Monitoring and Control of LDmicro PLC based Motion Control Systems Via Device-Net

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Abstract— **With the rapid changes on industries and information technologies in recent years, some traditional bulk electronic appliances have to be monitored for a long time. All of their control devices such as communication interfaces gradually enter the Internet information era. Control of all equipments has been performed through the use of computers. Most equipment uses PLC (Programmable logic controller) to connect with computer to monitor consuming devices. PLC's are widely used in industrial fields because they are easy to install and very flexible in applications. A PLC interacts with the external world through its inputs and outputs. Since technology for motion control of circuit drives became available, the use of PLC with power electronics in electric machine applications has been introduced in the manufacturing automation. This study defines the real time monitoring control of a two degree of freedom motion control system with PLC based SCADA system through Device-Net web communication.**

Keywords; ***SCADA, PLC, Device-Net, Motion Control***

I. INTRODUCTION

Electric motors and their drivers have become crucial parts of the manufacturing process. They are needed in many manufacturing applications such as automotive and textile industry. Because of their effect on product quality, the observation and control of those motors and drivers are necessary. An intelligent system, PLC, which is an outcome of the development of microelectronics and telecommunication systems, is used in order to carry out the observation and control of motors and drivers. Besides that, servomotors and their drivers are often used in accurate control applications of manufacturing processes. Servomotors are widely used in industrial applications because, they can produce high torques although they have low rotor inertia. A gear box integrated to the servomotor shaft provides high torque even in low revolutions. Servomotors are used in position and velocity control because of their high power, high torque and ability to generate quick feedback. Due to their use in applications that need accurate operations, servomotors ought to be quick in open-close operations and keep their stability in instantaneous load changes .

SCADA (Supervisory Control and Data Acquisition) is a data acquisition and observation system .The operation values that belong to motor and drivers can easily be controlled and observed via SCADA in motion control systems.

This study defines the real time monitoring control of a two degree of freedom motion control system with PLC based SCADA system through Device-Net web communication. Firstly, the system architecture, secondly, the system components and thirdly the results are described. Lastly, a general evaluation is carried out.

II. SYSTEM ARCHITECTURE

Servo system drivers take the necessary signals (rotation direction, velocity, position etc.) for controlling from the microprocessor, microcontroller or the CPU. On the other hand, the feedback signal is obtained by various sensors, the encoder or the position potentiometers. The controller takes the gathered data as the real position information and calculates the parameters based on those data in order to generate the signals that the driver requires [7].

In order to make the system work in real time, the speed of the communication between the PLC (which is used as the controller) and the SCADA (which is used for user control) becomes an important factor. There are serial or parallel communication technologies for such systems. The communication speed also depends on the properties of the selected hardware. In this study, the Device-Net protocol, which is suitable for PLC and can give successful results through short distances, is used. Device-Net is an open domain web that can be used in communication of different controlling devices such as PLCs, CPUs, sensors and actuators. Additionally, it also reduces the cost of maintenance because; less amount of cable is used in the set-up of Device-Net. Moreover, it proposes a suitable structure for the systems from different manufacturers such that there are many devices that are compatible with Device-Net. Therefore, the most economical system can be established with Device-Net [8]. The functional flow diagram can be seen in Fig 1.

The generated system consists of five primary elements such as;

- SCADA software
- AC servomotor and Driver System Setup
- Development of a PLC ladder diagram
- Establishment of the feedback system
- Development of web

