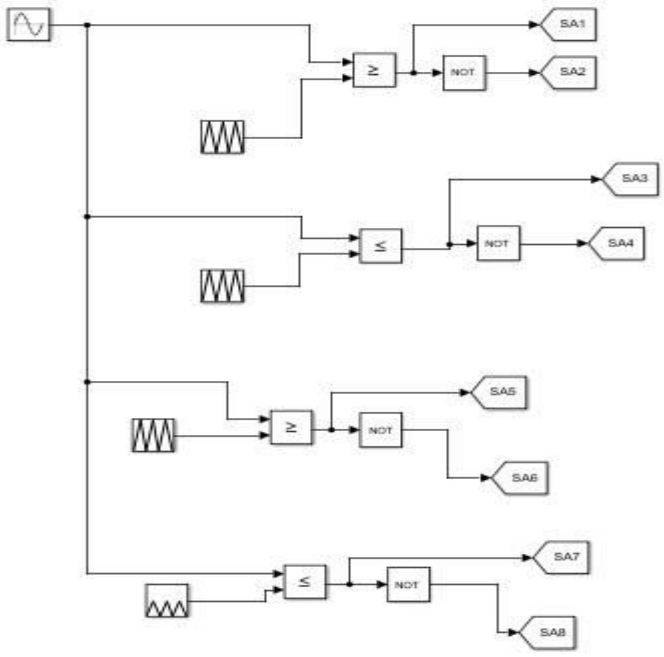


Fig.3. SPWM Technique for CHB Multilevel Inverter (for one phase)

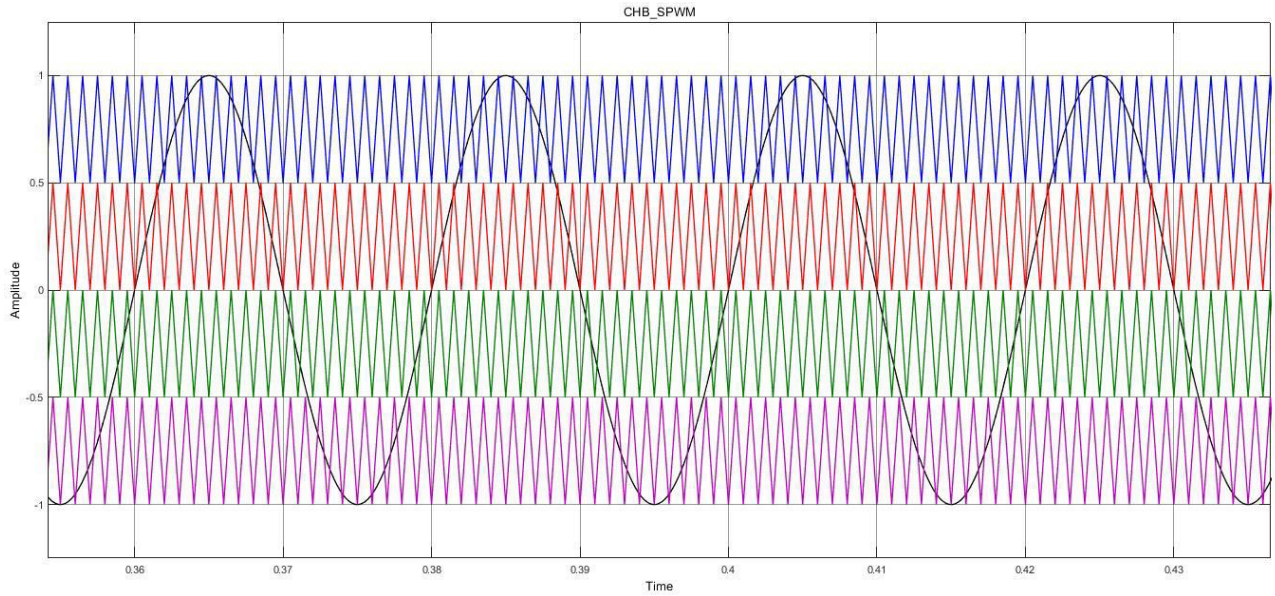


Fig.4. SPWM Waveform for 5-level CHB Multilevel Inverter

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

III.INDUCTION MOTOR WITH CASCADED H- BRIDGE MULTILEVEL INVERTER

The most commonly used electric motor in electric vehicle is the three phase induction motor due to its high efficiency, good speed regulation and absence of commutators. Fig.5 shows the schematic diagram of 5-level Cascaded H-bridge multilevel inverter fed induction motor, in which 6 H-bridge cells are required for the 5-level inverter. Two H-bridges for each phase and each H-bridge consists of 4 MOSFET switches. To trigger these switches SPWM technique is used. Fig.6. shows the complete simulink model for the 5-level CHB multilevel inverter fed IM. The 5-level output voltage waveforms for the three phases are shown in Fig.7. The performance of CHB multilevel inverter fed IM is in terms of stator current, torque and speed from Fig.8 to Fig.10 respectively.

