Web-Based Monitoring and Control of Electric System*

استخدام شبكة الانترنت للمراقبة والتحكم عن بعد فى منظومة كهربية

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ملخص البحث:

مع تطور شبكة الانترنت ازداد الاهتمام بتطوير الأنظمة المرتبطة بالشبكة. وحيث ان تطوير وصيانة نظم الطاقة الكهربية مكلف جدا فإن تطوير أنظمة يعول عليها للمراقبة والتحكم باستخدام شبكة الانترنت فى هذه الشبكات يصبح أمرا ضروريا. ومع التقدم الكبير في تكنولوجيا الحاسب الآلي أصبح من الممكن تطوير منظومة مرتبطة بشبكة الإنترنت تعمل فى الزمن الفعلى (real time) للمراقبة والتحكم عن بعد فى المنظومة الكهربية ، مما يسهل عمليات القياس والرصد وأى تطبيقات أخرى تساعد فى تشغيل المنظومة عن بعد.

في هذا البحث تم تصميم نظام للمراقبة والتحكم عن بعد فى شبكة قوى كهربية. ويتكون النظام المقترح من ثلاث طبقات ويمكنه إدارة شبكة القوى الكهربية من خلال جهاز كمبيوتر متصل على شبكة الانترنت . وهذا النظام يمكن استخدامه للمهندسين والطلاب لأغراض التدريب والتدريس ومحاكاة شبكة الرصد والمراقبة فى الزمن الفعلى. ويقدم البحث بعض التطبيقات لرصد ومراقبة الشبكة. ويمكن من خلاله بناء العديد من التطبيقات على الشبكات الكهربية لتطوير تدريس العديد من المقررات فى نظم القوى لطلاب أقسام الهندسة الكهربية. وتم التحقق من جدوى النظام المقترح بتطبيقه على عدد من طلاب السنة النهائية بقسم الهندسة الكهربية بكلية الهندسة جامعة المنصورة وتحليل اجاباتهم على نتائج استبيان تم توزيعه عليهم.

وتنبع اهمية تدريب الطلاب وصغار المهندسين على أنظمة المرقبة والتحكم عن بعد باستخدام شبكة الانترنت إلى أن العديد من شركات التوزيع فى مصر بدأت فى المراقبة والتحكم عن بعد فى شبكات التوزيع من خلال شبكة الانترنت، مما يجعل من الضرورى تعليم الطلاب وتدريب صغار المهندسين على المفاهيم الأساسية لهذه التكنولوجيا. لذا فمن الممكن استخدام النظام المقترح كنموذج أولي لتعليم وتدريب الطلاب والمهندسين.

Abstract

Significant advances in Internet and computer technology have made it possible to develop an Internet-based real time system to support remote monitoring and control made easy, where Internet-based control systems facilitates measurement, monitoring, and control of electric network and make it easy for any electric system applications could be done remotely.

In this research a Web based system has been designed and developed for remote monitoring and control of electric power network. The developed system is based on three-tier architecture and enables to manage the network through a computer connected on the Internet / Intranet. The recent and past information of power network is available to electric engineers and students for the purpose of training, teaching and simulate network monitoring and control. Using the proposed system enables utility and faculty to handle the issue of real time monitoring and control.

The research describes some applications of monitoring and control of the network. Many applications of electrical network will be built to teach utility engineers and student very complicated topics in electric power system courses.

Many electric power centers are computerized and managed through the internet, it is important to teach electrical students and train utility engineers the basic concepts behind web-based monitoring and control of power system. The proposed system could be used as a prototype system for teaching and training of electrical engineering students and utility engineers the previous concepts. The proposed system is validated using questionnaire for final year students and proved its validity.

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1. Introduction

The rapid progress of internet-based networking technologies enables a remote access to engineering laboratory equipment and instruments. Remote access power system network is gradually emerging with the advance of technology [1]. This topic and related issues has to be handled in the engineering curricula as platforms for inter-university collaborations electrical utilities aimed at establishing global training and distance education. Basically the remote web based real time system is based on the concept of using the web to monitor and control of the power system network. This concept needs to be addressed in the literature within unified and consistent framework.

This enables electrical engineering students to understand that concepts before they go to the real world. Implementation of that concept gives the chance to faculty members to study the pedagogical implications of using these new techniques for teaching the advanced technology for electrical engineering students. Also it enables utilities to train engineers for grasp all these new concepts.

This research work presents an architecture and implementation for remotely-accessible power system network with some case studies. This could help students and engineers to understand remote access technologies.

The proposed system helps student to grasp the concepts of the technology used to monitor and control of electrical network.

Web-based laboratory work may be a suitable option for sustainably providing high-level skills to power engineering students.

The proposed system helps in performing simulation work based on real time data. Students could interact with computer simulations, run test cases and undertake data analysis. The system interfaced to monitoring and control electrical network. And this leads to the construction of virtual electrical network which enable many simulation studies. These simulations could help in teaching student the basic concept of electrical real time data remote monitoring and control. Also it leads to explore the basic concepts behind the technologies needed to monitor and control the electrical network in real time. The following concepts will be very easy for students to grasp. The country efforts for restructuring of the power system, the concept of restructuring and deregulation of power system assumes the availability of both the system operating point and historical information, almost at every minute. Therefore, online system information is a prerequisite for restructuring of power system. This implies that there is a need to create a centralized database for the power system which is subjected to continuous upgrade [2-3].

Also this would facilitate researchers and experts to find solution for various bottlenecks in the system. Often system analysis and appropriate solution to prevent system failure in future is difficult due to poor access of system data. In this context, centralized database will bring transparency in analyzing the problems and finding the appropriate solution. The various aspects of data repository are data collection, data validation, authentication and updating, method of reporting and necessary backup, data storage and sharing the data among users through the Web [4].

