FOREX Publication
Open Access | Rapid and quality publishing

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 10, Issue 3 | Pages 727-730 | e-ISSN: 2347-470X

Co-Simulation of Three Phase Induction Motor Controlled by Three Level Inverter

Omar Kamil Dahham Alazzawi[1] and Maath Jasem Mahammad[2]

[1,2]University of Anbar College of Engineering, Electrical Engineering Department Ramadi, Iraq, [1]omar.dahham@uoanbar.edu.iq, [2]maath.mahammad@uoanbar.edu.iq

***Correspondence:** Omar Kamil Dahham; omar.dahham@uoanbar.edu.iq

ABSTRACT- The main objective of this research is to build and control a three-phase induction motor using the ANSYS Simplorer and Maxwell2D program to obtain a high-quality sinusoidal voltage profile with little distortion and therefore low harmonics. A control circuit has been proposed using diodes to control the motor speed by v/f method. This method depends on the principle of changing the source voltage in addition to the frequency in a fixed ratio to obtain the best working conditions and the best characteristics of the motor with the least possible losses. The modeling results show the effectiveness of the proposed circuit in controlling the motor speed effectively and enhancing the motor performance by reducing losses when using traditional methods of controlling the motor speed. The effectiveness of the control system is verified by analyzing the results using the ANSYS program.

Keywords: Control, Three Phase I, M, Maxwell2D, Inverter, Speed Control.

ARTICLE INFORMATION

Author(s): Omar Kamil Dahham Alazzawi and Maath Jasem Mahammad;
Received: 11/08/2022; **Accepted**: 25/09/2022; **Published**: 30/09/2022;
e-ISSN: 2347-470X;
Paper Id: IJEER110822;
Citation: 10.37391/IJEER.100351
Webpage-link:
https://ijeer.forexjournal.co.in/archive/volume-10/ijeer-100351.html

crossref member — CROSSREF.ORG THE CITATION LINKING BACKBONE

Publisher's Note: FOREX Publication stays neutral with regard to Jurisdictional claims in Published maps and institutional affiliations.

1. INTRODUCTION

Three-phase induction motors have several advantages that make it the best choice in many industrial fields. It is characterized by reliability, small size, simple structure, good efficiency, in addition to a relatively good power factor [1]. By virtue of the continuous development of variable frequency motors drives and controllers that operate with high efficiency with few harmonics and little distortion in the wave shape, induction motors have become more widespread and more widely used than other motors [2]. Controlling and changing the speed of induction motors depends on a set of theories, the first of which is changing the slip value and secondly changing the number of poles. These two theories do not meet the needs of applications that require changing speed in a wide field [3]. While the third theory or the third method, which depends on changing the frequency and voltage in a fixed ratio, is one of the best ways to control the motors by giving a wide speed range with little effect on the performance and characteristics of the motor [4, 5, 6].

Frequency control is an ideal way to regulate speed. However, there are some practical problems associated with changing the frequency, such as increasing harmonics, oscillation of motor torque, etc. which need to be studied and solved by researchers [7,8].

The ansys/simplorer 2016.2 program has several advantages, the most important of which is the integration between the models designed by Maxwell and the control circuits designed in the Simplorer program. Induction motors are designed using the Maxwell program, as the program contains the capabilities to accurately analyze non-linear and electromagnetic problems [7].

A 2200W three-phase induction motor was designed and built using Maxwell2D 2016.2 software and connected to a speed control circuit represented by three level inverters designed by the simplorer program.

1.1 Co-Simulation of the Induction Motor Speed Control Drive

1.1.1 Induction Motor Modelling Using Maxwell2D

The motor under study is a 3-phase induction motor with a capacity of 3 hp and two poles with a synchronous speed of 3000 rpm. The main dimension of the tested motor is shown in *table 1*. The assumption of simulation are the flux and electromagnetic field outside the motor is zero.

Table 1: Motor Data

Table Head	Motor Data *value*
Rated power	2200W
Rated voltage	380V
Rated speed	2850 rpm
Frequency	50Hz
Stator slots	24
Rotor slota	20
P.F	0.85
NO. of poles	2

Motor final design in maxwell2D shown in *figure 1*.

