Fault Detection and Protection of Induction Motor by Real Time Monitoring and Controlling of the Motor Parameters

Mehmet Fatih Işık
Electric and Electronics Engineering Department, Hitit University, Çorum, Turkey
Email: mehmetfatih@hitit.edu.tr

Mustafa Reşit Haboğlu
Mechanical Engineering Department, Hitit University, Çorum, Turkey
Email: mresithaboglu@hitit.edu.tr

Hilmi Yanmaz
Electrical Department, Hitit University Vocational High School, Çorum, Turkey
Email: hilmiyanmaz@hitit.edu.tr

Cemal Yilmaz
Department of Electrical-Electronic Engineering, Faculty of Technology, Gazi University, Ankara, Turkey
Email: cemal@gazi.edu.tr

***Abstract*—In this study, an fault detection and protection system is developed for the driver parameters of three phase asynchronous motors by using SCADA and PLC. As the fundamental units in the developed system, as asynchronous motor, frequency converter, PLC (Programmable Logic Controller) and SCADA is used. The basis of the fault detection and protection mode is generated by comparing the parameters received from the driver by the software with the optimum parameters. As a result of the study, it is confirmed that the controlling of the parameters belonging to the asynchronous motor can be fast and reliable.**

***Index Terms*—asynchronous motor, PLC, SCADA, fault detection**

I. Introduction

The developments in the technology allows the motors used in industrial manufacturing processes to be monitored and controlled in real time. The monitoring and control of the motors provides higher efficiency and opportunity to foresee the faults and malfunctions. Asynchronous motors used in electromechanical systems ought to be monitored and controlled consistently during the manufacturing process because of the fact that the product quality can easily be affected by a malfunction of the motor. Various control methods are developed or three phase asynchronous motors in recent years. Those developments aim for fast, reliable and efficient manufacturing process. The traditional control methods are being substituted by modern and smart control systems [1]-[2]. The control of electric motors, especially asynchronous motors with their advantages and design compatibility, is important [3]. The optimum control of asynchronous motors can be achieved by frequency converters with high performance [4].

The control of asynchronous motors depends on many different parameters so that it is relatively more difficult than the control of DC motors [1], [5]-[6]. Although there are several control methods for asynchronous motors, the use of speed drivers is common nowadays because of their relatively easiness. Additionally, many of the parameters that cannot be controlled with traditional control methods can be monitored and controlled with speed drivers.

In this study, a SCADA based measurement and control system is developed in order to control the parameters of a three phase asynchronous motor. An Omron CJ2M-CPU31 programmable controller (PLC) is used to develop the control system. A computer, a three phase asynchronous motor and an Omron 3G3RX frequency converter are the other components used in this research. The user interface is developed by using Omron CX-Supervisor software program.

II. Hardware Architecture

A PLC, frequency converter and a three phase asynchronous motor are used in the developed control and monitoring system. The block diagram representing the general working principle of the system is given in Fig. 1.

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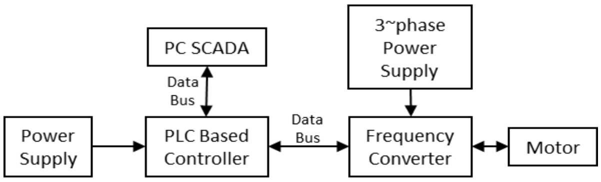

Figure 1. Block diagram of the hardware setup.

A. *Programmable Controller (PLC)*

PLC is a programmable device that is able to control the inputs and outputs according to the algorithm provided by the user [7]-[8]. Omron CJ2M-CPU31 PLC is used in the system. The power requirements of the PLC and other modules are supported by a 220/24 V power supply.

B. *3 Phase Asynchronous Motor*

The 3 phase asynchronous motor used in this study has star connection, 3.6 A of rated current, 380 V of input voltage and 3000 rpm rotation capacity.

C. *Frequency Converter*

In this study, the A4022EE type frequency converter which is among Omron 3G3RX speed controller series. The frequency converter used has an output frequency of 0-400 Hz. All of the hardware regarding the developed system is shown in Fig. 2.

Figure 2. The hardware of the system.

