Internet-Based ON/OFF Controller Using LabVIEW

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Abstract

This paper presents the development and implementation of an Internet-based remote ON/OFF control experiment in real-time using the DataSocket communication protocol in LabVIEW. The designed experiment is connected to the server computer using a Data Acquisition (DAQ) board. The objective of this experiment is to maintain the temperature inside a wooden box that is heated by a light bulb at some desired set-point value, which is selected by a remote client. The temperature is measured using a solid-state temperature sensor circuit connected to the DAQ board. When the temperature differs from the set-point value (with ± neutral zone), it results in the high-limit and the low-limit, and the controller turns a fan ON or OFF accordingly. The software for both the client and server computers is developed using DataSocket protocol in LabVIEW. The remote clients can monitor the temperature and control the set-point. The experiment is successfully used in the Electronics and Computer Technology (ECT) program's process control courses at the Bowling Green State University (BGSU).

I. Introduction

In the academic and industrial communities, remote real-time control of processes is receiving considerable attention. Various technologies are developed to perform the remote real-time control using Internet-based technology. LabVIEW is one of the well-known software packages used in process control applications [1]. LabVIEW uses various protocols such as TCP/IP, DataSocket, etc. that allow remote control using Internet. This paper describes real-time ON/OFF control [2] of a temperature-control experiment remotely using the DataSocket communication protocol in LabVIEW for a distance education laboratory.

Several universities have developed Internet-based process control laboratories for distance education using LabVIEW and its communication protocols. Researchers at the Fort valley State University studied LabVIEW's Internet capabilities [3]. The research identified the advantages and disadvantages of this technology [3]. A remote web-based engineering laboratory was developed at Drexel University, where every workstation has accessibility and controllability

over the Internet. The faculty at the Drexel University used LabVIEW Internet Development Toolkit (IDT) [4]. Students and faculty at the University of Tennessee at Chattanooga developed web-Based engineering laboratory using a unique site on a server that allows all users to remotely control any of their experiments over the Internet [5]. The University of Florida has also developed an on-line engineering laboratory for real-time control over the Internet, using the Virtual Instruments (VI) in LabVIEW [6]. The faculty at the University of Houston developed virtual labs in their engineering and engineering technology programs. These labs provided opportunities for non-traditional students to perform their laboratory experiments on-line [7]. Hakes and his colleagues developed an on-line analog signal-processing laboratory using LabVIEW's DataSocket protocol for remote control access [8]. Overstreet and Tzes have designed a generic virtual instrument that can be used for real time experimentation purposes at Polytechnic Universities control engineering laboratory in a remote access environment [9]. Using LabVIEW DataSocket protocol Cooney and Shiver controlled a robot remotely [10]. Another approach to web-based distance real-time control is developed at New Jersey Institute of Technology using the LabVIEW/DataSocket method [11]. To create DataSocket client Web page, the ActiveX and Visual Basic Codes were used in their approach. Peter Idowu developed an Internet-based electrical power and machinery laboratory at Penn State University [12]. Leonard Sokoloff [13] described an ON/OFF controller implementation using LabVIEW that uses two analog input channel of the DAQ board. Remote control using Internet is not implemented in that paper. In contrast, the ON/OFF controller presented in this paper uses only one analog input channel, and also adds the remote control feature using DataSocket protocol in LabVIEW [14].

The objective of this experiment is to maintain the temperature inside a wooden box that is heated by a light bulb at some desired set-point value, which is selected by a remote client. The designed experiment is connected to the server computer using a DAQ board. When the temperature crosses the neutral zone, the controller turns a fan ON or OFF accordingly. The hardware of the experiment is described in Section II. The software aspects of the experiment are discussed in Section III. Concluding remarks are offered in Section IV. The experiment is successfully designed, developed and used in process control courses offered by the Electronics and Computer Technology program at the Bowling Green State University.

