International Journal of Computer Applications (0975 – 8887)
International Conference on Quality Up-gradation in Engineering, Science and Technology (ICQUEST2015)

Starting Analysis of Induction Motor using SPWM

Saurabh.V. Pande
M.Tech (I.D.C) Final year
Department of Electrical Engg.
P.C.E Nagpur

K.B.Porate, PhD
Associate Professor
Department of Electrical Engg.
P.C.E Nagpur

Saket Singh
Assistant Professor
Department of Electrical Engg.
P.C.E Nagpur

ABSTRACT
Induction motors are widely used in both household and industrial application due to their high torque to volume ratio, ruggedness, robustness and low maintenance. Induction motor draws a high starting current during starting period which affects on Electromagnetic Torque, Speed & Current. Traditional methods includes DOL, auto-transformer starters, star-delta starters etc, control these parameters up to certain limit. Thyristorised based switching techniques include SPWM, SV-PWM and Hysteresis band PWM also suggested, to reduced variation in parameters at start.

This paper deals with starting analysis of induction motor using DOL as a traditional mechanism and sinusoidal pulse width modulation (SPWM) as a thyristorised based advanced mechanism.. Analysis is made for speed, torque and current during start. Simulations are made in MATLAB Environment and comparative results are estimated.

Keywords
Induction Motor, starting analysis, DOL, SPWM.

1. INTRODUCTION
Induction motors are widely used in both household and industrial applications. This is due to their high torque to volume ratio, ruggedness, robustness and low maintenance .etc. During starting, Induction motor faced problems like high current, Electromagnetic Torque stress and drop in voltage. Stiff supply takes care of these parameters up to certain limit.

Direct on line (DOL), Stator resistance Starter, Auto-transformer starter, Star-Delta starter etc are traditional starting methods of Induction motors reduces these variations to certain extent. Smooth and closed loop controls are not achievable using traditional starting mechanisms. [1][2][3][4]. Soft starters are suggested voltage control based fast switching power devices reduce these variations due to their controllable characteristics.SPWM,SV-PWM and Hysteresis band current control PWM etc, are suggested voltage control soft starters used for starting of Induction Motor with smooth and close loop control are achievable.[5]

This paper deals with starting analysis of Induction motor using SPWM as switching technique .Starting analysis is made for various parameters such as speed, Electromagnetic Torque and current at rated load .Analysis is carried out by developing simulation in MATLAB for DOL and SPWM as voltage control soft starting advanced techniques. Comparisons between all the parameters have been made for both the cases at rated load condition.

2. METHODOLGY
Starting analysis of Induction motor have been carried out in MATLAB Environment using DOL as traditional and SPWM as Soft starting advanced mechanism.

2.1 DOL MECHANISM
Direct on line mechanism are traditional starting mechanism with very high starting current, high Electromagnetic Torque stress, drop in supply voltage and speed as the characteristic features. The oscillations are much more times greater than the rated value which affects the performance of overall system.

2.2 SINUSODIAL PULSE WIDTH MODULATION (SPWM)
Sinusoidal Pulse width Modulation technique generates the required control signals by comparing a sinusoidal reference signal V_r of frequency f_r with a triangular carrier wave signal V_{cr} of frequency f_c .when $V_{cr} > V_r$ correspondingly the control pulses are generated thus firing the power valves else power valves remain off. The ratio of the sinusoidal reference signal V_r of frequency f_r to that of control the a triangular carrier wave signal V_{cr} of frequency f_c determines Amplitude modulation index ($\boldsymbol{M_a}$) and Frequency modulation index ($\boldsymbol{M_f}$) i.e

$$\boldsymbol{M_a = \frac{V_r}{V_{cr}}} \quad \text{--- (1)}$$

And

$$\boldsymbol{M_f = \frac{f_r}{f_{cr}}} \quad \text{--- (2)}$$

The RMS output voltage can be varied by varying the modulation index M.

