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Remote Controlling and Monitoring of Induction Motors through Internet

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Abstract

Induction motors are used more commonly than the other type of electric motors because of being low cost, robustness, and requiring less maintenance (especially squirrel-cage types), and able to work in harsh conditions. In this study, three separate single phased induction motors or one three-phased induction motor is simultaneously remote controlled. When it is requested continuously remote data collection of motor currents, voltages, and remote monitoring of motor status are implemented. Moreover, running under or over supply voltage conditions are prevented and it is only allowed running when the values return to nominal rates. The design consists of PIC18F4620 microcontroller connected with ethernet board, sensor cards and control card. The developed software and HTML labels belonging to web interface are embedded in the microcontroller. The serial ethernet board contains HTML labels in its buffer memory. The remote powering of induction motors was done by the help of any device connecting to the internet with using an IP number assigned to the serial ethernet board.

Keywords: *remote control, remote monitoring, serial ethernet board, induction motor, microcontroller*

1. Introduction

Nowadays, timer controlled systems have been easily replaced with remote controlled systems after the internet became widespread [1]. In these systems, it is known as an important issue to get information about not only the control, but also the conditions of the machines or devices through web. In accordance with this need, there are some works about implementation of condition monitoring of system through internet [2], and development of web-based remote controlling or monitoring practices [3, 4].

Currently, remote accessing, controlling and monitoring are possible through the internet. It is observed that many systems were used for controlling and monitoring processes. There are some successful examples such as monitoring of induction motor parameters based on Zigbee protocol [5-7], the control of simulation and motion control of induction motors using a computer [8], real-time monitoring and controlling of induction motor parameters [9], cruise control of induction motors using the techniques of GSM and PWM [10], monitoring the positions of three-phase induction motors by means of GSM technology [11, 12], the control of motor through the ethernet with LabVIEW using PLC [13]. In addition to these a PLC Scada based fault detection and protection system is implemented in ref [14]. In that study, the web-based user interface for remote control and monitoring was developed and presented online to users. Different control technologies such as microcontrollers, data acquisition boards (DAQ), programmable logic controllers (PLC) and FPGA (Field Programmable Gate Array) are used for monitoring and control of the systems. In most of them, wireless communication techniques such as RF, ZigBee, Bluetooth and GPRS are widely preferred for remote monitoring purposes. Application of the system is possible to wireless greenhouse monitoring. An example system is developed for the real-time monitoring, collecting of parameters and remote control of the greenhouse environment [15].

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In this study, microcontroller based remote powering of three separate single phased induction motors or one three-phased induction motor, and continuously monitoring of motor currents and voltages are implemented. In this implemented work, a serial ethernet card usage provides a cost effective solution by eliminating the usage of a seperate host computer.

2. Controlling and Monitoring of Induction Motors through the Internet

This application of controlling and monitoring the induction motors through the internet with the serial ethernet board consist of two main parts; software and hardware as seen in Figure 1. In software, MicroC programming language is used for the serial ethernet board and PIC18F4620 microcontroller works as a server. The libraries of programming language for the ethernet and serial communication were used. In the hardware, Hall Effect typed LA-55P current sensors and LV-25P voltage sensors are used. With these sensors, instant values of the current and voltage of the induction motors are sampled using the feature of analogue/digital conversion of the microcontroller.

