Smart Phone Based Energy Monitoring System for 3 Phase Induction Motors

Mehmet Fatih Işık[1], Mustafa Reşit Haboğlu[2], and Büşra Yartaşı[1]
[1]Electric and Electronics Engineering Department, Hitit University, Çorum, Turkey
[2]Mechanical Engineering Department, Hitit University, Çorum, Turkey
Email: {mehmetfatih, mresithaboglu}@hitit.edu.tr, byartasi@gmail.com

***Abstract*—In this study, a mobile device based monitoring and control system is developed for 3 phase asynchronous motor parameters. The designed system consists of an asynchronous motor, a frequency converter, a Programmable Logic Controller (PLC), a mobile interface server and mobile devices. The monitoring and control is obtained by a simple application that is installed to the mobile device. Among the driver parameters, especially the ones related to the energy consumption are chosen to be monitored and controlled. Thus, an energy monitoring system is developed.**

***Index Terms*—asynchronous motor, PLC, energy monitoring, control**

I. Introduction

Real time monitoring and control of the motors used in industrial manufacturing processes have become possible with the developing technology. With the help of this feature, it is possible to detect the faults and malfunctions of the motors before they happen. Additionally, the motors can work with higher efficiencies with real time monitoring and control. One of the most common motor types used in the industry is asynchronous motors. There is a fact that the product quality is highly dependent on the working process of the motors. That is, in case of a malfunction in the motor, the product quality decreases. Therefore, there is a need for real time monitoring and control of asynchronous motors used in electromechanical systems consistently. In recent years, several control methods for three phase asynchronous motors are developed in order to obtain fast, reliable and efficient manufacturing processes. The modern and smart control systems have taken the position of conventional control methods in recent years [1], [2]. It is significant for the control of electric motors, especially asynchronous motors, to be compatible with the used system [3]. Frequency converters provide high performance to the optimum control of asynchronous motors [4].

The control of asynchronous motors is relatively difficult when compared with the control of DC motors. Because, the control of asynchronous motors depends on many different parameters [1], [5], [6]. The use of speed drivers provides relatively easy control when compared to the other present control methods for asynchronous motors. In addition to that, the control and monitoring of many different parameters that cannot be controlled with traditional control methods is possible with speed drivers. Therefore, speed drivers are commonly used to control asynchronous motors.

The use of asynchronous motors constitutes about 70% of the motor types in industrial manufacturing processes because of their several advantages such as simple structure and easy maintenance. Additionally, most of the energy is consumed by those motors in manufacturing systems. The energy efficiency is affected by the parameters such as the control system, power quality, coil heat and losses. Those parameters increase the energy consumption. In order to prevent that much energy consumption, higher efficiency motors ought to be preferred. In addition to that, the efficiency of the speed driver should be high.

In this study, the power parameters that belong to asynchronous motors are monitored. As a result, a mobile based monitoring system is developed for those types of motor in order to constitute an energy efficient system.

II. System Architecture

In this study, a 3 phase asynchronous motor is used. Those kind of motors are the most common types that are used in the industry for their strong couple, multi variable, nonlinear and time varying characteristics [7], [8]. The asynchronous motor used in this study has a star connection, 3000rpm rotation capacity, 380V of input voltage and 3.6A of rated current. The block diagram showing the asynchronous motor control system can be seen in Fig. 1.

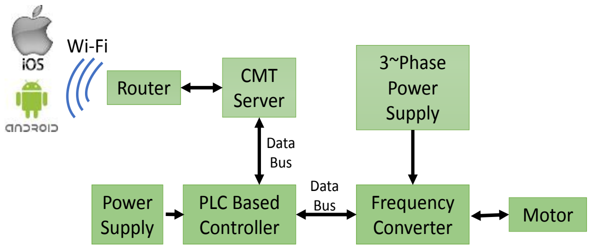

Figure 1. Block diagram of the asynchronous motor control system

A PLC is used for the control of the motor. PLC is a control system that contains user interface for remote

Manuscript received February 15, 2016; revised June 2, 2016.

doi: 10.18178/ijeee.5.1.90-93

controlling of automation systems by using input and output units [9]-[16].

A frequency converter having a frequency range of 0-400 Hz is used. The type of the frequency converter is A4022EE from speed controller series of Omron 3G3RX.

