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A Web Based Educational Programming Logic Controller Training Set Based On Vocational High School Students' Demands

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ABSTRACT

The purpose of this study was to design and develop a Programming Logic Controller Training Set according to vocational high school students' educational needs. In this regard, by using the properties of distance education the proposed system supported "hands-on" PLC programming laboratory exercises in industrial automation area. The system allowed students to access and control the PLC training set remotely. For this purpose, researcher designed a web site to facilitate students' interactivity and support PLC programming. In the training set, Induction Motor, Frequency Converter and Encoder tripart controlled by Siemens Simatic S7-200 PLC controller by the help of SIMATIC Step 7 Programming Software were used to make the system more effective and efficient. Moreover, training set included an IP camera system allowing to monitor devices and pilot application. By working with this novel remote accessible training set, students and researchers received a chance to inhere self-paced learning experiences. Also, The PLC training set offered an effective learning environment for distance education, which is based on presenting the content on the web and opening it to the online users and provided a safe and economical solution for multiple users in a workplace to enhance the quality of education with less overall cost.

Keywords: *Distance Education, Self-Pace Learning, Individual Learning, Remote Access, Online Laboratory, PLC Training Set*

INTRODUCTION

Developments in the Internet technology have enabled new teaching methods that overcome the limitations of time and place. Web based education is one of these systems. The applicational studies regarding Web-based Learning have expanded considerably nowadays. The ability to reach content wherever the user wants it has increased the popularity of Web Based Learning. Especially in technical areas where content is difficult, the usage areas of web-based teaching are increasing. (Horton, 2000) In this education method, students work with simulations rather than actual systems. This may bring up problems with particular frequency in vocational and technical classes. Experiments conducted with simulations do not accurately mimic systems' actual behavior (Erdemir & Kuzucuoğlu, 2011). Programming Logic Controllers are an important part of the electric-electronic technology field, which is the locomotive of technology. However, difficulties arise in the teaching of this course and there is lack of training set which causes metarial shortage in some schools. (MEB, 2017). Reality feeling is higher in remote access laboratory especially if cam is used than virtual laboratory. Besides this, remote access laboratories enable access and supervision flexibilities. Implementing application with the support of feedback, cooperation in individual study, using simulations to increase the student's level of expertise and so on facts make e-learning environment valuable. Web-based education has separately gains in terms of students, trainers and institutions. Agents like quality of training materials, usability, supporting students by trainers, management system, ease of access and viewing etc. should be considered when web based learning is applied. Web-based learning has entered the world of education as a continuation of computer-aided education and has developed and spreading very rapidly. The main reason for this is the increasing demand of students, the need for better teaching techniques and new technologies used in teaching (Çakır, Eryılmaz, & Uluyol, 2014). While web-based learning is being carried out, it is necessary to pay attention to factors such as the quality of the learning materials, usability, system support by the learners, management of the system, accessibility, imaging and feedback mechanisms (Gülbahar, 2012).

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Nowadays if manufacturing topic is handled in any business segment, first thing that stands out in relief is rising competitive pressures. Concepts such as speed, quality, reliability, flexibility, standards, low cost are highly important in terms of competitiveness. At this point, "automation" is put into use. Industrial automation can be defined as a process that provides putting needed operations automatically in action to execute enquired and aimed way of industrial manufacturing system (Kurtulan, 2007). Relays, contactors, timers and counters are traditionally used as elements in control circuits. Using Programmable Logic Controllers (PLC) is gradually increasing instead of these elements. If any modifying is demanded in control function, it is enough to just change PLC program. Any control function, which is designed as traditionally contacted, can readily be adapted to the PLC by an operator. Currently major application areas of PLCs are: automation in factories, elevator systems, automated packaging, power distribution systems, conveying belt systems, filling systems, automobile industry systems, baling presses, plaster and cement machines, vacuum systems, central / auxiliary lubrication systems, wood processing machines, gate control systems, hydraulic lifts, food industry, laboratory equipment, electrical installations, storage systems, etc.