RMS value of output Voltage is given as,

$$\mathbf{V_o = V_s\left(\sum_{m=1}^{2p} \frac{\delta_m}{\pi}\right)^{1/2}} \quad \text{---- (3)}$$

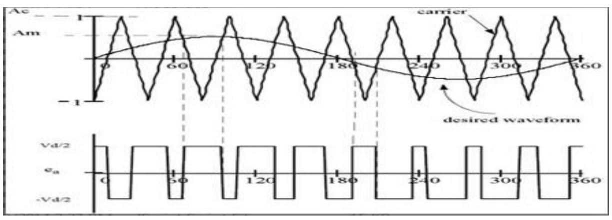

Figure-1 Control signal using SPWM

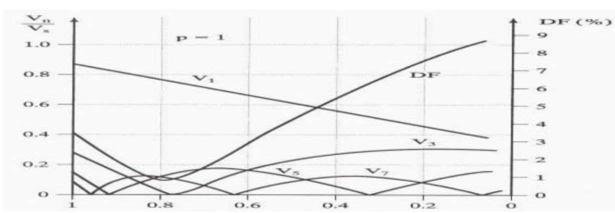

Figure: 2 Modulation Index

The harmonic profile of a sine triangle inverter's output voltage can be described as:

$$f_h = (jm_{f+\_}k)f_h \text{ ---- (4)}$$

For a sine triangle inverter, the lowest harmonic present in the output voltage is shifted to the inverter switching frequency. The harmonics in the inverter output voltage waveform appear at sidebands of the switching frequencies and its multiples i.e., around m*f*, 2m*f*, 3m*f* and so on. Thus, the harmonics for a sine triangle inverter are shifted to higher frequencies which are easy to filter and also their effect due to high frequency is not dominant in the torque pulsations. [4]

3. SIMULATIONS

Starting Analysis of the Induction motor has been developed in MATLAB Environment. The specifications & rating of Induction motor considered for the analysis have been reported in Table 1. Analysis of Induction motor is carried out using DOL & SPWM as switching technique. The specifications of Induction Motor are reported in Table 1:-[11]

3.1 Case-1 Starting Analysis by DOL Mechanism

Starting Analysis of Induction motor has been carried out using DOL mechanism in the MATLAB Environment. Using DOL technique speed reached to steady state speed i.e. 1440 rpm in 0.15 sec reported in figure 3.1. Electromagnetic torque during starting is also rises to 391 N-m at 0.015sec and than settles down to rated value i.e. 15 N-m at 0.15 sec, reported in figure 3.2. The Current during starting rises to 147A at 0.020sec and then settles down to rated value 4.4 A at 0.15sec, reported in figure 3.3.