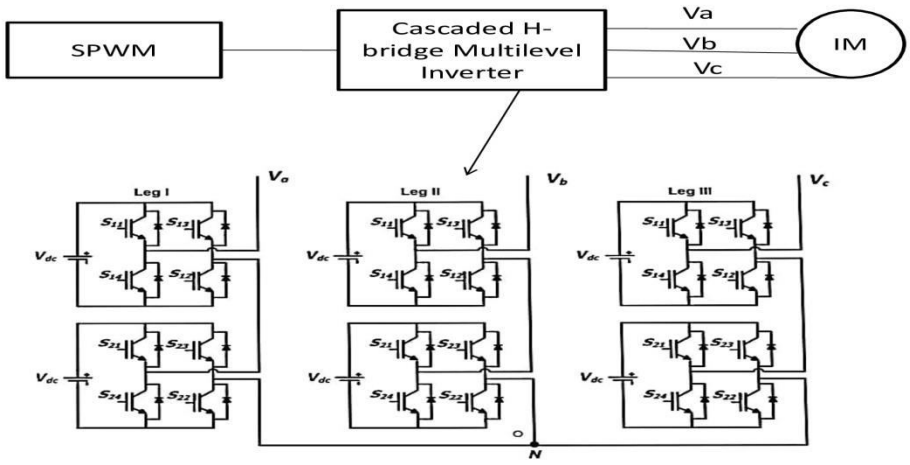


Fig.5. Schematic Diagram of 5-level Cascaded H-bridge multilevel inverter fed IM

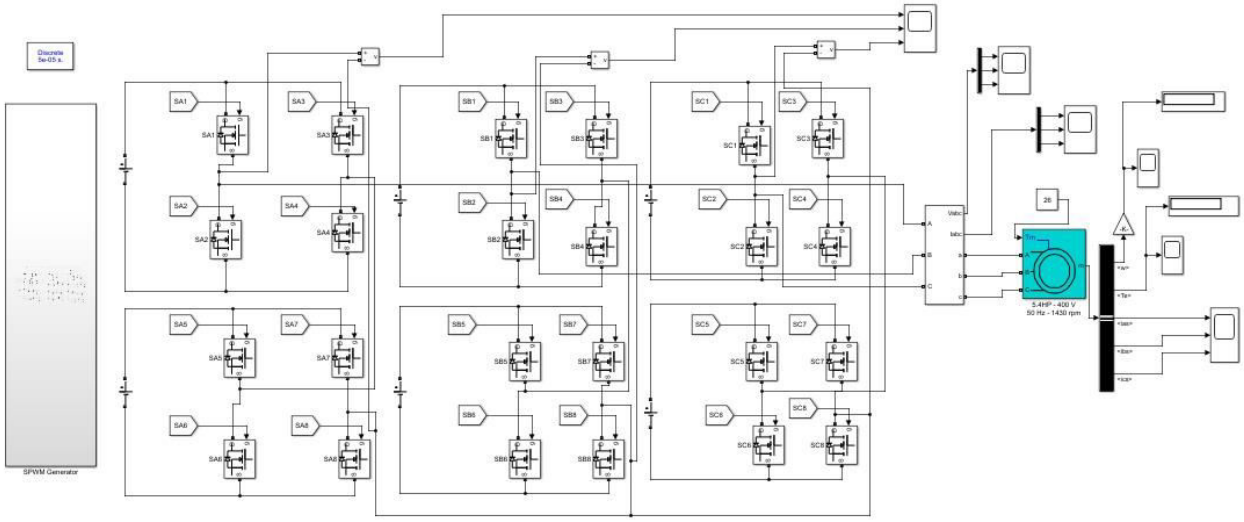


Fig.6. Simulink Diagram of 5-level Cascaded H-bridge multilevel inverter fed IM

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

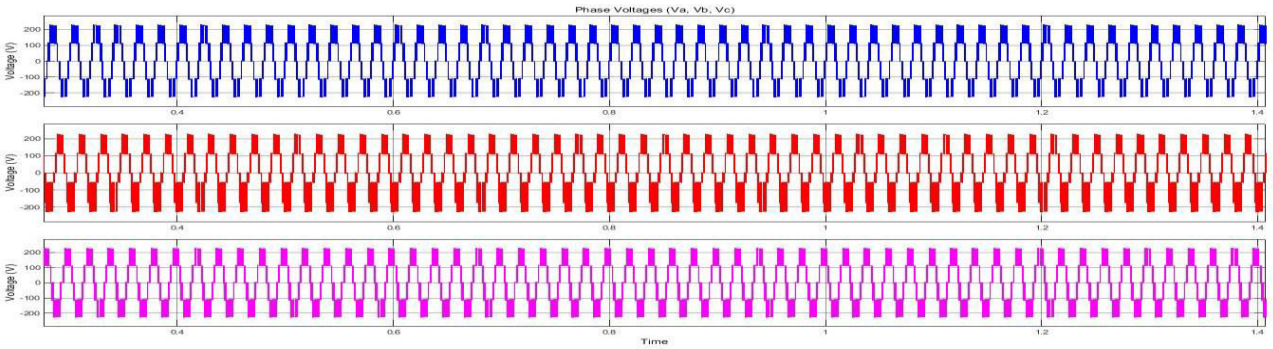


Fig.7. 5 level Output Voltage Waveform

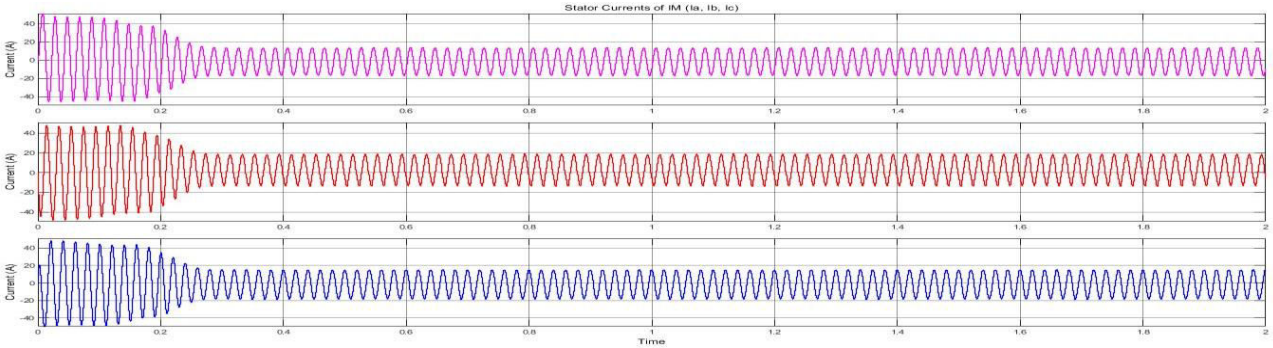


Fig.8. Three Phase Stator current of CHB Multilevel inverter fed IM

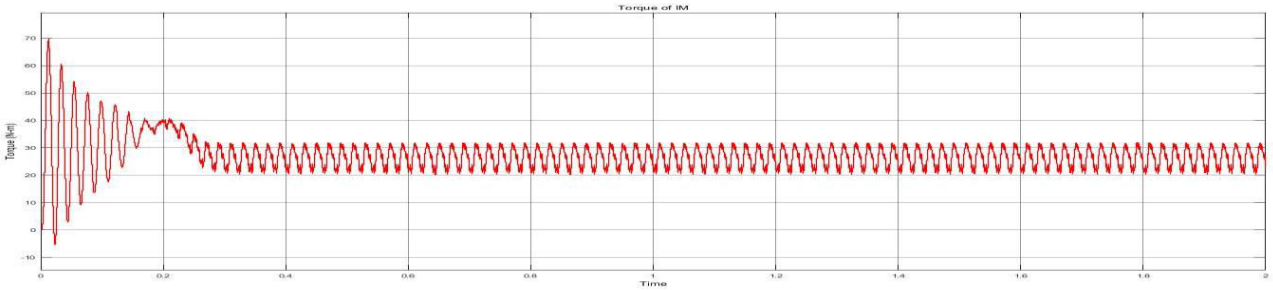


Fig.9. Electromagnetic Torque of CHB multilevel inverter fed IM

