Design and Implementation of Remote Measurement System for Smart Plug Test-bed

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Abstract

This paper describes the development of remote measurement system for smart plug test-bed using the internet. Currently, various remote and virtual laboratories are introduced using the multimedia technologies but the Internet based remote test-bed using the electrical power measurement hardware system is not present. In this paper, we developed the remote electrical power measurement system for smart plug test-bed by combining the GPIB program which controls the hardware with the web programming which controls the internet. The high power load and programmable AC power source were considered as the measurement devices. The client program includes the user-interface and IP camera which carry out power measurement and report remotely. Several electrical measurements were set up to verify the test process. It has been found that the virtual measurements are feasible and valid.

Keywords: *remote measurement system, Smart plug test-bed, High power load, Programmable AC power source, GPIB*

1. Introduction

The technique of Internet and the remote virtual experiments have been applied in many fields for many years. In electrical and electronic measurement tests, the main problems are increase in instrument cost and complexity, and the limited budget for the equipment. The development of telecommunication and information technologies has opened new possibilities in realization of sharing in the field of measurement [1-2].

With the rapid progress of the microprocessor and communication technologies, more and more instrumentations can be reconfigured and controlled remotely. These new functionalities have been making remote training via Internet possible. New possibilities in the way test or laboratory exercises are performed include the simulation, the automated data acquisition and the remote control of instruments, all of which are online. Currently, there are two approaches to conducting measurements online, virtual and remote laboratories [3-4].

The virtual lab is based on software such as LabVIEW, Matlab/Simulink, Java Applet, Flash or other software to simulate the lab environment. Virtual laboratories can be used for experiments that would require equipments that are too expensive.

Remote laboratory, by definition, is an experiment which is conducted and controlled remotely through the Internet. The experiments use real components or instrumentation at a different location from where they are being controlled or conducted [5].

In this paper develops remote measurement system that performs electrical power test for smart plugs using the electrical load and programmable AC power source through the Internet. The result of this experiment shows the possibilities of remote measurement test-bed.

2. System Configuration

The server in the proposed system is connected to measurement instruments like high power electrical load and programmable AC power source. When users log in to server over the Internet, they are able to control the equipments. An IP camera can also be used to live broadcast what is happening in the smart plug test-bed. It does not matter if the user is in a nearby test-bed or on the other side of the world. To achieve that mentioned above, a client-server environment was designed, as shown in Figure 1.

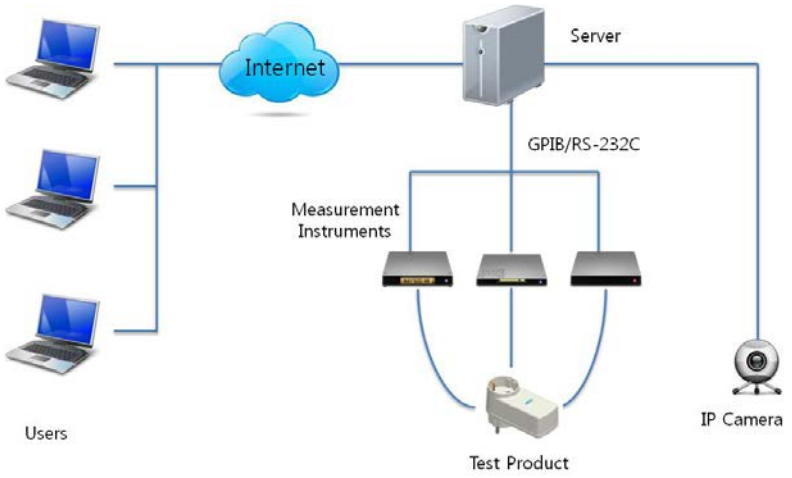


Figure 1. System Configuration

2.1. Server System

The network configuration and control flow of server/client system appears in Figure 2. The server system is composed of a web server, and a control program. The web server carries out communication with user to log in and to reserve schedules as shown in Figure 3. On the Web page, user launches client program that ask the control server to send a command to the instruments. The control program is made up MFC as its front end for control with measurement instruments through GPIB/RS-232C as shown in Figure 4 and communication with client program through the Internet. An IP camera (SONY SNC-P5 Network Camera) is attached to experiment set-up.

