Implementation of ON/OFF and PID controller using TCP Protocol Based on Virtual Instrumentation

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Abstract

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is the software which gives virtual existence of hardware, reduces its cost and hence termed as Virtual Instrumentation. This paper deals with the implementation of ON/OFF and PID controller for controlling the temperature of a heating element inside a wooden box with the help of LabVIEW. In this software, Transmission Control Protocol (TCP) is used for developing an online transmission process between client and server. Client has control over the set point and Server has control over the temperature. In hardware section, a Data Acquisition (DAQ) card reads temperature from sensor and delivers to Server. With the help of internet protocol, client provides the value of set point according to which the control actions are taken by the server. The paper also includes discussions regarding the advantages and disadvantages of TCP/IP.

Keywords

Data Acquisition, ON/OFF, PID, TCP/IP, LabVIEW

1. Introduction

The basic controllers used to control a process variable at its set point are ON/OFF, P, PI, PID and PID fuzzy. There are various networking protocols used in LabVIEW such as DS (DataSocket Protocol), TCP (Transmission Control Protocol), and UDP (User Datagram Protocol) which provides online facilities to the users. These are the basic tools for communication over internet.

In 2007, S. Murthy, et al. [1] described in their paper about protocols and the way these protocols help in improving networking capabilities of many measurement and automation applications. LabVIEW encourages such protocols in control applications. In 2003, E. Rézaei, et al. [2] and in 2009, K. Prerna, et al. [3] proposed a system where the temperature of a bulb inside a wooden box is controlled by using ON/OFF controller, with the help of DS Protocol and also developed the algorithm. In 2011, R. Dutta, et al. [4] proposed a system where the temperature of a set of light bulbs inside a wooden box is controlled using DS Protocol and digital temperature sensor. In 2011, A.O. Neaga, et al. [5] proposed a system to control liquid nitrogen to its set point using ON/OFF controller, but there are certain defects in the control loop. In 2011, S.K. Sahoo, et al. [6] described about PI-PID controller in order to control the speed of DC motors using various algorithms. In 2009, J. Liu, et al. [7], described about various PID algorithms to control position of a DC motor using (Data Acquisition) DAQ. In 2012, Y. Li, et al. [8] discussed about vulnerabilities of TCP/IP by exposing it to attacks. In 2011, J.H. Zhang, et al. [9] proposed an acquisition diagnostic system for remote ground equipment using LabVIEW.

The objective of this paper is to measure and control the temperature of a heating element inside a box. This is performed by using LabVIEW (Laboratory Virtual Instrument Engineering Workbench) software, by developing a "Client" and a "Server". They communicate using TCP/IP, Server controls the temperature using ON/OFF and PID controller. Client has an option to decide the set point.

Rest of the paper is organized as; the Proposed System is discussed in Section 2. Algorithm of the controllers is described in Section 3. The simulation results along with discussions on it are presented in Section 4. More details about the TCP/IP protocol are discussed in Section 5. The paper is concluded in Section 6.

2. Proposed System

The main objective of this is to maintain the temperature inside a wooden box which is heated

by a heating element i.e. a bulb, at some desired value of set point which is selected by Client. Figure 1 shows the block diagram of Proposed System. The heating element is covered by a wooden box and on heating; the temperature is sensed by temperature sensor and is transmitted to the server PC with the help of DAQ card. Since, the output of sensor is in voltage form, the server PC converts it to temperature using Equation 1.