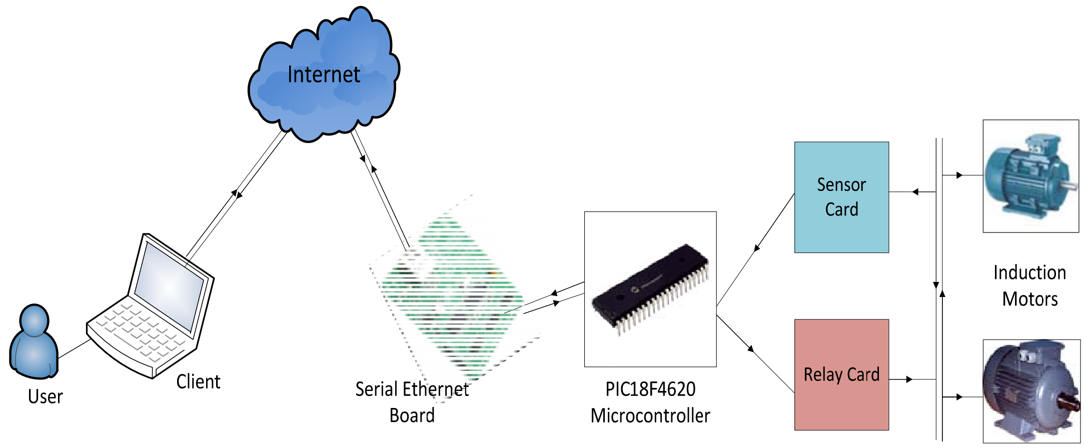


Figure 1. Controlling and monitoring of the induction motors through the internet with the serial ethernet board

2.1. Hardware Description of the Performed System

In this part, hardware for the monitoring and controlling system of induction motor with the serial ethernet board is described. The designed system consists of sensor card, relay and contactor card, microcontroller and the serial ethernet board.

2.1.1. The Sensor Card

Hall Effect typed current and voltage sensors are used to continuously monitor the current rating and voltage of the motor. LA-55P current sensor and LV-25P voltage sensor are used on the sensor card. Open-circuit diagram of current and voltage sensors is seen in Figure 2.

The reduced induction motor currents are measured with these sensors. The reduction value of the sensor is 1000 times (see Equation 1). As seen in Figure 3, when this current passed over R_M resistance which is about 100Ω, the voltage that falls on this resistance becomes 0,24V (Equation 2).

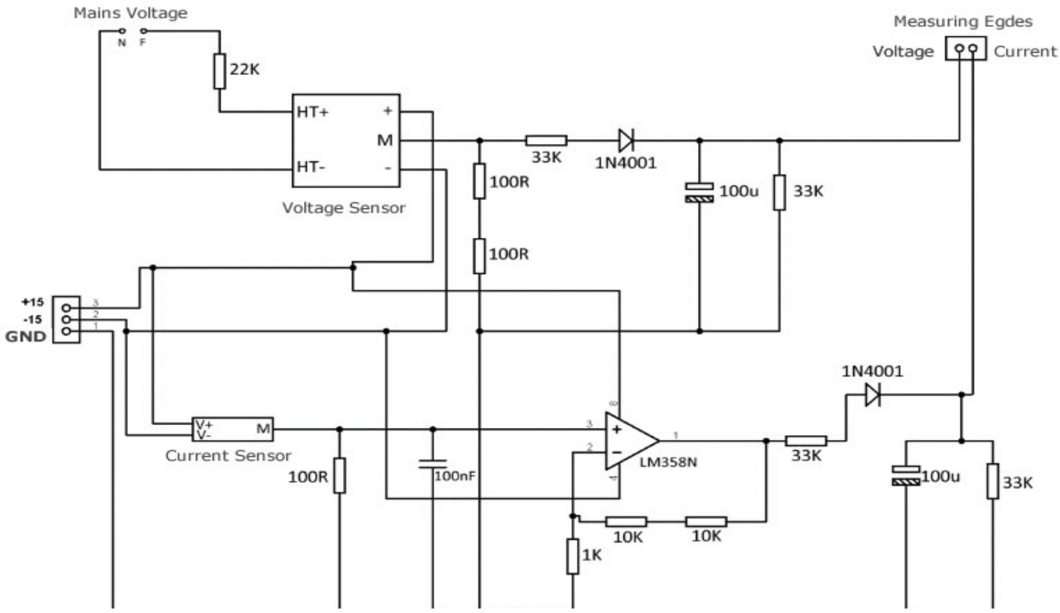


Figure 2. Open-circuit diagram of current and voltage sensors

When this voltage converted to digital with ADC on the microcontroller, its value becomes 49 (Equation 3). Even the induction motor works in maximum current value, a very little value occurs because of the reduction rate in sensor output. Therefore, the output signal must be amplified using an amplifier. In order to increase this current sensor output(0,24V) to the level of 5V, we need to amplify (Equation 4).

