Design and Implementation of Real Time Monitoring and Control System for Robot Arms Used in Industrial Applications

MEHMET FATİH IŞIK[1], MUSTAFA REŞİT HABOĞLU[2]
[1] Electric and Electronics Engineering Department
[2] Mechanical Engineering Department
Hitit University
Çorum
TURKEY
mehmetfatih@hitit.edu.tr, mresithaboglu@hitit.edu.tr

Abstract: - In this study, a real time control and monitoring is developed for a 6 degrees of freedom robot arm used in industrial applications. Unlike the conventional monitoring and control systems, this study is supported by a camera besides the parameter. A prototype consisting of electrical and mechanical hardware is designed. The motor driver parameters are transferred to the computer by using a programmable logic controller (PLC). Those parameters are monitored and controlled in the computer via the developed software. Simultaneously, the camera display is also transferred to the computer. As a result, a real time monitoring and control system for robotic systems used in industrial applications is designed and implemented successfully.

Key-Words: - Monitoring and Control, Robot Arm, PLC

1. Introduction

The need for the reduction of human labor for the monitoring and control of manufacturing processes brings the requirement for remote monitoring and control systems [1]. There are various methods for the monitoring and control of robotic systems [2-7]. The main purpose of those methods is to provide fast, reliable and efficient manufacturing processes. For this reason, the conventional monitoring and control systems are substituted by modern and smart systems [8-9]. There are many studies in the literature that investigate modern control systems. Those studies generally focus on monitoring and control of electric motor parameters. During manufacturing processes, multiple electric motors can be used at the same time. The application of industrial robot arms is an example to such systems. The monitoring and control of each motor used in the robot arm is very important. The control system should monitor and control all the parameters of all the motors at the same time in order to complete the process without any error.

A real time monitoring and control of a robot arm used in an industrial application is designed and implemented successfully in this study. The system components are described in this article.

2. The Design of Mechanical System

The designed robot arm system and the axis configurations can be seen in Fig. 1.

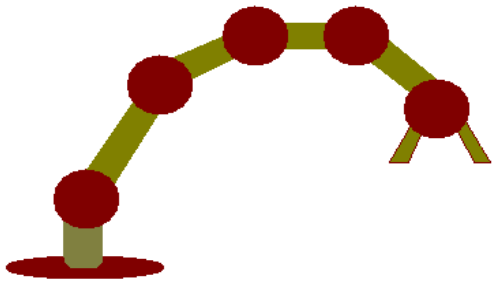

Figure 1. Robot arm design

A belt-wheel system is used for the joints in the mechanical system. A reduction gear is used at the joints that have high rotational and holding couples. For the connection between the shaft and the motor, couplings are processed and adapted with desired dimensions. The required dimensions of mechanical system and step motors are determined. The system is sketched by using the software program called AutoCad.

The prototype regarding the mimicking of axial motion of the mechanical system is presented in Fig. 2.

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Figure 2. Robot arm prototype

3. The Control Unit

The developments in the technology bring the requirement of sensitive and fast systems for machines. Servo motors and step motors have substituted the conventional systems because of their programmability and sensitivity [10]. Furthermore, step motors are preferred for smaller systems due to their low cost and easier controllability.

The main components of the designed control system are as follows;

1. Programmable logic controller (PLC)
2. Step motor and driver circuit
3. SCADA software

Table 1 shows the specifications of the PLC which is used for the control unit of the step motor.

Table 1. Technical specifications of Omron CJ2M-CPU31 PLC

User Memory	5K steps
I/O Bits	2,560 bits
Overhead Processing Time	270 µs
Execution Time	0.04 µs min.
I/O Interrupts and External Interrupts	Interrupt task startup time: 31 µs Return time to cyclic task: 10 µs
Basic I/O Units	No limit
I/O Area	2,560 bits

The programmable logic controller (PLC) is an important control system that presents proper input/output (I/O) units and user interface that is suitable with the system structure for the remote control of industrial automation systems [11-17].

The block diagram of the step motor control unit is given in Fig. 3.