The use of industrial automation technology does seem sufficient in production in Turkey. The underlying main reason is the inadequate source of qualified manpower in this area. However, according to the National Industry Strategy Document covering the recent years, Turkey aims to become a manufacturing base of Eurasia in medium and high-tech products. Main sectors of manufacture have been defined as automobile, machinery, white goods, electronics, textile, food and iron & steel respectively. Achieving such a goal will enhance necessity for flexible and fast learning environments in the field of industrial automation, as a result of rapidly increasing demand of employment. Against this background, PLC Training have an important place in industrial automation and electrical technology curriculum in vocational schools and vocational high schools as well as colleges. According to data from Ministry of Education source, there is parabolic growth in demand for PLC Education set in Vocational High Schools in the last 5 years as of recent years.

Thanks to the today's ever evolving industry of information technology, laboratory/training set systems and devices over the Internet allow remote access and/or emulation. Resaerch in this realm in the international arena suggests that packet programs and simulation based applications including Java Applets, Lab VIEW, Matlab/Simulink, Working Model, Scilab, Mathematica, and SimQuick Multisim, and VisSim are predominantly used.

There are some advantages of simulation based studies such as progressing by the speed of learner and preventing physical damage to user or mechanism through the experiment. However, applying directly theoretical knowledge covered in the courses into laboratory experiments is very important part of vocational and technical education. Remote access real-time lab and test environments methodology are developed as a solution to the problem associated with simulation based training environment that it never replaces for actual laboratory work.

When studies on the remote-access laboratory are reviewed in general, it is observed that several web based experiments have been done. For instance, a remote access control system allows the control experiments enabling users via the Internet (Yeung & Huang, 9). Applications that provide remote access to electronic devices and circuits, make internet-based applications possible in experiments (Strandman, Berntzen, Fjeldly, Ytterdal, &Shur, 2002; Hurley & Chi, 2005; Asumadu, Tanner, Fitzmaurice, Kelly, Ogunleye, Belter, &Koh, 2005). In laboratory applications electrical machine experiments can be done remotely (Sepe, Chamberland, &Short, 1999; Tsakiris, Filippidis, Grammalidis, Tzovaras, &Strintzis, 2005; Martis, Hedesiu, Szabo, Tataranu, Jurca, &Oprea, 2006; Sepe,2001; Zhuanfeng, Weiguo,Xiwei, &Xin, 2005; Gökbulut, Bal, &Dandil, 2006), induction motors (Vanijjirattikhan, Ayhan, Tipsuwan, &Chow, 2003; Chang, Wu, Chiu, &Yu, 2003; Bellmunt, Miracle, Arellano, Sumper, &Andreu, 2006; Saygın & Kahraman, F., 2004; Ioannides, 2004; Zhang Zeng, &Zhang, 2007; Aydoğmuş &Aydoğmuş, 2009; Birbir & Nogay, 2008; Bektaş, Bayındır, &Çolak, 2007).

Similar studies in the literature deployed the PLC experiment through an Internet-based hardware and software structure of the laboratory. Remote experiments can be monitored in real time by the Internet via a web camera (Chang, Wu, Chiu, &Yu, 2003). In elsewhere, Bellmunt, Miracle, Arellano, Sumper, &Andreu (2006) examined remote control of PLC devices and their usage over the internet for experimental purposes. In addition, some studies applied remote controlling and using PLC devices over the Internet for experimental purposes (Saygın & Kahraman, 2004; Ioannides, 2004; Zhang, Zeng, & Zhang, 2007).

The studies reviewed in the international literature showed that the Internet is frequently used in implementation of scientific and educational applications. It is projected that traditional education will be replaced by distance learning technologies, reconstructing the current education system. Yet, in our country, although the sampling studies on the distance education and especially web-based training, (Aydoğmuş & Aydoğmuş, 2009; Birbir & Nogay, 2008) and studies on web-based laboratory models as well as remote access experiments via the Internet are extremely important for vocational and technical education, they are in limited numbers. They are contented with animation or various simulation methods in many E-learning environments. However, practical experimental studies are essential point in technical and engineering education.