II. Hardware for Remote ON/OFF Control Experiment

Figure 1 shows a general setup for the experiment. The hardware for server workstation consists of a PC with Pentium III, 550 MHz processor, 128 Mb RAM, Network Interface Card (NIC), National Instruments DAQ board. The server software includes Windows 98, NI-DAQ driver, LabVIEW 5.1 and NI-DataSocket Manager. The designed experiment is connected to the DAQ board. The server is connected to the BGSupernet, the Internet for the Bowling Green State University. The server is assigned static IP address. The clients could be any PC's with NIC that can run a LabVIEW program.

The objective of the experiment is to maintain the temperature inside a wooden box at some desired set-point value, within neutral zone limits, using a two-state-controller mode. The wooden box is heated with a light bulb. The temperature is measured using LM335 solid-state

temperature sensor based circuit, which gives 1mV/°F. A signal conditioner is designed to modify the voltage corresponding to 0 to 120 °F to DAQ board voltage range of -10 V to +10 V. The output of the signal conditioner circuit is connected to an analog input channel of the DAQ board. The proposed ON/OFF controller method uses only one analog input channel, which is in contrast with Sokoloff's [13] method where two analog input channels were used. When the temperature differs from the set-point value (with ± neutral zone), it results in the high-limit and the low-limit, and a fan is turned on and off accordingly. The digital output port of the data acquisition board is connected to the solid-state relay (SSR) that controls the operation of the fan. Figure 2 gives a schematic diagram of this experiment.
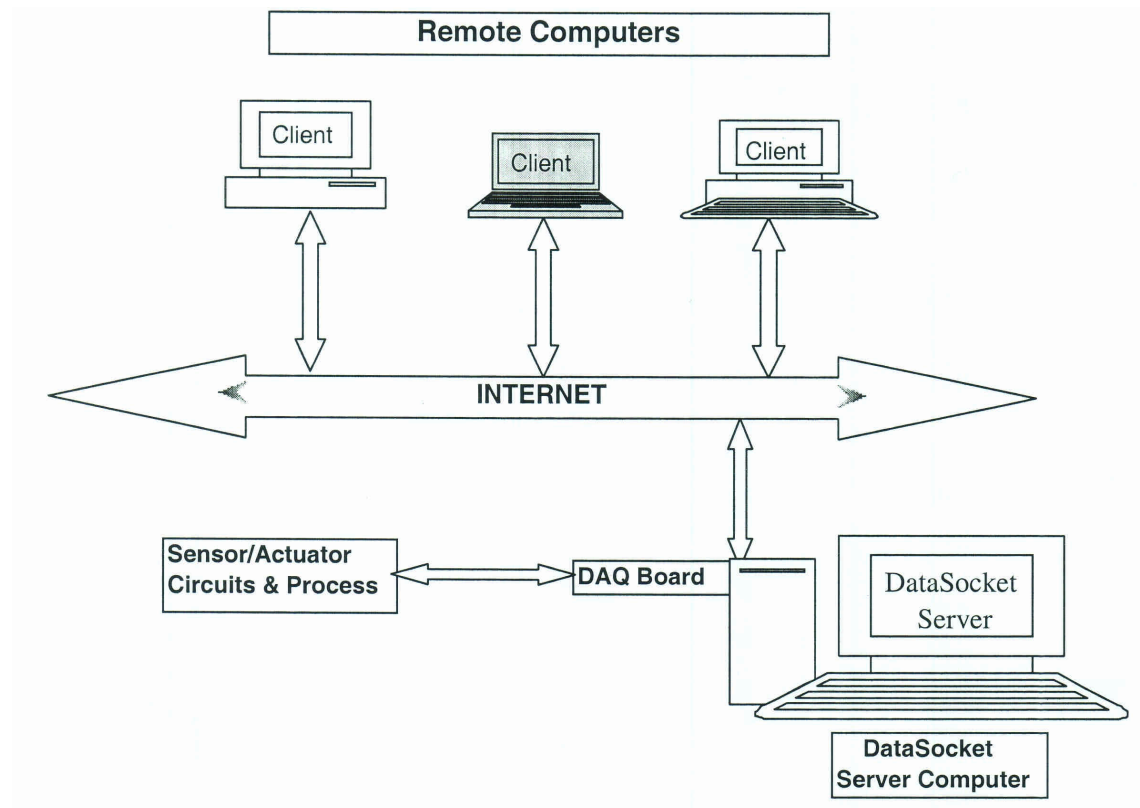

