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Process Instrumentation Made Easy Using LabVIEW and Soft PID

Dr. Neelima Iyer[1], Pooja Pawar[2], Nagappa Karaganagi[3], Umesh Borole[4], Gaurav Bandal[5]

Sr. Principal Scientist and Chair, Instrumentation & Communication Unit, CSIR- National Chemical Laboratory, (NCL), Pune, India

Project Student, Department of E & TC, Instrumentation & Communication Unit, NCL, Pune, India

Assistant Professor, Department of Instrumentation & Control Engineering, Government College of Engineering & Research, Awasari (Kd), (GCOEARA) Pune, India

Sponsored Final year Students, Department of Instrumentation & Control Engineering, GCOEARA, Pune, India

ABSTRACT: With the development and popularization of computer technology, digitizer is replacing analog device gradually. The measurement and control technology plays an important role in the process of production. As the time going, the traditional instruments are appearing the shortages. It becomes necessary to improve traditional instruments. The aim of our paper is to replace the traditional PID instrument with virtual, soft PID that has same controlling capabilities as that of traditional instrument. This designing is possible using LabVIEW – proprietary development by National Instruments (NI). NI PC add on DAQ card is used for interfacing with the hardware.

KEYWORDS: PID, LabVIEW, simulation, control, industry, real time.

I. INTRODUCTION

A typical Process Instrumentation, four parameters are important – flow, temperature, pressure and level. To control these parameters PID controllers are used. The PID controller means Proportional Integral Derivative Controller used in many industries to compensate the tracking errors occurred in the various processes. PID controllers are used in control systems which are being used in the automated processes in industries. The job of a typical control system is to maintain something that is variable or changeable in a prescribed state. PID controllers are manufactured by Honeywell Experion, Emerson – Delta V, Foxboro, Yokogawa, GEFRAN etc. The operation of PID controller used in process is as per programming done. Language of PID controller and programming differs from manufacturer to manufacturer. Engineer trained for a particular Process Instrumentation application using PID from say Honeywell can not immediately adopt the operation of say Yokogawa PID. PID controller tuning is done by various methods i.e. Ziegler-Nichols, Cohen-coon, Lambda tuning etc. PID controller tuning for Honeywell and Emerson is done by controller gain (Kc) and for Yokogawa & Foxboro is done by proportional band. PID configured and programmed for a particular process can not be immediately reconfigured for another process. If there is a problem with hard PID, rectifying problem and sometimes ordering the same new PID takes lot of time. All these problems can be solved by using Soft PID using LabVIEW as mentioned below.

II. RELATED WORK

1. PID THEORY

The “P” stands for proportional control, “I” for integral control and “D” for derivative control. This is also what is called a three term controller. The basic function of a controller is to execute an algorithm based on the control engineer's input the operators desired set point value and the current plant process value. In most cases, the requirement

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is for the controller to act so that the process value is as close to the set point as possible. In a basic process control loop, the control engineer utilizes the PID algorithms to achieve this.

A. Proportional action :-

The proportional mode alone is simplest of the three. It characterized based on continuous linear relationship between controller input and output. It is also known as correspondence control, droop control and modulating control. The adjustable parameter of the proportional mode, Kc, is called as proportional gain. It simply amplifies the error based upon the gain. P mode generates offset. The proportional action responds to error in one to one correspondence.

B. Integral action :-

The integral mode sometimes used as single mode controller but is commonly found in combination with proportional mode. However, integral controller alone can not be used due to integral wind up problem. The adjustable parameter associated with integral mode is integral time Ti, or reset rate 1/Ti. The integral term magnifies the effect of long-term steady-state errors, applying ever-increasing effort until they reduce to zero.

C. Derivative action:-

The derivative mode of control is also called as rate control or preact control because its output is based on rate of change of input variable. This control is never used alone and commonly found in combination with proportional control because output of this mode alone would be zero for constant value of input.