To fill all previous gabs authors of this research describe the structure and function of a remote access system for power network which offer students interactive real-world experimentation in electrical engineering courses.

First, the physical system was developed with all necessary industrial sensors and actuators. For local monitoring of test experiments, the microcontroller circuit is implemented, and dedicated experimentation modules and interface forms were developed using Microsoft C# [5]. To enable use of this system over a network, authors selected client/server architecture, and all client and server software modules were implemented. For long-distance learning purposes, a dynamic website was developed. The proposed approach was based on PHP (which is a widely used, general-purpose scripting language) [6] to support access to experiments via a web server, and LabVIEW [7] software results in the client computer.

A real time virtual laboratory is designed and implemented. Students can access the laboratory web site and perform their experiments without any limitation of time and location so as the students can observe the signals by changing the parameters of the experiment and evaluate the results.

2. Survey

Teaching or training in the field of engineering requires a lot of equipments and a lot of lab-based work. To teach electrical engineering students the concepts behind monitoring and control of electric network, many lab and real time data and work are needed. Many authors propose a work related to that point and we will survey the previous work in this section.

In his research [8] Sysala focused on education in the field of Measurement and control of technological processes. In one part of this sphere students obtain theoretical knowledge in an application of commercial systems for measurement, visualization and control of technological processes. The system is controlled and data are measured via a programmable logic controller (PLC). All systems were tested on the real equipment. The programmable controller controls the system and at the same time is a data source for master applications that are designed for the systems.

Zhuang and Morgera [9] presented implementation details of a new undergraduate course of internet-based Instrumentation and Control. The course has a companion laboratory that is supported by the National Science Foundation and industry. The combination is offered to senior-level undergraduate engineering students interested in sensing, instrumentation, control, and web programming that want to learn more about the integration of these technologies for solving real-world engineering problems.

Lindh et. al. [10] proposed a web based system that used by utility sector for collection of measurement data and for the electrical systems in industrial plants. That system could collect data from electrical system and monitor the status of that system using the web.

Evolution and cost of measurement equipment, continuous training, and distance learning make it difficult to provide a complete set of updated workbenches to every student. For a preliminary familiarization and experimentation with instrumentation and measurement procedures, the use of virtual equipment is often considered more than sufficient from the educational point of view, while the hands-on approach with real instrumentation and measurement systems still remains necessary to complete and refine the student's practical expertise. Creation and distribution of workbenches in networked computer laboratories therefore becomes attractive and convenient.

Y.S Ong, et al [11] proposed and discussed a prototype software package that includes a web-based power flow simulator and a Java-based graphical user interface (GUI) that may be used as a flexible and portable independent front-end for teaching power system operation and control. A setup which provides an interactive distance learning environment capability is also included. Lecturers are given the ability to plan and design new power system scenarios easily, while students will work with these designed scenarios. All that is required is any Java-enabled terminal connected to the Internet. A six-bus, two generator system under light, medium and peak load conditions is used to illustrate the underlying principles of power system operation and control.

The introduction of information and communication technologies in education in general, and of Web-based experimentation solutions in engineering education in particular, presents many challenges.

D. Gillet describes in his research [12] the current situation according to the institutional, educational and technological objectives. The aim is to outline a way toward enhanced functionalities of the learning resources and expended opportunities in flexible higher education. In the flexible scheme considered here, the students can freely chose between a distance (Web based) and a traditional (on-campus) access to learning resources and support. The author proposed a system called "eMersion". This system is used as a learning environment that has been designed and assessed to ensure that it sustain this bimodality. The system doing that continuity; by bringing the necessary added value for knowledge and know-how appropriation by students.

R. Gupta, et al [13] designed and developed a Web based system for remote monitoring of electric power distribution network. The developed system is based on three-tier architecture and enables to manage the distribution network through a computer connected on the Internet/ Intranet. Under this development, the real time database, which is a part of practical Distribution Automation system, has been converted into commercial database.

T. Zimmer et al [14] propose a new way to integrate training in the use of advanced measurement equipment into education at University level. It uses some features of the WWW such as the accessibility of multimedia documents, the simplicity of HTML syntax and particularly the Web's networked structure. The basic idea is that, on one side there is an instrumentation pool, i.e. a number of instruments located anywhere in the world, on the other side, a detailed description of the instrument and its front panel are available on the Web and can be accessed by any Web browser for a specific declared user group. This link permits students to learn how to use advanced measurement equipment and to perform real measurements with instruments not available at their university.

Adaptive hypermedia is a new area of research at the crossroads of hypermedia and adaptive systems. Education is the largest application area of adaptive hypermedia systems.

The internet-based education system, especially, web-based one, has become more popular year by year as information technology spreads world-widely. However, to make it more effective in power system education, not only text or image-based educational content but also simulation-based one should be supported. Because students can gain their experiences by doing in a simulation environment called "learning by doing".

As a result of advanced technologies in information and networks, power monitoring systems not only benefit efficient power supply, but also instantaneous power control. Furthermore, as computer hardware becomes more popular and software interfaces are more user-friendly, graphic monitoring provides not just traditional control interface which uses simple light signals and buttons to display and control. It can easily display texts, numbers, graphics, and other useful contents. It also raises the add-on values of graphic monitoring systems. P. H. Wu et al in his research [15] use Microsoft Visual Basic (VB) as the tool to develop graphic monitoring software. His research, integrating teaching contents, current communication, and computer and control technology, focuses on designs of power monitoring systems.

E. Warnier et al [16] designed a web based monitoring and control system for industrial process. This system make the ability for Enabling remote monitoring and adjustment of plants, enabling collaboration between skilled plant managers situated in geographically diverse locations, enabling the business to relocate the physical location of plant management staff easily in response to business needs.

D. Blanc [17] discusses the monitoring and control system for an automated cooling process. The plant is located in an experiment environment and with some distance between the principal components of the system namely the cooling station of the lead target temperature measurements and the experiment control room.