Figure 1. General Experimental Setup

III. Software for Remote ON/OFF Control Experiment

The software for the Remote ON/OFF controller lab experiment is developed using LabVIEW. There are two distinct parts in the software:

    1. ON/OFF controller server program and logic
    2. Internet communication using DataSocket protocol

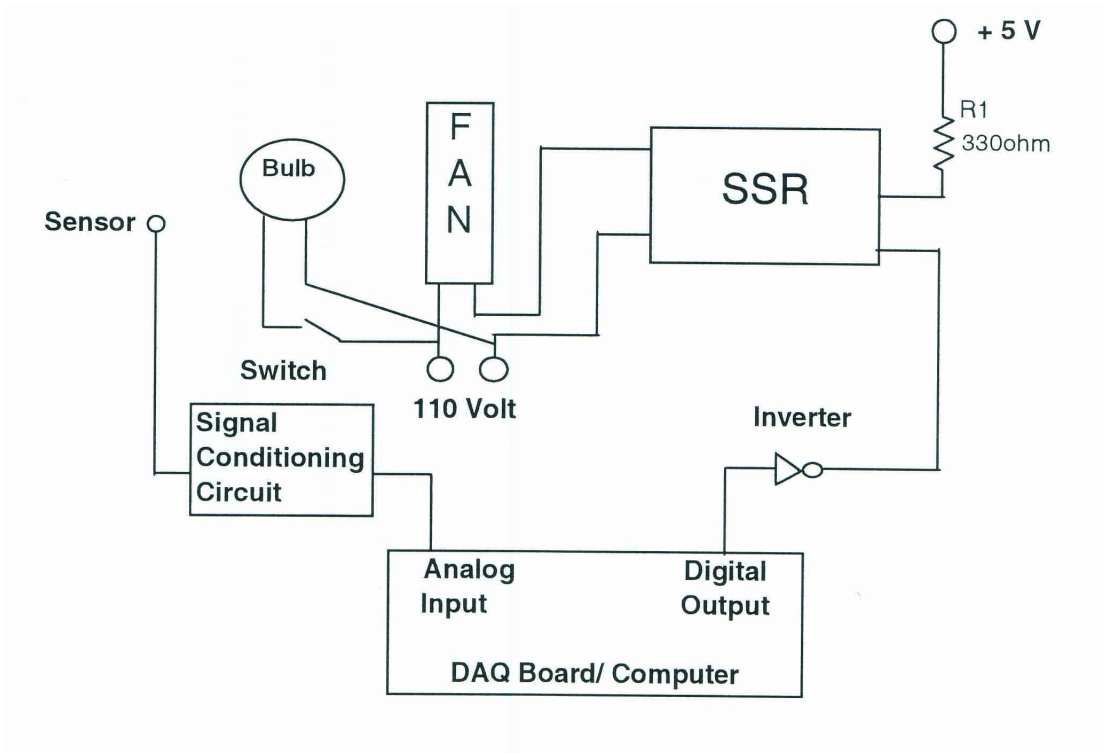These parts will be explained in the following sections.

