1st Proceeding of International Conference on Science and Technology UISU (ICST)
"Contribution of Engineering Disciplines to Achieving Sustainable Development Goals Research Realizing the Vision of Golden Indonesia 2045"
ISSN:3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

Analysis of Three Phase Induction Motor Settings To Load Changes Using Artificial Neural Networks

Raja Harahap[1)], Rahmad Fauzi[2)], Christian Maruli Dame Pasaribu[3)], M. Zulfin[4)], Suherman[5)]
[1,2,3,4,5)]Department of Electrical Engineering, University of North Sumatra
Jl. Almamater, USU Medan Campus, Indonesia
raja@usu.ac.id

Abstract - benefits of induction motors in the industrial world today are numerous. This is because this induction motor has many advantages such as strong and simple construction and is cheaper to maintain. However, there are weaknesses in regulating speed and torque. One of the 3-phase induction motor speed regulation is vector control. This method is connected to a PID controller to control the input and output to reach the expected value. However, with the development of an increasingly modern era, it can now be done automatically, especially in regulating PID control, in this experiment, it wants to be done using an artificial neural network controller to be able to study the data that has been done by the PID controller to find out the input and output expected by the system so that the speed control on the induction motor runs stably. this method is able to control the speed to remain stable even though the load changes. In this study, loading tests will be carried out at 0 Nm, 80 Nm, 140 Nm, 290 Nm and 400 Nm and reference speeds of 40 rps, 75 rps and 120 rps. The simulation results of using the artificial neural network controller show that the system can reach the expected reference speed in less than 3 ms and the average steady state error is 0.5241%.

Keywords: Phase Induction Motor, Vector Control, Artificial Neural Network.

1. INTRODUCTION

Electrical machines are the era of modern infrastructure development today because they are more efficient and reliable. Induction motors are electrical devices that convert electrical energy into mechanical energy. Induction motors have many advantages, namely simple shape, strong enough construction, sturdy, higher reliability, relatively cheap operating costs, able to be connected with overload capacity, minimal maintenance, good efficiency and better performance [1].

But behind the advantages of induction motors there are shortcomings, namely the difficulty in setting a constant rotational speed when the load changes. This is caused by an increase in motor torque, thereby increasing the current in the rotor and causing the slip between the rotating field and the load rotor will enlarge the coupling so that the current increases causing the slip between the rotating field and the rotor to increase creating instability in the speed of the induction motor [2].

The FOC method is a coordinate transformation, current setting, sensitive to parameter changes which makes it more complex but produces better precision [4].

Current technological advances create the use of increasingly better and efficient control systems, so that services become reliable. With the advancement of computer technology, Artificial Intelligence (AI) is able to understand patterns and things, and predict well. Artificial Intelligence (AI) functions as a control system in computational techniques that replace mathematical models formed into a number of process elements that can communicate through network interconnections [5].

Artificial neural networks are a representation of Artificial Intelligence that can train a system to be intelligent. The artificial neural network training dataset is taken from the input and output of a PID controller on a closed loop system. With a constant speed (setpoint) and the same plant, artificial neural networks can have performances that resemble PID controllers. The training parameters can show the number of epochs, validation checks and gradient descent, while the graph results can explain the Performance, Training State and Regression information [6].

The journal related to this research entitled 'Speed Control Under Load Uncertainty of Induction Motor Using Neural Network Auto-Tuning PID Controller' (2019) author Wasusatein, et al. shows that using a neural network auto-tuning PID control approach can result in an improvement in induction motor speed control performance even under uncertain loads. [8].

The journal that is the reference of this research is entitled 'Artificial Neural Network Based Speed Estimator for Sensorless Field Oriented Control of Three Phase Induction Motor' (2019) author Md. Mahmudul Hasan shows The use of ANN-based speed estimation in Field Oriented Control (FOC) provides the ability to control three-phase induction motors with sensorless implementation or without direct sensors. This enables a simpler, more efficient, and responsive control system to desired changes in speed and torque. This method eliminates the need for additional speed sensors thereby reducing costs and increasing the complexity of the control system [9].

The thesis which is the guideline for this research entitled 'Speed Regulation of 3-phase Induction Motor Using Power Electronic Converter with Artificial Neural Network' (2017) author Moh Ilham Akbar Arrizqo shows the results of constant speed testing with a certain load carried out simulated with a variation of 10 hidden layers with the smallest error of 1.417 and 3 different torque loads resulting in a steady error of 0.0132% [10].