III. Software Methodology

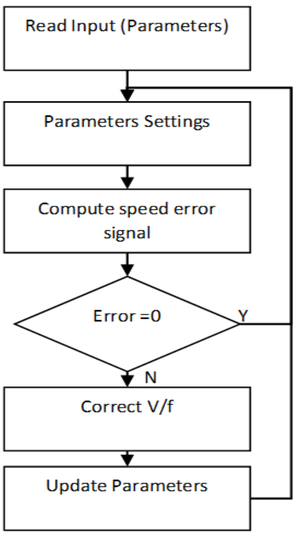

Figure 3. The V/f algorithm.

The selection of the software units depends on their fast and reliable data acquisition, flexible recording and monitoring, ability to present data as graphs and such facts. The developed algorithms can be seen in Fig. 3 and Fig. 4.

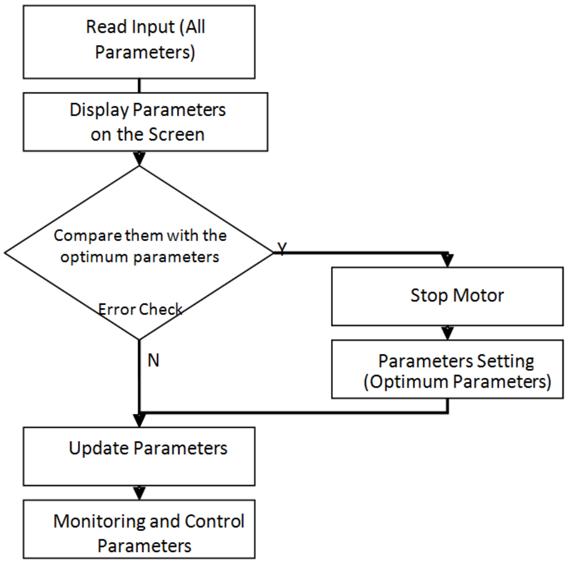

Figure 4. The protection, control and monitoring algorithm.

A. *Scada Software*

SCADA (Supervisory Control and Data Acquisition) is a data acquisition and observation system [9]. Recent studies provide the opportunity to develop PLC based SCADA systems for various applications [10]-[14]. In addition to that, PC, web and mobile based SCADA system applications are also available in several studies [15]-[19].

Omron CX-Supervisor software is used in this study. Fig. 5 shows the parameter monitoring and control screen.

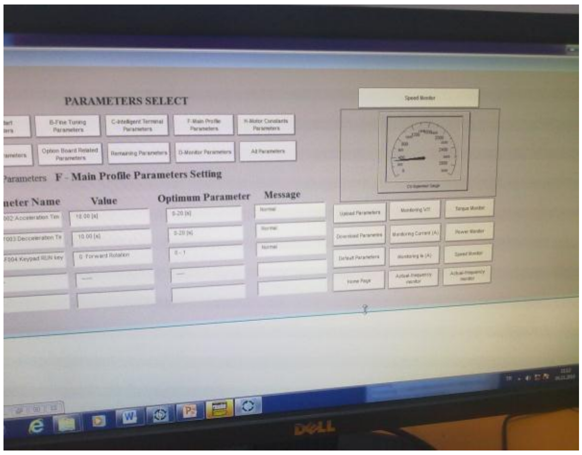

Figure 5. SCADA screen view

IV. Apllication

The real time parameter data of the motor are read by Omron 3G3RX frequency converter in the study and transmitted to the PLC through the communication module. Data received from the driver are transferred to the computer by using the USB port and the communication protocol between the SCADA and the PLC. The user interface developed under CX-Supervisor program creates the database in real time with the received data. The parameters constituting the database are filtered and displayed on the screen in for monitoring and control.

The outputs of PLC are read through the port number 3200 while the inputs are read through the port number 3300. Fig. 6 shows the definitions to activate those address parameters.

