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IP BASED REMOTE MONITORING OF POWER SYSTEM AS WELL AS CONTROL USING LABVIEW VIRTUALISATION

M.R. Arun
Research Scholar,
Anna University, Chennai

ABSTRACT

This paper proposes an essential control system in power system applications. In the current scenario a variety of controlling techniques are adapted in power system including computerized control method. Traditional method of metering hardware instruments associated with controller have limited capability in the internet connection and human machine interface, sensitivity to environmental impact and high cost, so hardware controllers are in limited usage . But presently for every application, automation with remote monitoring, effective control and protection is preferable. So an alternative method of software controller is programmed and utilized for this application. In power system, transformer plays a vital role in power transmission and distribution. The operational status of the transformer is very essential to know the mode of operation. So a computer controlled method using Lab VIEW has been designed to measure, monitor and control the transformer quantities. The objective is to provide reactive power compensation for voltage regulation and protection of transformer from unexpected failure due to abnormal effects using software controlled method with reduced installation cost and enhancing the performance of power system by remote access. As a part of implementation of the project it has been simulated for mere analysis and a real time mini model was developed. Here monitoring of the real time electrical quantities was done by fetching the analog voltage and current as input from the transformer using instrumentation transformer .Also the control program was developed in LabVIEW to display the output such as real power, reactive power, apparent power, power factor, harmonics content and fundamental frequency. As per the objective, for obtaining better voltage regulation and power quality, reactive power compensation was carried out using Thyristor switched capacitor (TSC) banks. Due to the addition of capacitors, corresponding harmonics reduction was achieved and it was displayed. For protection, the status of various protective devices is monitored and if suppose any abnormal condition is there, then alarm indication or tripping is carried out. For overload protection, the winding temperature limit was set for the transformer and isolation of transformer from source is carried out when it exceeds the safe temperature limit to avoid breakdown. Comparably the proposed controller functions with fabulous features to that of the existing control methods in power system

KEYWORDS:

Power factor, Harmonics, Reactive Power, Transformer, DAQ card.

1. INTRODUCTION

With the fast revolution of Internet technology, the development of web-based applications is seen worldwide nowadays. Thanks to the technology emerged in the new age; the quality of living society is also significantly modernized. From electrical energy viewpoints, the application of this web technology also owns the potential of upgrading the performance of the control and operation of a modern power system. This aspect can be employed to investigate the feasibility of applying the network programming technique for software upgrade of electrical power measurement.

In the past decades, several software packages suitable for the instrumentation and measurement applications have been introduced to the market. The main purpose of these packages is to help engineers increase their knowledge about the acquired data; however, most software packages lag the feature of architecture and portability. In other words, most of them cannot be employed on the field to immediately manipulate the acquired information or perform data analysis. This has motivated the proposed method to enhance the functionality of existent measurement software for this application.

It is expected that through the proposed system, the software can be manipulated anywhere and anytime. In the instrumentation and measurement, the data analysis may be a time-consuming work. Through the conventional design, utility engineers usually confronts with a tremendous amount of data, such as real power injection, reactive power injection, bus voltage magnitudes, and bus voltage phase angles.

Therefore, a user-friendly interface design that can relieve the engineers' burden and help users familiarize the software manipulation would be beneficial. This encourages the Graphical User Interface (GUI) developed for the electric power measurement.

In this software prototype, many dialog windows for users to analyze the acquired data are designed in the package. The user can change the important parameters through the dialog windows and monitor the variation of the data as time varies. Advantages of this design are the fast interpretation of the result and the interactive visual communication between user and software. The communication and coordination between the user and virtual instrument can be facilitated through this World Wide Web (WWW) environment.

1.1 Project Description

In Today's world there are thousands of inventions at each and every moment to facilitate human. We are walking in the world of automation towards the destiny of unmanned world, where all the operations and actions except some basic needs of human will be carried out by machines. In such a crucial condition it is necessary to make automation in Electrical system. To perform real power, reactive power, apparent power and power factor were measured and necessary steps were taken as shown in the block diagram in Fig.1.1.