$$PV = 6. Vin + 60 \qquad (1)$$

Where, PV is Process Variable

Vin is voltage measured by sensor

This value of temperature i.e. process variable (PV) is sent to client PC. The client PC on receiving PV sends set point (SP) value to the server PC. Depending upon the SP, ON/OFF and PID controller take necessary actions. The actions are in the form of signals that control the operation of fan. When the temperature crosses the neutral zone, controller turns a fan ON or OFF accordingly. Neutral zone is the zone bounded by low and high limit.
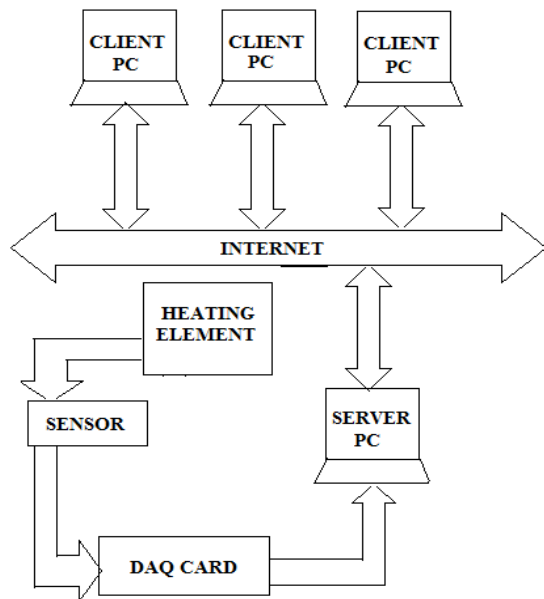

Figure1. Block Diagram of the Proposed System.

3. Algorithm

The flow chart of the proposed system is shown in Figure 2. Equation 2 is used by Server in order to find error,

$$Error = Set Point- Process variable \qquad (2)$$

After the calculation of error the temperature is controlled by two ways. The algorithms for these two controllers are discussed in following two sub-sections respectively.
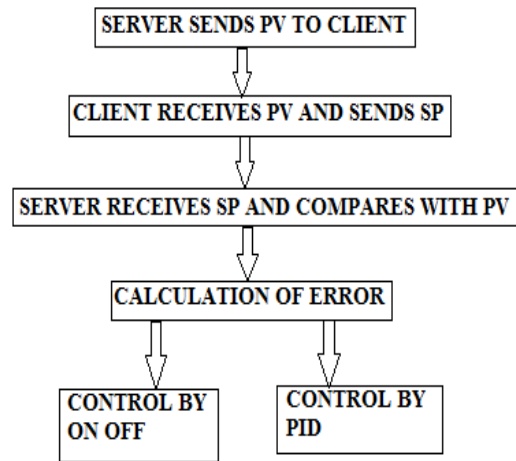

Figure 2. Flow chart of proposed system.

Algorithm for ON/OFF controller:

The logic behind the implementation of the controller is described as,
1. The calculated error is compared with upper limit and lower limit.

2. Accordingly, the indicators show the state and action has been taken. The state is seen through the "Within Limit" and "Out of Limit" indicator. The control action has been implemented by using a fan in order to control the temperature. So the "Fan ON" and "Fan OFF" indicators show the control action to be taken.

3. The comparison has been done with three conditions.
A). If Error > 0 AND PV > Low Limit then the indicators states are:
    Cooling Fan ON: OFF
    Cooling Fan OFF: ON
    Within Limit: ON
    Out of Limit: OFF
    If condition is not satisfied, then the indicators states are:
    Cooling Fan ON: ON
    Cooling Fan OFF: OFF
    Within Limit: OFF
    Out of Limit: ON

B). If Error < 0 AND Tout< High Limit, then the indicators states are:

Cooling Fan ON: ON
Cooling Fan OFF: OFF
Within Limit: ON
Out of Limit: OFF
If condition is not satisfied, then the indicators
states are:
Cooling Fan ON: OFF
Cooling Fan OFF: ON
Within Limit: OFF
Out of Limit: ON
C). If Error = 0 then the indicators states are:
Cooling Fan ON: OFF
Cooling Fan OFF: OFF
Within Limit: ON
Out of Limit: OFF
If condition is not satisfied, then the indicators
states are,
Cooling Fan ON: OFF
Cooling Fan OFF: ON
Within Limit: OFF
Out of Limit: ON

Algorithm for PID controller:

Using the following steps, manually the PID tuning
parameters has been set and the output response is
obtained.