F. Michau et al [18] present how "*teaching and learning with technologies*" may improve academic education and corporate training for engineering sciences. It particularly details examples of web-based learning tools for control and open distance learning experiments developed at the Grenoble National Polytechnic Institute (INPG, France). This research describes the observed improvements brought by information and communication technologies in the academic context at different levels: the academic institution, the teacher and finally the user. Then it presents four significant approaches to web-based learning developed at the INPG. The first three approaches are intended to enrich and complete the traditional face-to-face teaching and learning in control with highly interactive, self-learning tools, including hypertext, exercise bases, simulations, and virtual and remote laboratories. The fourth approach is seen as a substitution for traditional face-to face teaching and learning, providing open distance learning in the context of continuing education.

Authors of this research describe the structure and function of a remote access system for power network which offer students interactive real-world experimentation in electrical engineering courses.

3. Proposed System

3.1 Overview

The proposed system consists mainly of two major components, *software and hardware components*. Also monitoring and control strategy are presented. The architecture of that system is shown in Figure 1.

3.2 The Proposed Software Components

Three tier architecture, as depicted in Figure 2, has been chosen for monitoring of system using Internet technology. This architecture provides greater application scalability, high flexibility, high efficiency, lower maintenance, and reusability of components. In this design, each tier can be run either on a separate machine or on the single machine. It improves system processing performance. A typical three layer architecture is divided into: Presentation tier, Application tier, and Data base tier as explained in the following section:

i. Presentation tier

This tier enables user to interact with the database through the web browser in a user friendly manner from remote location. It is also called user services layer. It provides user to access the application. This layer optionally permits to feed and manipulate data. This tier could be build using java [19] technology as a client and server side programming or PHP [20] and JavaScript [21] as a client and server side programming. In the current proposed system we used PHP and JavaScript technology.

Ajax concept of web programming [21] and jscript with HTML as a client side web programming are used to present the data from and to the real world system. The proposed client interface software will be web2 based [22] graphical user interface.

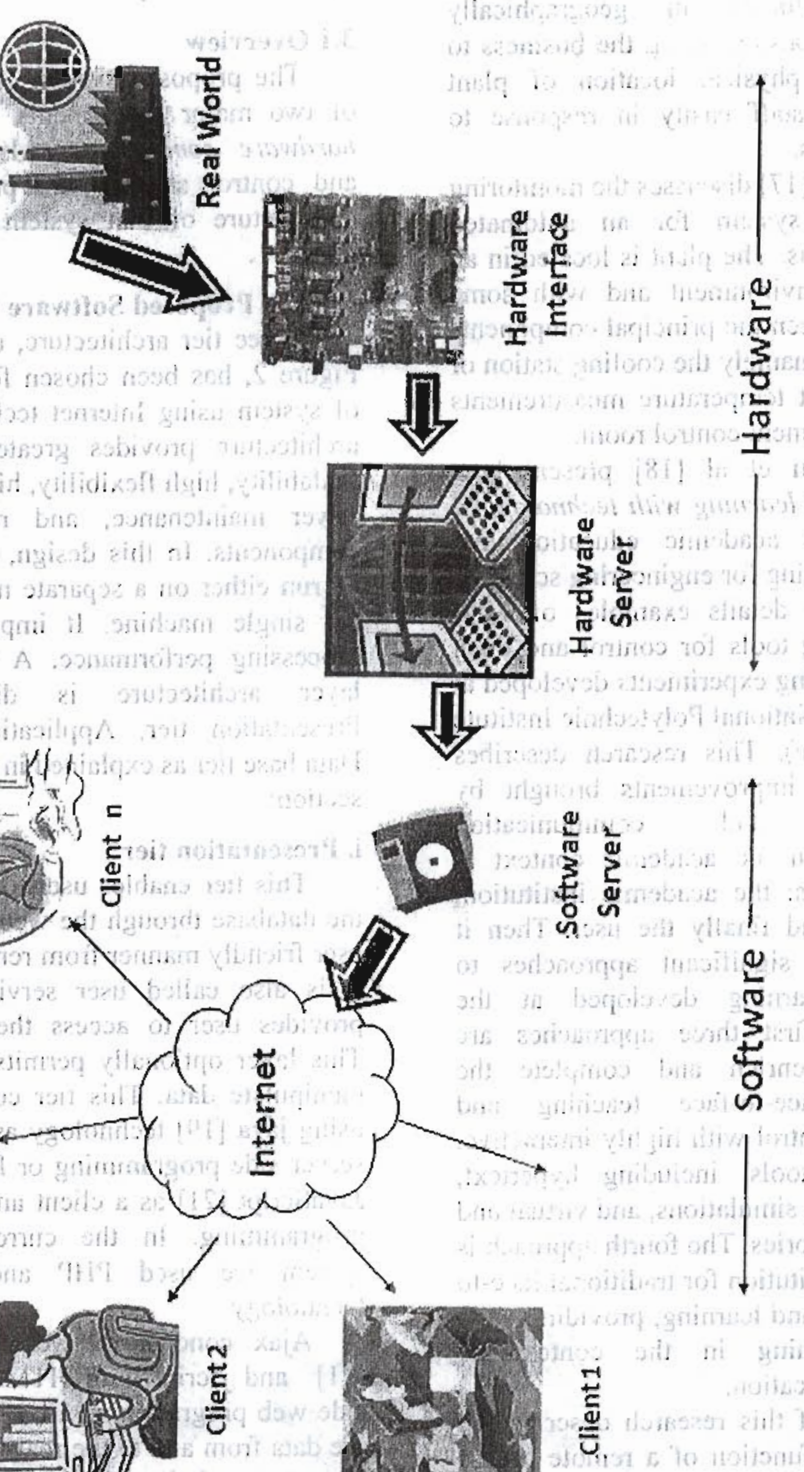

Fig. 1 The architecture of the proposed system

ii. Application tier

Application tier consists of web server and application logic for data monitoring and control. This tier is also called application service layer. The logics and rules are separately stored in the files using Web scripts. These logics and rules are properly interfaced with the main Web server in this tier. In the current development of monitoring system, apache server [23] has been used as Web server. This provides management services that are shared by multiple applications.

iii. Data base tier

This tier is also called data service layer. It concerns with persistent data usually stored in a database or in permanent storage. This is the actual Relational Data Base Management System (RDBMS) access layer. It can be accessed either through the application services layer or on event created by the user services layer. The system built using Ajax technique based on web2 concepts [23].