ISSN:3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

In this study, an analysis using a 3-phase induction motor using the artificial neural network method is expected to obtain better results that can adapt quickly to changing loads and obtain the smallest possible error.

2. LITERATURE REVIEW

A. Motor Induksi

Motor induksi merupakan salah satu mesin-mesin listrik yang mampu mengubah energi listrik menjadi energi mekanik yang berupa tenaga putar. Motor induksi merupakan mesin listrik arus bolak-balik (ac).Motor induksi terdiri dari dua bagian utama, yaitu: stator dan rotor. Prinsip kerja motor induksi berdasarkan prinsip induksi elektromagnetik.

Motor induksi banyak digunakan didunia industri. Popularitasnya karena rancangan nya yang sederhana, murah dan mudah didapat, dan dapat langsung disambungkan ke sumber daya AC. Motor induksi memiliki banyak keunggulan yaitu bentuk yang sederhana, konstruksi cukup kuat, kokoh, kehandalan yang lebih tinggi, biaya operasi yang relatif murah, mampu dihubungkan dengan kapasitas overload, pemeliharaan yang minimal, effisiensi yang baik dan performa yang lebih baik [1].

B. Vector control Method

Vector control is one of the AC motor speed regulation methods which is the same as DC motor regulation which uses feedback. This method is required to perform d-q transformation [4]. With this method, fast torque response can be achieved. Steps of vector control method:

1. D-q transformation
2. Velocity estimation
3. Finding the error signal from the reference and measuring the velocity
4. The error signal is input to the controller to generate a torque reference signal
5. Calculation of currents for d and q axis, rotor flux position and transformation into real model
6. Signal generation through pulse generator to inverter.

Field Oriented Control (FOC) is a method of controlling an induction motor that is like a DC motor by separating the control of the amplifier current from the motor load current.DC motor by separating the control of the amplifier current from the motor load current, which isthus flux and torque are set separately. This method requiresto perform d-q transformation. With this method, fast torque response is obtained[10].

Clarke transformation is used totransform the three-phase signals such as current, voltage and flux from a three-coordinate (a, b, c) into a two-phase coordinate orthogonal system (ds, ds) [11].

Vector control in the fieldoriented control method was invented by Blaschke to adapt the characteristics of theDC motor in induction motors. A method of transforming a system that iscoupled to decoupled allows for independent regulation of motor torque and flux.independent of motor torque and flux.

C. Kontrol PID

Proportional-Integral-Derivative (PID) control is one of the most commonly used control techniques in control systems. controllers that are able to receive input from each variation of reference speed and actual speed, to receive data from the results of PID control used in the workspace block diagram in the Matlab library, PID control in this study was chosen because of its superiority in the control process that can accelerate the system to a steady state.

D. Jaringan Saraf Tiruan

Proportional-integral-derivative (PID) control is a feedback control loop mechanism that is widely used in industrial control systems and various other applications that require continuously modulated control. The PID controller continuously calculates the error value as the difference between the desired setpoint and the measured process variable (PV) and applies corrections based on proportional, integral and derivative [4].

III. RESULTS AND DISCUSSION

The specifications of the induction motor used are in accordance with the specifications on the name plate, namely:

Motor Power	: 160kW
Voltage	: 400 V
Motor Speed	: 37300 rps
Pole Pair	: 2
Resistor Stator	: 0,087 Ω
Resistor Rotor	: 0,228 Ω

1st Proceeding of International Conference on Science and Technology UISU (ICST)
"Contribution of Engineering Disciplines to Achieving Sustainable Development Goals Research Realizing the Vision of Golden Indonesia 2045"
ISSN:3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

Inductansi Stator : 8 mΩ
InductansiRorot : 8 mΩ
Mutual Inductansi : 34,7e-3
Inertia : 1,662 j

Furthermore, simulation is carried out on the PID test to get the dataset value for the experiment to be carried out in Simulink Matlab using the model as shown below.