III. VIRTUAL INSTRUMENTATION VERSUS TRADITIONAL INSTRUMENTATION

Virtual instruments are defined by the user while traditional instruments have fixed vendor-defined functionality. Every virtual instrument consists of two parts – software and hardware. A virtual instrument typically has a sticker price comparable to and many times less than a similar traditional instrument for the current measurement task. However, the savings compound over time, because virtual instruments are much more flexible when changing measurement tasks. By not using vendor-defined, prepackaged software and hardware, engineers and scientists get maximum user-defined flexibility. A traditional instrument provides them with all software and measurement circuitry packaged into a product with a finite list of fixed-functionality using the instrument front panel. A virtual instrument provides all the software and hardware needed to accomplish the measurement or control task. In addition, with a virtual instrument, engineers and scientists can customize the acquisition, analysis, storage, sharing, and presentation functionality using productive, powerful software.

A. DATA ACQUISITION:-

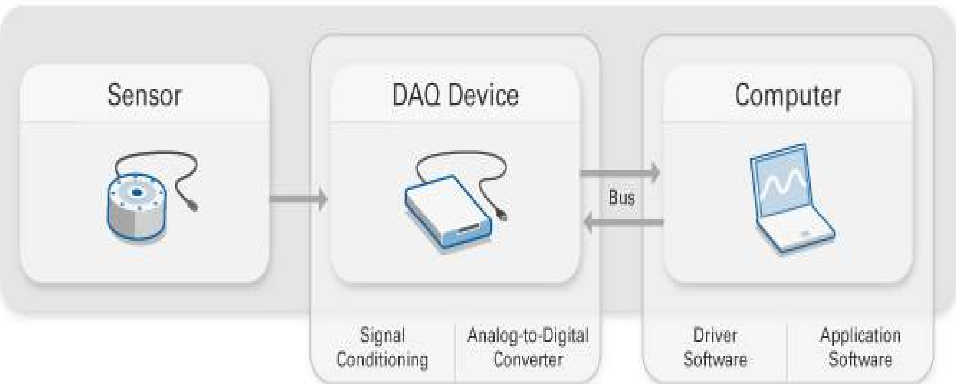

Fig. 1 Data Acquisition

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Data acquisition (DAQ) is the process of measuring an electrical or physical parameter such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC based DAQ systems take advantage of the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible and cost-effective measurement solution.

Process Instrumentation application for level control and measurements is developed at Instrumentation & Communication Unit, NCL, Pune.

IV. PROCESS BLOCK DIAGRAM

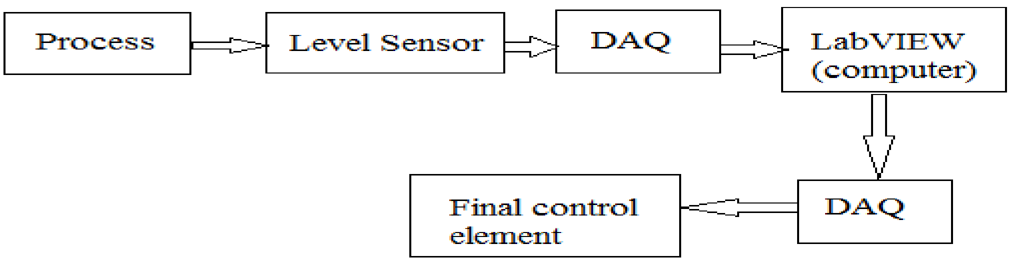

Fig. 2 Process block diagram

Figure 2 shows the process block diagram of overall system. Level is measured by level sensor, an output of which is voltage/current signal. This transmitter signal is sent to LabVIEW based soft PID Controller using DAQ. LabVIEW based soft PID Controller is used to generate the control signal. The control signal is a voltage signal, which is fed to final control element using DAQ. In this application we regulate the level of tank. Level of the tank is being measured by the level sensor. The output of level sensor is feed to the controller through data acquisition card NI PCI 6014. The signal is given to the soft PID as the process variable, and set point will be set by user. The corresponding control action will be generated by the PID. Further the control signal is used to produce PWM signal. This work is carried out in a laboratory. Real time control process will be executed shortly.