The major benefits of the three tier architecture are reusability, flexibility, manageability, maintainability, and scalability.

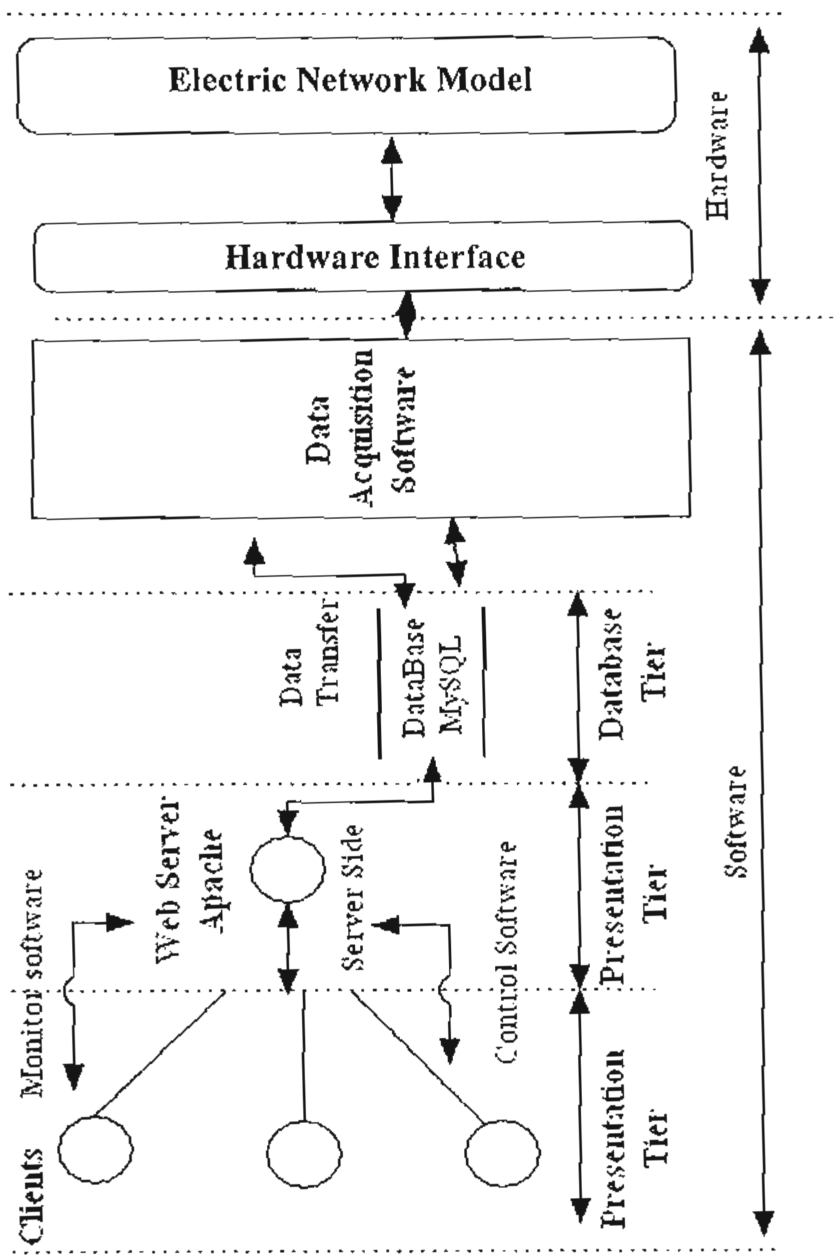

Figure 2 The proposed software and hardware components

3.3. Hardware Environment

In this proposed work, a micro-controller interfaced is used to control the network. The microcontroller interfaces with sensors using an analog to digital converter (ADC) are used. Ethernet data communication between the micro-controller and a remote web-client is performed.

Data acquisition system is used to collect information from electric networks and store it in a database on the server side as shown in Figure 2.

3.4 Monitoring and Control Strategy

The electric power system monitoring process is the continuous measurement of the power system network information such as voltages (V), currents (I), phase angle between V&I, frequency, active power, reactive power, harmonics, and so on. That is to assure optimum operation and control of power system under normal and abnormal conditions.

Recently the continuously measured data are displayed on monitors of computers that exist in the control and monitoring room that is SCADA system where real-time measurements are displayed for the electric power system network operators.

The proposed system enables simulated electric utility to remotely monitor and control the electrical network components such as transformers and lines in real time. Now, the core objective of this research is to establish a web-based system to monitor and control of electrical network. This could be successfully achieved using three tier architecture [24]. One major task of the proposed system is to retrieve the network information, transmit it to control center and store them in the real time database. Generally the real time database exists at the control center as a proprietary database.

3.4.1. Monitoring phase program

Application logic layer receives request from clients for data, retrieves the relevant data from standard database and sends these data to the appropriate client. Application logic program resides on the server side. This program has been designed and developed using PHP [20] technology. PHP technology enables to make the dynamic and interactive web pages. It uses server-side scripting to dynamically produce web pages that are not affected by the type of browser. The default scripting language used for PHP is Jscript [21]. PHP pages have the extension "*.php" instead of "*.htm", which is in HTML page. When a page is requested by a browser by selecting and clicking a specific hyperlink, the web server interpret PHP content within the web page before sending the HTML stuff to the browser. This way all the PHP scripts are run on the web server and no PHP code will ever be passed to the web browser. It is to be noted that any web pages containing PHP code cannot be run by just simply opening the page in a web browser. PHP allows to use the capability of a web server to process user requests and to provide dynamic data.