Titled "Remote Access PLC Training Set," this study stands out from the rest of the literature by offering a new design with integrated, flexible, interactive structure, and original remote access software developed by using the Visual Basic.NET language without ordered package program. Some of the main achievements of this study are accessing and controling of real devices via the Internet, enabling remote users to upload and download PLC programs. In addition, this study suggests a system that enables users to open the PLC editor program from server on client PC and to allow coding. Besides this, an integrated e-learning platform has been developed with attaining interactive learning objects from web interface and virtual PLC program.

DESIGNING THE LEARNING ENVIRONMENT

In this proposed architecture, pilot experiment constitutes Induction Motor, Frequency Converter and Encoder tripart controlled by Siemens Simatic S7-200 PLC controller by the help of SIMATIC Step 7 Programming Software as an example for demonstrating the effectiveness of the set. An IP Camera allows monitoring the devices and pilot application behavior. By working with this novel remote accessible training set, students and researchers not only can carry out experiments but also they can learn how to work on system and program. This study is fairly complex. Yet, it offers an effective learning environment for distant education, and provides a safe and economical solution for multiple users in a workplace to enhance the quality of education with less overall cost. The main purpose of this study is to implement the technology of remote access and distance education to the PLC training, which is the basis of industrial automation field. With using the set of designed Remote Accessible PLC Training, users can use educational content and testing materials sheets interactively. Also with the user name and password controlled web-based interface real-time full duplex access, the users can get access to PLC Training set from any computer with Internet access and observe the simulation switches, output LEDs and motor positions with an IP camera. Since induction motors are widely used in industry, 3-phase induction motor is preferred as an example for control application. Some advantages of these motors are their simple structure and strength. In addition, they are easy to model and they require less maintenance.