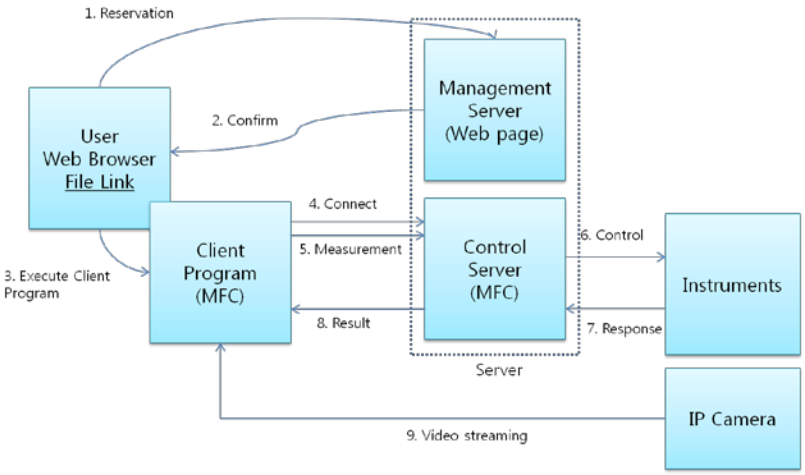
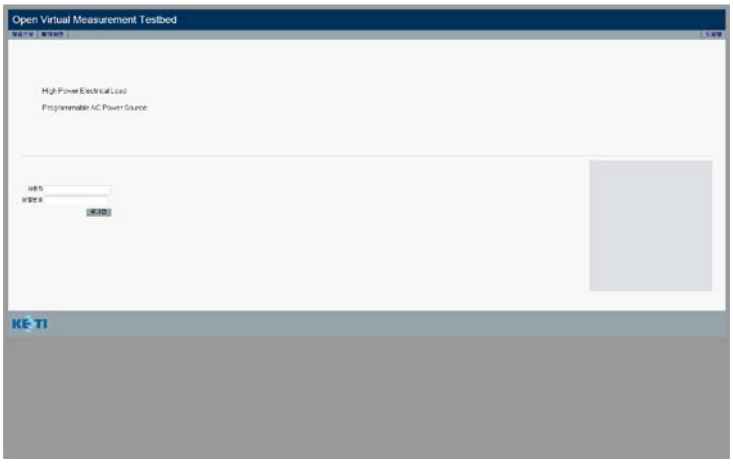
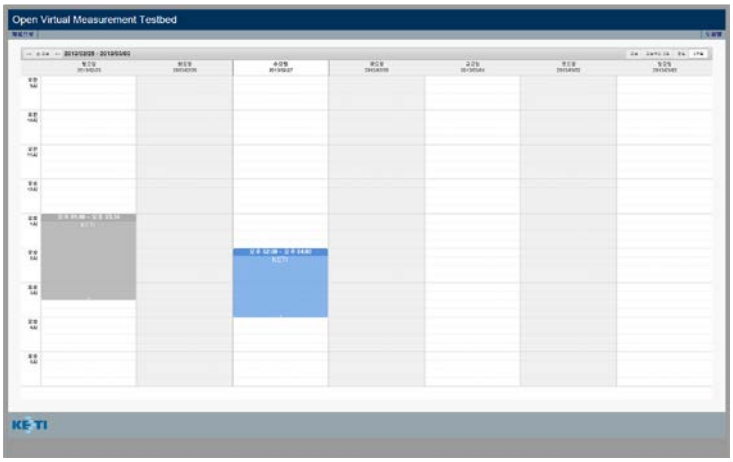


Figure 2. Control Flow



(a) Main page



(b) Reservation Page

Figure 3. Management Server Web Page

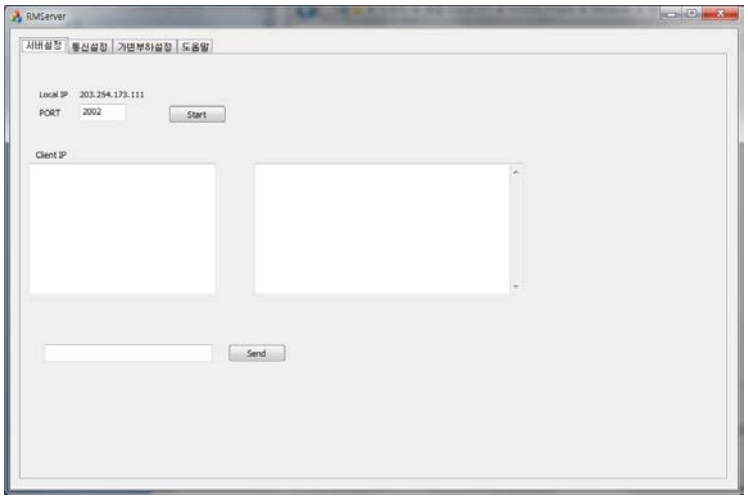
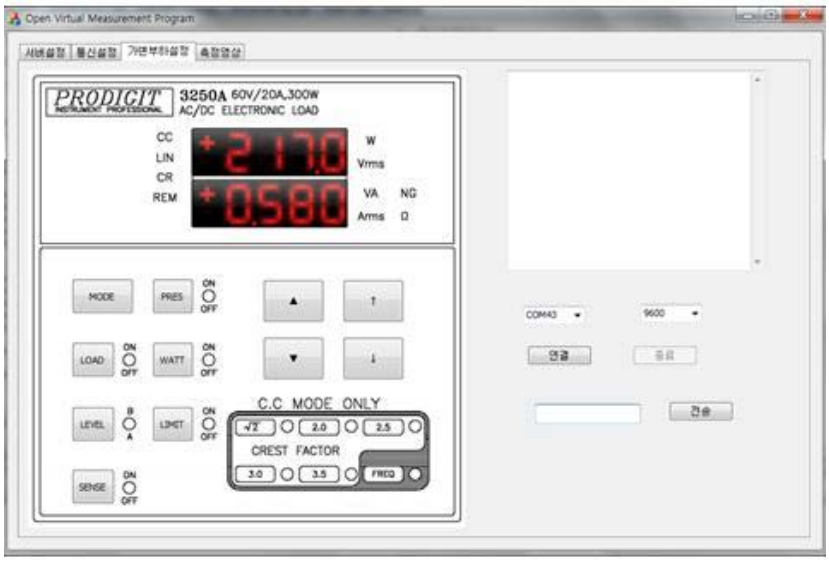