A. Soft PID:-

AS mentioned in the introduction, there are number of advantages of using LabVIEW Soft PID over hard PID. First of all very less maintenance cost, in fact non maintenance cost, Usage is flexible, reconfiguration of PID can be done by engineer in the control room. As soft PID is used on LabVIEW platform, number of LabVIEW based functionalities and tool kits can be added along with soft PID for Process Automation and control. This becomes a total solution. The following block is used to build the soft PID (Fig.3)

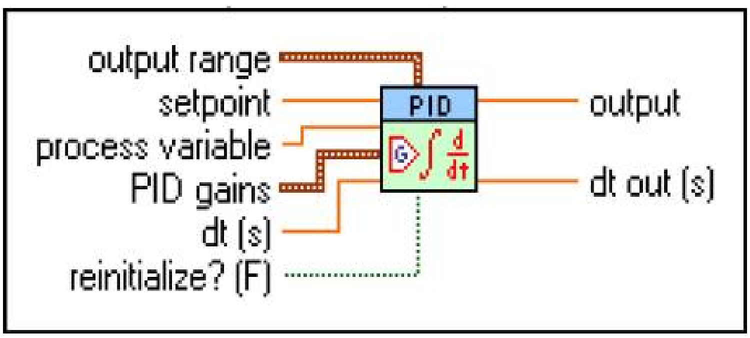

Fig.3 Soft PID

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- **output range :-**specifies the range to which to coerce the control output.
- **Setpoint** specifies the setpoint value, or desired value, of the process variable being controlled.
- **process variable** specifies the measured value of the process variable being controlled. This value is equal to the feedback value of the feedback control loop.
- **PID gains** specifies the proportional gain, integral time, and derivative time parameters of the controller.
- **proportional gain (Kc)** specifies the proportional gain of the controller. The default is 1. In the equation that defines the PID controller, *KC* represents the proportional gain.
- **integral time (Ti, min)** specifies the integral time in minutes. The default is 0.01.
- **derivative time (Td, min)** specifies the derivative time in minutes. The default is 0.
- **dt (s)** specifies the loop-cycle time, or interval in seconds, at which this VI is called.
- **reinitialize?** specifies whether to reinitialize the internal parameters, such as the integrated error, of the controller. Set **reinitialize?** to TRUE if your application must stop and restart the control loop without restarting the entire application. The default is FALSE.
- **output**returns the control output of the PID algorithm that is applied to the controlled process. If this VI receives an invalid input, **output** returns NaN.
- **dt out (s)** returns the actual time interval in seconds. **dt out (s)** returns either the value of **dt (s)** or the computed interval if you set **dt (s)** to –1.

V. SIMULATION AND RESULTS

LABVIEW BASED SOFT PID :-

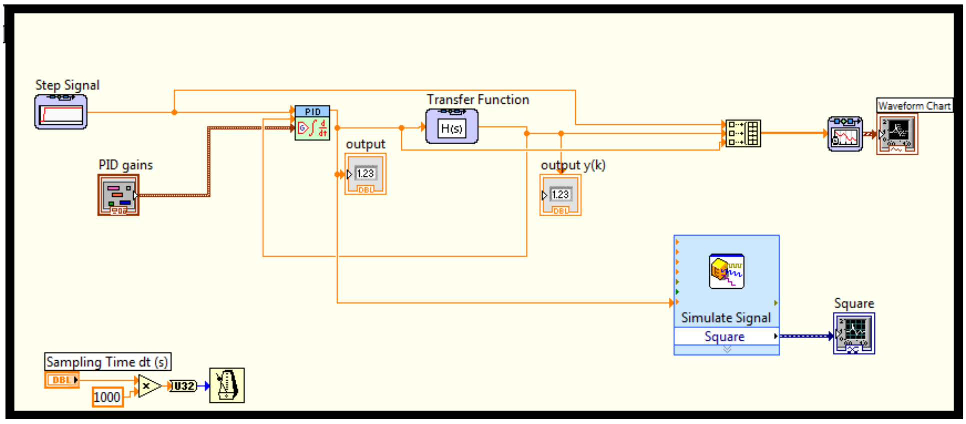

Fig.4 Simulation block diagram

The above figure 4 shows the simulation block diagram of LabVIEW based soft PID controller. In this simulation, one transfer function model is used to check the effect of LabVIEW based soft PID controller. The step signal is applied as set point to soft PID controller. Here the control signal which is generated by soft PID controller is applied to PWM generator. The output of PWM generator is applied to the chosen plant model. As the output of soft PID controller changes the dusty cycle of the PWM signal also changes. The variation between control signal, step signal and the final output signal is observed on graph paper display. The results of the above simulation are as shown in Fig.5 and Fig.6 .