$$\frac{2.4A}{1000} = 0{,}0024\ A = 2{,}4mA \quad (1)$$

$$V = I.R \quad V = 0{,}0024 \times 100\Omega = 0{,}24V \quad (2)$$

$$\text{The measured numerical value} = \frac{0{,}24V\ .\ 1023}{5V} = 49{,}104 \cong 49 \quad (3)$$

$$X\ .\ 0{,}24V = 5V \quad X = 20{,}83 \cong 21 \quad (4)$$

The non-inverting amplifier for the current sensors is given in Figure 3. R_1 and R_f resistance values of this non-inverting amplifier are chosen as 1kΩ and 20kΩ according to the Equation (4).

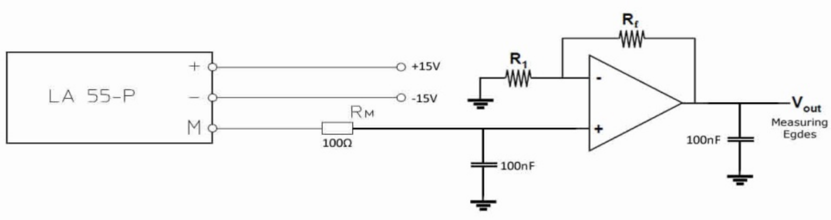


Figure 3. Current sensor and non-inverting amplifier circuit [16]

LV-25P voltage sensors are used to measure the line voltages of the induction motors. The sensor decreases the signal at the ratio of 2500:1000. This value was re-adjusted to the real value in the MicroC software later. In Figure 4, there is the electronic circuit belonging to voltage sensor.

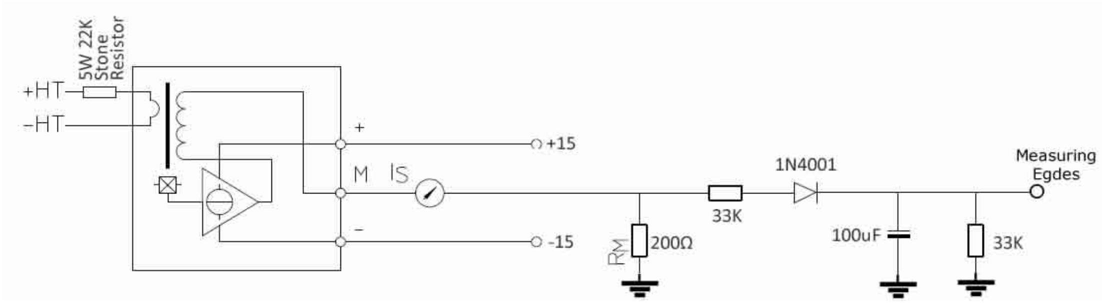


Figure 4. The circuit of voltage sensor [17]

In this research, three pieces of sensor cards are used to monitor the voltages and currents of the three separate single phased or one three phased induction motor to get information about whether they work in normal conditions or not and to remote control of them (see Figure 5).

2.1.2. Microcontroller and Serial Ethernet Board

PIC18F4620 typed microcontroller is used in this work. It has 13 channels featured as analogue digital converter. Six channels are used for the sensors. The serial ethernet board is connected to PIC18F4620 microcontroller through 10-pins connector as seen in Figure 6. The serial ethernet board works in 3.3V or 5V. It takes 5V feed from the connector's pins number 5 and 6 through microcontroller card. The electric terminals on the microcontroller card are designed for the connection of other cards. A crystal about 8 MHz is used for PIC18F4620 microcontroller.