Application logic layer works according to the flow chart as shown in Fig. 3. When client requests for system data through Web browser, an appropriate PHP code page is triggered to run at server side. The logic embedded in the PHP code collects the required data from database server and present it to the appropriate client on the web. Application logic program updates information every minute at the clients Web browser.

3.4.2. Controlling phase program

This component of software is responsible for the controlling phase. By means of this layer received a data from the web and trigger the interface card to control the power system operation.

4. Case Study1

In this experimental case study a simplified electric network is used to simulate a lab work. This is done by simulating some loads and power supply for monitoring and controlling the power system.

4.1. System under study

The case under study consists of a simple real electrical system with 220 volt supply, sensors and a Data Acquisition System (DAS) board connected to the computer server.

The single line diagram of the studied system is shown in Figure 3. It consists of a three phase power supply, resistive loads (lambs), contactors, relays and current transformers

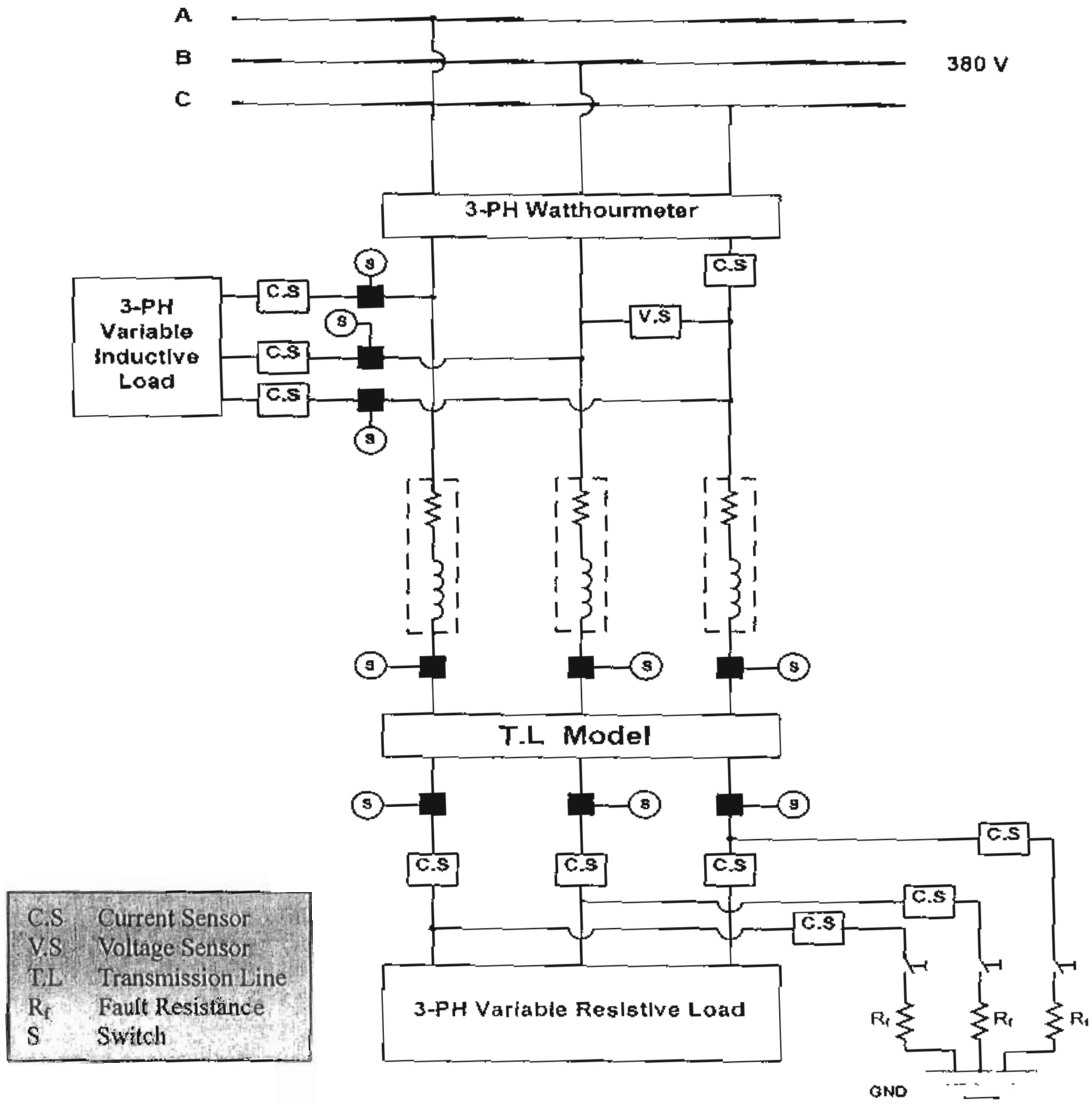

Fig. 3 Single line diagram of the studied system

4.2. Data Acquisition System (DAS)

The main function of DAS board is to collect data from real system and send it to the computer (server) and send data back from computer to real network. The DAS board used in this study consists of eight analog inputs, eight analog outputs, eight digital inputs and eight digital outputs.

The analog inputs are used to read analog signals such as current and voltage and the digital inputs are used to read all digital signals or status such as circuit breaker (contactor) status. The digital outputs are used to control system (on/off) from control center (computer). In this system we will not use analog outputs.

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breaker (contactor) status. The digital outputs are used to control system (on/off) from control center (computer).

DAS is connected to the computer using USB port. USB port has several merits: it is fast reliable and all computers support it, however it has some difficulty in programming, but it is a good choice.