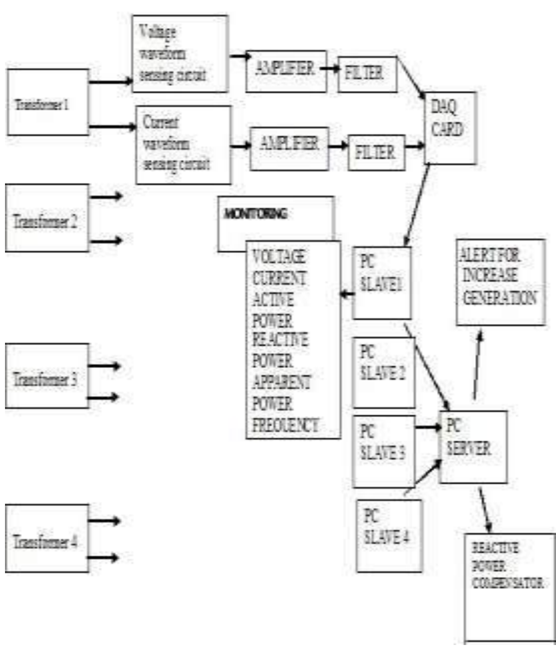


Fig 1.1 Overall System Block Diagram

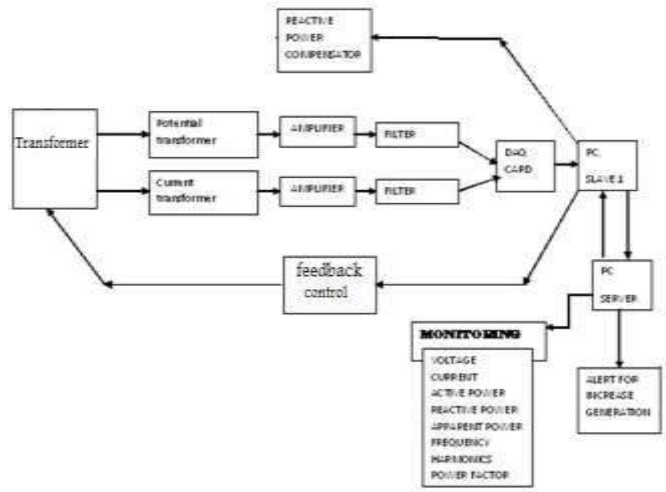


Fig 1.2 Control Block Diagram

Traditionally these parameters are measured by metering instruments. The traditional method of measurement gives the problem of risk in reading, storing data, remote accessing. This can be made easy by using a PC. In this project an approach is made to overcome the problems by measuring the electrical quantities using Digital Sampling Technique and the data is processed on the PC.

From generation to end user driven machines and facilities, electrical power goes through a series of systems and links. In each step of the power chain, the quality and amount of power is important to measure and control. National Instruments provides tools to perform power quality monitoring, power metering and distribution monitoring.

In power system, transformers play a vital role in power transmission and distribution. Healthy operation of transformer is essential for efficient power transfer and distribution. Hence monitoring and control is important as well as safe operation to be taken in to account. As per the secondary output voltage and line current of the monitoring transformer is measured from which the instantaneous power, reactive power, active power, power factor, harmonics, frequency and apparent power are displayed using the controlled program developed using LabVIEW. LabVIEW graphical program developed in the PC acts as controller in this system. Considering control session based on the desired power factor, reactive power compensation is carried out and enhanced actual power factor is obtained, which in turn improves voltage stability and harmonics distortion. Thus in turn shows effective preference towards reduction of losses and less current consumption and energy saving. If the active power demanded by both load and line losses is not met by present generation level, then generation alert is sent for increasing the power. If it is not possible to increase the power generation, then load shedding is carried out on priority basis.