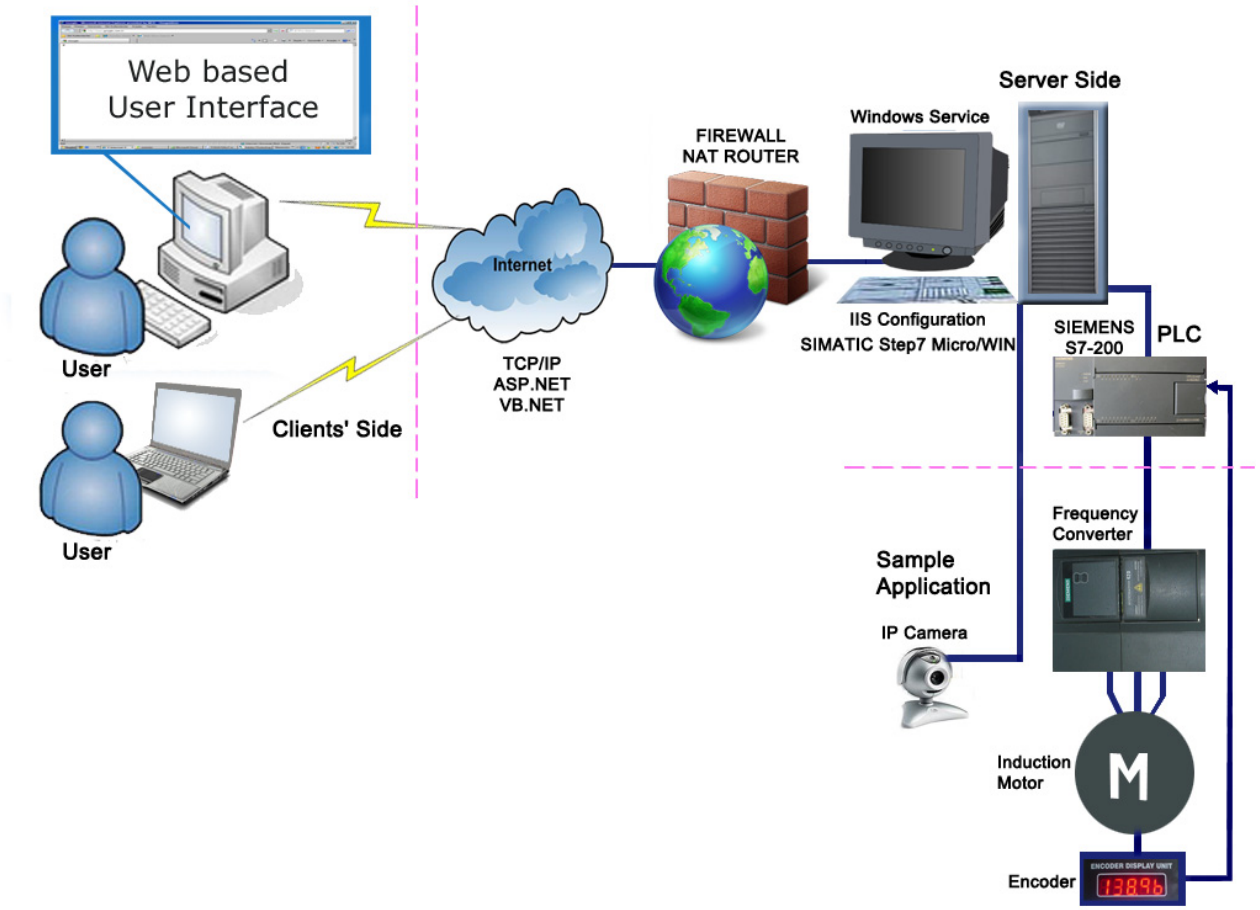


Figure 1. General Architecture of the designed system by asynchronous motor speed control with frequency convertor experiment.

The software architecture; as shown in Figure 2, is consisted of three