III. Smart Phone Software and Application

A software program called EasyBuilder-Pro is used for the design of monitoring and control screen. Before the design process, the suitable PLC model and the screen type is chosen from the program. Ethernet connection is used to obtain the communication with PLCs.

The screen of monitoring and control is uploaded to a server. The server device is named as CMT-SVR. An access point is used for the wireless communication between the server and the mobile device. An IOS/Android based mobile device can reach to this wireless connection with the help of an application named CMT-Viewer. By only using that application, the control and monitoring of the asynchronous motor system is possible.

Several steps are performed for the configuration of the application software. Firstly, the PLC device is added to the software by clicking on the PLC button on the system parameters setting screen of the EasyBuilder-Pro program. This action is done in order to choose the PLC that is connected with the mobile device server properly. This screen is shown in Fig. 2.

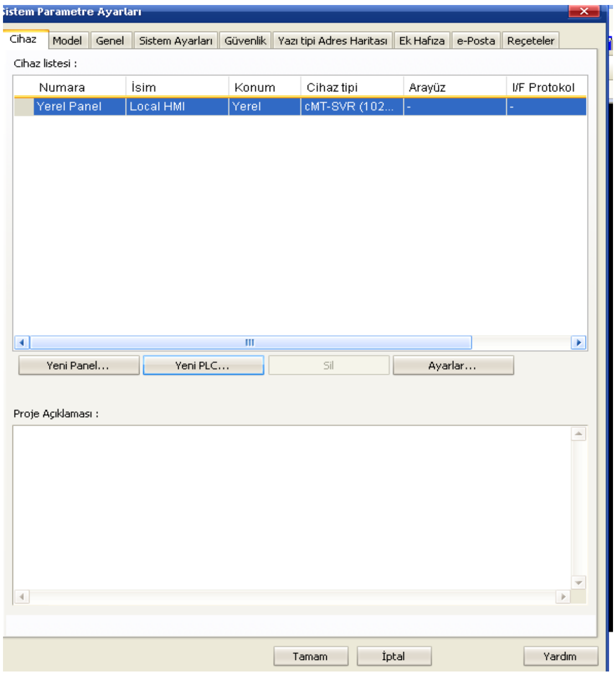

Figure 2. PLC selection screen on EasyBuilder-Pro

After the PLC selection, the device is renamed on the device properties screen. The brand named “OMRON CJ2M” is chosen for the PLC type. This situation is shown in Fig. 3.

The CMT-Viewer application is provided by IOS/Android application stores. After downloading the application, 6 server devices are created as seen in Fig. 4.