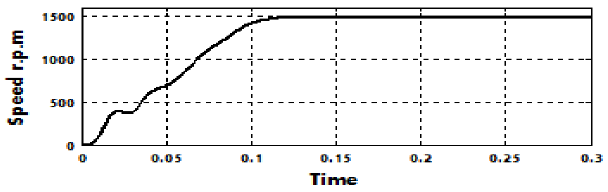

Figure:-3.1 Speed-DOL

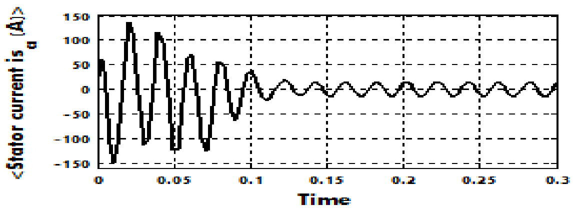

Figure:-3.2 Current-DOL

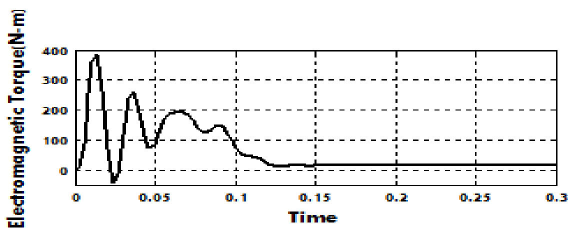

Figure:-3.3 Electromagnetic Torque-DOL

3.2 Case-2 Analyses by SPWM

Starting Analysis of Induction motor for parameters reported in "Table 1" has been carried out using SPWM mechanism in the MATLAB Environment. Simulation block diagram comprises of comparator, Bridge inverter, Supply voltage and Induction motor etc and reported in "figure 3.4". Control signal are generated from comparator using SPWM switching technique which is given to power valves .Thus corresponding switches are ON and supplying the Induction motor. Using SPWM technique speed settles down steady state value i.e. 1440 rpm in 0.2 sec, reported in "figure 3.5". Electromagnetic torque during starting rises to 235 N-m at 0.01sec and than settles down to rated value i.e. 15 N-m at 0.225 sec, reported in "figure 3.6". The Current during starting rises to 130 A at 0.010sec and then settles down to rated value 4.4 A at 0.225sec, reported in "figure 3.7".

Table 1:Induction Motor Parameters

Parameters	Rating	Parameters	Rating
Input Capacity	2.2 KW,	Friction Factor	0.0001 N.m.s
Supply voltage	415 V	Current	4.4 A
Frequency	50 Hz	Power factor	0.85
Poles	4	Stator resistance	0.435 ohms
Stator Reactance	0.0022 ohms	Rotor resistance	0.816 ohms
Rotor Reactance	0.0022 ohms	Mutual Reactance	0.069 ohms
Inertia	0.089 kg.m^2	Torque	15 N-m

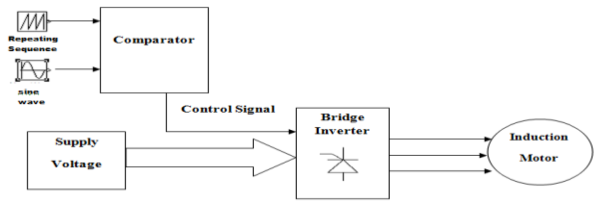

Figure 3.4: PWM Inverter Fed Induction Motor

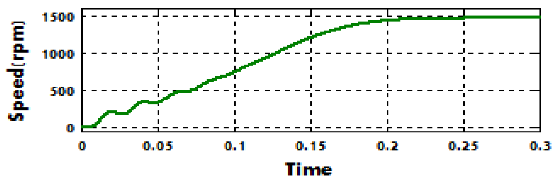

Figure:-3.5 Speed-SPWM

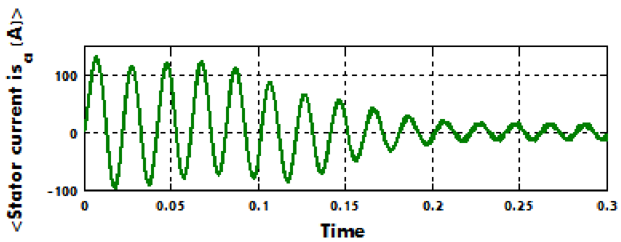

Figure:3.7 Current-SPWM

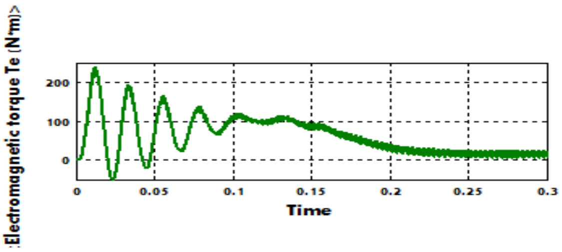

Figure:3.6 Electromagnetic Torque-SPWM

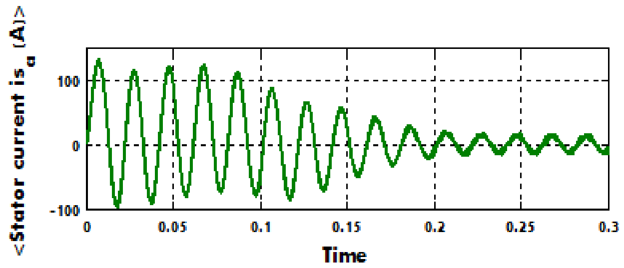

Figure:3.7 Current-SPWM

4. RESULTS

Starting Analysis of IM Using DOL and SPWM Technique is carried out in MATLAB Environment. Comparison for speed, torque and current has been carried out. Speed during starting requires 25% more duration to settles down to rated value for SPWM technique than DOL mechanism Electromagnetic torque at starting reduced by 14.32% with delay of 0.075sec.Current at starting reduced by 17 A and then settles down to rated value with delay of 0.075sec with application of SPWM technique. Oscillations and amplitude during starting for parameters including speed, Electromagnetic torque and current have been reduced is the benefit of SPWM technique over DOL mechanism. Improve in the parameters during start, improves the overall efficiency of Induction motor and life of induction motor and overall cost too.