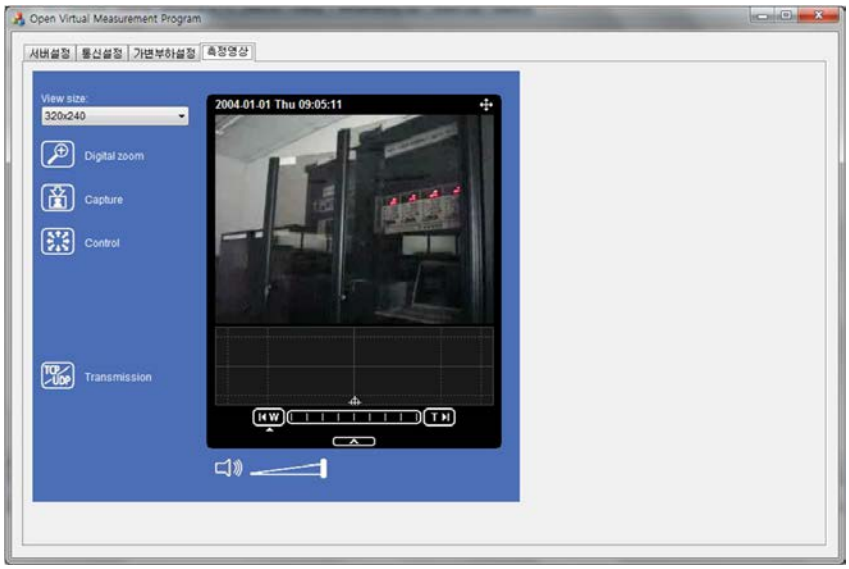
Figure 4. Control Server Program

2.2. Client System

When the client application links to the management server through the Internet, it transfers authentication code. Upon validation, the control server transfers control commands, measurement data, and control status using client program as shown in Figure 5. The user can change video display and camera position using pan/tilt/zoom interfaces of IP camera.



(a) Control panel



(b) IP camera panel

Figure 5. Client Program

2.3. Measurement Instruments

The High Power Electronic Load (PRODIGIT Electronics Co. Ltd., 3250A) is used for evaluation of the specification characteristics of AD/DC high power suppliers and the service life characteristics of batteries. It can be used to work with GPIB/RS-232C interfaces [6].

The Programmable AC Power Source (EXTECH Electronics Co. Ltd., 6600) is very useful for performance evaluation of electrical and electronics equipments in non-ideal conditions of the ac power system. The power source has comprehensive measurement of voltage, frequency, current, power and power factor. It also provides GPIB/RS-232C interfaces [7].

(a) High power electrical load

(b) Programmable AC power source

Figure 6. System Configuration

3. Experiments

Figure 7 illustrates the measurement set-up of smart plug test-bed. The measurement test sample is smart plug as show in Figure 8 [8].