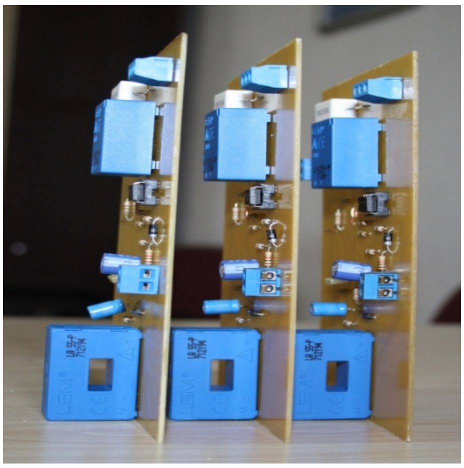


Figure 5. Modular sensor cards

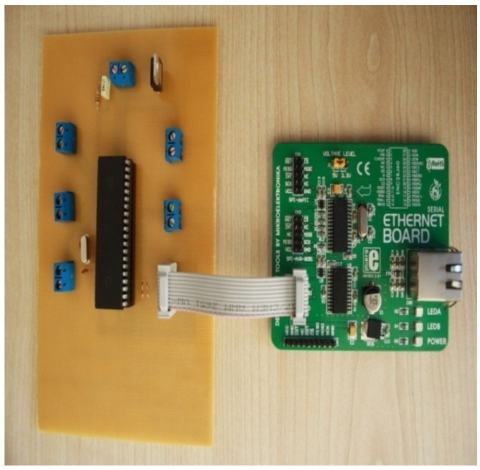


Figure 6. The connection of microcontroller and the serial ethernet boardRelay card and contactor

The relay card connected to the microcontroller card is used to switch the contactors. The induction motors connected to the contactor were stopped and started using web interface. Also, relay card and contactor have function to protect induction motors under or over voltage conditions. A whole system is seen in Figure 7.

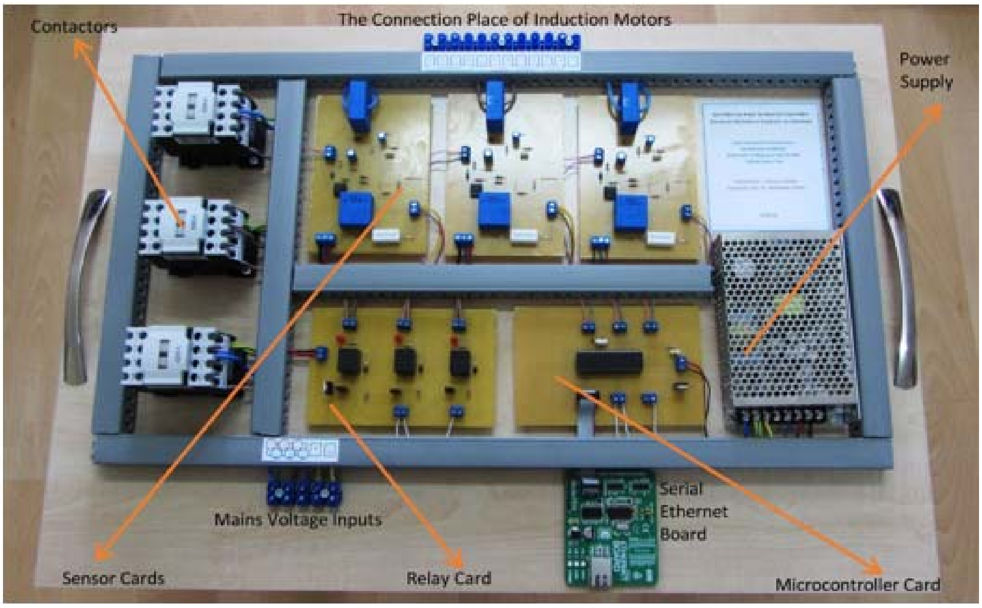


Figure 7. The overall picture of the system performed

2.2. The Software of the Performed System

The software of the system is developed using MicroC microcontroller programming language. The hex file created with the developed software is sent to PIC18F4620 with the PICkit2 programmer. The developed software contains MAC address belonging to ENC28J60 entegration in the serial ethernet board and IP address, HTML tags belonging to the web page which will appear when we connect to the system using web browser together with IP address, data transmission technique and the codes for current and voltage values. The simplified operational flow chart of the software is given in Figure 8.