5. CONCLUSION AND FUTURE SCOPE

- In SPWM during start speed settles down to rated value at 0.2 sec which is greater by 0.05 sec as compare to DOL mechanism.
- Oscillation in the speed are smoother in SPWM at start is the benefit of this mechanism.
- Comparison also made for estimation of Electromagnetic torque at start. With SPWM oscillations in the electromagnetic torque are reduced by 56 N-m with very small delay of 0.075 sec. In SPWM Electromagnetic Torque at start is smoother than DOL.
- Starting analysis estimation is also carried out for current .Using SPWM Starting current is 130 A which is reduced by 17 A as compared to DOL. The duration to settles down the current is 0.225 sec which is more by 0.075sec but smoother is the benefit.

Starting analysis can also be possible by SV-PWM open loop and closed loop, hysteresis band current control mechanism etc.

6. ACKNOWLEDGMENTS

Our thanks to the experts who have contributed towards development of the template.

7. REFERENCES

[1] StanislavRusnok, PavelSobota, Martin Slivka, Pavel Svoboda, "Assessment Transients During Starting of Induction Motor in Matlab-Simulink And Verification by Measurement", Advanced Research in Scientific Areas December 2012, SECTION11. Electronics, Electrical Systems, Electrical Engineering 3-7-2012 P.P 1672-76. .

[2] Umashankar S , Ambili Mathew , Sujyothi P, Nithya V G , Sreedevi T S,"Investigation on steady state and transient behaviourof Induction machine model under various reference frames",School of Electrical Engineering,VIT University, Vellore- 632014,Tamil Nadu,India.

[3] SateanTunyasrirut, SompongSrilad and TianchaiSuksri," Comparison Power Quality of the Voltage Source Inverter type SVPWM and SPWM Technique for Induction motor Drive SICE Annual Conference 2008

[4] Fan Lin, Kun Li and Yang Liu,"A Design and Implementation of Edge Controller for SPWM Waves",Proceeding of the IEEE International Conference on Information and Automation Shenzhen, China June 2011PR0001/08/0000-0241 ¥400 © 2008 SICE

[5] Nakamae E, Yamashita H, Kaneda K, Ohnogi Y, Kagawa K,“Noiseless variable speed Squirrel Cage Induction Motor”, IEEE Transaction of Energy Conversion, Vol. 5, No. 2, June 1990, pp. 380-385

[6] Ion Boldea and Syed A.Naser,"The Induction Machine Handbook", CRC PRESS.pp8.1-8.7.

[7] Ali Emadi,"Energy Efficient Electric Motors", Illinois Institute of Technology Chicago, Third edition MARCEL DEKKER, INC.

[8] H.Austin,"Electric Motors &Drives",Third Edition 2009,An Imprint of Elsevier,pp.198-206,267-270.

[9] S.K.Pillai,"A New Course on Electrical Drives",Second Edition Aug-1988,pp 89-103.

[10] Rashid M. H., ‘‘Power Electronics Circuits, Devices and Applications’’ Third Edition, Pearson Prentice Hall, pp. 186-190.

[11] Om Hari Gupta ,Dr. SatyaSheel,"Control of Induction motor drive with PSpice-MATLAB interfacing",2012 IEEE International Conference on Power Electronics, Drives and Energy Systems December16-19, 2012, Bengaluru, India.

[12] RikDeDencker,DucoW.J.PulleAndroVeltman,"Advanced ElectricalDrivesAnalysisModelling,Control",2011,Springer.

[13] V.Subrahmanyam “Electric Drives Concepts and Application”Fourteen Edition 2004,Tata. Mcgraw-Hill, pp 510-525.