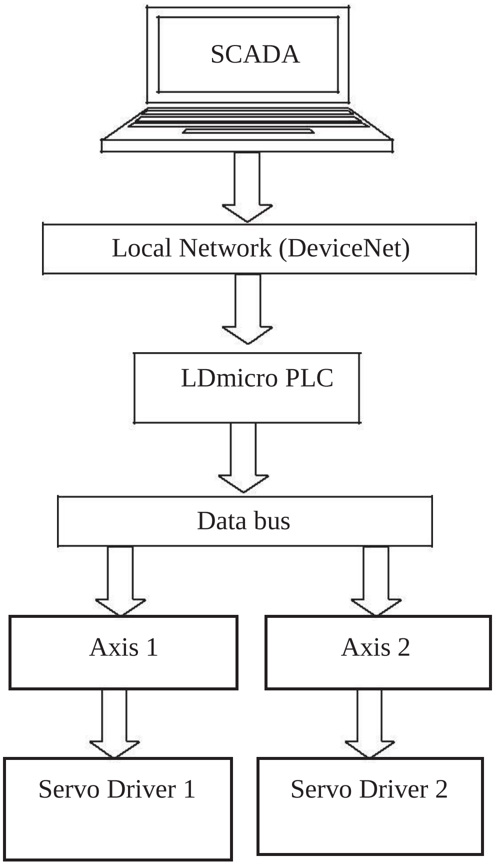

Figure 1. Axial monitoring and control system flow diagram

III. SYSTEM COMPONENTS

A. *Programmable Logic Controller (PLC)*

Programmable logic controller (PLC) is a significant controlling unit that presents a communication interface proper I/O (Input/Output) units to the hardware in order to remote and control the industrial system and carries out the software program according to the user demand [9-10]. It is an industrial CPU that is used as the maintenance unit instead of remote control systems working with relays. Those devices are widely used in industrial automation circuits with the development of new technology. Nowadays, PLCs consist of commands for special mathematical operations besides the logic based operations. More complicated remote and control operations are carried out as the command set extends [11]. An Omron CX-Programmer is used for the PLC ladder diagram. Omron PLC consists of 16 digital input and 32 digital outputs.

B. *Servomotor and Servo Driver*

The servomotor used in this study is Omron PLC and the servo driver is used. The technical details that belong to servomotor and servo driver are given in Table 1 and Table 2 respectively.

TABLE I. ldmicro SERVO DRIVER TECHNICAL SPECIFICATIONS

Servo Driver			
Continuous output current (rms)			2.6 A
Input power supply	Main circuit	Power supply capacity	0.9 KVA
		Power supply voltage	50/60 Hz
		Rated current	4.1/2.4 A *1
		Heat value *2	33/24 W *1
	Control Circuit	Power supply voltage	240VAC
		Heat value *2	4 W
Maximum applicable motor capacity			400 W

TABLE II. ldmicro SERVOMOTOR TECHNICAL SPECIFICATIONS

Servo Motor		
Rated output	W	400
Rated torque	Nm	1.3
Rated rotation speed	r/min	3000
Momentary Maximum rotation speed	r/min	6000
Momentary maximum torque	Nm	3.8
Rated current	A (rms)	2.4

The connection between the drivers of servomotors and PLC is presented in Fig 2.

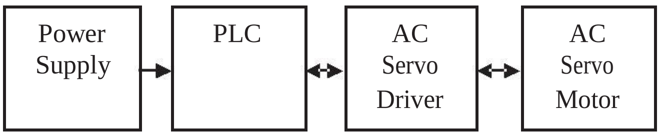

Figure 2. Schematic of the connection between the servomotor driver and PLC

C. *Device-Net Web Configuration*

The communication and data acquisition is provided by USB connection. Device-Net Ethernet protocol is used to connect the PLC and the CPU that has the SCADA software.

D. Servomotor Control Scheme

The position and velocity values demanded by the user during the control process are monitored on the screen. The block diagram that belongs to this control system is given in Fig 3.

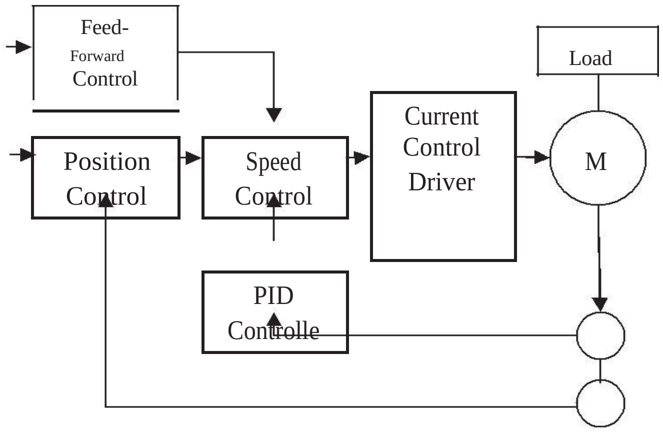

Figure 3. The block diagram of AC servomotor control

The control block diagram generates the signal in order to achieve the desired position and velocity values. The signal stops when the parameters reach the desired values.

E. SCADA

An LDmicro CX-Supervisor SCADA software program is used. The developed SCADA software provides a user interface and monitoring on the screen. The user can control the system by entering the desired position and velocity values to the software program. Besides that, the instantaneous parameters can be monitored on the screen at the same time. The software program also provides the capability of recording the actions of the user on the system. The position control form of the developed SCADA software can be seen in Fig 4.