tiers. User side at Client Tier, for communication control and hosting PC at Server Tier and for pilot experimental works Application Tier.

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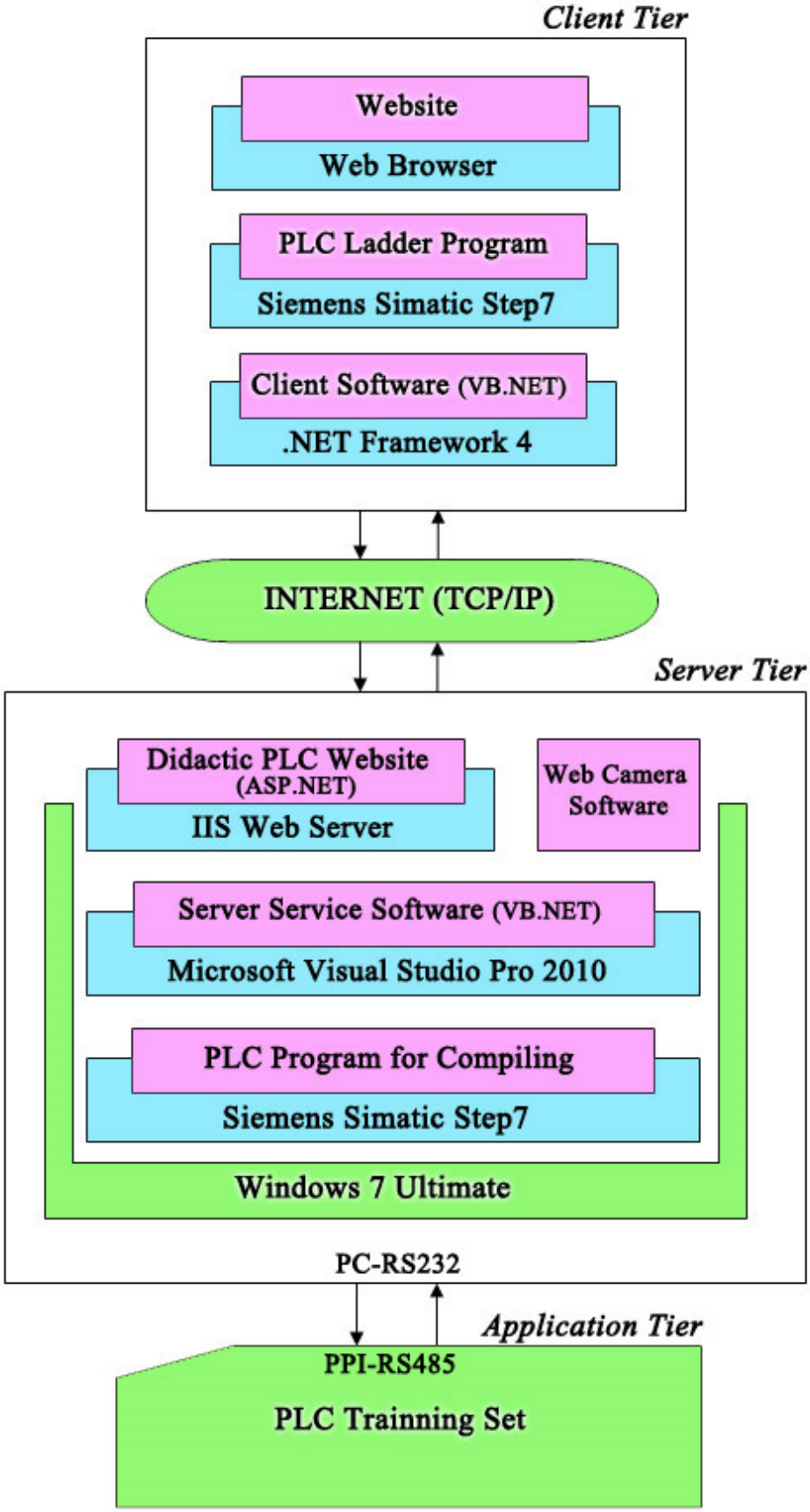