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 10, Issue 3 | Pages 727-730 | e-ISSN: 2347-470X

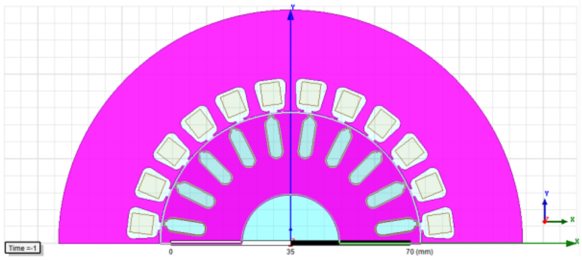
Figure 1: Motor Design

1.2 Simplorer Implementation of the Three-Level Inverter

By using the feature of linking the models designed in the Maxwell program and the Simplorer program, the power sources designed for the motor were canceled and replaced with. external sources designed by the Simplorer program, which is the three-level inverter.

In this design the three-phase induction motor is equipped with a power source taken from a three-level inverter as shown in *figure 2*, each leg in three-level inverter is constituted by four controllable switches with four uncontrollable diodes and two clamping diodes. Two equal capacitors divide the DC vector voltage into three voltage levels +E/2, 0, -E/2 hence the name 3-level.

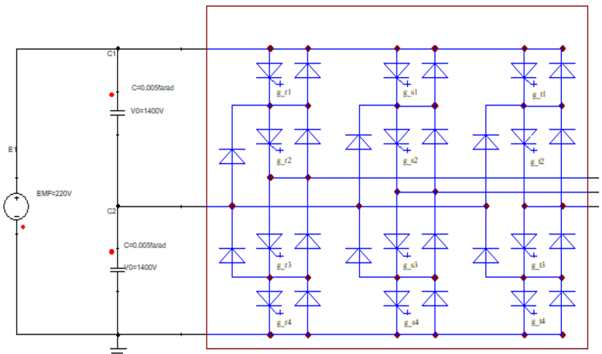
Figure 2: Three Level Inverter

Table 2 shows the circuit description of three level inverter controller.

Table 2: Circuit description of three level inverter controller

Table Head	Circuit Description		
	Description [Unit]	***Direction***	***Data Type***
G_R1	Control Signal diode 1 Phase R	Input/Output	Real
G_R2	Control Signal diode 2 Phase R	Input/Output	Real
G_R3	Control Signal diode 3 Phase R	Input/Output	Real
G_R4	Control Signal diode 4 Phase R	Input/Output	Real
G_S1	Control Signal diode 1 Phase S	Input/Output	Real
G_S2	Control Signal diode 2 Phase S	Input/Output	Real
G_S3	Control Signal diode 3 Phase S	Input/Output	Real
G_S4	Control Signal diode 4 Phase S	Input/Output	Real
G_T1	Control Signal diode 1 Phase T	Input/Output	Real
G_T2	Control Signal diode 2 Phase T	Input/Output	Real
G_T3	Control Signal diode 3 Phase T	Input/Output	Real
G_T4	Control Signal diode 4 Phase T	Input/Output	Real

The control signals of the inverter are determined by a three-phase control block shown in *figure 3*. And the control parameters shown in *table 3*.

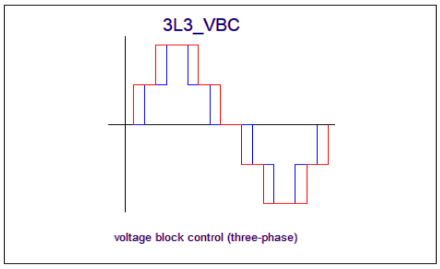

Figure 3: Control Signals

The speed of the induction motor is directly proportional to the value of the source frequency, and therefore the speed of the motor can be controlled by changing the frequency, but this change, if it is done without changing the value of the applied voltage, leads to an increase in the flux flow in the air gap and thus an increase in the value of losses. To bypass this problem, the motor speed is controlled by changing the frequency and voltage in a fixed ratio and by using the inverter frequency and voltage control circuit by changing the frequency and angle of the thyristor control as shown in *table 3*.

2. SIMULATION DESIGN AND ANALYSIS

Table 3: Thyristor Control

Table Head	Thyristor Control		
	Description	***Data Type***	***Default Value [Unit]***
FREQUENCY	Frequency AC Voltage	real	0-100 [Hz]
ALPHA	Angle at Positive E dge	real	0-180 [degree]

2.1 Simulation Model and Results

The final design of the motor speed control circuit is shown in *figure 4*. which was made by calling the motor model from the Maxwell design program and feeding it through the designed control circuit.

