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SHE-PWN technique incorporating series-sub multilevel inverter topology for V/F control induction motor

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ABSTRACT

SHE-PWM Techniques are the concept based on the decomposition of PWM voltage/current wave form using Fourier theory and formulations of given waveform properties. Generally, CHB Multilevel inverter using H Bridge Topology for each level output connected in series, Series sub topology using in Multilevel inverter reduced no of switches it can reduce switching loss and price for the same level. In industrial application various types of control available for speed control induction motor. V/f control of induction motor is most widely used in industry because it's simple, reliable and constant torque method. Here provide seven-level series sub multilevel inverter fed v/f control induction motor this inverter topology with SHE-PWM Technique eliminate dominant harmonic like 5^{th},7^{th},11^{th},13^{th} and highly reduced THD of the output voltage. Performance of the Induction motor in this system has been verified in MATLAB/simulink® environment.

Keywords: *Selective harmonic elimination, Multilevel inverter, Induction motor, Series-sub topology, etc.*

1. INTRODUCTION

A Historically Selective Harmonic Elimination Techniques introduced the early 1960s, after several year letters using Fourier theory to mathematically express the harmonic content of PWM Voltage/Current waveforms by a nonlinear and transcendental equations. The elimination of specific low order harmonic in output voltage/current waveform by selective Harmonic Elimination technique and direct control over output waveforms.

The topology used in this paper is series connected sub multilevel inverter topology. Generally, we found Cascaded H-bridge Multilevel inverter topology 12 switches in single phase system and this series connected sub multilevel inverter topology for the same seven level 8 switches used it can be reduced switching loss also. CHB can be divided in too symmetrical and asymmetrical according to connected DC Sources connected to each cell. Series connected sub multilevel inverter topology reduced the no of dc source compare to CHB MLI. The modulation techniques used for optimum harmonic reduction.

Speed control of induction motor is very important in industrial and engineering applications. Economical control strategy used for speed control of induction motor. V/f speed control of induction motor using the principle of constant v/f ratio required that the magnitude and frequency of the applied to the stator of a motor maintain a constant ratio. Thus maximum constant torque produced by v/f ratio maintained.

2. SELECTIVE HARMONIC ELIMINATION TECHNIQUE (SHE-PWM)

Generally, conventional PWM control method and space vector PWM method is applied to multilevel inverter modulation control. These methods will cause extra losses due to high switching frequencies. For this reason, low switching frequency control methods, such as selective harmonics methods are used for modulation control. By placing notches in the output wave form at the proper location, certain harmonics can be eliminated. This allows losses and higher efficiency. SHE –PWM concept of based on the decomposition of PWM Voltage /Current waveform using flourier theory and merely dependant on the formulation of Given waveform and its properties.

2.1 Fourier Series

In general Fourier series is given by

$$V(wt) = a_0 + \sum_{n=1}^{m} (a_n \cos nwt + b_n \sin nwt) \qquad (2.1)$$

In solving we get,

$$b_n = \frac{4Vdc}{n\pi} \sum_{i=1}^{s} \cos n\alpha_i \qquad (2.2)$$

Where n=1,3,5,7,….and s= no. of d,c sources

To eliminate the fifth and seventh harmonics V5 and V7 set the zero in the above equation. To determine switching angles the following equation must be solved.

$$[\cos(\theta_1) + \cos(\theta_2) + \cos(\theta_3)] = 3M \qquad (2.3)$$

$$[\cos(5\theta_1) + \cos(5\theta_2) + \cos(5\theta_3)] = 0 \qquad (2.4)$$

$$[\cos(7\theta_1) + \cos(7\theta_2) + \cos(7\theta_3)] = 0 \qquad (2.5)$$

Where M represents modulation index varies from 0 to 1

2.2 Modulation Index

The normalized fundamental frequency component is a function of modulation Index its written as

$$\mathrm{M} = \frac{\mathrm{h}_1}{\mathrm{mV}_{\mathrm{dc}}} \qquad (2.6)$$

Where M=Modulation index, m-No.of switching, h1 = Fundamental Component and Vdc = DC Voltages used.