1. First T_i and T_d values has been set to zero.

2. K_c has been increased until the output of the loop
oscillates.

3. K_c has been set to approximately half of that value
for a "quarter amplitude decay" type response.

4. T_i has been increased until any offset is corrected
for the process.

5. K_c has been increased if required but too
much K_c causes excessive response and overshoot.

4. Results and Discussion

In LabVIEW the front panel shows only the inputs
and the outputs. The main programming part is
presented in the block diagram. The front panel of the
ON/OFF controller server is shown in Figure 3 and
the block diagram is shown in Figure 4.In this case,
the value of PV is greater than SP, the calculated
error is positive and hence the "fan OFF" indicator is
turned ON. Since PV is less than the high limit, the
"within limits" indicator is turned ON while the rest
two indicators remain OFF. The TCP/IP icons can be

seen in the block diagram. The detailed description
about these icons is mentioned in Section 5. The port
address is 2055 which is given as input to the TCP
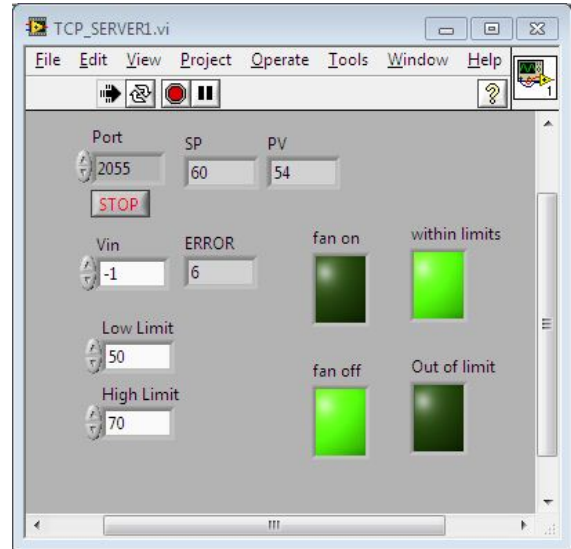OPEN CONNECTION in Client side and as input to
TCP LISTEN icon in Server side.

Figure 3. Front Panel of ON/OFF controller Server.
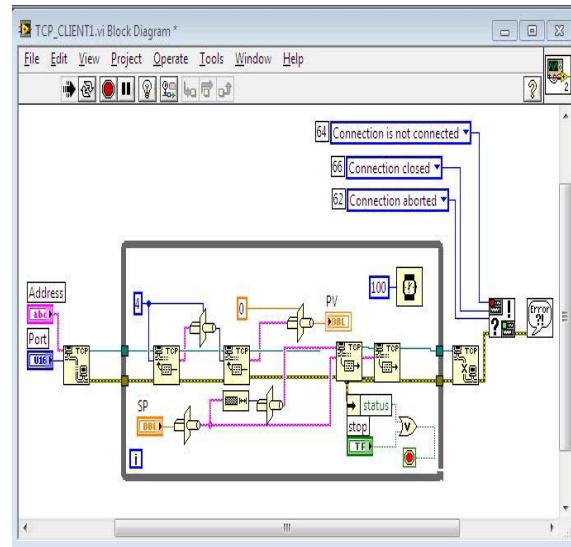

Figure 4. Block Diagram of ON/OFF controller Client.

The front panel of the PID controller server using
TCP protocol is shown in Figure 5 where the set
point is set to 60. The front panel of PID controller
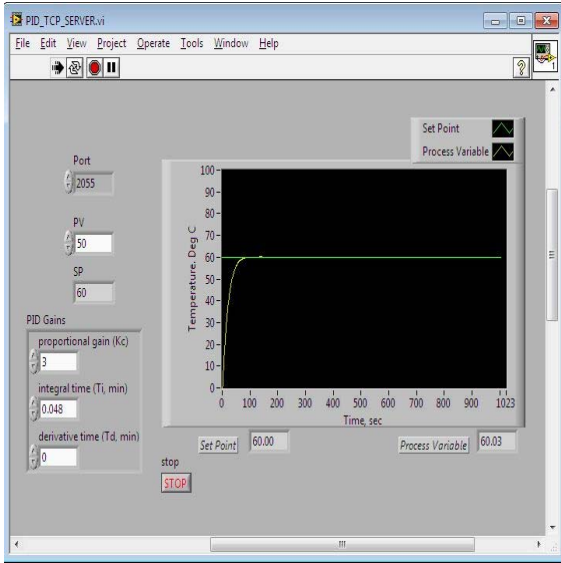client is shown in Figure 6.

Figure 5. Front Panel of PID controller Server.