4.3 Controlling the network

Controlling the system is done by the server computer. The operator sends the from computer screen (software interface) to the system.

The software sends these data to DAS and DAS apply this order and convert it to its digital outputs according to order it received from computer. The order is executed to switch on/off any piece of the network.

A high level language is needed to build the system and its Graphical User Interface. In this proposal, authors use the visual basic language to build the system and its user interface Figure 4.

Figure 5 illustrates the user interface window:

- The most left part of the window gives the information about the side serve connection of board to computer and the status of the power supply and the USB. It also explains the number of boards.
- The remaining part of the window is used to monitor and control of the real system. ***Every line in the figure illustrates:***

1. Circuit breaker status: If its color is ***red*** that mean C.B is ***off*** and the reading of current will be zero, and if its color is ***green*** that mean C.B is ***on***.
2. The real values of current passing through loads.
3. Select button: this select button is to control this line on and off. So if you want to turn on any line, select it and click the ON button, you will see on the user window that the line is connected.

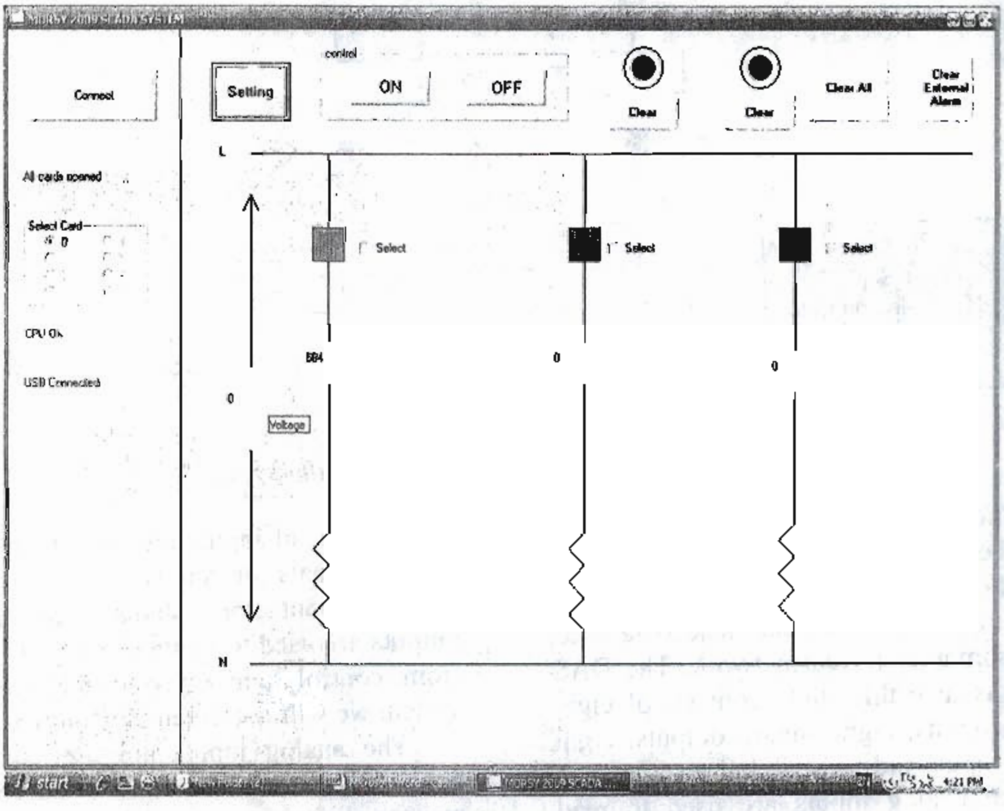

Fig. 4 System window for case study 1

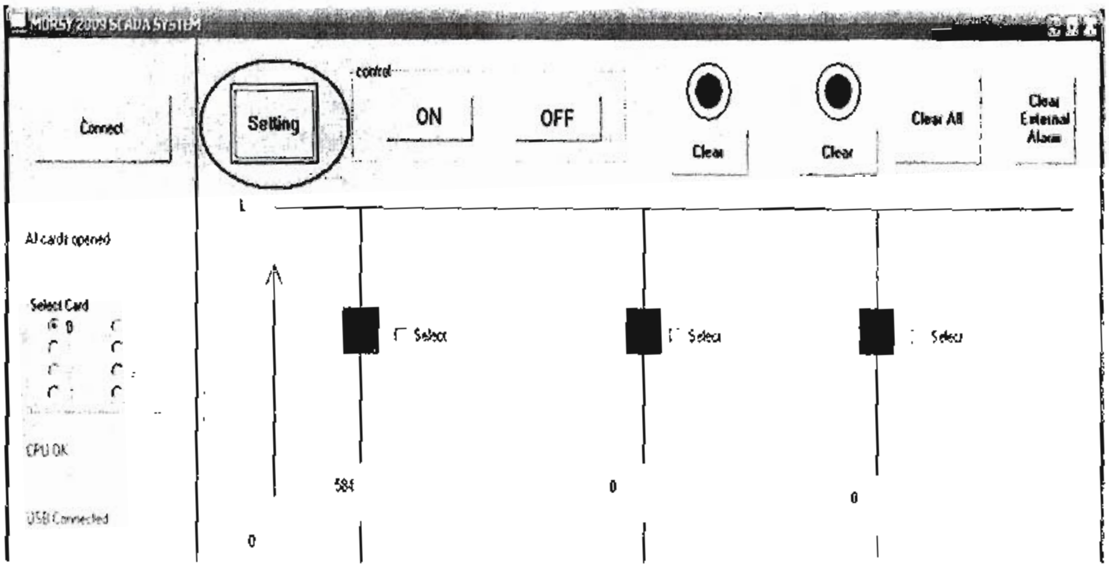

Figure 5: Interface window for case study 1

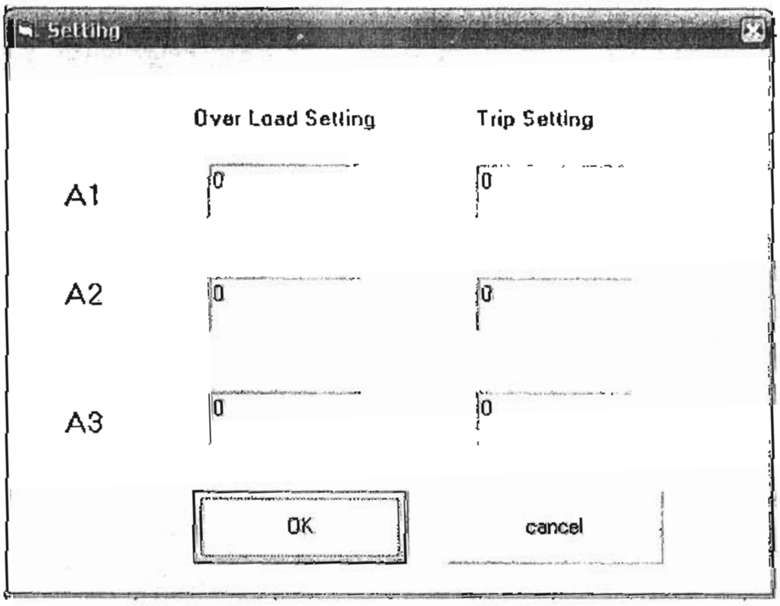

Fig. 6 Setting window

4.4. Protection setting

The setting of the system can be detected using the setting button that was explained by Figure 5. By clicking the setting button you will see the form shown by Figure 6. In that figure, there are two settings: over load setting and trip setting.

1- Over load setting : by inserting the values of over load to every line , if it reach this value you will see over load alarm

2- Trip setting : insert the value (fault value), if it reach this value this will cause :
   - line will trip (disconnected)
   - trip alarm appears on screen
   - external alarm

The operator will see alarms and will clear them; there is button to clear external alarm.

5. Case Study2

To show the validity of the proposed technique another case study is proposed. The objective of this case study is to monitor and control the main parameters of an induction motor. The following sections explain the details of that case study.

5.1. System description