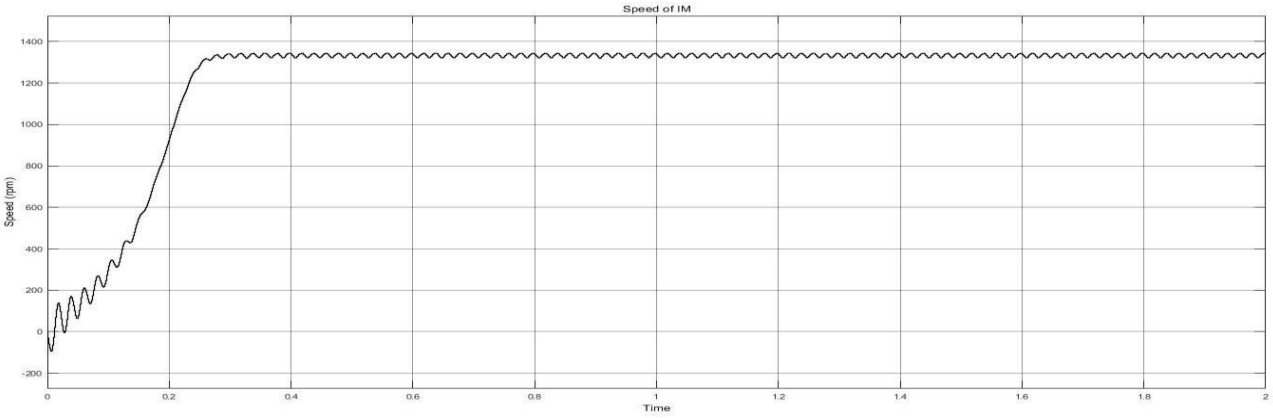


Fig.10. Speed of CHB Multilevel Inverter fed IM

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

IV.PMSM WITH CASCADED H- BRIDGE MULTILEVEL INVERTER

Permanent magnet synchronous motors have 30%-60% higher torque capacity and 30% better torque utilization with faster acceleration and deceleration, compare to asynchronous induction type motors, hence used in traction and electric vehicle. Fig.11 and Fig. 12 shows the schematic diagram and simulink model of 5-level CHB multilevel inverter fed PMSM respectively.