Figure 2. Schematic Diagram of the Temperature Control Experiment

III.1 ON/OFF Controller Server Program and Logic

The LabVIEW program on the server first reads the voltage from the analog input channel of the DAQ board and converts it to a temperature using the equation

$$T_{out} = 6\ V_{in} + 60,$$

where T_{out} is the process temperature, and V_{in} is the input voltage from the DAQ board. The desired Set-point temperature value of the process is obtained from the client computer, and the Error is determined using the equation

$$Error = Set\text{-}point - T_{out}.$$

Based on the error and neutral zone High Limit and Low Limit, an ON/OFF controller logic is implemented using LabVIEW. In this logic, Digital Output Channel is the output logic value sent to the DAQ board which controls the fan through the SSR, Cooling Fan Indicators are the LED ON/OFF indicators on the front panel of the LabVIEW VI that show the state of the fan, and Within Limits Indicator shows if the process is operating within the neutral zone. The Cooling Fan ON Indicator is also defined as a local read only variable which is used in the logic implementation. The LabVIEW front panel of the server program VI is shown in Figure 3, and the logic of the program follows:
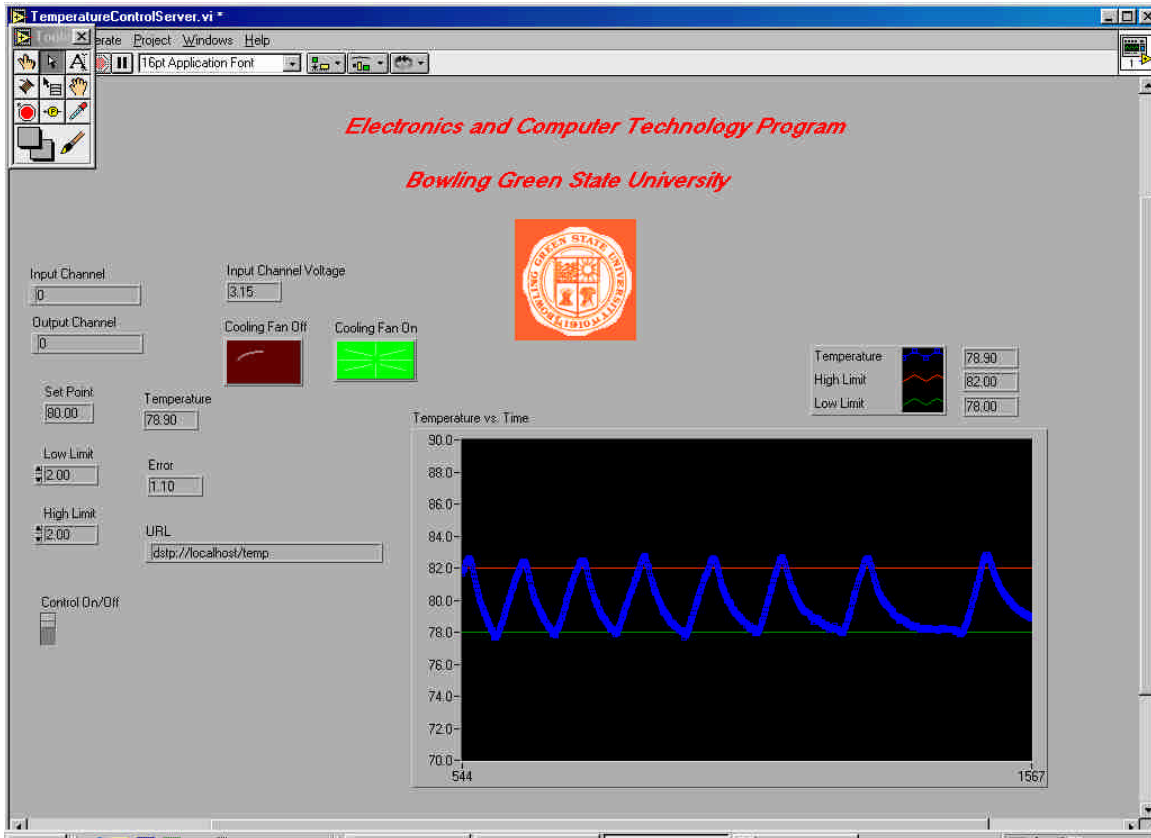
Figure 3. Server Front Panel