For over load protection of transformer, winding temperature taken into account and if it crosses the limit isolation of the transformer from the source is carried out. The status of the circuit breaker and relays are monitored and if any abnormal condition occurs alarm indication is given. The measurements and data access tools available in LabVIEW helps for remote front panel access. The LabVIEW with controller program avoids the requirement of various hardware feedback controllers. The project provides an effective reduction of hardware requirement in metering and displaying aspects.

The benefits of NI's Electrical Power and Systems Monitoring Approach are:

a) From single end, it is possible to carry out multiple functions like measurements of power quality parameters, power metering and recording of sequence of events.
b) Shorter time for program development due to graphical Programming library.
c) Easily adapts to future requirements.
d) Easily integrates with existing control systems and software.

1.2 Literature Survey

For the implementation of the project, literature survey on remote transformer monitoring, online web based control, alternative methods of use of software controllers instead of hardware controllers and voltage control using reactive power compensators were carried out.

1.3 Hardware Modules

The project as per real time concern requires hardware modules for implementation. It includes driver circuit for Triac switching, capacitor banks for reactive power compensation, USB DAQ card for system interface, instrument transformers for high rating measurements and temperature transducer for winding temperature measurement.

2. IMPLEMENTATION OF THE PROJECT

The implementation of the project includes software controller program and user interface development using LabVIEW, instrumentation transformers circuitry for acquiring of data from power line circuit, driver circuits for switching capacitor banks.

2.1 Power Factor Improvement Calculation

The kVA demand of the load can be reduced by improving the power factor. To achieve this, the power factor improvement calculation is carried out. Consider the case of load with apparent power demand of 0.6 power factor. Suppose it is required to improve the power factor to 0.9, the calculation of kVA required for reactive power compensation is shown below

(Assumption: Active power demand of load is taken as constant)

Power Factor $= \cos\varphi$
$= kW / kVA$

When the power factor is 0.6,

$\cos\varphi_1 = 0.6$
$= kW / kVA_1$
$= kW / 5000$
$KW = 5000 \times 0.6 = 3000$

When the power factor is 0.9,

$\cos\varphi_2 = 0.9$
$= kW / kVA_2$
$KW = kVA_2 \times 0.9$

For the same value of kW, the new value of kVA demand is calculated as shown below

$3000 = kVA_2 \times 0.9$
$kVA_2 = (3000) / 0.9$
$= 3333.33$ kVA

Required **kVAr** rating for the capacitor to improve the PF from 0.6 to 0.9

$= kVA_1 \times \sin\varphi_1 - kVA_2 \times \sin\varphi_2$
$= 5000 \times \sin(53.1) - 3333.33 \times \sin(25.84)$
$= 5000 \times 0.8 - 3333.33 \times 0.436$
$= 4000 - 1453$
$= 2547$ kVAr
Say **2550 kVAr**

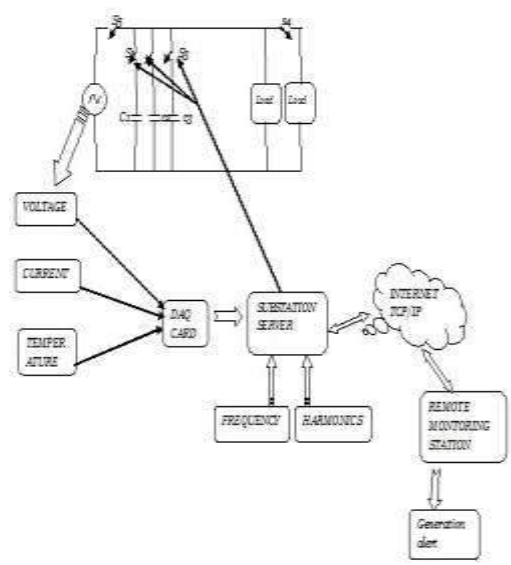


Fig. 1.3 System Implementation- Block Diagram

2.2 Thermocouple Implementation

The configuration of thermocouple interface to PC for monitoring winding temperature, for safe operation of transformer is given below in Fig.1.4