2.3. The Operation of the Performed System

The developed system works both on local area network and through internet. System needs a permanent IP for the serial ethernet board. If the system is worked on the local area network, device and the serial ethernet board must be on the same network. It is possible to get access to the system using the IP of the serial ethernet board. When the system works, verification of the motor current and voltage values are displayed in both web interface and multimeters in parallel (Figure 9). Because three separate pieces of sensor cards designed, the motor current and voltage values, status of the each motor are obtained and three different single-phased induction motors can be controlled. With the small changes in software, remote monitoring and controlling of one three-phase induction motor can be done, too.

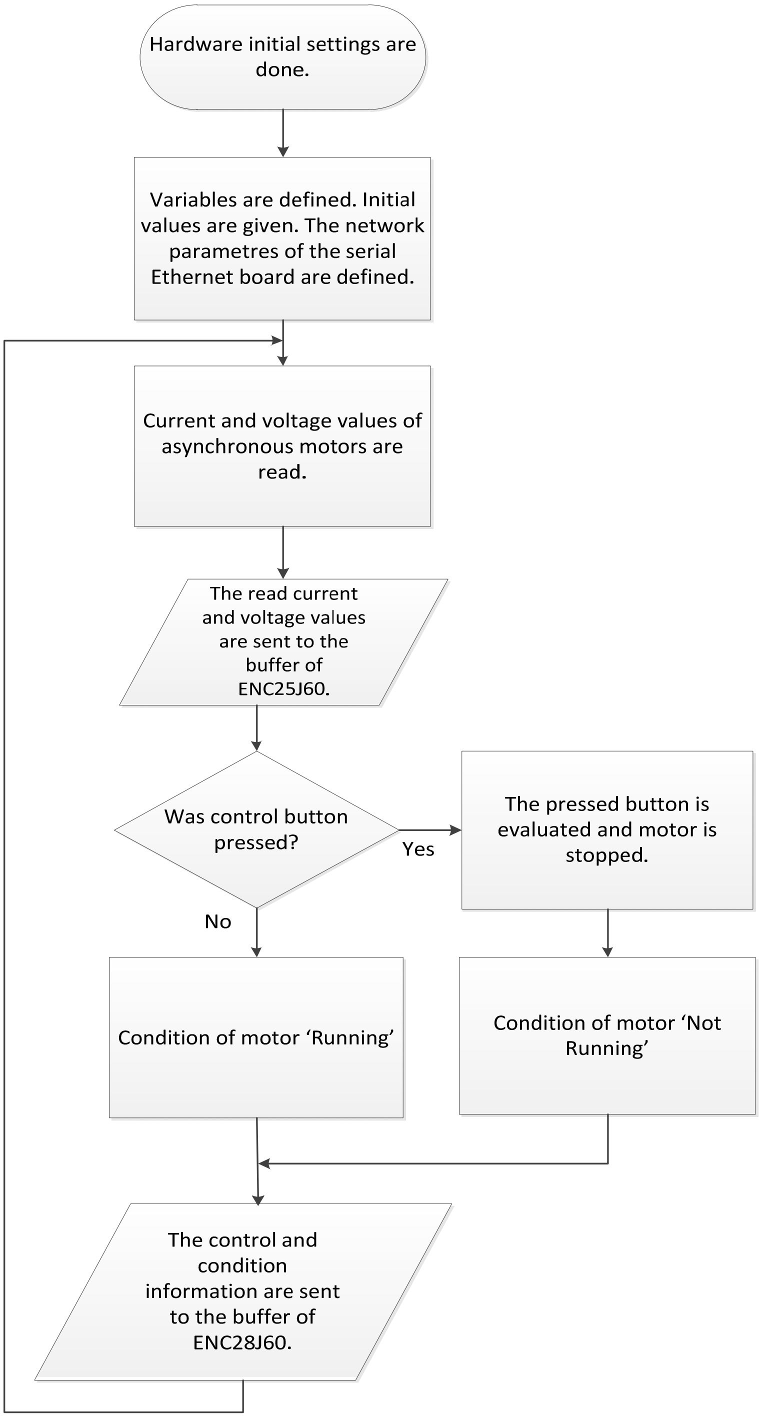


Figure 8. The flow chart of the software

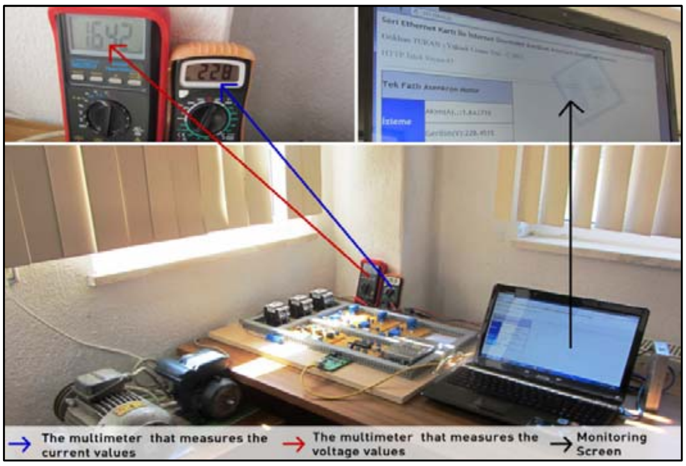


Figure 9. The view of the whole system when it is running

The motors used in this application, and the developed GUI for the results and status of the system are shown in Figure 10 and 11 respectively.

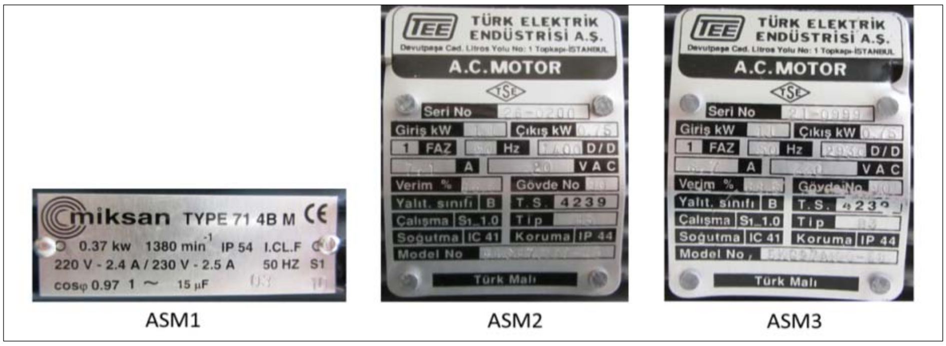


Figure 10. Motor Labels for the single phased induction motors used in the application

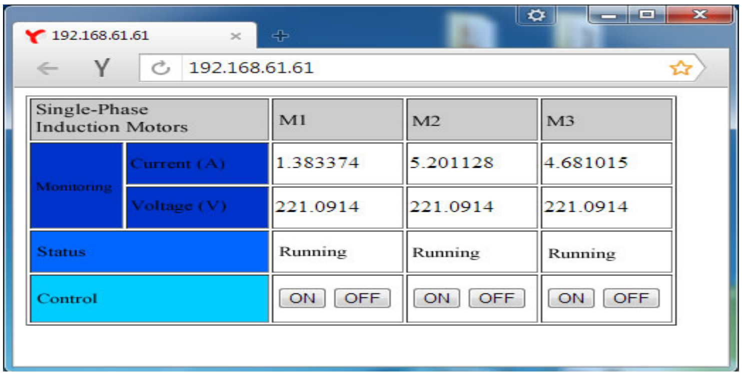


Figure 11. The developed GUI for the displaying the values, status and control of the single phased induction motors

Motor current and voltage values can be displayed and instantaneously be monitored using Chart API tools as seen in Figure 12.