Case 1
Test condition:

        Error ≥ 0

        AND

        $T_{out} \leq$ Set-point – Low Limit

                True situation: Assign the following values to the variables

                        Digital Output Channel: False

                        Cooling Fan ON Indicator: False

                        Cooling Fan OFF Indicator: NOT False (Inverted)

                        Within Limits Indicator: False

              False Situation: Go to next Case

Case2
Test condition:

        $T_{out} \geq$ Set-point – Low Limit

        AND

        $T_{out} \leq$ Set-point + High Limit

        AND

        Cooling Fan ON

                True situation: Assign the following values to the variables

                        Digital Output Channel: True

Cooling Fan ON Indicator: True
Cooling FAN OFF Indicator: NOT True
Within Limits Indicator: True
False situation: Go to next Case

Case 3
Test condition:
$T_{out} \geq$ Set-point + High Limit
AND
Error ≤ 0
True Situation: Assign the following values to the variables
Digital Output Channel: True
Cooling Fan ON Indicator: True
Cooling Fan OFF Indicator: NOT True
Within Limits Indicator: False
False situation: Assign the following values to the variables
Digital Output Indicator: False
Cooling Fan ON Indicator: False
Cooling Fan OFF Indicator: NOT False
Within Limits indicator: True

III.2 Internet Communication using DataSocket Protocol

DataSocket is a communication protocol in LabVIEW. It permits reading, writing, and sharing of live data between applications and/or different data sources and destinations. DataSocket uses an URL format similar to http, which is called dstp (DataSocket Transfer Protocol). Dstp allows two way communications and data exchange between applications. This protocol is used in both server and client applications. LabVIEW has several built-in SubVIs that can be used within DataSocket programming. These SubVIs include DataSocket Open Connection, DataSocket Close Connection, DataSocket Read Double and DataSocket Write Double. DataSocket Server Manager application program allows the user to configure security options such as which systems have permission to write, create, and read data on the DataSocket Server.

Server DataSocket Program Implementation

The DataSocket protocol based program in the server computer opens bi-directional communication using DataSocket Open Connection subVI. The URL of the server is selected as "dstp://localhost/file_name." The server receives set point information from the client as a double precision value. The server sends the process temperature and neutral zone limits as double precision values to the clients. At any given time only one client can control the process remotely, on the basis of the first who logs into the server to control the process. However, many clients can simultaneously monitor the experiment remotely. The analog input channel and the digital output channel numbers are set from the server front panel. The Low-Limit and the High-Limit of the temperature control neutral zone are also set from the server front panel. The client controls the set-point on the server. The LabVIEW front panel of the server program VI is shown in Figure 3.