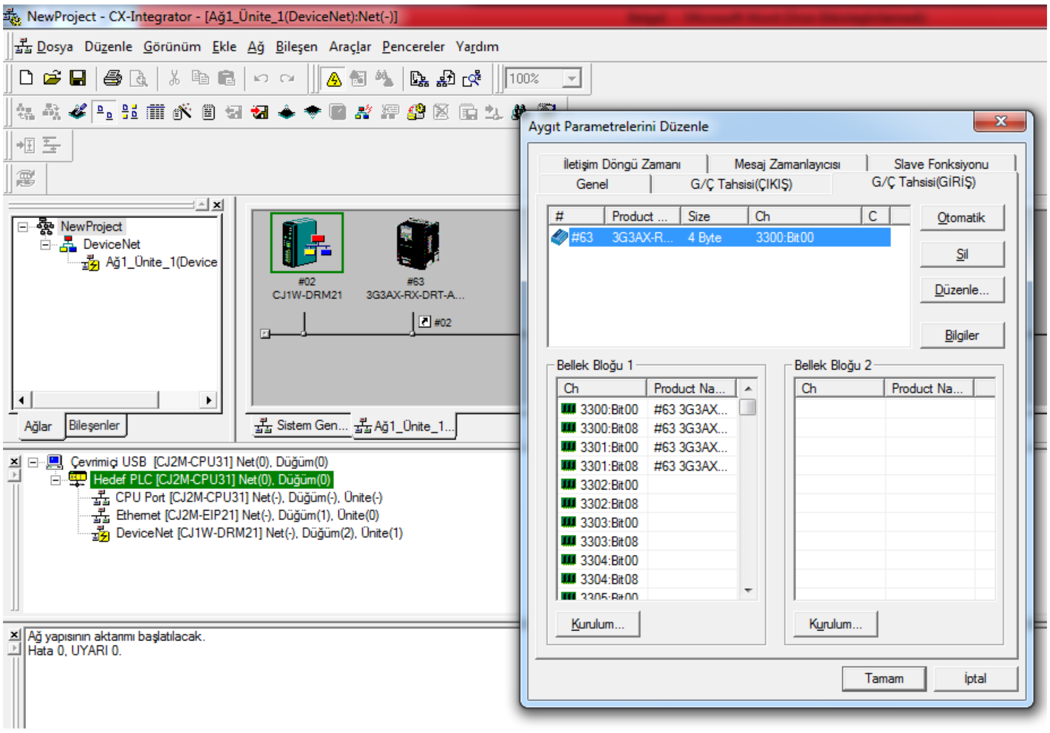

Figure 6. Settings of the input/output parameters

The parameters obtained after the designations are displayed on the screen as shown in Fig. 7. According to Fig. 7, the parameters are received from the driver as groups of categories.

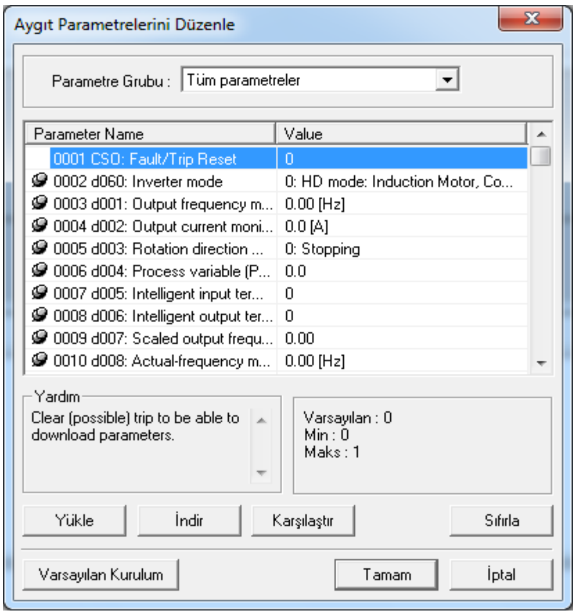

Figure 7. The parameters and addresses of the driver

V. Experimental Results

In this section, experiments regarding the changes in frequency-speed, protection, monitoring and control of the parameters of asynchronous motor are described.

Fig. 8 shows the torque characteristics for different speed values of 600 to 1800 rpm. The results show that the torque decreases as the speed and the load increases.

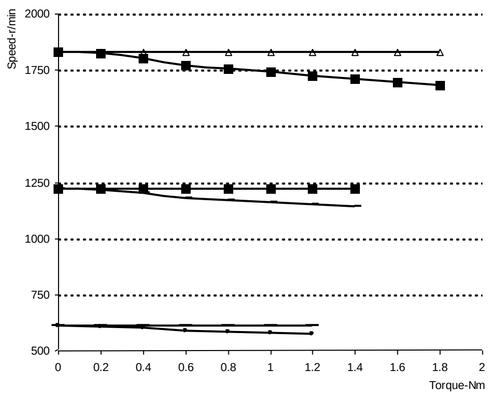

Figure 8. Speed-torque characteristics for different speed and load values

Another experiment is between the stator voltage and the frequency. The stator voltage increases as the frequency increases which can be seen in Fig. 9.