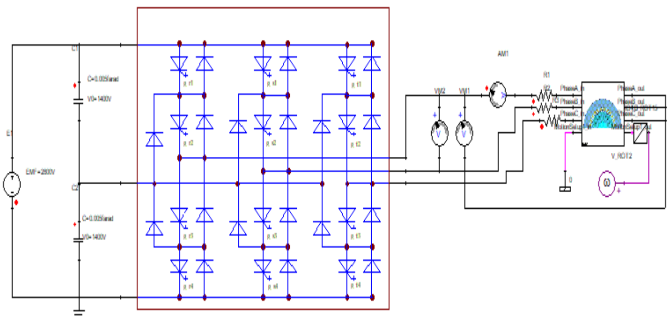
Figure 4: Motor Control Circuit

The modeling was done by applying a set of frequencies starting from 40 Hz to 60 Hz, with an increase of 5 Hz each time, taking into account the value of the applied voltage to achieve a constant frequency to voltage ratio of 7.6.

FOREX Publication
Open Access | Rapid and quality publishing
International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 10, Issue 3 | Pages 727-730 | e-ISSN: 2347-470X

The *figure 5* shows the effect of changing the frequency and voltage on the magnetic flux density of the motor, as it is clear that the flux density increases with increasing frequency.

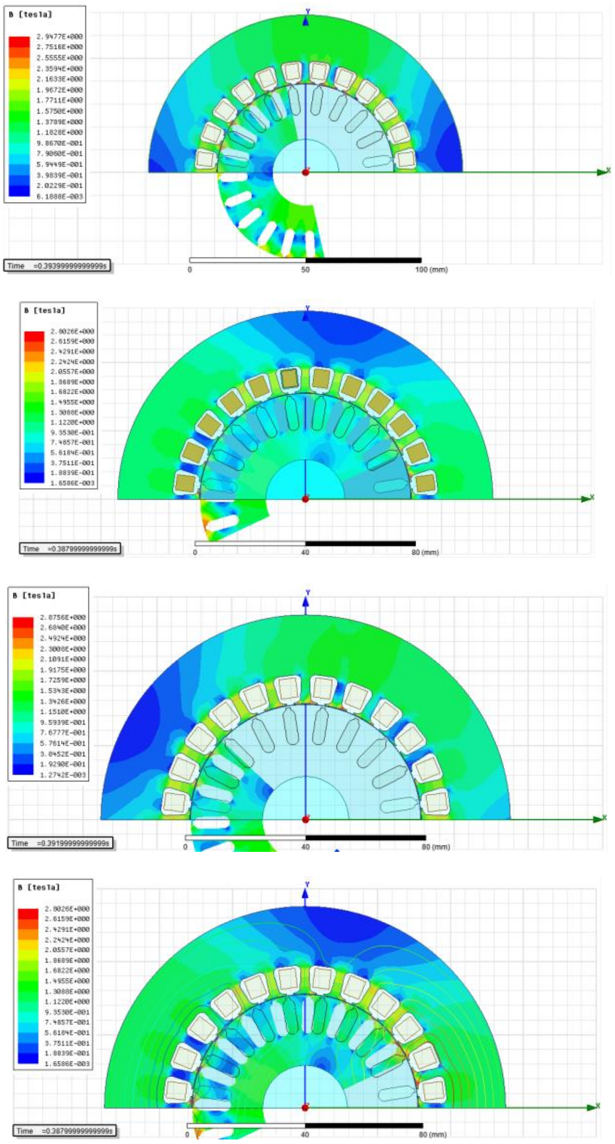

Figure 5: Flux Density

The inverter output current and voltage per phase and induced emf of induction motor at 50 Hz 380V is shown in *figure 6*.