Client DataSocket Program Implementaion

The client computer also opens bi-directional communication using DataSocket Open Connection subVI. The URL of the server is selected as "dstp://ip_address of server/file_name." This URL allows connection between clients and the server using DataSocket protocol to process the information. The client sends set-point information to the server as a double precision value. The server sends the process temperature and neutral zone limits as double precision values to the clients, which are plotted on a graph on the clients' computers. The DataSocket connection is closed using the DataSocket Close Connection subVI. Figure 4 shows the client's LabVIEW program VI.
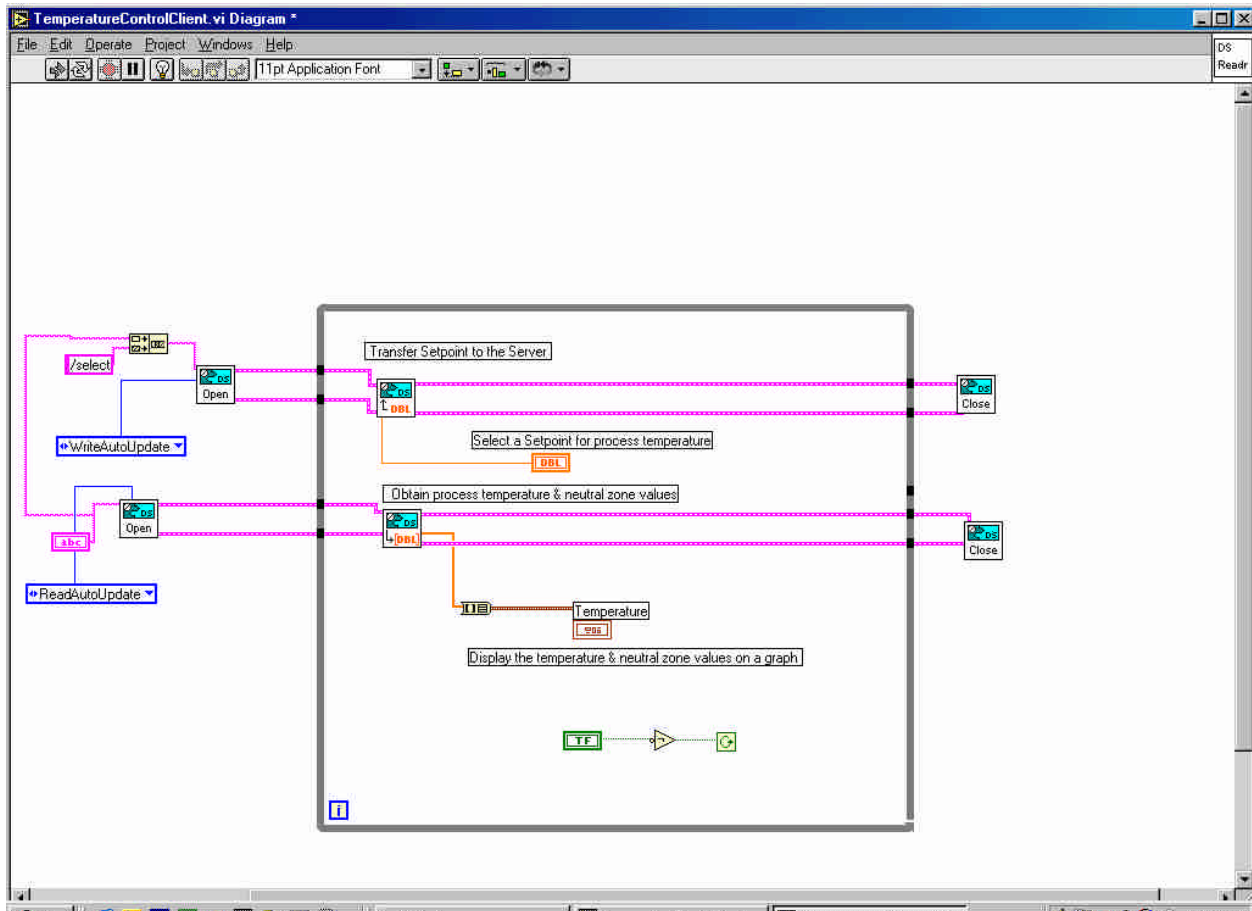

Figure 4. Client LabVIEW Program VI

IV. Conclusions

The overall purpose of this paper is to develop an Internet-based experiment to monitor and control a real-time process remotely. The studies concentrated on the development and setup of an ON/OFF controller for a temperature control process using DataSocket protocol in LabVIEW. The experiment was successfully tested in the ECT program's process control courses at the Bowling Green State University. This remote real-time monitoring and control capability will provide the ECT program an opportunity to include process control experiments in distance

learning classes, and successfully utilize the University's recent investment in the BGsupernet infrastructure.

Acknowledgements

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Biographical Information

Edwin Rézaei completed his Master of Industrial Technology degree at Bowling Green State University, Ohio, in August 2002. He also received his B.S. in Electronics and Computer Technology at Bowling Green State University, Ohio, in May 1999. His academic interests are in the area of control systems, computer networking, and communication systems. He is a member of ISA.

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