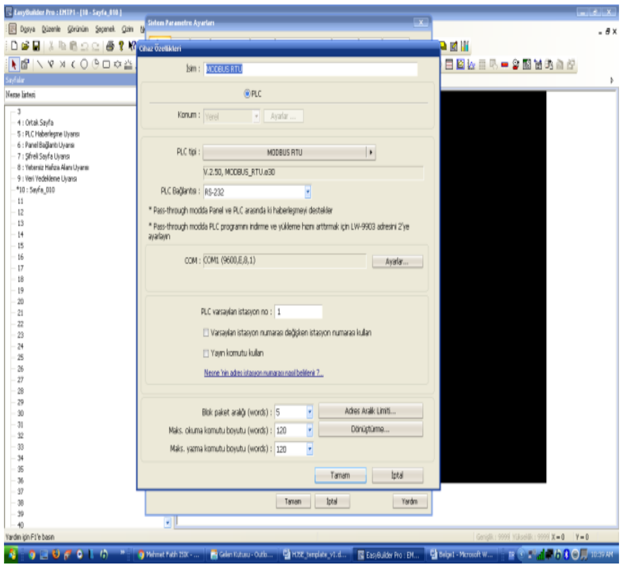

Figure 3. Device properties selection screen on EasyBuilder-Pro

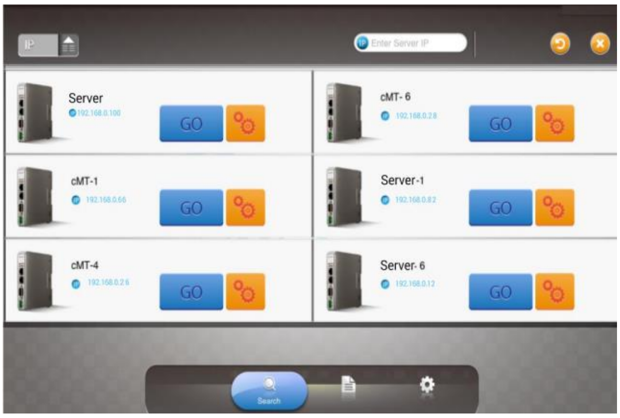

Figure 4. IOS/Android access screen view

Each device seen in Fig. 4 is organized in an order that the addresses of Ethernet 1 and 2 channels can be reached by the application. The IP address of the PLC is set to 192.168.250.80. This is the default address of the PLC.

After the settings which are indicated above are obtained, the necessary parameter settings ought to be done on the server device. Those settings are crucial for the mobile device connection to the server. The IP address that belong to the device should be opened via an interface software. This process can be done with either mobile device or the PC. The Ethernet 1 and Ethernet 2 settings can be done with this interface screen. The IP address of that interface is 192.168.0.103. A new IP address is set for Ethernet 2 with a number different from the address of the PLC such as 192.168.250.x where x is a 3 digit number). The other constraints such as Mask, Gateway and DNS should be the same as the ones that belong to Ethernet 1. The screen that belongs to the settings of Ethernet 1 and Ethernet 2 is shown in Fig. 5.

With this order, the communication between CMT-SVR and PLC is obtained without any error. Besides, the system shows a communication error message in case of any error. The address settings for the connection between mobile devices and the PLC are obtained. The input/output addresses of the PLC ladder diagram are shown via CIO_Bit.

If the communication of server and PLC is obtained successfully, each device can be reached by clicking the “GO” button which is seen in Fig. 4. After the loading process, the monitoring and control screen for the asynchronous motor can be viewed. In this screen, the user can control the parameters of the asynchronous motor while monitoring them in real time. The monitoring and control screen is presented in Fig. 6.

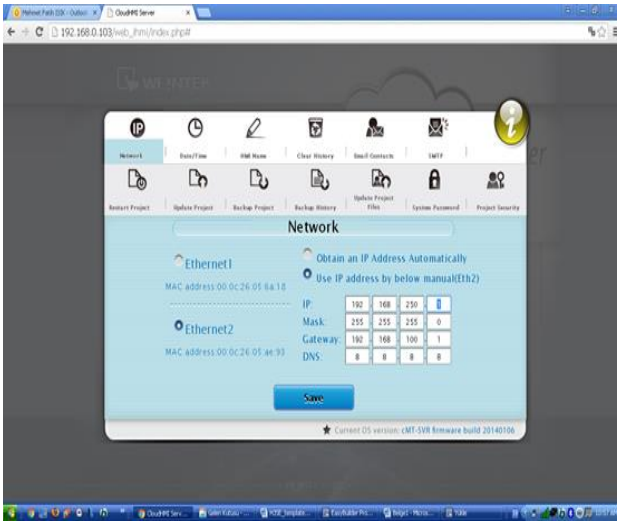

Figure 5. The connection settings of Ethernet 1 and Ethernet 2

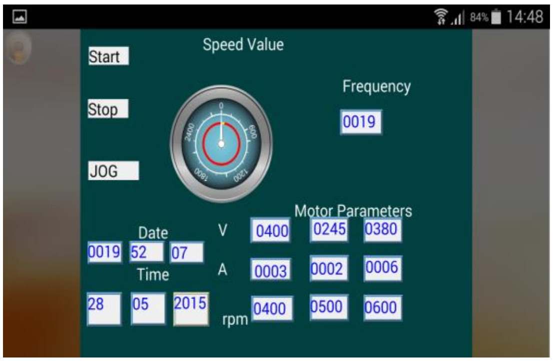

Figure 6. Monitoring and control screen for the asynchronous motor via IOS/Android application

Figure 7. General view of the asynchronous motor control system

The general view of the system containing the mobile device, PLC and the asynchronous motor is shown in Fig. 7.

IV. Results

The torque value for idle running of the motor for 380V and 50Hz is measured and result is presented in Fig. 8.