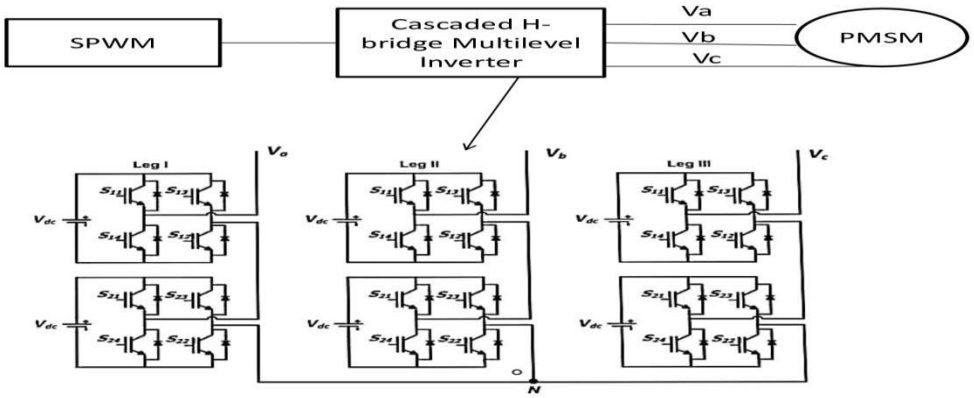


Fig.11. Schematic Diagram of 5-level CHB Multilevel Inverter fed PMSM

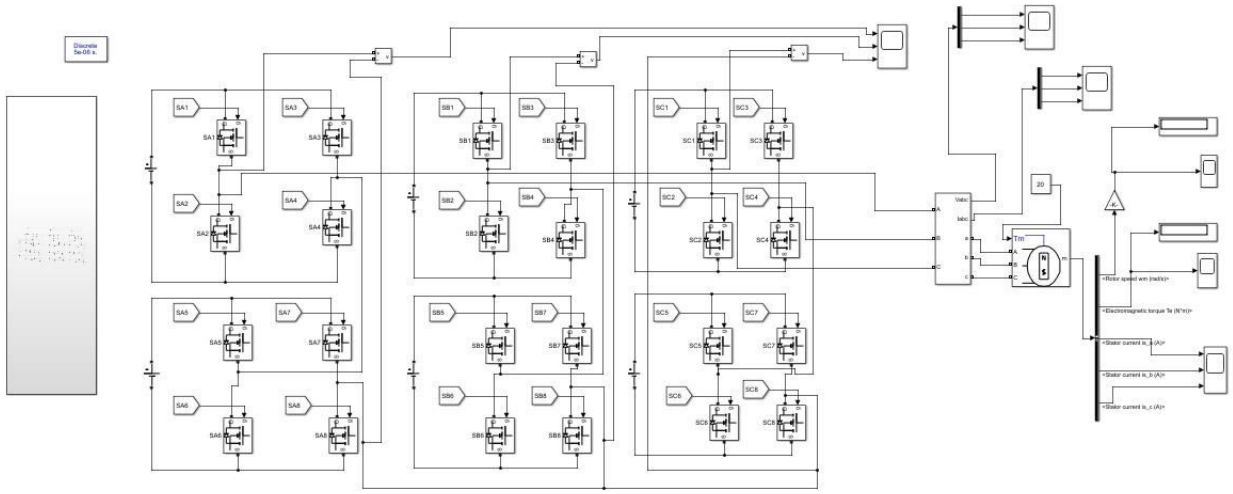


Fig.12. Simulink Diagram of 5-level CHB Multilevel Inverter fed PMSM

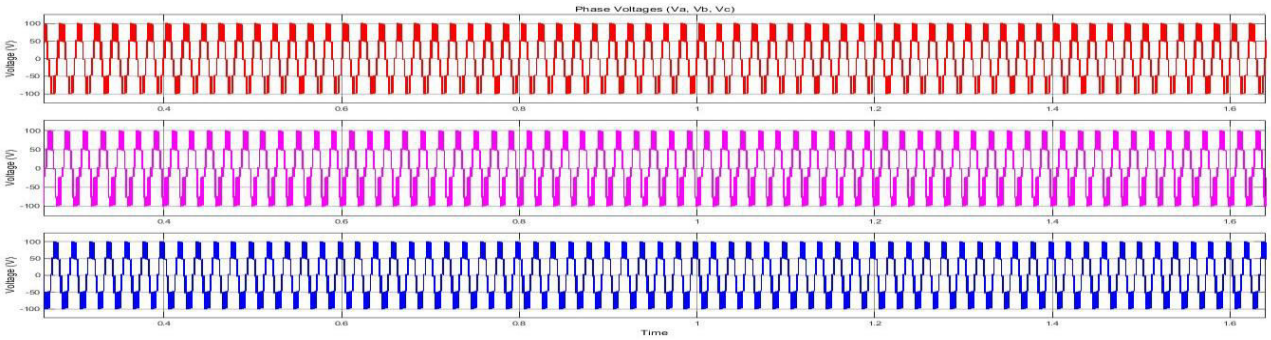


Fig.13. 5-level Output Voltage Waveform

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

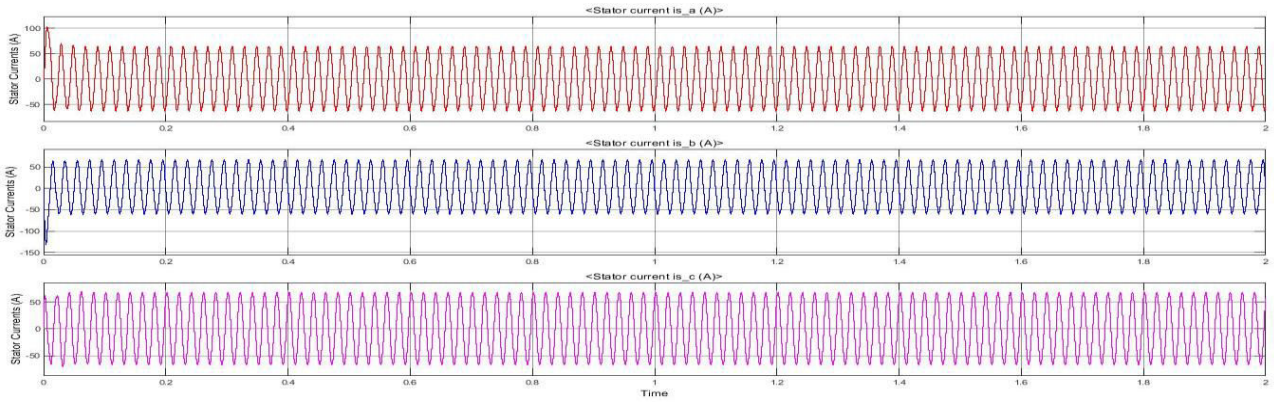


Fig.14 Three Phase Stator Current of CHB multilevel inverter fed PMSM

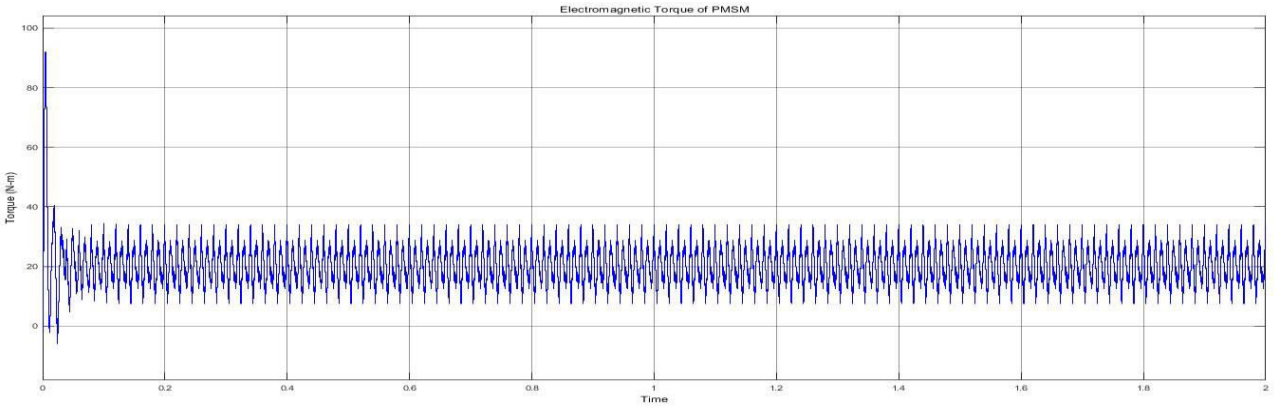