Table-1: Switching angle for different modulation index for seven level

Modulation Index Level	Modulation Index M	Alpha 1	Alpha 2	Alpha 3
High M	1.0	11.68	31.18	58.58
	0.85	22.77	49.38	64.57
Medium M	0.4	44.17	74.33	87.40
Low M	0.1	55.85	63.43	83.02

3. SEVEN LEVEL SERIES-CONNECTED SUB MULTILEVEL INVERTER TOPOLOGY

In this topology, sub multilevel inverter is connected in series to get desired output voltage level. This type of topology is also has been symmetric and asymmetric topology because as the voltage level increase. Optimized topology would be always with n=1.The optimal number of switches can be calculated using Equation

$$Nlevel = \{2(2)\frac{N_{switch} - 4}{(2)} - 1, \; for, n = 1 \qquad (3.1)$$

$$Nlevel = \{2(n+1)\frac{N_{switch}-4}{(n+2)} - 1,\ for, n \geq 2 \qquad (3.2)$$

N*level* =number of level

The seven-level inverter is connected series-sub multilevel inverter topology by using two sub-multilevel inverter topology, each sub multilevel inverter having 2 switches, example D.C source having one would be 110V and other would be 220V asymmetric. Four switches are exclusively kept for H-Bride inverter. The seven-level multilevel topology is as shown in fig and switching table

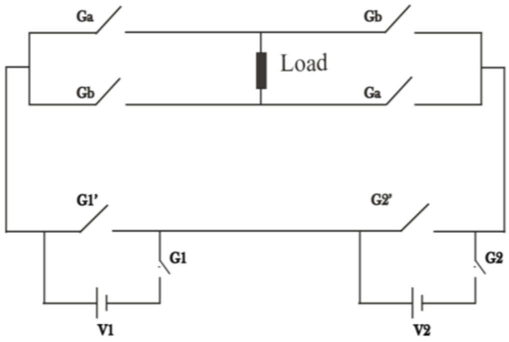

Fig-1: Series Sub Multilevel Inverter Topology

Table-2: Switching Table

Voltage Level	G1	G2	G1'	G2'	Ga	Gb
0	0	0	1	1	1	0
10	1	0	0	1	1	0
20	0	1	1	0	1	0
30	1	1	0	0	1	0

4. V/F CONTROL INDUCTION MOTOR

A 3-Phase induction motor basically constant speed motor so it's somewhat difficult to control to control its speed. The speed control of induction motor is done at the cost of decreases in efficiency and low electrical power factor. he basic formula speed and torque of the three-phase induction motor as the methods of speed control depends upon these formulae synchronous speed.

Ns=120f/P

Where, Ns = Synchronous speed

F = Supply Frequency

P = No. of poles

Various method for speed control of induction motor

i. Pole changing
ii. Variable supply frequency control
iii. Variable supply voltage control
iv. Variable rotor resistance control
v. V/F control
vi. Slip Recovery

4.1 V/F Speed control of Induction Motor

Synchronous speed can be controlled by varying the supply frequency, Voltage induced in the stator is $E_1 \alpha \varphi f$
Where φ is the air-gap flux and Fis supply frequency. As we can the neglect the stator voltage drop we obtained terminal voltage $V_1 \alpha \varphi f$

Thus reducing the frequency without changing the supply voltage will lead to an increase in the air gap flux which is undesirable. Hence whenever frequency is varied in order to control speed, the terminal voltage is also varied so as to maintain the v/f ratio constant. Thus by maintaining a constant v/f ratio, the maximum torque of the maximum torque of the motor becomes constant for changing speed. As can be seen when v/f control is implemented for various frequencies inside the operation system the maximum torque remains the same as the speed various thus maintaining the v/f ratio constant maximum torque while controlling the speed as per requirement.

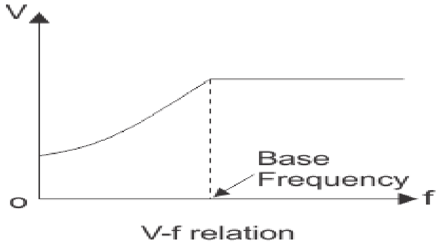

Fig-2: V/F Constant Speed Control principle

The ratio of v/f remain constant with the change of flux may be constant may with the change of frequency and flux be constant and the torque is independent of the supply frequency.