In this case, also the PV value is sent to the client and the client sets the SP. This is the manual tuning results where the values of tuning parameters of PID controller, K_c, T_i and T_d has been tuned to 3, 0.048 and 0 respectively.
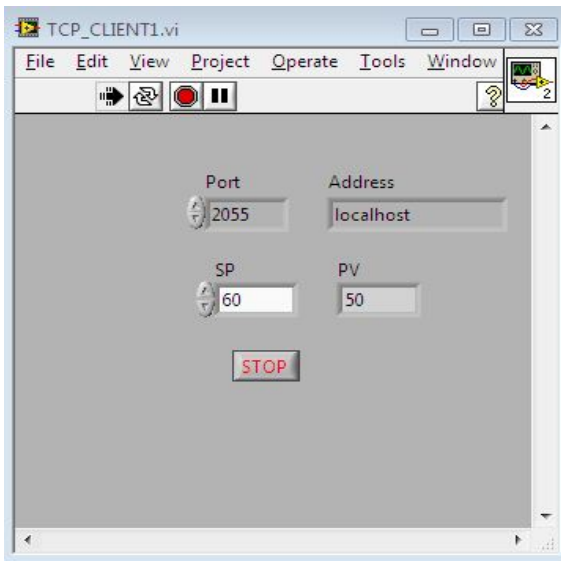

Figure 6. Front Panel of PID controller Client.

The graph obtained in the front panel of server is shown in Figure 7. It is clearly seen that the PV is controlled to its SP value with less time.
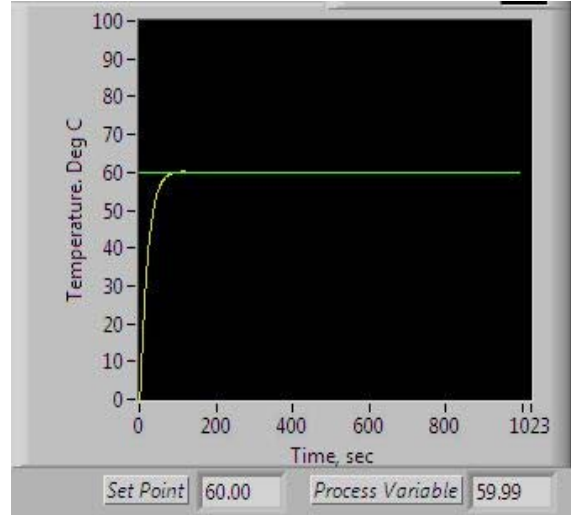

Figure 7. Graph of PID controller.

5. Communication through Internet using TCP/IP

TCP allows to setup data communication between virtual instruments on a network using internet protocol addresses and port numbers. The Advantages of TCP/IP is that it allows variable length messages which help the clients to initiate the transfer of information, data is buffered by receiver and servers can be developed wherever it is necessary. The Disadvantage of TCP/IP is that it is very complicated to setup.

For Client PC

In Client PC, "TCP OPEN CONNECTION" has been called with the IP Number, the port number that has been connected with a suitable timeout. For "TCP WRITE", a string and CONNECTION ID has been provided that is obtained from "TCP OPEN CONNECTION". The SP that is in integer format has been converted to string by using typecast. "TCP READ" has been called and is provided with the connection id (obtained from TCP OPEN CONNECTION), a mode, and a number of bytes to read. When transmission is over, "TCP CLOSE CONNECTION" has been called.

For Server PC

"TCP CREATE LISTENER" has been called and this provides a listener id. In a while loop; "TCP LISTENER" has been called using the listener id that is just obtained. When a connection comes in, the

"LISTENER" function has returned without an error. "TCP READ" and "TCP WRITE" has been called. When transmission is over, "TCP CLOSE CONNECTION" has been called, and the loop is repeated, to wait for another connection to come in.

6. Conclusion

PID controller response is faster and stable than ON/OFF controller. Basing on the operation, ON/OFF controller is more simple and easy to program than PID controller. Using TCP/IP, the online operation becomes easier for remote clients and server. ON/OFF controller does not work properly all the time since it goes for force error correction. PID controller eliminates the temperature error by increasing the correcting output. The work can be extended by using Fuzzy PID controllers. Online communication can be extended by using FTP (File Transfer Protocol), e-mails, etc.

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