Fig.15. Electromagnetic Torque of CHB Multilevel Inverter fed PMSM

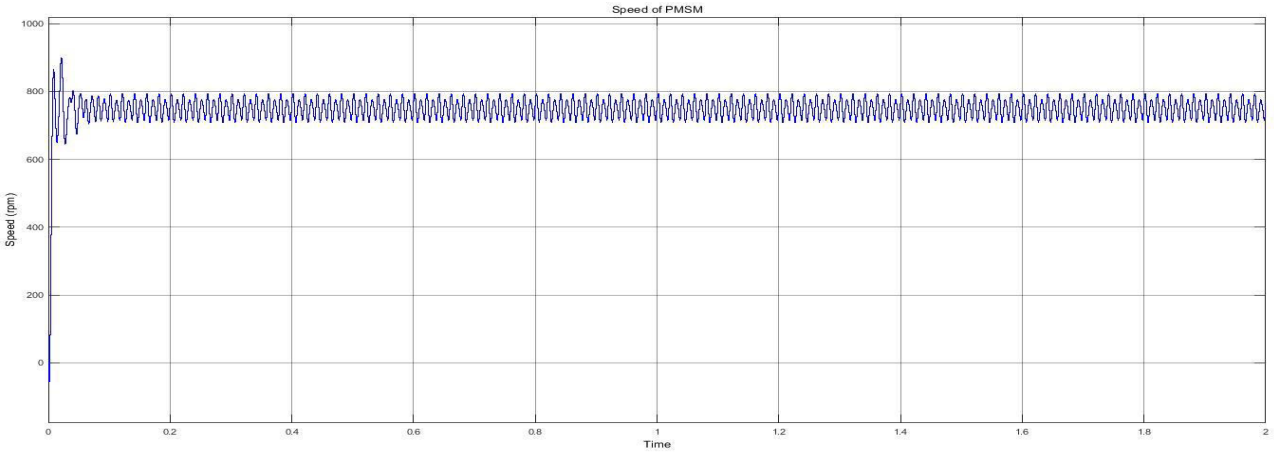


Fig.16. Speed of CHB Multilevel Inverter fed PMSM

The 5-level output voltage waveforms for the three phases are shown in Fig.13. The performance of CHB multilevel inverter fed IM is in terms of stator current, torque and speed from Fig.14 to Fig.16 respectively.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

V. RESULT AND DISCUSSION

Below table shows the performance of CHB multilevel inverter fed IM and PMSM. The THD of voltage and the stator current is calculated by FFT analysis in MATLAB simulink. The transient time of IM stator current is 0.3 sec as referring the fig.8 and the transient time of PMSM stator current is 0.1 sec referring fig.14. The load torque given to induction motor is 26 N-m which is the rated torque of the motor for which output torque obtained is 23.52 N-m. And as for PMSM the given load torque to motor is 20 N-m for which obtained torque is 30.41 N-m.