Figure 2. Software Architecture of the Designed System

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User password controlled web site works on server. In fact, authentication is not required for navigating the web site but the Remote Access PLC page. When the user logs on the server, web based user interface is displayed. Student can download appropriate ladder program for study and test. All client PCs are assumed that Simatic Step7 program installed as default.

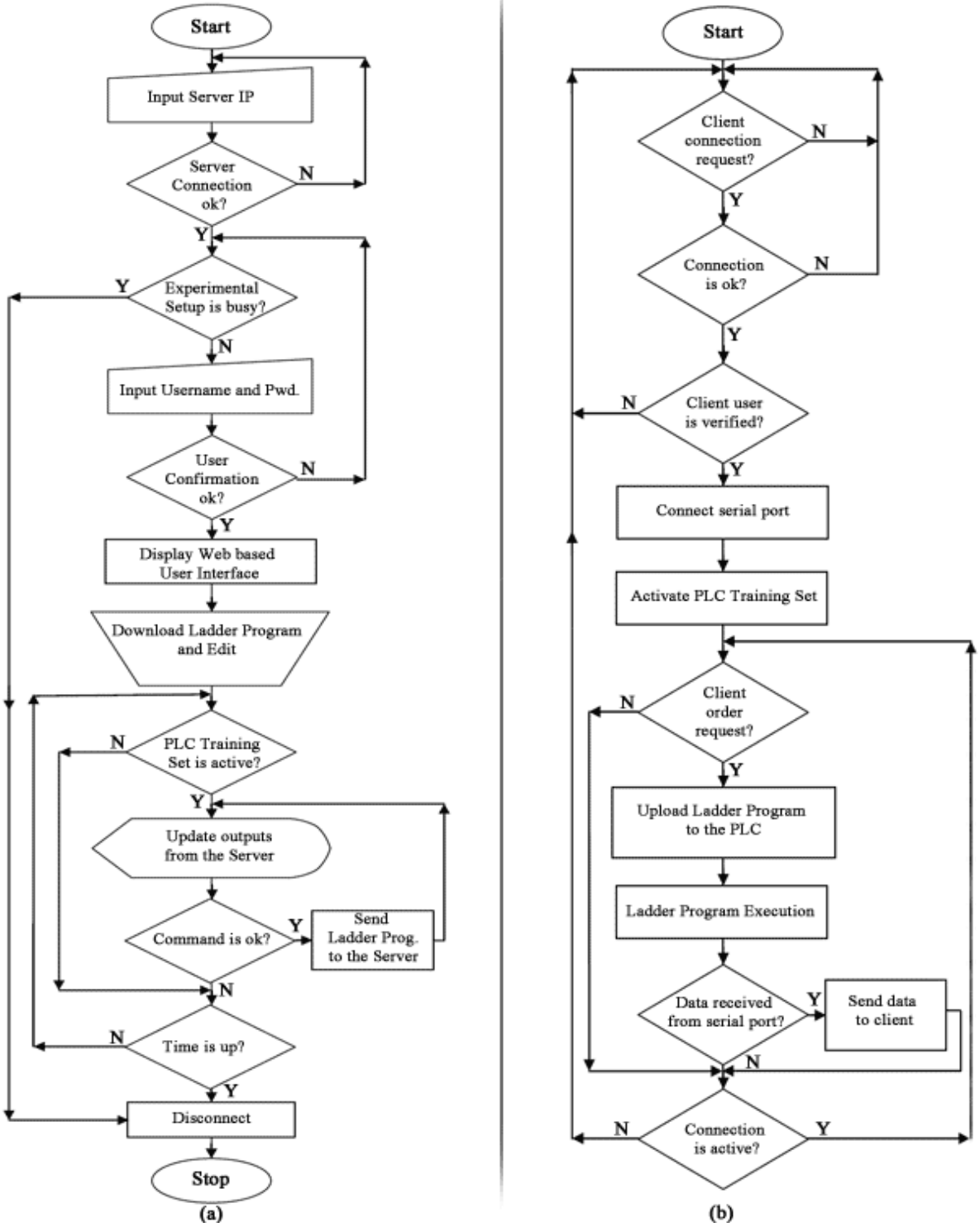


Figure 3. (a) Client and (b) Server software flow chart of the Designed System

While conducting the experiment, if time limit expires (30 minutes) server automatically ends the session. User can upload the ladder program via server software after having the program tested under Step7 Ladder Program editor.

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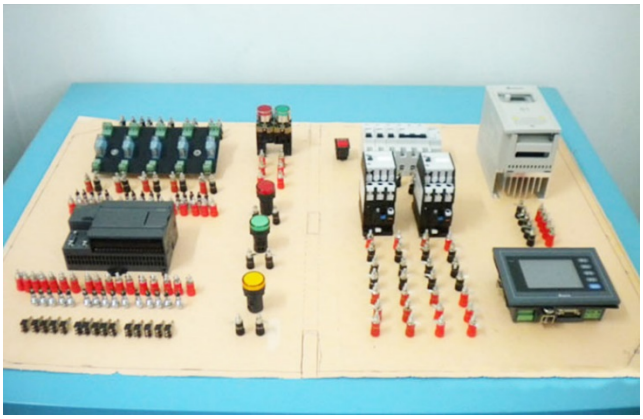


Figure 4. A view of the experiment set from the design phase

In the Figure 4 the developed system layout is designed and components located on the sketch. Components in the experimental set were selected after the researh about the other training sets in the market and experimental applications in the curriculum of PLC class and opinions of vocational branch teachers.

17 different experiments were applied with the PLC training set. Those are discontinuous and continuous working operations, forward reverse working operations, asynchronous motor star delta starter operations, speed adjusting and position control of motor with frequency convertor, motor speed setting using PID functions etc.

The training set components are PLC and modules, three phase asynchronous motor, encoder, frequency convertor, plexiglass panel, experimental box, table, 24V DC power supply, PPI cable, connectors, and overload relay, born connectors, relay, 3 phase male and female plug, 3 phase automatic fuse, power switch with LED.

IMPLEMENTATION OF PROPOSED SYSTEM

Controlling induction motor speed and direction of rotation is aimed in pilot experiment by the help of Frequency converter. Server software was developed to manage hardware services and connection between the PLC training set and Client User. Using remote access PLC set, clients only need web browser and client software which is readily downloaded from Remote Access PLC Web Page after logged on.