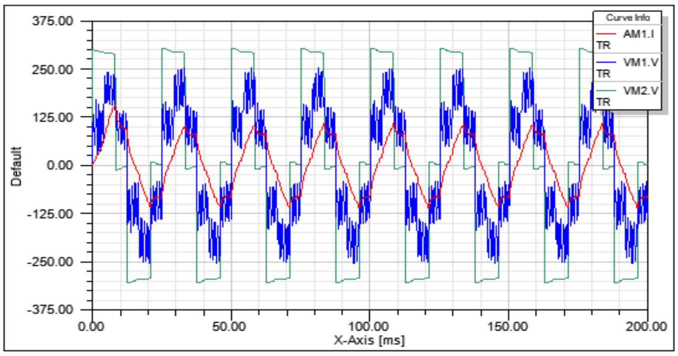

Figure 6: Inverter Output

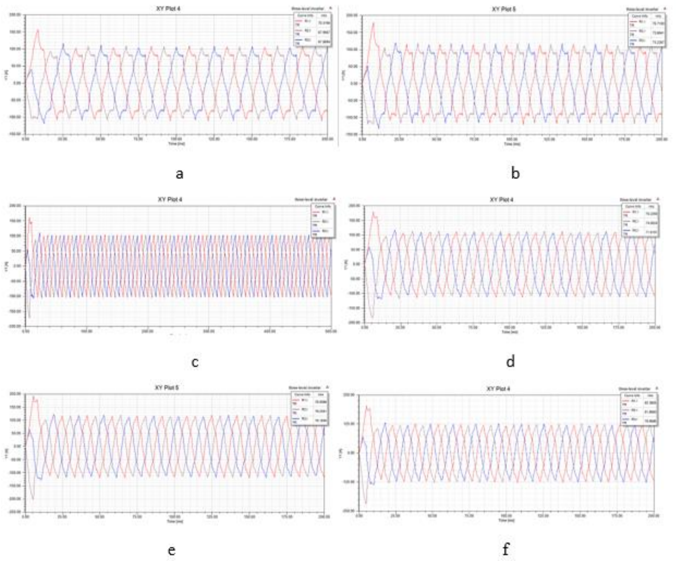

Figure 7: Output Current Waveform for (a) 40Hz, (b) 45Hz, (c) 50Hz, (d) 55Hz, (e) 60Hz, (f) 65Hz

3. RESULTS

Table 4: Motor Performance

Table 4 shows the co-simulation results of the speed control system and motor behaviour for each stage of controller which analyzed by FEA (Finite Element Analysis). The efficiency was calculated according to the ratio of output power to input power.

Table Head	Motor Performances					
Frequency (Hz)	***40***	***45***	***50***	***55***	***60***	***65***
Rated Voltage (V)	304	342	380	416	456	494
Rated Speed(rpm)	2280	2565	2850	3135	3420	3705
Winding Current(A)	5.5502	5.322	5.275	5.181	5.018	4.989
Output Power (kw)	1.777	2.029	2.282	2.587	2.447	2.660
Power factor	0.6083	0.643	0.657	0.693	0.617	0.623
Torque (N.m)	7.442	7.55	7.646	7.88	6.832	6.855
Efficiency	0.6771	0.725	0.747	0.768	0.752	0.758

Figure 8 shows the effect of changing the velocity on the stator current, as it shows that the velocity with the current is inversely proportional.

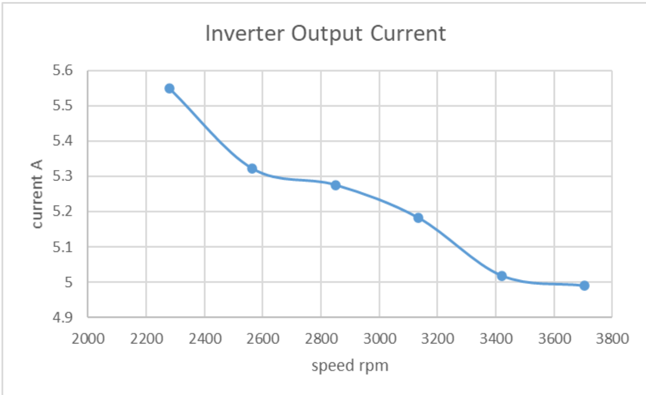

Figure 8: Current – Speed Curve

Figure 9 shows an increase in the motor power with an increase in frequency and voltage, or in other words, an increase in speed.