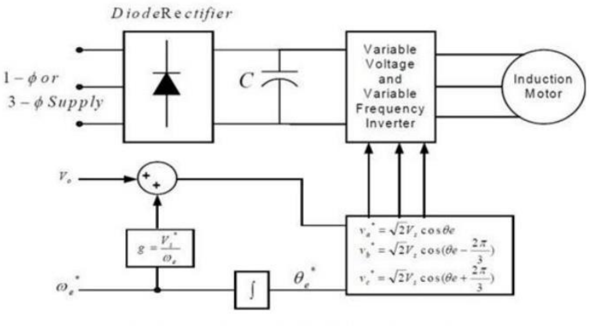

Fig-3: Open Loop V/F Control Induction Motor

5. SIMULATION RESULTS

Table-3: Inverter & Motor Ratings

Inverter rating	
Inverter kVA rating	5kVA
Number of switches	8 per phase
Nominal AC output voltage	400V
Control technique	SHEPWM
V_1	110V
V_2	220V
Switching frequency	5kHz
Induction Motor Ratings	
Input Voltage	400V
Nominal Speed	1430 rpm
Output power	5.4 hp (4kW)
Stator Resistance R_s	1.405 Ω
Stator Inductance L_s	0.15839 H
Rotor Resistance R_r	1.395 Ω
Rotor Inductance L_r	0.15839 H

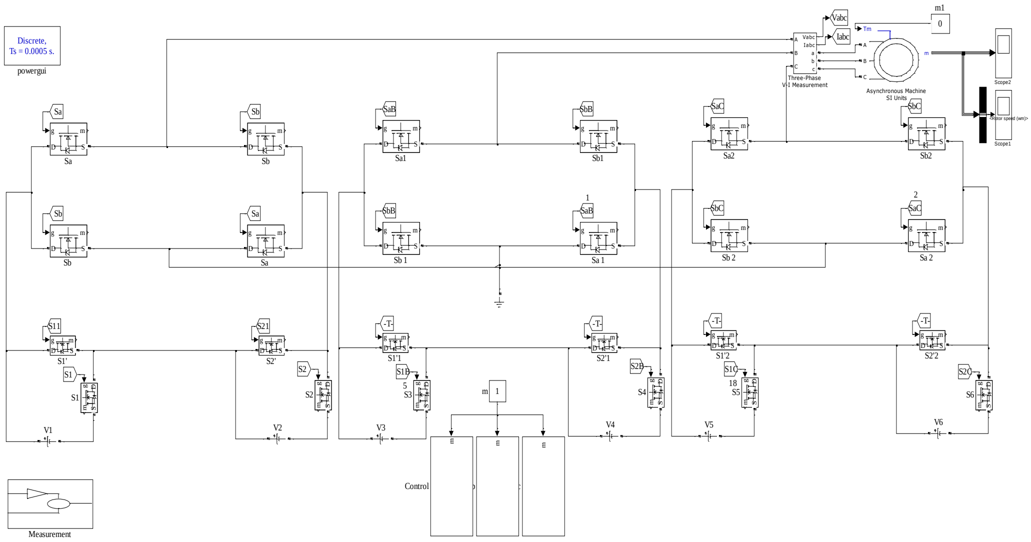

Fig-4: 3-Phase Series Sub Multilevel Inverter with SHE-PWM Techniques

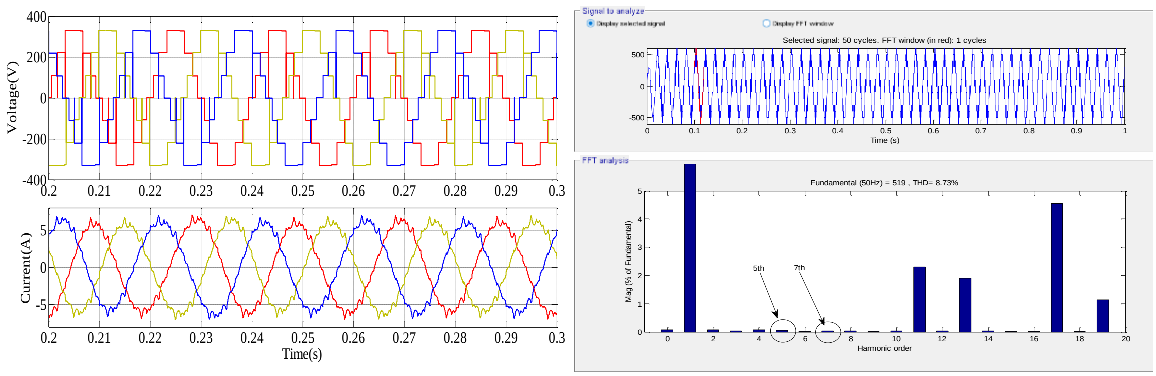

Fig-4: (1) Voltage and Current waveform AT M=1, V=405Volts, F=50Hz, V/F Ratio=8.1, Speed =1488 rpm(2) FFT Analysis SHE-PWM

Table-4: Open Loop V/F Speed Control of Induction Motor at Different Voltage and frequency