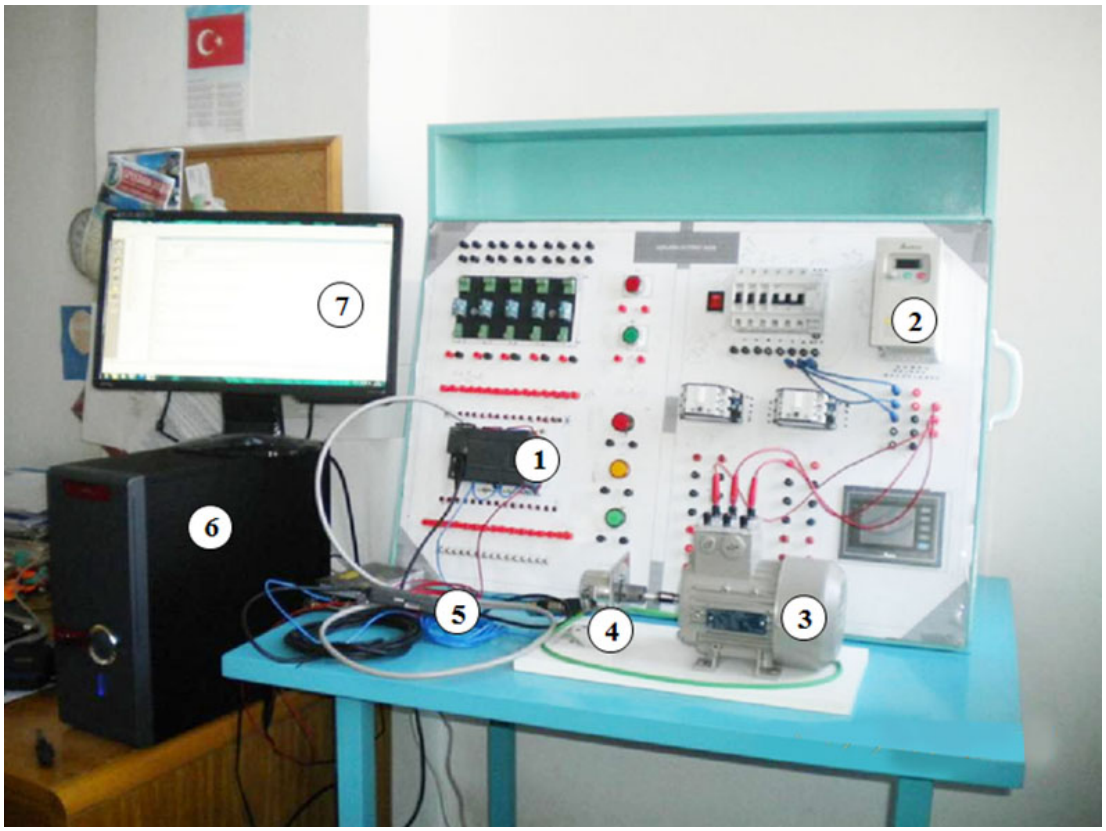


Figure 5. General view of the Designed web based remote access PLC training set.

The constituents of the experimental setup are:

1. PLC for control of the system (Siemens S7-200 CPU 224 XP)
2. Frequency converter for speed alteration (Delta VFD007S43A)
3. Induction motor (0,25 KW, 3-phase,1500/min)
4. Encoder (500 P/REV, Optical Incremental)
5. PC/PPI Cable (for connecting S7-200 to serial port of PC)
6. Server PC (2.80 Ghz Intel Core i5 CPU, 4,00GB RAM, Win7 Ultimate)
7. Server PC Screen (BenQ 22")

As it is shown in Figure6 according to the knowledge level user can study theoretical information from PLC Programming page (a). Just after downloads the program which is dealing with the existing subject (b). Modifies the downloaded sample program if needed to discover thoroughly. Changes parameters etc. After uploads the program to the PLC and goes to Remote Access PLC page to use Training Set. Logins with username and password if the server isn't busy. After running the ladder program on the PLC set, he can monitor the live video of the experimental setup via the Live Monitoring page.