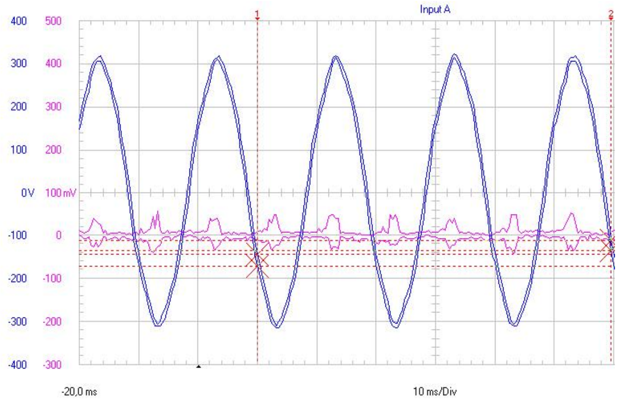

Figure 8. Motor input voltage/current graph

The relationship between the stator voltage and frequency is given in Fig. 9. It can be concluded from the figure that as the frequency increases, the stator voltage also increases.

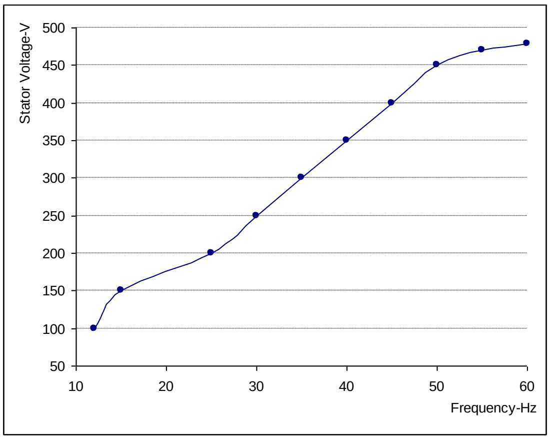

Figure 9. The stator voltage change for different frequency values

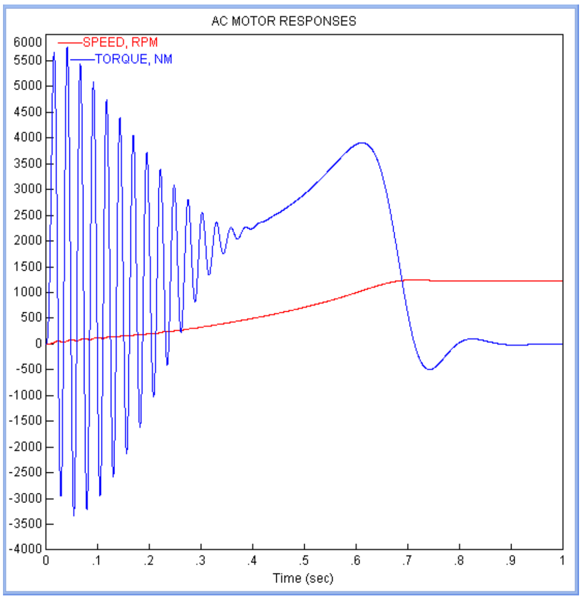

Figure 10. AC motor speed and torque graph

The relationship seen in Fig. 9 is constant. As the frequency increases above 50Hz, the stator voltage becomes a concave down curve.

The motor speed and the torque values with time for AC motors is presented in Fig. 10.

V. Conclusion

The main feature of energy efficiency is to obtain more work with less energy. Many parameters that belong to the asynchronous motors can be monitored with the developed system in this study. The basis of this monitoring system consists of mobile devices. By using the application on the mobile device, the parameters that affect the energy costs of the manufacturing system such as current, voltage, frequency, coil temperature and resistance can be monitored. Thus, the user can easily monitor any parameter belonging to any motor in real time. This feature is possible with only downloading the necessary application to the mobile device from IOS/Android application stores. This study contributes to the efficiency of manufacturing systems with its real time monitoring feature.

References

[1] W. J. Shyr, T. J. Su, C. M. Lin, "Development of remote monitoring and control system based on PLC and webaccess for learning mechatronics," *International Journal of Advanced Robotic Systems*, vol. 10, no. 97, pp. 1-7, 2013.

[2] C. Ciufudean and F. Neri, "Open research issues on multi-models for complex technological systems," *WSEAS Transactions on Systems*, vol. 13, 2014.