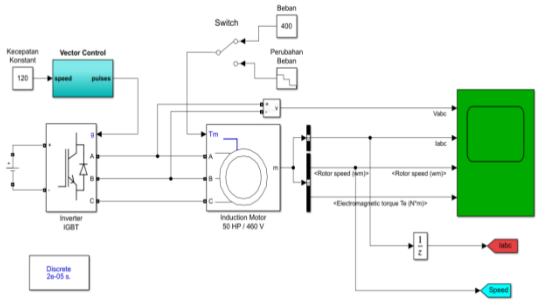

Figure 1. Simulink Block of three Phase |Induction Motor

Then the actual data value on the 3-phase induction motor using PID is obtained which looks like in table 1.

Tabel 1. Hasil simulasi kontrol PID.

Kecepatan Referensi	Beban	kecepatan Aktual
40	0	40.4809
	80	40.5556
	140	40.6575
	290	41.2073
	400	42.8056
75	0	76.8426
	80	77.2038
	140	77.5872
	290	79.5974
	400	85.3653
120	0	124.8310
	80	125.7728
	140	126.7699
	290	131.8822
	400	145.6695

The next stage will take a dataset on the simulink value obtained and take input and target data to create an artificial neural network block. In 10-layer artificial neural network training, the regression value is obtained as shown in Figure 2.

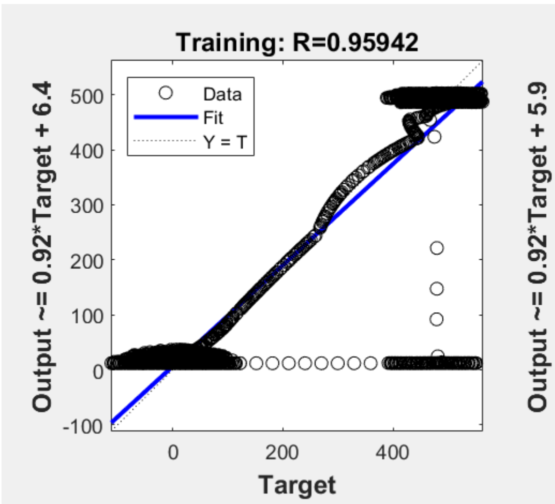

Figure 2. Regression plot

One of the results of this research is as in the experiment below, where measurements will be observed at speeds of 40, 75 and 120 at a change of 290 Nm.

ISSN:3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

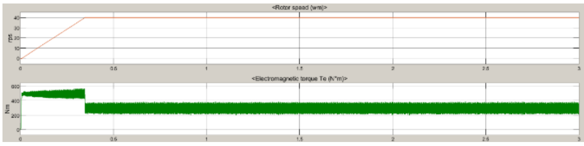

Figure 3. 40 speed 290 Nm load

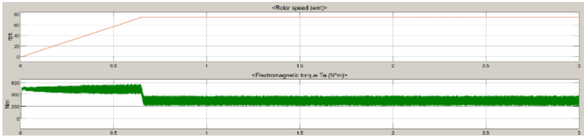

Figure 4. Speed 75 load 290 Nm

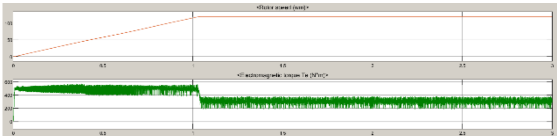

Figure 5. Speed 120 load 290 Nm

This experiment obtained the time response speed time response result of the controller.

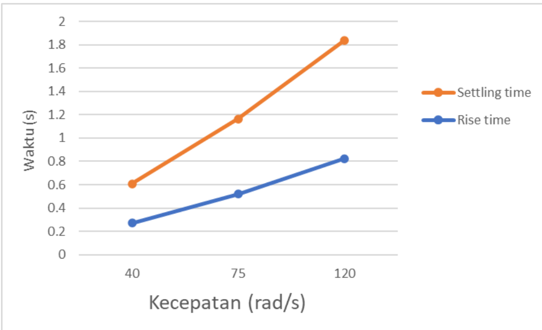

Figure 6 . Time response at load 290 Nm

Respon rise time and settling timerunning increases every time because the JST 10 hidden layer requires time to reach setpoint.

4. CONCLUSIONS

Based on the analysis that has been done, the following conclusions are obtained.

1.Artificial neural network training with variations of 1-10 hidden layers produces the smallest error in the artificial neural network of 0.0511.

2.Testing constant speeds of 40, 75 and 120 rad/s, at loads of 40, 120, 290 and 400 Nm obtained an average steady-state error value of 0.01827% and an overshoot of 0.5241%.