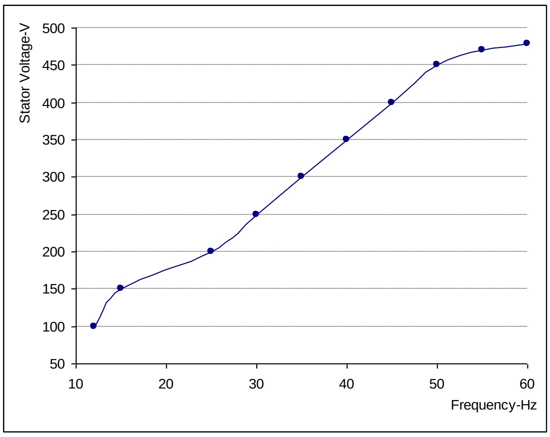

Figure 9. The stator voltage changes for different frequency values

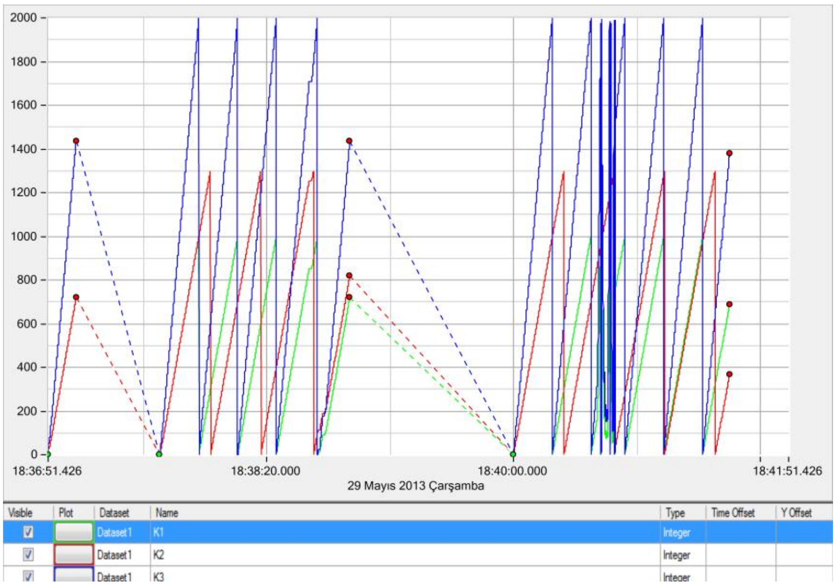

Figure 10. The work graph of the motor with time

Additionally, the working situation of the motor can also be monitored by data log viewer. The graph representing the working situation of the motor is presented. The speed values and loaded or unloaded working situations of the motor for 6 minutes of runtime are shown in Fig. 10.

VI. Experimental Results

In this study, the parameters of a 3 phase asynchronous motor are monitored and controlled successfully. Especially for the prevention of a motor fault in an industrial application, the developed system becomes important. The system can be used in experimental studies for investigations. Besides that, it can also be used for educational purposes in electric, electronics, mechanical, mechatronics and automation engineering fields. After the necessary modifications on the hardware and the software, the system will be able to monitor and control asynchronous motors with desired size and number.

One of the important features of the system is the protection module. It is seen that the protection module enables the protection mode for the motor and send a warning message to the user when the system encounters a possible problem. The data regarding the working situations of the motor are recorded and displayed on the graphs.

When compared to the existing systems, the developed system is an efficient, economic and compact system consisting of several properties.

References

[1] C. Yılmaz, O. Gürdal, and İ. Koşalay, "Network induced delay of asynchronous motor connectes to profibus-dp network using fuzzy logic control algorithm," *Expert System with Applications*, vol. 37, no. 32, pp. 3248-3255, 2010.

[2] C. Yıldız, "Control of vectoral asynchronous motor by using genetic algorithm based fuzzy logic," MS Thesis, Kahramanmaras Sutcu Imam University, Institute of Natural Sciences, Turkey, 2008.

[3] C, Öz and N. Abut, "The speed control of asynchronous motors by microprocessors," *Elektrik Mühendisliği Dergisi*, vol. 375, pp. 197-202, 1990.

[4] V. Jerkovic, Z. Spoljaric, and Z. Valter, "Optimal control of induction motor using high performance frequency converter," *IEEE*, vol. 978, no. 1, pp. 1742-1744, 2008.