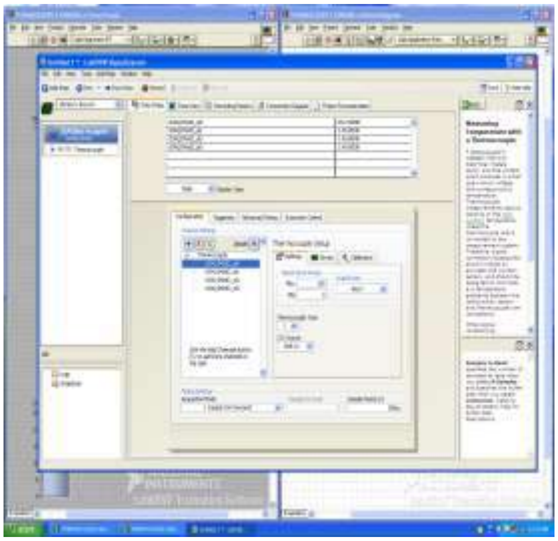


Fig. 1.4 Thermocouple Configuration Panel

2.3 Capacitor Bank and Driver Circuit

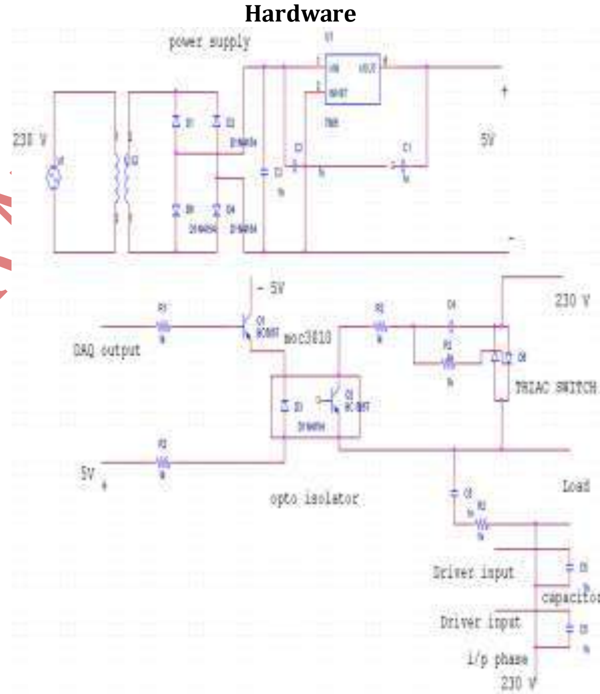
In order to perform voltage control in real time, electrical signal should be obtained from the instrument transformer and it is interfaced to the PC, so a hardware development of driver circuits , capacitor banks, power supply ,instrumentation transformer installation are carried out for controller to satisfy its functioning.

Fig. 1.5 Hardware Compensator and Driver circuit Module

3. HARDWARE DEVELOPED

The user friendly interface enhanced complex PC based controller, developed with the LabVIEW software provides more performance compared to hardware controllers (P, PI, PID).They replace various functional controllers such as automatic power factor controller, relay controllers, circuit breaker controllers, sensor based protective controllers, monitoring controllers etc used in substation into a single master controller using PC. This satisfies all requirements such as monitoring of electrical quantities in the substation, continuous monitoring of the status of protective devices such as buchholz relay, over current protection relay, differential relay, pressure relief valve, earth fault and the associated circuit breaker for safe mode of operation.