3. Testing constant speeds of 40, 75 and 120 rad/s at loadings of 40 to 400 obtained 2.9592s.

REFERENCES

[1]. Wijaya, Mochtar. (2001). Dasar-dasar Mesin Listrik. Penerbit Djambatan: Jakarta. ISBN 979-428-428-9.

[2]. Muslim, Buhari. (2015). Kendali Kecepatan Motor Induksi Tiga Fasa Menggunakan Kontroler Fuzzy-PID.

[3]. Suwarni dan Prasetia, Abdul Muis. (2022). Pengaturan kecepatan motor induksi tiga fasa dengan direct torque control menggunakan jaringan saraf tiruan. Jurusan Teknik Elektro, Universitas Borneo Taraka: Indonesia. Jurnal ELTEK Vol. 20, No. 2, Oktober 2022, hal.24-32. P-ISSN: 1693-4024 e-ISSN: 2355-0740. DOI: 10.33795/Eltek.v2.336.

[4]. Arrizqo, Moh Ilham Akbar. (2017). Pengaturan Kecepatan Motor Induksi 3 Fasa menggunkanan Power Electronic Converter dengan Kontroler Jaringan Saraf Tiruan

[5]. Happyanto, Dedid Cahya dan Purnomo, Mauridhi Hery. (2013). Teknik Kendali Motor Induksi Tiga Fasa Berbasis Kecerdasan Komputasional Sebagai Penggerak Mobil Listrik. Graha Ilmu: Surabaya. ISBN: 978-602-262-181-1.

ISSN:3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

[6]. Santoso, Budy, dll. (2020). Machine Learning & Reasoning Fuzzy Logic Algoritma, Manual, Matlab & Rapid Miner. Penerbit Deepublish: Yogyakarta. ISBN: 978-628-02-0631-3.

[7]. Siang, Jong Jek. (2005). Jaringan Syaraf Tiruan & Pemgrogramannya Menggunakan Matlab. Penerbit ANDI: Yogyakarta. ISBN: 979-731-636-X.

[8]. Nurdiansyah, Erwin Dwi dan Haryudo, Subuh Isnur, (2018). Pengendalian Kecepatan Motor Induksi Satu Fasa Berbasis Backpropagation. Prodi Teknik Elektro, Fakultas Universitas Negeri Surabaya: Surabaya.

[9]. Wasudetein, Wasu dll. (2018). Speed Control Under Load Uncertainty of Induction Network Based Speed Estimator for Sensorless Field Oriented Control of Three Phase Induction Motor. Departement of Electrical & Electronic Engineering, Rajshahi University of Engineering & Technology Rajshahi: Bangladesh.

[10]. Herdianto. (2013). Prediksi Kerusakan Motor Induksi Menggunakan Metode Jaringan Saraf Tiruan Backpropagation.

[11]. Afandy, Luqman H. (2016). "Sistem Pengendalian Kecepatan Motor Induksi 3 Fasa Multi Penggerak dengan Sumber Inverter Pada Mobil Listrik Menggunakan Jaringan Syaraf Tiruan". Jurnal Teknik Elektro. Universitas Jember.

[12]. Staperman Douwe and Klien Hans. "Design of Propultion and Electrical Power Generation System" London. EC2R 5BJ

[13]. Mehrotra, Prashant. (1999). Artificial Neural Networks in Induction Motor Speed Estimation and Control. National Library of Canada

[14]. Mohan, Ned. (2014). Advanced Electric Drives Analysis, Control, and Modeling Using MATLAB/Simulink. The Math Works, Inc: USA. ISBN 978-1-118-48548-4

[15]. Woud, Klein Hans dan Stapersma, Douwe. (2002). Design of Propulsion and Electric Power Generation Systems. Published by ImarEST, The Institute of Marine Engineering, Science and Technology, 80 Coleman Street: London. ISBN 1-902536-47-9.

[16]. Lubis, Roy Stevenson. (2020). Pengendalian Kecepatan Motor Induksi Tiga Fasa Inverter Space Vector Pulse Width Modulation (SVPWM). Negeri Sriwijaya.

[17]. Fatqurrohman, Fajar. (2021). AnalisaPengaturanKecepatan Motor Induksi 3 FasaDengan Variable Speed Drive MenggunakanKontrol PI PadaPenggerak HOIST ARTG (Automatic Rubber Tyre Gantry) CRANE.