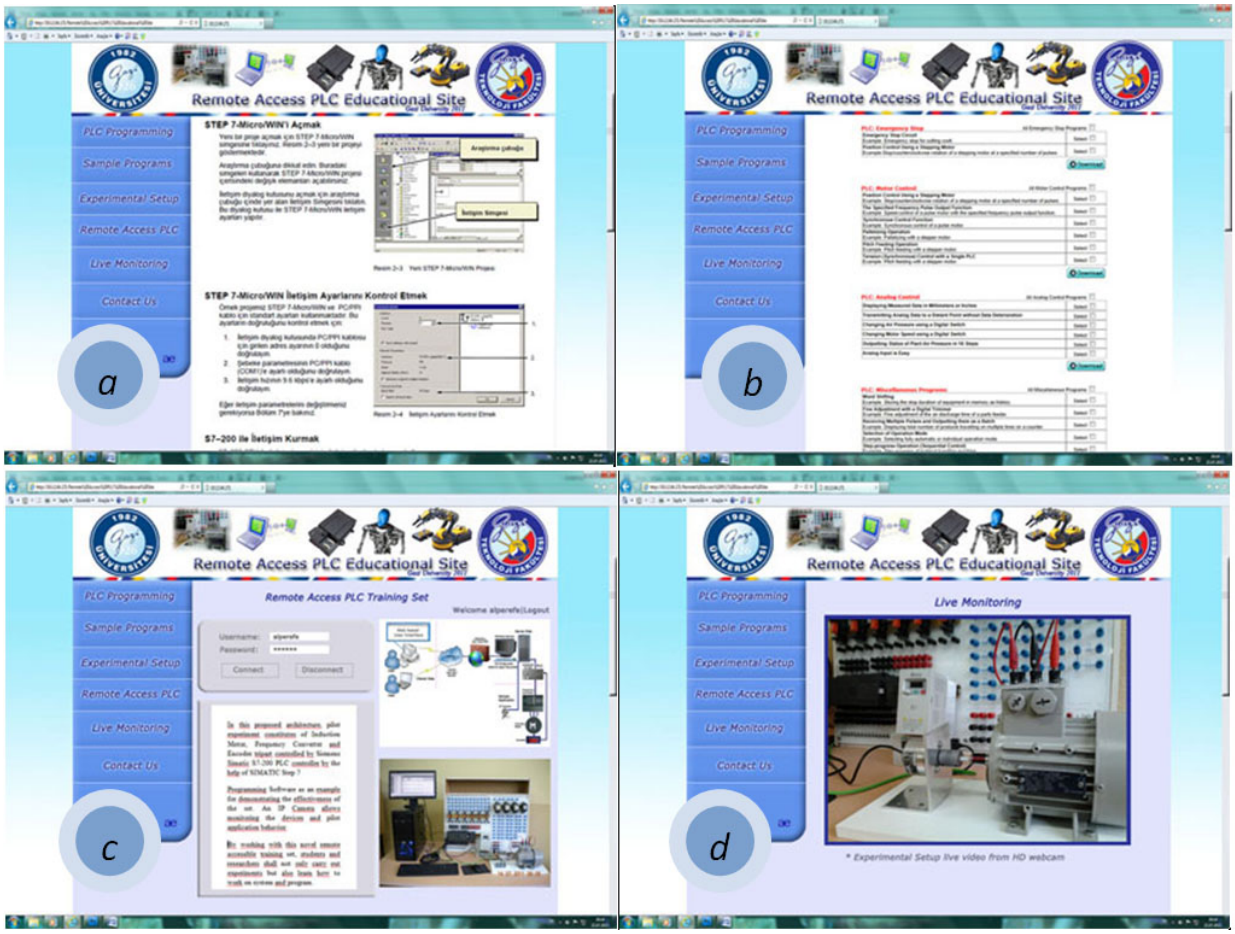


Figure 6: Web user interfaces samples of Remote Access PLC Web Site

CONCLUSION AND SUGGESTIONS

In this proposed architecture, pilot experiment constitutes Induction Motor, Frequency Converter and Encoder tripart controlled by Siemens Simatic S7-200 PLC controller by the help of SIMATIC Step 7 Programming Software as an example for demonstrating the effectiveness of the set. An IP Camera allows monitoring the devices and pilot application behavior. By working with this novel remote accessible training set, students and researchers not only carry out experiments but also they will learn how to work on system and program.

What separates this study from others is that; it provides remote access to the PLC without using either any packaged software or extra PLC module.

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After the implementation of the Proposed Remote Access PLC Training Set and Educational Web Site; subsequent conclusion has been reached that this study offers an effective learning environment for distance education. Furthermore, it provides a novel, safe and economical solution for multiple users in a workplace to enhance the quality of education without significant increase in the overall cost.

The next step would be to apply PLC training set into class environment by which students get a chance to interact with. In this way, a valuable feedback regarding using PLC training set might be received. Researchers might conduct both qualitative and quantitative research technics and further analysis might be needed to look at variables such as academic success, retention level and psychomotor skills.

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