This system consists of a 3 phase induction motor with an inverter as speed controller. Also a molded case circuit breaker is used as a protection item. Magnet contactor is used for control input power monitoring.

5.2. Monitoring Phase

The system is monitored during its operation. The monitoring phase is done to show the status of the motor. The parameters which could be monitored are:

- The Motor on-off state using sensor connected to the on/off source switch.
- Motor voltage using voltage transformer to scale down the voltage so that it can be measured and transformed to the data acquisition circuit.
- Motor current using current transformer.
- Speed using tachogenerator.
- Temperature, using temperature sensor.
- Frequency, directly from the inverter.

Within various speeds the current flow, voltage and frequency would measured and monitored. Also the same values could be measured and monitored at various loads. Motor load curves would be deduced and monitored. Temperature of the inverter and the motor are monitored, alarm will be highlighted at a certain limit of that temperature.

After running the LabVIEW code of case study 2, the following interface window is pop up (Figure 7) which shows the real parameters data of the case study. That controlled parameters are:

- The three phase voltage,
- The three phase currents,
- Inverter DC link voltage,
- Motor power,
- Motor Speed,
- Motor Temperature and
- System frequency ***Control phase***

Figure 8 shows the total screen output for control and measured values.

At that phase the following parameters could be controlled:

- The system automatically going to Off status if the temperature alarm is fired
- From the computer interface window at the running mode (Fig. 7), the following action could be happened:
  - The system could be switched On or Off,
  - The motor speed could be changed,
  - The direction of the motor could be reversed,
- Given the motor parameters in a real time mode and the availability of the parameters on the database could help in running short circuit and no-load tests.

Figure 7 shows the graphic plot of the motor voltage, and explains also the screen output for the motor temperature and frequency.

6. Validation

The proposed system is validated by using questionnaire for 4^{th} grade students after the run of the experiment. Authors chose 20 students build questionnaire and the results are shown in Table 1.

From Table 1, the global results show the satisfaction of the chosen sample. The satisfaction is reasonable. Some comments and outcomes are shown below.