[5] İ. Çolak, "Asynchronous motors," *Nobel Yayınları*, pp. 115-121, 2001.
[6] Z. Koca, "Vectoral speed control of three phase asynchronous motors by using neural networks," MS Thesis, Kahramanmaraş Sutcu Imam University, Institute of Natural Sciences, Turkey, 2006.
[7] Omron Device Net Operation Manual Cat. No. W267-E1-11 Revised, April 2008
[8] M. G. Ioannides, "Design and implementation of PLC-based monitoring control system for induction motor," *IEEE Trans. Energy Conversion*, vol. 19, no. 3, pp. 469-478, 2004.
[9] J. J. Liu, L. X. Yao, X. Y. Liu, Y. An, Ya Guo, and Z. F. Liang, "Asia-Pacific digital object identifier," in *Proc. Power and Energy Engineering Conference (APPEEC)*, 2010, pp. 1-4.
[10] B. Dieu, "Application of the SCADA system in wastewater treatment plants," *ISATrans*, vol. 40, pp. 267-281, 2001.
[11] A. Honda, F. Okano, K. Ooshima, N. Akino, K. Kikuchi, Y. Tanai, *et al.*, "Application of PLC to dynamic control system for liquid he cryogenic pumping facility on JT-60U NBI system," *Fusion Eng Des*, vol. 83, pp. 276-279, 2008.
[12] G. Urdaneta, J. A. Colmenares, N. V. Queipo, N. Arape, C. Arevalo, M. Ruz, *et al*., "A reference software architecture for the development of industrial automation high-level applications in the petroleum industry," *ComputInd*, vol. 58, pp. 35-45, 2007.
[13] Z. Aydogmus, "Implementation of a fuzzy-based level control using SCADA," *Expert Syst Appl*, vol. 36, pp. 6593-6597, 2009.
[14] A. Fadaei and K. Salahshoor, "Design and implementation of a new fuzzy PID controller for networked control systems," *ISA Trans*, vol. 47, pp. 351-361, 2008.
[15] Y. Awl and K. CH, "Developing a PC-based automated monitoring and control platform for electric power systems," *Electr Power Syst Res*, vol. 64, pp. 129-136, 2003.
[16] S. A. Avlonitis, M. Pappas, K. Moutesidis, D. Avlonitis, K. Kouroumbas, and N. Vlachakis, "PC based SCADA system and additional safety measures for small desalination plants," *Desalination*, vol. 165, pp. 165-176, 2004.
[17] M. Patel, G. R. Cole, T. L. Pryor , and N. A. Wilmot, "Development of a novel SCADA system for laboratory testing," *ISA Trans*, vol. 43, pp. 477-490, 2004.
[18] A. Salihbegovic, V. Marinkovic, Z. Cico, E. Karavdic, and N. Delic, "Web based multilayered distributed SCADA/HMI system in refinery application," *Comput Stand Interfaces*, vol. 31, pp. 599-612, 2009.
[19] E. Ozdemir and M. Karacor, "Mobile phone based SCADA for industrial automation," *ISA Trans*, vol. 45, pp. 67-75, 2006.

Mehmet Fatih IŞIK, received the B.S. degree in electrical education from Gazi University, Ankara, Turkey in 1999, the M.S. degree in electrical education from Gazi University, Ankara, Turkey, in 2002, and the Ph.D. degree in electrical education from Gazi University, Ankara, in 2009. Currently, he is an Assistant Professor of Electrical and Electronic at Hitit University, Çorum, Turkey. He is the Director of the Electrical and Electronic Department in the Hitit University. His fields of interest include automatic control, electrical machinery, training sets and robotics.

Mustafa Reşit Haboğlu received his B.Sc. degree from the Department of Mechatronics Engineering of Sabanci University, Turkey, in 2009, M.S. degree from the Koc University Department of Mechanical Engineering in 2012. He is currently a Research Assistant at Hitit University Faculty of Engineering. His research interests include automatic control, mechatronics and composite materials manufacturing.

Hilmi YANMAZ, received the B.S. degree in electronic education from Gazi University, Ankara, Turkey in 1993, the M.S. degree in electrical education. Currently, he is an Lecturer of Electrical department at Hitit University, Çorum, Turkey. He is the Director of the Electrical Department in the Hitit University. His fields of interest include automatic control, electrical machinery, and robotics.

Cemal Yılmaz received he B.Sc. degree from Gazi University, Turkey, in 1997, M.S. degree from the Gazi University in 2001, and Ph. D. degree from Gazi University in 2007 all in electrical engineering. He is currently an Associate Professor at Gazi University. He research interests include power system modeling and analysis, smart building and renewable energy systems.