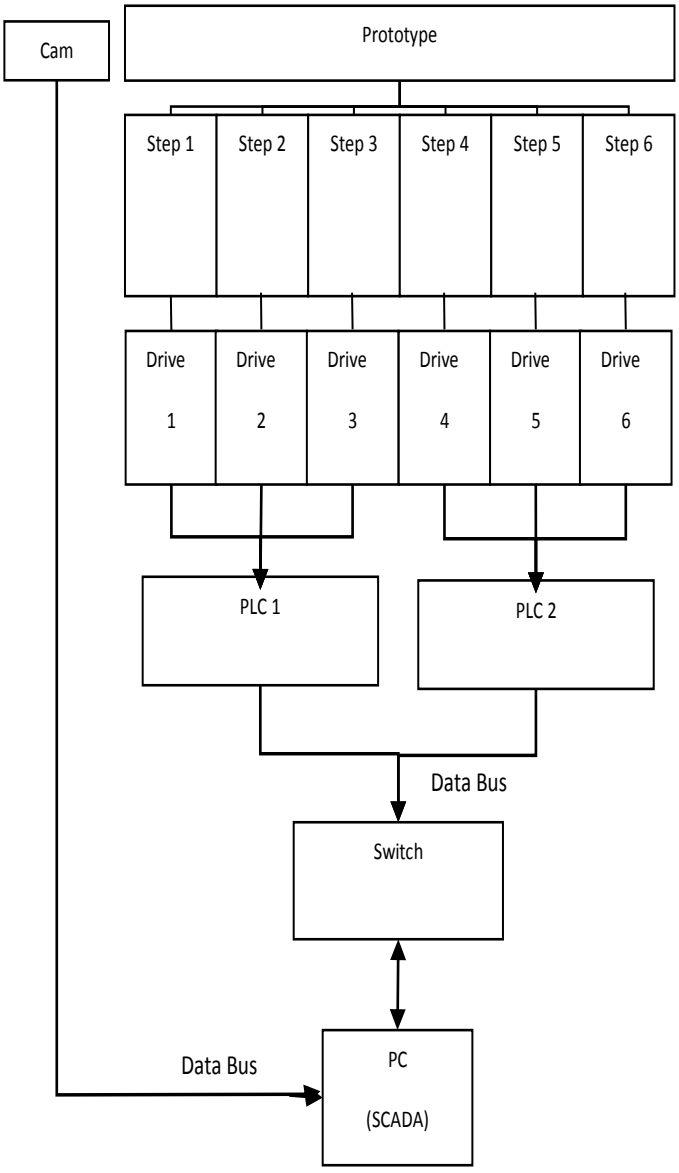

Figure 3. The block diagram of the hardware

A photographic view from the driver circuit can be seen in Fig. 4.

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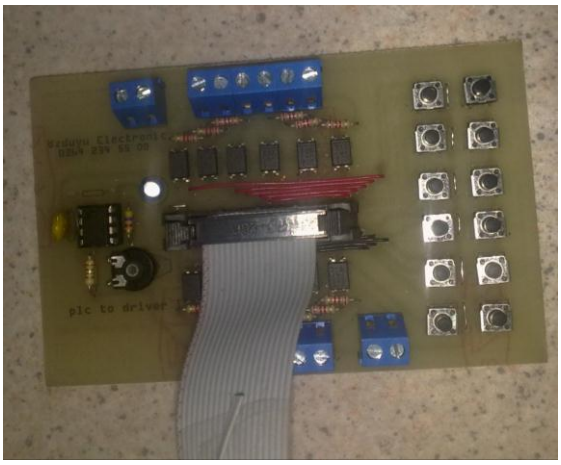

Figure 4. Step motor driver circuit

4. Software and Applications

Two different software programs are developed for the step motor control unit. First one is developed for the PLC which is the supervisor of the system. The other one is developed for SCADA, the monitoring and control unit of the system. The values that are sent to the addresses (that are determined on the PLC as inputs and outputs) via SCADA constitute the working algorithm of the system.

Omron CX-Programmer is used to develop the PLC software. A fraction of the ladder diagram is given in Fig. 5.