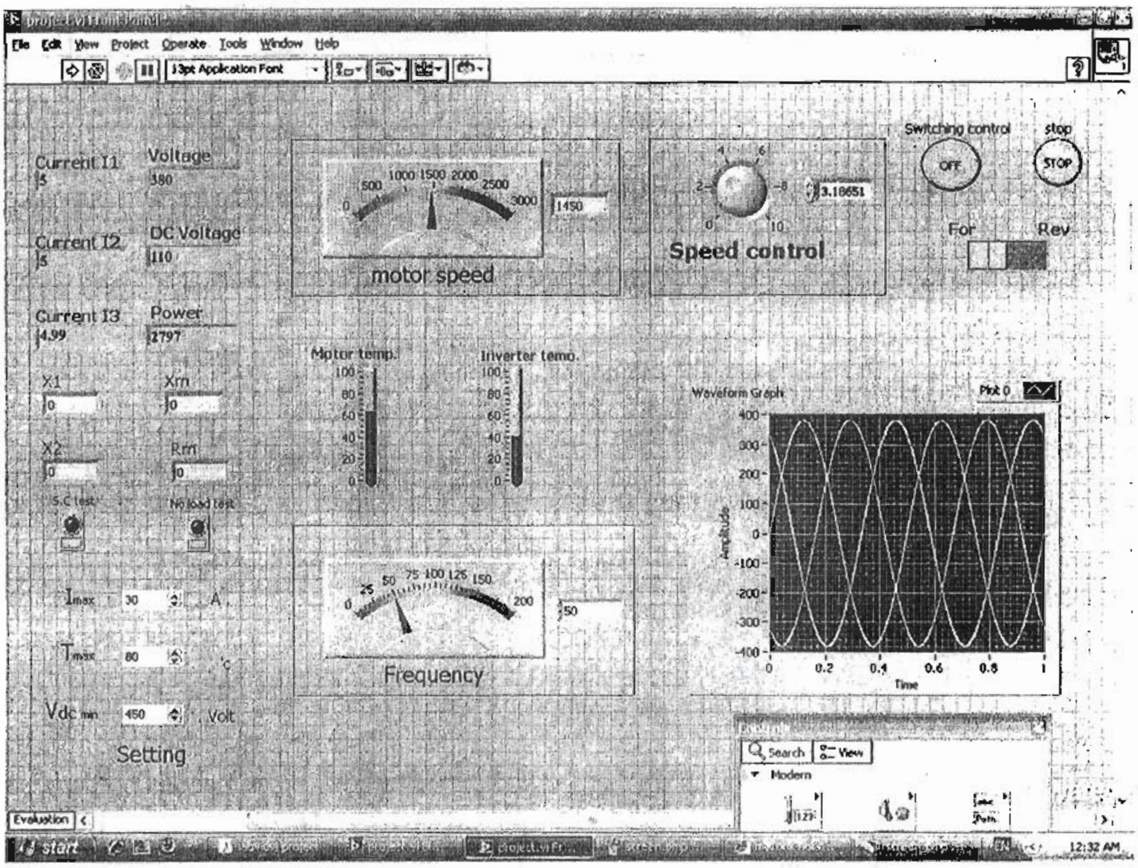

Fig. 7 LabVIEW running mode of case study 2

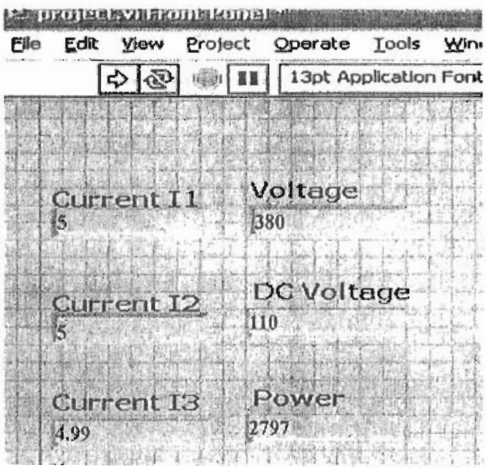

Figure 8 Total screen output for control and measured values.

Table 1 Statistical Results of the Questionnaire's Students Answers

Question	Strongly agree	Agree to some extent	Do not Agree
Student have previous experience about this kind of experiments	4	11	5
is it good if the same technique in all labs	18	2	0
I can do the experiment alone again	6	12	2
It's easy to do the same kind of experiments again	2	15	3
Running this experiment is useful for students	20	0	0
It could be useful for me to do the same experiment from home	16	4	0
I enjoyed learning with that experiment	18	2	0
This kind of experiment explore the lab work during the course	7	10	3
The experiment is based on information I did study previous	2	16	2
It is hard to do the technique with some other courses	3	11	6
There is some disadvantages on that experiment	0	5	15
The time valuable for the experiment is enough	3	12	5
The place of running the experiment is quit and comfortable	6	11	3

7. Conclusion

In this research a web based monitoring and control for electrical power network is designed and implemented. This system is used to monitor and control of two real simple case studies of power network. Hardware and software interface is designed which make it easy for future more complicated case studies to be easy implemented.

This system makes it easy for the development of feasible and cost-effective remote power system engineering applications

The system is designed which make any future application does not put any burden for designers. Only the design of power network is needed and the system could work well.

The proposed system is simple and cost effective way to be used for utilities and universities for training purposes for senior engineers and final year electrical engineering students.

Therefore, it could be used as an innovative teaching method to circumvent Lab courses problems.

This Internet-based, client-server architecture system could be specifically used to allow flexible management of remote electrical.

The proposed system could be used for real time laboratory applications in education.

One long term target of the system is to use the internet to build full web based real time laboratory for electrical engineering student for education purposes.

Finally, a general methodology to create a web-based remote laboratory has been presented.

This proposed solution is portable via the employment of the TCP/IP protocol suite (Transmission Control Protocol/ Internet Protocol). It is also extensible because of the high level of abstraction in system implementation. This approach offers a valuable component to remote engineering instruction that cannot be replaced by simulation software packages. Compared to the traditional way of teaching, due to the absence of schedule and physical constraints, this new approach reaches students who otherwise would not have chance to take these courses and allows a larger and more diversified audience to access learning opportunities.

A Web base monitoring for power network has been implemented using 3-tier Internet architecture. The application tier has been realized through the server and data tier through MySQL (Structured Query Language) database engine, application layer is implemented using PHP language. A set of test cases have been designed and carried out for system monitoring and control. The test results demonstrate proper functioning of developed software components and idea of Web based monitoring of power network. A full case study2 is implemented, which is more complex than the first case study.

This Internet based laboratory is an effective alternative to setting up a traditional laboratory to support class courses in electrical engineering education. It has the following advantages:

1) reducing costs by sharing laboratory equipment;
2) allowing users to have greater oversight in electrical engineering by performing a variety of experiments based on physical plants;
3) allowing users to access at anytime and from anywhere.

The system validation has been done using questionnaire for a group of 4th grade students after implementing the experiment.

- ***Future Work***

A plan for the future work is as follows:

A simplified distribution system could be used and simulated in the lab as a real system considering loads and power supply. Hardware interface and software would be built to monitor and control the system. The implementation of that system could be done either by visual basic language or LabVIEW package. All decision making could be done from the computer (as a control center) and it will be reflected back to the real system through the hard and software interface. Authors have gained little bit experience from that system. Based on that experience, they propose that building the same system on the distribution level could be time and cost effective.

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