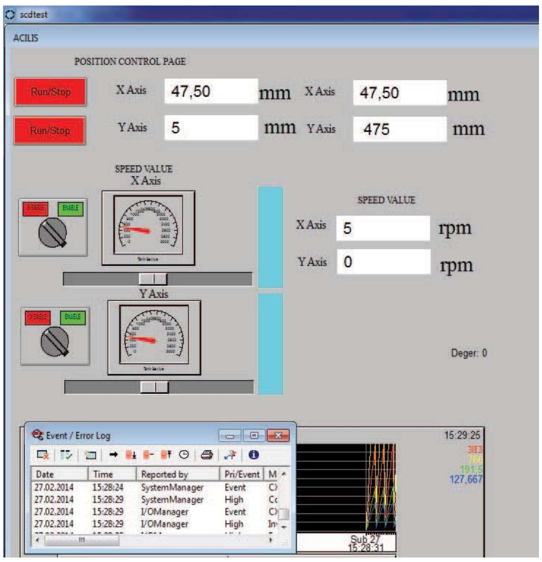

Figure 4. The position control form of SCADA software

The position values for the two degree of freedom system can be entered to the specified area and the real time position values are also monitored on the form. The system gives an alert to the user when the desired position values are satisfied. Additionally, a basic simulation of the moving system can be seen on the form.

IV. RESULTS

Two different applications (i) velocity control, (ii) position control) are carried out on the two degree of freedom control system. The settling, rise time and overshoot values are monitored for the dynamic responses of servomotors having a revolution of 300 rpm and without loading. The ladder responses according to the PID parameters integrated to the system are shown in Fig 5.

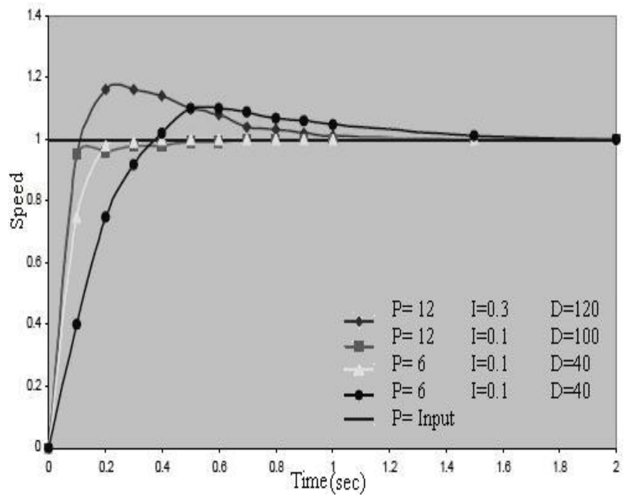

Figure 5. PID Control Step Responses

Another application is the monitoring and control of the working performance of the system based on the position change. It is seen that the position values entered to the SCADA system and the real values are convenient (Fig 6).

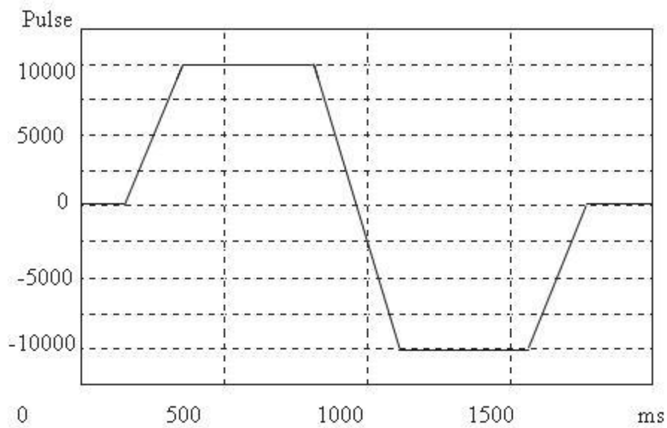

Figure 6. The position response of the system to a ramp input

The technical details that belong to DeviceNet, Ethernet and ControlNet are given in Table III [12].

TABLE III. OMRON SERVOMOTOR TECHNICAL SPECIFICATIONS

	DeviceNet	Ethernet	ControlNet
Data Rate (Mbps)	0.5	10	5
Max. Data Size (Byte)	8	1500	504
Max.Lenght (m)	100	2500	1000
Bit Time (3s)	2	0.1	0.2
Max.number of Nodes	64	>500	99

V. CONCLUSION

In this study, the control of position and velocity of a two degree of freedom servo system generated by PLC is carried out through SCADA and a prototype is produced. The PLC program algorithm and a CX-Programmer ladder diagram are formed. The generated ladder diagram is loaded to the PLC program via USB port. SCADA software consisting of position and velocity controlling pages is developed in order to enter the desired position and velocity values. Additional spaces are integrated to the software in order to monitor and compare the desired and real parameters. A feedback system is provided through the Encoder by making the connections of servomotors and drivers. The performance of the system, which is produced as a prototype after the experimental works, is evaluated according to the velocity and position values. As an example, servomotors are asked to move X-axis 11 mm and Y-axis 8 mm and the values are monitored on the SCADA screen. Besides that the velocity control is applied on the SCADA screen and the real parameters are monitored. The collected data verify that the developed SCADA system and the generated Device-Net web structure works properly with PLC.

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