SR NO.	PARAMETERS		CASCADED H-BRIDGE MULTILEVEL INVERTER FED IM	CASCADED H-BRIDGE MULTILEVEL INVERTER FED PMSM
1	THD of Voltage	Va	27.54%	26.99%
		Vb	36.63%	30.61%
		Vc	28.07%	27.12%
2	THD of Stator Current	Ia	4.53%	4.74%
		Ib	6.99%	7.43%
		Ic	4.465	4.47%
3	Transient Time of Stator Current		0.3 sec	0.1 sec
4	Load Torque applied (Rated Torque)		26 N-m	20 N-m
5	Output Torque		23.52 N-m	30.41 N-m

VI.CONCLUSION

This paper simulated the three phase 5-level Cascaded H-bridge multilevel inverter using SPWM and three phase output voltage is obtained. This output voltage is supplied to Induction Motor and PMSM and the motors properties such as torque, speed and stator current are observed. The PMSM gives higher output torque as compare to asynchronous three phase induction motor. In extension to this work a suitable drive with appropriate controller can be done for both the motors.

REFERENCES

[1] Jih-Sheng Lai, Fang Zheng Peng, “Multilevel Converters - A New Breed of Power Converters,” IEEE Transaction of Industry Applications, VOL. 32, NO. 3, May-June 1996.

[2] Jose Rodriguez, Jih-Sheng Lai, Fang Zheng Peng, “Multilevel Inverter: A Survey of Topologies, Controls, and Applications,” IEEE Transaction on Industry Electronics, VOL. 49, NO. 4, August 2002.

[3] Zhong Du, Burak Ozpineci, Leon M. Tolbert, John N. Chiasson, “DC–AC Cascaded H-Bridge Multilevel Boost Inverter with No Inductors for Electric/Hybrid Electric Vehicle Applications,” IEEE Transaction on Industry Application, VOL. 45, NO. 3, MAY/JUNE 2009.

[4] Anjali Sudarsanan, Roopa R, Sanjana S , “Comparison of Conventional & New Multilevel Inverter Topology,” International Journal of Science & Engineering Research, Volume 6, Issue 2, February 2015, ISSN 2229-5518.

[5] Rushikesh Mali, Nitin Adam, Akshay Satpaise, “Performance Comparison of Two Level Inverter with Classical Multilevel Inverter Topologies,” 978-1-5386- 8158-9/19/$31.00 ©2019 IEEE.

[6] A. Venkadesan, Priyatosh Panda, Priti Agrawal, Var Puli, “Cascaded H-bridge Multilevel Inverter for Induction Motor Drives,” International Journal of Research in Engineering and Technology, eISSN: 2319-1163 / pISSN: 2321-7308.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 7, July 2022||

|DOI:10.15662/IJAREEIE.2022.1107030 |

[7] Basanti Bhagat, Gurpreet Singh, "Performance Evaluation of Voltage Source Inverter Feed Induction Motor Drive," International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056.

[8] C.S. Sharma, Tali Ngwali, "Simulation and Analysis of PWM Inverter Fed Induction Motor Drive," International Journal of Science, Engineering and Technology Reasearch (IJSETR) Volume 2, Issue 2, February 2013, ISSN: 2278- 7798.

[9] S. Naresh, "Three Phase Seventeen Level Single Switch Cascaded Multilevel Inverter Fed Induction Motor," IJARET, Volume 7, Issue 4, July-August 2016.

[10] Ritesh Manikrao Patil, Dhote V.P., Archana Thosar, "Comparative Study of PWM Techniques to Feed Permanent Magnet Synchronous Motor," 2018 IEEE International Conference on Current Trends toward Converging Technologies, Coimbatore, India. 978-1-5386-3702-9/18/$31.00 © 2018 IEEE.