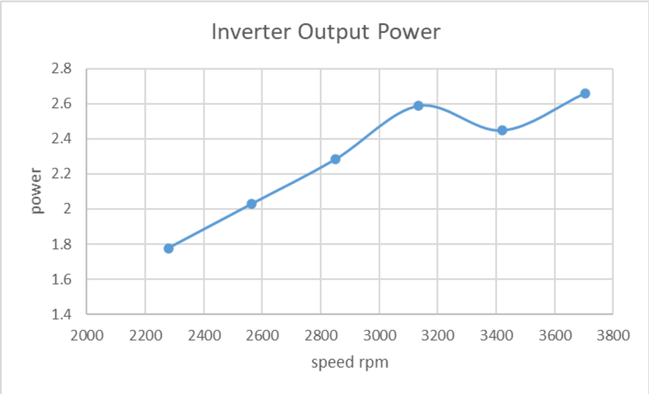

Figure 9: Power-Speed Curve

Figure 10 shows an increase in the motor efficiency with an increase frequency and voltage, or in other words, an increase in speed.

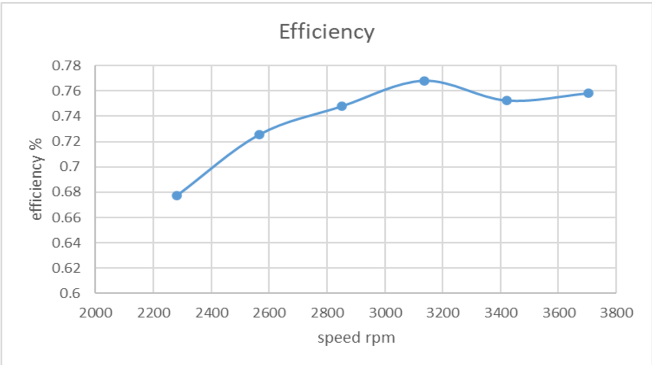

Figure 10: Efficiency- Speed Curve

4. CONCLUSION

In this paper, it is proposed speed control system by using two-dimensional finite element method coupled with the equivalent circuit simulation method in Simplorer to analyze the performance of a three-phase induction motor that is fed by a three-level invertor. In addition to clarification the effect of changing frequency and voltage on the electromagnetic field values of the motor. The simulation shows the motor's performances under the influence of speed control circuit at different speeds, the motor performance was acceptable at all values of the selected speeds, which gives an indication of the efficiency of this type of control.

REFERENCES

[1] Benyin Shen, "Traction motor", Beijing, China, China Railway Publishing House, 2010.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] Ashwini Kadam "Simulation & Implementation Of Three Phase Induction Motor On Single Phase By Using PWM Techniques," International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014

[3] Weida Xie, "Electric traction and control", Beijing, China, China Railway Publishing House, 2010.

[4] G. Carrara, S. Gardella, M. Marchesoni, R. Salutari, G. Sciutto "A New Multilevel Pwm Method: A Theoretical Analysis" IEEE Transactions on Power Electronics, Vol. 7, No. 3, pp.497-505, July 1992.

[5] J.K. Steinke, "Control Strategy for a Three Phase AC Traction Drive with a 3-level GTO PWM Inverter", IEEE PESC-1988, pp. 431-438.

[6] Anish Gopinath, Baiju, "Space Vector PWM for Multilevel Inverters- A Fractal Approach" PEDS-2007, Vol.56, No. 4, pp 1230-1237.

[7] Lettl, Jiri, "Matrix Converter Induction Motor Drive," Power Electronics and Motion Control Conference, 2006. EPE-PEMC 2006. 12th International, vol., no., pp.787-792, Aug. 30 2006-Sept. 1 2006.

[8] A. Singh, A. Dalal, R. Roy, and P. Kumar, "Improved dynamic model of induction motor including the effects of saturation," in Power Electronics, Drives and Energy Systems (PEDES), 2014 IEEE International Conference on, Dec 2014, pp. 1–5.

[9] Vijayaprabhu. A and Kumaresan. M (2022), PMSG Wind Turbine Based Current Fed Three Phase Inverter with Model Predictive Control. IJEER 10(2), 282-289. DOI: 10.37391/IJEER.100238.

[10] Nishtha Choubisa, Dr. Upendra Prasad (2017), Closed Loop Control of Switched-Capacitor Inverter Using Series/Parallel Conversion. IJEER 5(3), 13-17. DOI: 10.37391/IJEER.050301. http://ijeer.forexjournal.co.in/archive/volume-5/ijeer-050301.php