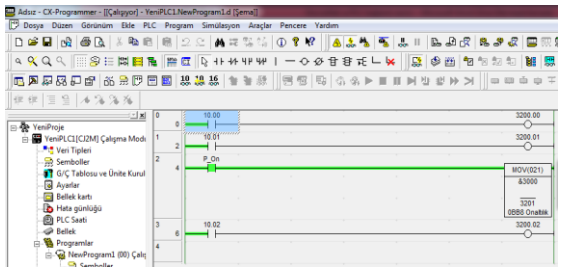

Figure 5. A view from the PLC ladder diagram

SCADA (Supervisory Control and Data Acquisition) is a data acquisition and observation system [18]. PLC based SCADA systems for different applications have been developed successfully in academic studies in recent years [19-23]. In addition, there are also studies that use PC, web and mobile based SCADA systems [24-28].

The SCADA software is developed by using an Omron CX-Supervisor program. The monitoring and control system is also constituted.

The monitoring system consists of camera view, the simulation and the parameter values. The monitoring screen is given in Fig. 6.

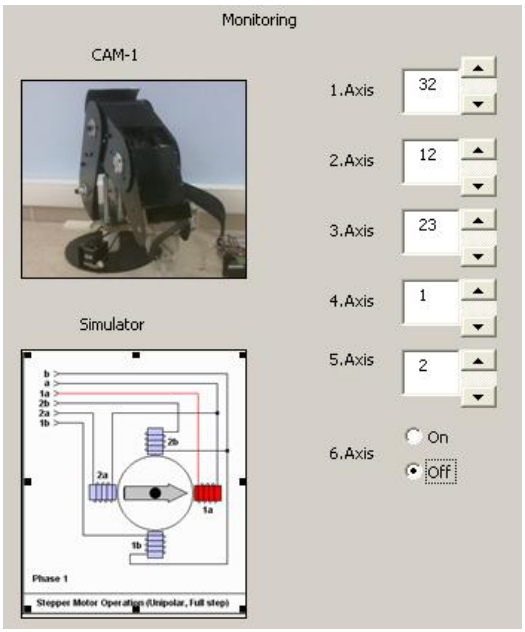

Figure 6. Monitoring screen

Fig. 7 shows the table screen for the process parameters.

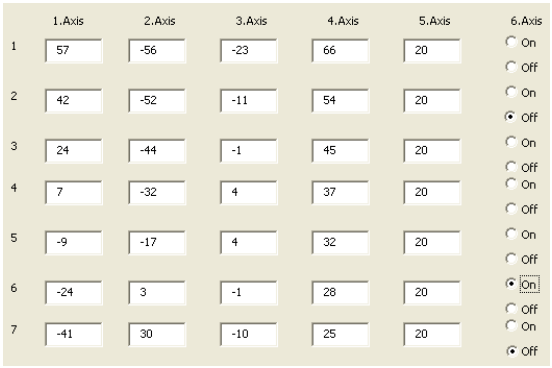

Figure 7. Table screen for the process parameters

5. Results

Especially for the systems that perform position control in industrial manufacturing applications, the motor control is also an important factor besides choosing the proper motor for the operation. In this study, a real time monitoring and control system is developed for a robot arm which is an important component of robotic systems used in manufacturing processes. The monitoring system is also supported by a camera view. A prototype is

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constituted in order to provide the adaptations between step motors and the designed mechanical system. Special couplings are used for adaptation. The PLC communication by using the SCADA interface for the control of step motor positions is obtained. Thus, a numerical value is taken as a position input for the robot arm to reach the desired position. The step motor control system is designed in a manner that it is easy to control by the user. The table screen provides the ability to process multiple positioning for the system. The prototype and the monitoring developed in this study will be useful for position control, maintenance services and the improvement of the students majoring in the fields of electrics, mechanical and mechatronics engineering.

6. Future Work

In this research, the real time monitoring and control of an industrial robot arm is developed. This study can constitute the fundamentals of a future work which will provide the ability to control separate procedures at the same time. With the help of that system, the real time monitoring of the system failures at all stages of the process will be obtained. Most of the studies about the issue focus on only the monitoring of parameters and camera view. However, interference in a possible error condition is not provided in those systems. Therefore, the future work may contain both manual and automatic error interference systems besides the monitoring. Additionally, the application of smart phones might be included for interference. The user can either use the web access feature of the smart phone for monitoring or just scan the QR code provided and reach the real time parameters.

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