Fig. 1.6 Driver Hardware



Circuit for Switching

4. SIMULATION

For effective designing of a controller with required features, analysis of the system is vital important. Accordingly, system architecture is concluded by simulation of the project and required specification is theoretically analyzed. Here the circuit design is first simulated using LabVIEW and further it was enhanced for practical implementation. Some part of my project simulation is carried out in Matlab .The following are some of the simulation carried out while project was executed.

4.1 Lab view Simulation

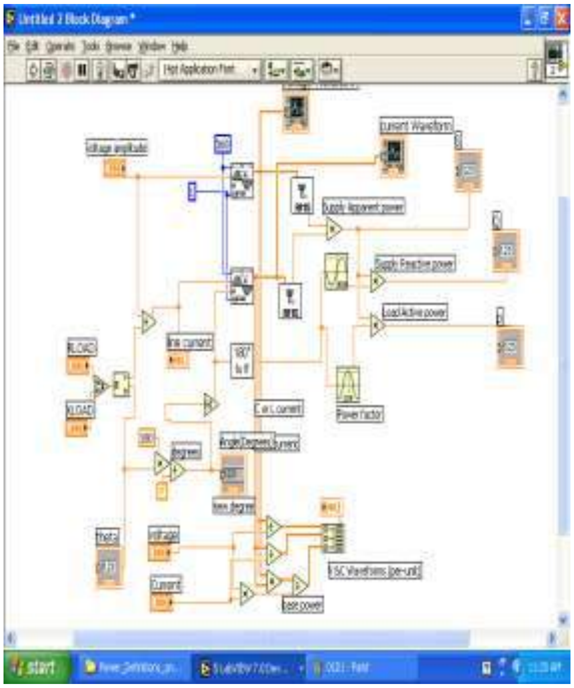


Fig. 1.8 Block Diagram for Monitoring Electrical Quantities

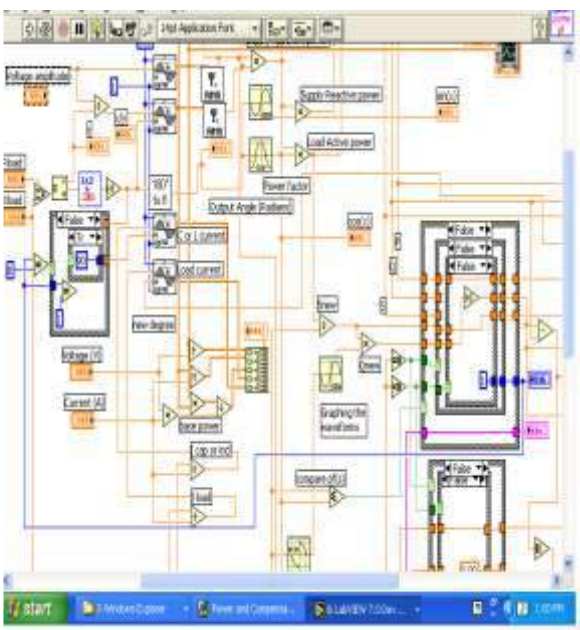


Fig. 1.9 Block Diagram for Controlling Electrical Quantities

Fig.1.9 shows the user interface for monitoring electrical quantities such as voltage, current, power, power factor in front panel of LabVIEW.