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Fig.5 soft PID response

In above mentioned figure 5, white signal is input signal i.e. step to PID. Green signal is control signal. Red is output signal. Ziegler- Nichols method is sued for calculation the P, I and D parameters of PID. Calculated P value = 20 and I value = 70 are fed as input to PID gain block (Fig. 4). Third order transfer function (30s + 70) / (S^3 + $10s^2$ + 50s + 70) is used for simulation purpose.

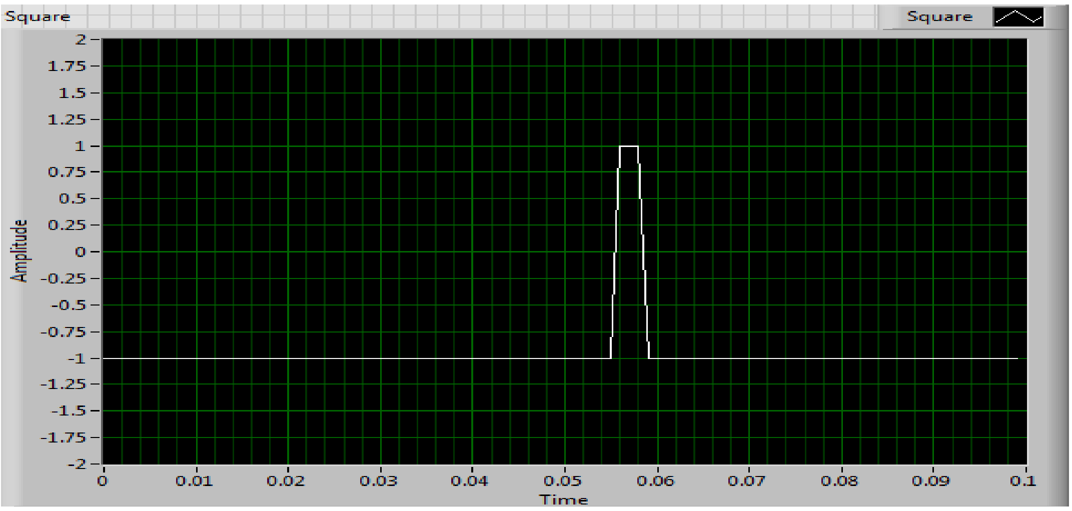

Fig.6 PWM signal

Please refer to Fig. 4, In simulation signal block, PID block output is also given to duty cycle input terminal. As PID output changes, the duty cycle of PWM signal changes (in Fig.6). PWM signal can be used for control action.

VI. CONCLUSION AND FUTURE SCOPE

In Process Instrumentation scenario, tuning of hard PID is cumbersome task for the Instrumentation engineer. Soft PID implementation using LabVIEW has made Process Instrumentation scenario clean, compact with controls at desk top.

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With LabVIEW RT, complicated process scenario can be handled by making interrupt driven system. LabVIEW RT as a Master control, instrumentation solution can also be further enhanced using wireless communication protocols for sub system in process instrumentation.

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BIOGRAPHY

Dr. Neelima Iyer is Senior Principal Scientist and Chair, Instrumentation & Communication Unit, CSIR-National Chemical Laboratory, Pune, India. She is also Professor, Engineering Sciences, Academy of Scientific & Innovative Research (AcSIR). She perused Master from Pune University, Master from BITS, Pilani and Doctorate in Instrumentation Science from Pune University. She has research experience of 28 years in the field of instrument development, embedded electronics, PC based, LabVIEW based, Wireless Instrumentation & Non Invasive developments and 11 years experience in the field of Voice Over IP (VOIP) telecommunication.

Prof. N.M. .Karajanagi, M.Tech (Systems and Controller Engineering), I.I.T., Bombay, having 20 years of teaching experience and seven months industrial experience. He is Life member of ISTE, DMSOI, ISOI.