[3] C. Saygin and F. Kahraman, "A web-based programmable logic controller laboratory for manufacturing engineering education," *International Journal of Advanced Manufactured Technology*, vol. 24, pp. 590-598, 2004.

[4] I. Mougharbel, A. E. Hajj, H. Artail, and C. Riman, "Remote lab experiments models: A comparative study," *International Journal of Engineering Education*, vol. 22, no. 4, pp. 849-857, 2006.

[5] W. Hui, P. J. H. Hu, T. H. K. Clark, K. Y. Tam, and J. Milton, "Technology-Assisted learning: A longitudinal field study of knowledge category learning effectiveness and satisfaction in language learning," *Journal of Computer Assisted Learning*, vol. 24, pp. 245-259, 2008.

[6] A. Siddique, G. S. Yadava, and B. Singh, "A review of stator fault monitoring techniques of induction motors," *IEEE Trans. Energy Convers*, vol. 20, no. 1, pp. 106-114, 2005.

[7] A. Yang, J. Wu, W. Zhang, and X. Kan, "Research on asynchronous motor vector control system based on rotor parameters time-varying," *WSEAS Transactions on Systems*, vol. 7, no. 4, pp. 384-393, 2008.

[8] P. Haiguo, W. Zhixin, and Z. Huaqiang, "Cooperative PSO based PID neural network integral control strategy and simulation research with asynchronous motor controller design," *WSEAS Transactions on Circuits and Systems*, vol. 8, no. 8, pp. 696-708, 2009.

[9] M. F. Isik, M. R. Haboglu, and H. Yanmaz, "Monitoring and control of PLC-based motion control systems via Device-Net," in *Proc. 16th International Power Electronics and Motion Conference and Exposition IEEE*, Antalya, September 21-24, 2014, pp. 963-966.

[10] M. F. Isik and A. Coskun, "Bilgisayar destekli elektrik makinalari egitimi," in *Proc. International Conference on Educational Sciences, Eastern Mediterranean University*, Famagusta, June 23-25, 2008, pp. 1016-1021.

[11] I. Coskun, M. F. Isik, and H. Yanmaz, "PLC denetimli servo kontrol sistemi egitim setinin tasarimi ve uygulamasi," in *Proc. International Conference on Educational Sciences*, Eastern Mediterranean University, Famagusta, June 23-25, 2008, pp. 455-462.

[12] I. Coskun and M. F. Isik, "Design and application of the technical training set for PLC-based power supply unit developed for industrial applications," *Procedia-Social and Behavioral Sciences*, vol. 1, no. 1, pp. 1658-1662, 2009.

[13] M. F. Isik and I. Coskun, "Servo control education tool for industrial applications," *Electronics and Electrical Engineering*, vol. 10, no. 106, pp. 159-164, 2010.

[14] M. G. Ioannides, "Design and implementation of PLC-based monitoring control system for induction motor," *IEEE Trans. Energy Conversion*, vol. 3, no. 19, pp. 469-478, 2004.

[15] Y. Birbir and H. S. Nogay, "Design and implementation of PLC based monitoring control system for three-phase induction motors fed by PWM inverter," *Int. Journal of Systems Applications, Engineering & Development*, vol. 2, no. 3, pp. 128-135, 2008.

[16] M. F. Isik and M. R. Haboglu, "Design and implementation of real time monitoring and control system for robot arms used in industrial applications," in *Proc. 15th International Conference on Robotics, Control and Manufacturing Technology*, Kuala Lumpur, April 23-25, 2015, pp. 33-37.

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 Mechatronics Engineering Department of Sabanci University, Turkey, in 2009 and his M.S. degree from the Mechanical Engineering Department of Koc University, Turkey in 2012. He is currently a research assistant and a PhD candidate at Hitit University Mechanical Engineering Department. His research interests include automatic control, mechatronics, robotics and composite materials manufacturing.

Büşra Yartaşi received her B.S. degree from Electric and Electronics Engineering Department of Atatürk University, Turkey in 2012 and her M.S. degree from University of Southampton, UK in 2015. She is currently a research assistant at Electric and Electronics Engineering Department of Hitit University. Her research interests are silicon photonics, optoelectronics and micro ring resonators.