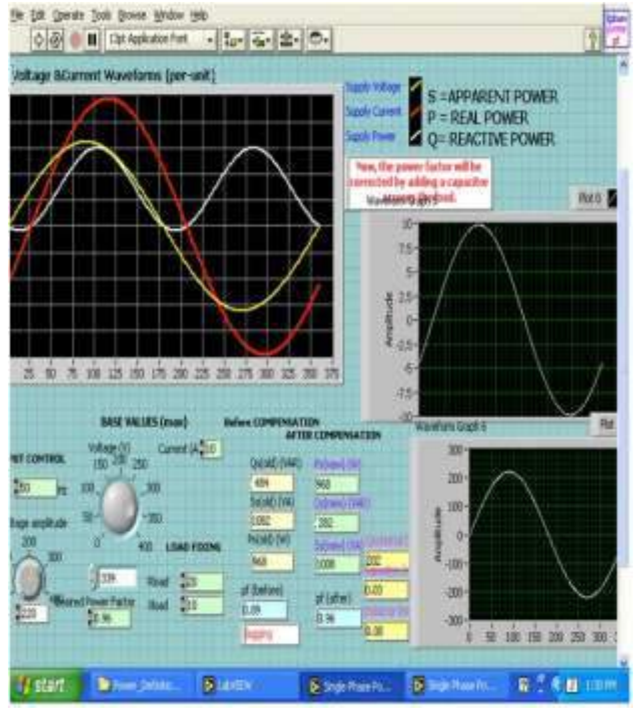


Fig. 1.10 Front Panel for Monitoring Electrical Quantities

4.2 MATLAB Simulation

Using Mat lab simulink package, reactive power compensation analysis had been carried out and based on that designing had been performed. Here the Matlab analysis output had been shown in Fig.1.11

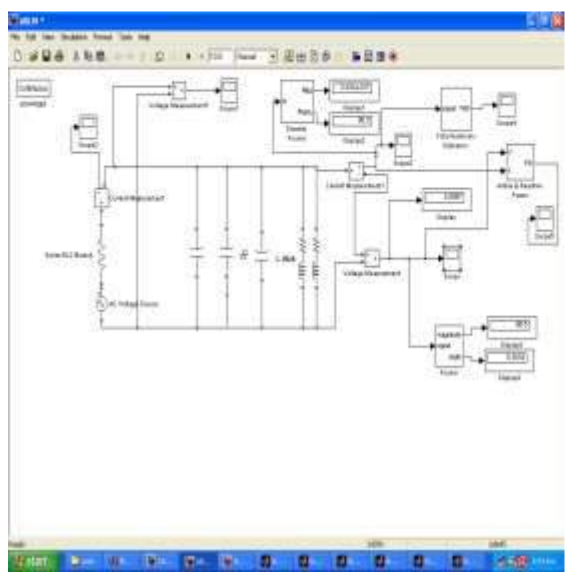


Fig. 1.11 Reactive Power Simulation in Matlab

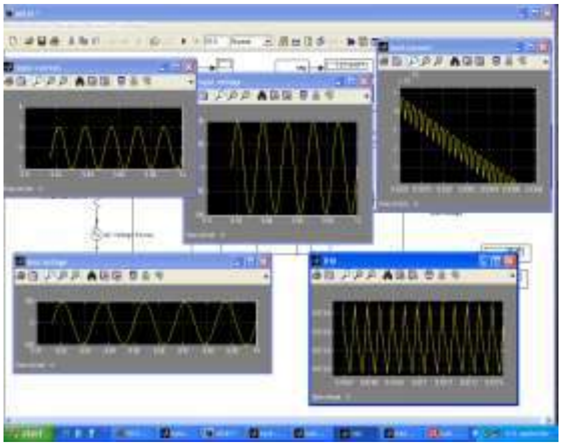


Fig. 1.12 Matlab Simulation Output

4.3 Temperature Monitoring

For safe operation of the transformer, the winding temperature is monitored and if any abnormal condition take place compared to reference value indication as well as isolation of transformer from source is performed which is shown below in Fig 1.13