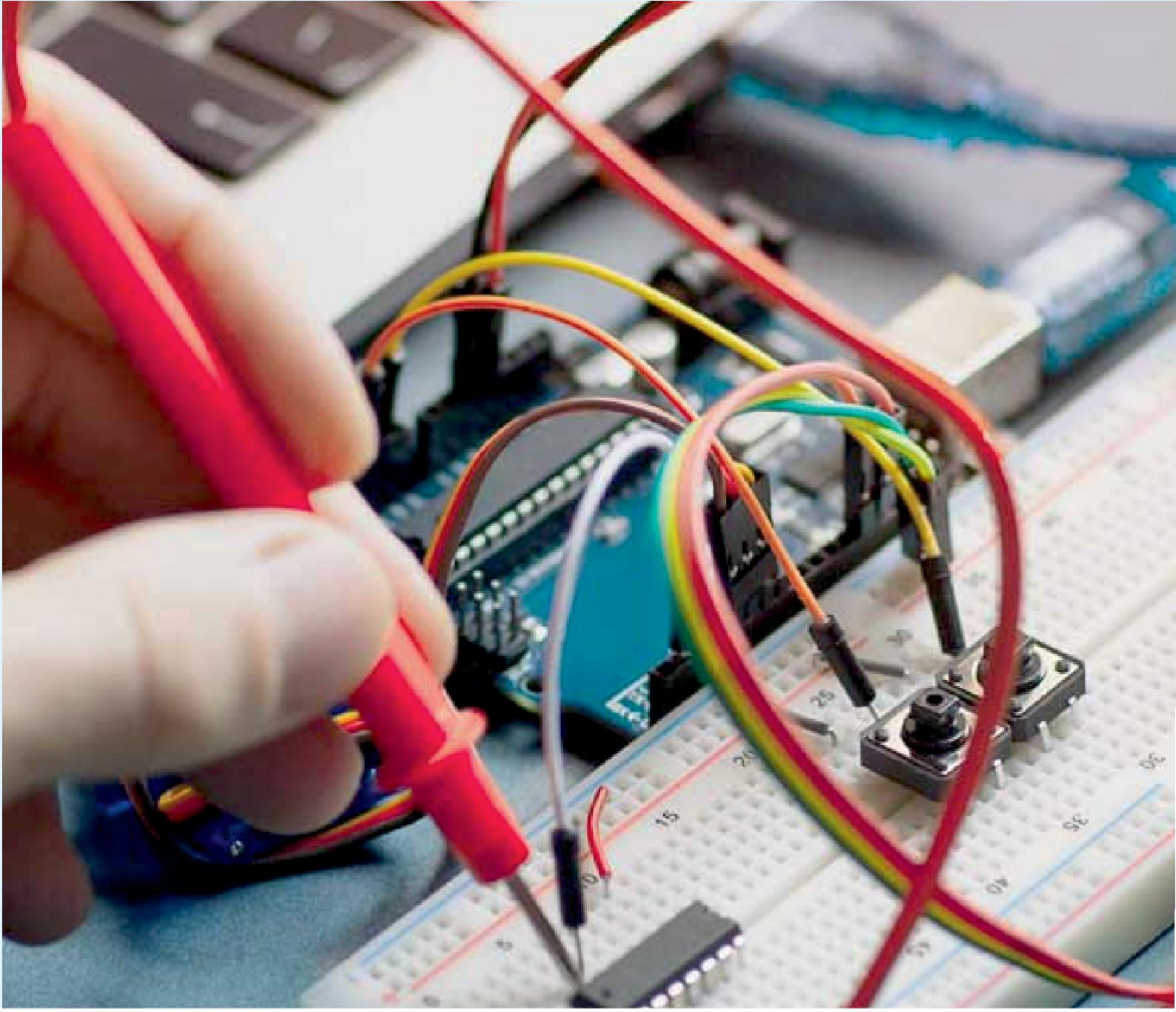
[11] Sravan Kumar Thappeta , Ranga .J, "A New Cascaded Multilevel Inverter Fed Permanent Magnet Synchronous Motor By Using Sinusoidal Pulse Width Modulation," International Journal of Engineering Research & Technology (IJERT ISSN: 2278-0181 Vol. 2 Issue 9, September – 2013.

[12] Divya Subramanian, Rebiya Rasheed, "Five Level Cascaded H-Bridge Multilevel Inverter Using Multicarrier Pulse Width Modulation Technique," (IJEIT) Volume 3, Issue 1, July 2013.

[13] M.Haris Dr.M.K.Pathak, Dr.PramodAgarwal, "Comparison of SPWM Multilevel Inverter Fed PMSM drive with Two level Inverter Fed Drive," IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE-2014), May 09-11, 2014, Jaipur, India.

[14] V. V. Narasimha Murthy, P. N. V. V. Gangadhar Rao, "Performance Analysis of Cascaded H-Bridge Multilevel Inverter Fed PMSM Drive," International Journal of Engineering Research & Technology, ISSN: 2278-0181 Vol. 3 Issue 6, June – 2014.

[15] Kranthi. V, Chennaiah. P, "Design and Simulation of Multilevel Inverter Fed PMSM," International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 1, January – 2014.



INNO SPACE
SJIF Scientific Journal Impact Factor

doi cross ref

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

Impact Factor: 8.18

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

www.ijareeie.com

Scan to save the contact details