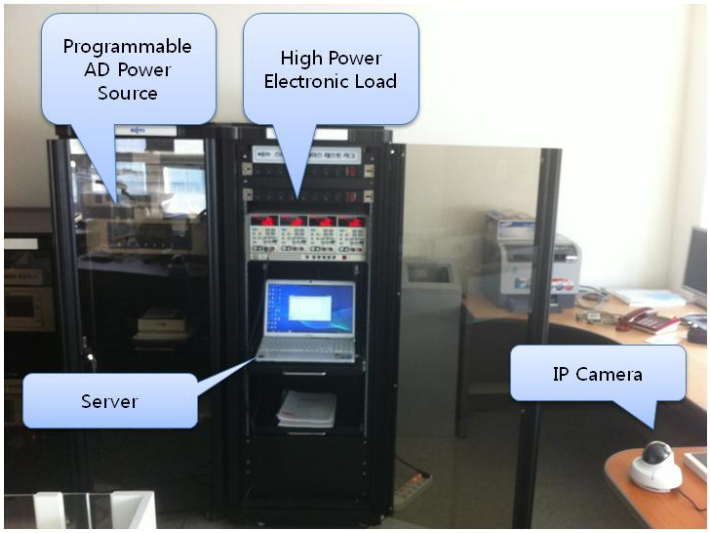


Figure 7. Experimental Set-up

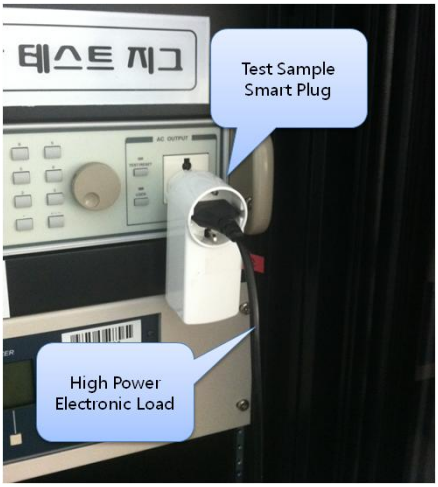


Figure 8. Test Sample

Figure 9 and Figure 10 illustrate scatter plots of the relationship between measured current from instruments and smart plug that send current data through 2.4 GHz RF network. The data is fitted to a linear polynomial using a least square method.

Each curve was fitted using a Matlab program (curve fitting toolbox) to obtain regression functions. Curve fit techniques are typically used where the underlying relations are generally known but too complicated to model in detail and the function is easily measured. These types of curves are generally considered to be empirical models. Statistical data regressions are performed to fit the measured data to mathematical equations.

The low range (0~1A) and high range (1~15A) models produced determination coefficients (R^2) are 0.9994 and 0.998 respectively.

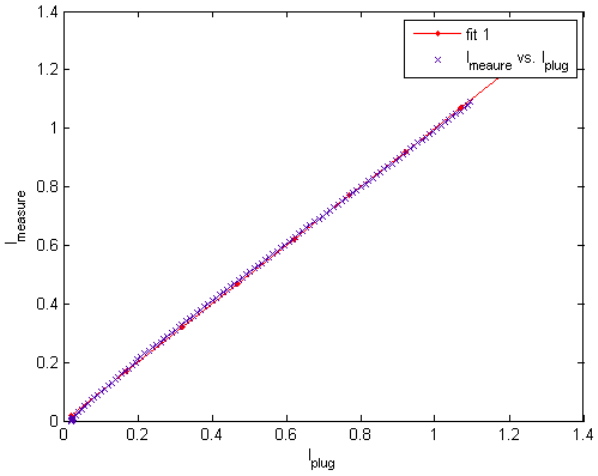


Figure 9. Low Range Current Model

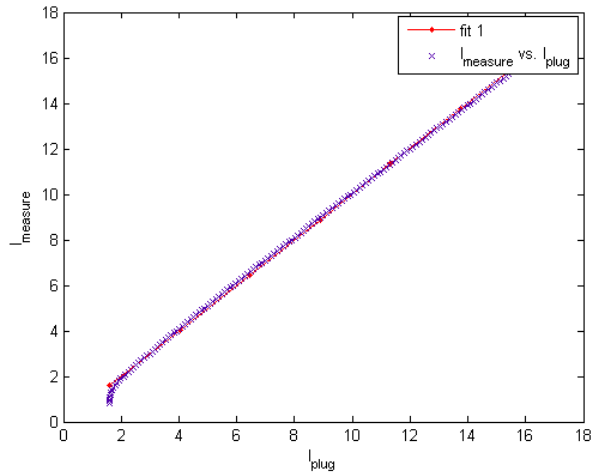


Figure 10. High Range Current Model

4. Conclusion

A methodology has been developed and demonstrated for electrical power test that is based on the electrical load and programmable AC power source through the Internet. To implement remote measurement system for smart plug test-bed, the server-client interface program was designed. Remote users can control the real instrument and view the real time result of experiment at the same time. The results showed that the proposed method can verify the current consumption.

Acknowledgments

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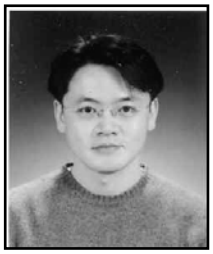

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