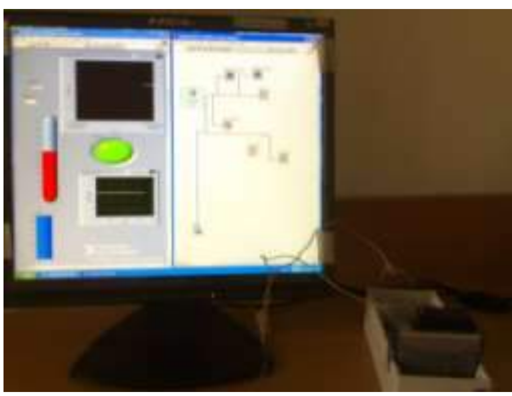


Fig. 1.13 Temperature Monitoring using Thermocouple

4.4 Automatic Generation Alert

As the power quality has to be increased, reactive power compensation is carried. Consequently enhanced actual power factor is obtained, which in turn improves voltage stability and harmonics. If the power demanded by load is not optimized, then generation alert is sent for increasing the power. This is performed because the frequency is highly affected and also overload leads to damage of equipments due to high current flow and losses in the circuit. The message alert which is sent is shown in Fig.1.14

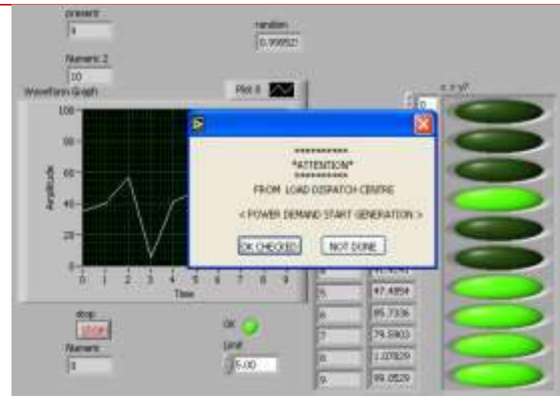


Fig. 1.14 Automatic Message Alert Block Diagram

4.5 Remote Access of Front Panel

The remote monitoring and control of the front panel is performed using web publishing tool and corresponding output had been shown in Fig.1.15

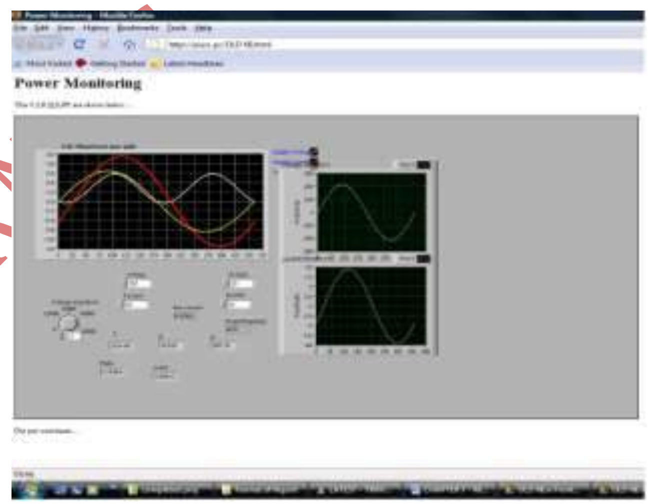


Fig. 1.15 Remote Front Panel Using Internet Explorer

5. CONCLUSION

The progress in science and technology is a perennial process. The existing technology for monitoring in panel board is found to be space consuming and not economical because of the high hardware cost. The proposed system developed for transformer protection and reactive power control is an efficient system, having used advancements like LabVIEW software and web communication. The system developed has reduced hardware costs by replacing hardware controller by that of software. And also in the project ineffective mode of communications (RF, power line communication) is replaced with web communication. The other added features are possibility of maintaining the history of data acquired already and user friendly interface for data analysis. The developed system performs the function of monitoring of all electrical quantities like power, power factor, voltage and current, also power factor improvement for enhancing power quality, voltage stability and harmonic reduction. The proposed system helps the process of protection of transformer indicating the abnormal conditions in transformer operation. Here thermocouple is used as a transducer for the purpose of monitoring the winding temperature. The future improvements for the project work shall be done by extending the system for remote monitoring and control for a complex power system network using client –server configuration, which includes many substations. Also up gradation can be done for automatic billing of power consumption of HT industries .The system was assumed to be balanced one and hence the analysis was carried out for the single phase system but in future improvement shall be made with respect to three phase system.

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