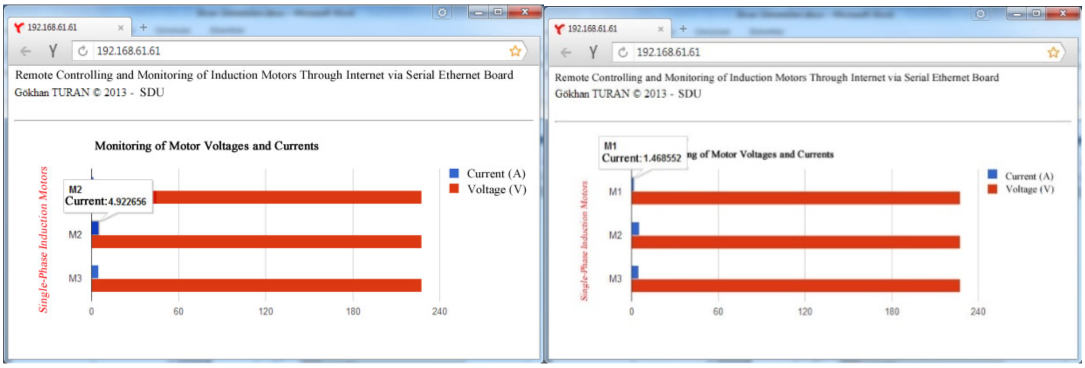


Figure 12. Monitoring the motor values in bar graphs

A motor saving relay is added to the study to perform a protection when one of the supply phases is missing for three phased induction motor. The connection diagram for the motor saving relay is seen in Figure 13. Label of the three phased induction motor is given in Figure 14.

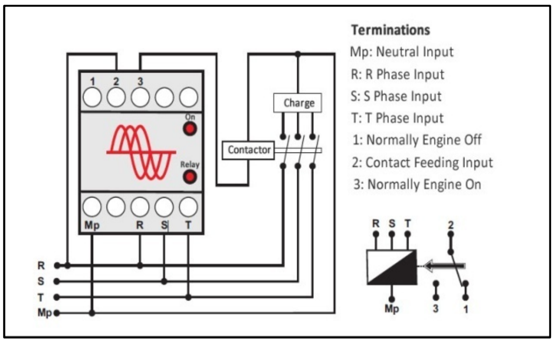
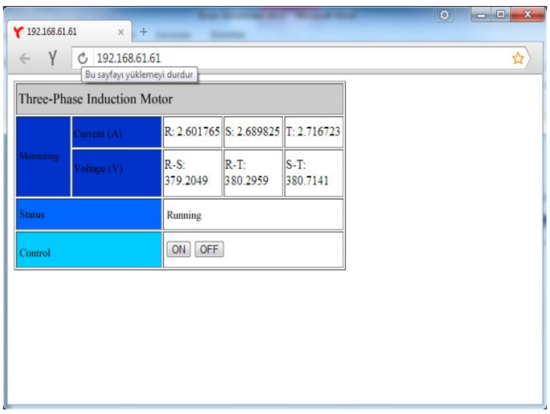


Figure 13. Motor saving relay's terminations

Figure 14. Motor label of three phase motor used in the application

The user interface developed for this application, and displaying of values for the induction motor are shown in Figure 15 and Figure 16 respectively.



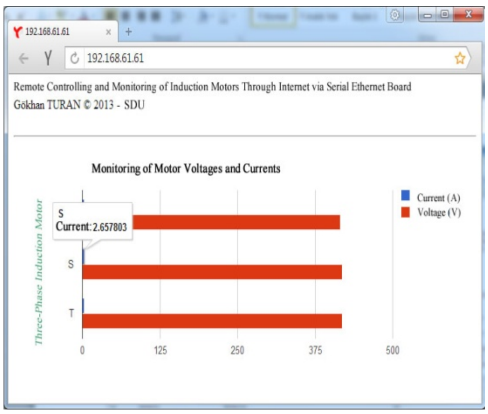


Figure 15. The software GUI developed for the three phase induction motor

Figure 16. Displaying three phase induction motor currents and voltages in bar graph