Frequency Hz	Voltage	V/F Ratio	5th Harmonics	7Th Harmonics	THD	Speed RPM	M.I
52	425	8.17	0.05%	0.03%	8.79%	1546	1.05
50	405	8.1	0.04%	0.03%	8.74%	1488	1
48	387	8.06	0.17%	0.12%	8.77%	1441	0.95
45	368	8.17	0.07%	0.04%	9.74%	1346	0.90
43	345	8.02	0.06%	0.05%	10.24%	1290	0.85
35	285	8.14	0.15%	0.12%	13.59%	1070	0.70

6.CONCLUSION

In this paper to obtain smooth waveform with eliminate dominant Harmonic 5^{th} and 7^{th} are completely eliminate by we use SHEPWM technique. All triplent harmonics can be completely removed 3 phase topology which can highly reduce THD. V/F speed control of induction motor with different voltage and frequency with constant v/f ratio. This harmonics free supply gives the smooth performance of 3 phase induction motor and that is verified by the MATLAB/simulink®.

7. REFERENCES

[1] M. S. A. Dahidah, G. Konstantinou, and V. G. Agelidis, "A Review of Multilevel Selective Harmonic Elimination PWM: Formulations, Solving Algorithms, Implementation and Applications," *in IEEE Transactions on Power Electronics, vol. 30*, no. 8, pp. 4091-4106, Aug. 2015.
[2] F. Zhang and Y. Yan, "Selective Harmonic Elimination PWM Control Scheme on a Three-Phase Four-Leg Voltage Source Inverter," *in IEEE Transactions on Power Electronics*, vol. 24, no. 7, pp. 1682-1689, July 2009.

[3] S. Nithya, C. R. Balamurugan and S. P. Natarajan, "Design and analysis of new multilevel inverter topology with induction motor load," *International Conference on Information Communication and Embedded Systems (ICICES2014), Chennai, 2014*, pp. 1-5.
[4] M. Mythili and N. Kayalvizhi, "Harmonic minimization in multilevel inverters using selective harmonic elimination PWM technique," *2013 International Conference on Renewable Energy and Sustainable Energy (ICRESE), Coimbatore, 2013*, pp. 70-74.
[5] S. Farzana, Y. Sumith and K. Ravisankar, "Performance enhancement of three phase induction motor by using multi level inverter," 2017 *International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bangalore, 2017*, pp. 720-725.
[6] G. Rajpriya, S. Ravi and A. M. A. Zaidi, "Design and development of MATLAB Simulink based Selective Harmonic Elimination technique for three phase voltage source inverter," 2013 *International Conference on Advanced Computing and Communication Systems, Coimbatore, 2013*, pp. 1-5.
[7] Pradeep R,Jaseerali E Y and Nizam V N, "Multilevel Inverter Using series Connected Sub –Multilevel Topology with Selective Harmonic Reduction,"2014 *International Confereance on Computational of Power, Energy, Information and Communication,2014*,pp.168-173
[8] Siriroj Sirisukprasert, Jih-Sheng Lai and Tian-Hua Liu, "Optimum Harmonic Reduction With a wide Range of Modulation Indexes For Multilevel Converters," *IEEE Transactions on Industrial Electronics, 2002, Volume: 49,Issues*-4,pp.875-881
[9] Neeraj Sheth, Vanya Goel, R.D.Kulkarni and V.P.Joshi, "Performance Analysis of Seven Level Three Phase Asymmetric Multilevel Inverter at Various Modulation Indices," *2016 International Conference on Electrical Power and Energy System,* 2016,pp . 407-416
[10] Mitul Vekaria, darshan Thakar and Hitesh Prajapati, "Matlab Simulation of Induction Motor Drive using V/F Control Method" *International Fournal For Scientific Research & Development ,vol-5*, Issues -01,2017,pp.2321-0613
[11] Mr.Pramod Hingmire,Santoshkumar Rayarao, "Development of a v/f control scheme for controlling the induction motor both open loop and closed loop in Matlab." *International Journal of Scientific Engineering and applied science, Vol-2*, Issues June-2016, ISSN:2395-3470.
[12] K.Swetha, V.Rameshbabu, "Performance Analysis of V/F Controlled Inverter Fed Induction Motor under Different Condition." *International journal of Engineering Trends and Technology.* Vol-26, Aug-2015
[13] Hanan Mikhael D.Habbi, Hussein Jalil Ajeel, Inaam Ibrahim Ali, " Speed Control of Induction Motor using PI and V/F Scalar controllers." *International journal of Computer Applications,* Vol-151-No-7, Oct-2016

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