3. Conclusion

In this study, a system of controlling and monitoring induction motors through the internet with the serial ethernet board is implemented. This designed system is internet based and enables the user to control them from anywhere and any device connected to the internet. With this system, simultaneous remote powering of three separate single phased induction motors or one three-phased induction motor, and continuous monitoring of their currents and voltages drawn from supply were realized. In this way, remote data collection about the conditions of induction motors can be obtained. It also protects the motors in the existences of over or under voltage conditions, and it automatically allows only when the values return to normal rates. The performed study is low cost because it is not based on computer, and it is fast compared to alternative systems. The system can be controlled any device connected to the internet, and it can be integrated with any device having ethernet interface.

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References

[1] Alp U, Ayaz H, Karadeniz M, Dikici C, Bozma I. *Remote Access via the Internet Robots*. IEEE 17th Signal Processing and Communications Applications Conference. Turkey. 2009.
[2] Baytürk M, Çetin G, Çetin A. The Application of Internet Based Greenhouse Automation System Designed with Embedded Server. *Journal of Informatics Technologies*. 2013; 6(2): 55-59.
[3] Delikanlı K. Remote-Access Control Laboratory. M.Sc. Thesis. Suleyman Demirel University, Graduate School of Applied and Natural Sciences, Isparta, Turkey. 2009.
[4] Özsoy Ö, Geniş G. PC and *Microcontroller Based Automation Implementation of Asynchronous Motor*. 4th Automation Symposium. Turkey. 2007.
[5] Bayındır R, Şen M. A Parameter Monitoring System for Induction Motors Based on Zigbee Protocol, *Gazi University Journal of Science*. 2011; 24(4): 763-771.
[6] Kumar M, Sharma M, Narayan R, Joshi S, Kumar S. *Zigbee Based Parameter Monitoring and Controlling System for Induction Machine*. Conference on Advances in Communication and Control Systems. Dehradun. 2013.
[7] Patil RR, Date TN, Kushare BE. ZigBee *Based Parameters Monitoring System for Induction Motor*. 2014 IEEE Students' Conference on Electrical, Electronics and Computer Science. India. 2014.
[8] Abdullah M. Simulation and Control of Induction Motor Operations by Using a Computer. *Al-Ustath Iraqi Academic Journal*. 2013; 2(205): 211-222.
[9] Bayındır R, Vadi S. Real-Time Monitoring and Control of the Parameters of an Induction Motor. *Research Journal Elektronika IR Elektrotechnika*. 2013; 19(10): 145-150.
[10] Joshi PS, Jain AM. Wireless Speed Control of an Induction Motor Using PWM Technique with GSM. *Journal of Electrical and Electronics Engineering*. 2013; 6(2): 1-5.
[11] Shaikh NB, Dhamal SS, Hadpe SS, Varade KP. Online Off-Site Condition Monitoring of Three Phase Induction Motor by Using GSM Technology. *International Journal Of Emerging Technology And Advanced Engineering*. 2013; 3(4): 693-696.
[12] Bhaskar V, Manohar TG. GSM Based Motor Monitoring and Speed Control. *International Journal of Mechanical and Industrial Engineering*. 2011; 1(2): 87-92.
[13] Barsoum NN, Chin PR. Ethernet Control AC Motor via PLC Using LabVIEW. *Scientific Research Intelligent Control and Automation*. 2011; 2(4): 330-339.
[14] Venkatesan L, Kanagavalli S, Aarthi PR, Yamuna KS. PLC Scada Based Fault Identification and Protection for Three Phase Induction Motor. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2014; 12(8): 5766-5773.
[15] Gao L, Cheng M, Tang J. A Wireless Greenhouse Monitoring System based on Solar Energy, *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2013; 11(9): 5448~5454.
[16] Lem, Access Date: 02.09.2014. http://www.lem.com/docs/products/la%2055-p%20e.pdf. 2014.
[17] Lem Measurement. Access Date: 02.09.2014. http://www.lem.com/docs/products/lv%2025-p.pdf. 2014