

Designing PID Controller using LabVIEW for Controlling Fluid Level of Vessel

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ABSTRACT

The primary aim of our project is to replace the PID instrument with virtual PID that has equal controlling capabilities as that of instrument. This designing is possible on software called LabVIEW developed by National Instruments. We also intend to use a DAQ card for interfacing with the hardware. This DAQ card is product of the same company National Instruments. The hardware is a Multiloop Trainer Kit mounted with a tank whose level has to be controlled using a feedback control loop. The flow of project execution is: The designed PID will be generating the necessary controlling electronic signal. This signal will be acquired by DAQ card. The DAQ card transfers it to the I to P converter which will convert the electrical pulses 4-20mA into pneumatic signal 3-15psig to actuate the control valve. This conversion take place as the control valve acts on pneumatic signals only. The control valve controls the fluid flow to maintain the fluid level in tank. The tank is fitted with a capacitive level sensor and a transmitter. This assembly takes the level readings from tank and transmits it to the DAQ card. These values are called process values and are further processed into the designed PID. This way a closed loop system is formed.

KEYWORDS

DAQ card (Data Acquisition), LabVIEW (Laboratory Virtual Instrument Engineering workbench), PID.

INTRODUCTION

In the present era of Industrial Automation, ease of work is one of the major concerns. This design enables the operator to operate the process sophisticatedly with an ease. Instead of giving manual inputs to the PID, this designed PID can adjust the input parameters just by mouse clicks. Firstly what is a control system?

A control system is a device, or set of devices to manage, command, direct or regulate the behavior of other device(s) or system(s). There are two common classes of control systems: logic or sequential controls, and feedback or linear controls. There is also fuzzy logic, which attempts to combine some of the design simplicity of logic with the utility of linear control.

I. 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 (electronic controller) based on the control engineer's input (tuning constants), the operators desired operating value (set point) and the current plant process value. In most cases, the requirement 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.

Proportional action: It simply amplifies the error based upon the gain. P mode generates offset.

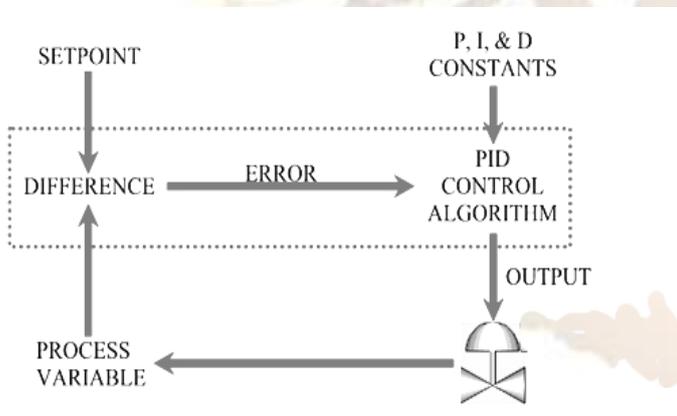
Integral action: The integral term magnifies the effect of long-term steady-state errors, applying ever-increasing effort until they reduce to zero. In the example of the furnace, working at various temperatures, if the heat being applied does not bring the furnace up to set point, for whatever reason, integral action increasingly moves the proportional band relative to the set point until the PV error is reduced to zero and the set point is achieved. In the furnace example, suppose the temperature is increasing towards a set point at which, say, 50% of the available power will be required for steady-state. At low temperatures, 100% of available power is applied. When the PV is within, say 10° of the SP the heat input begins to be reduced by the proportional controller. (Note that this implies a 20° "proportional band" (PB) from full to no power input, evenly spread around the set point value). At the set point the controller will be applying 50% power as required, but stray stored heat within the heater sub-system and in the walls of the furnace will keep the measured temperature rising beyond what is required. At 10° above SP, we reach the top of the proportional band (PB) and no power is applied, but the temperature may continue to rise even further before beginning to fall back. Eventually as the PV falls back into the PB, heat is applied again, but now the heater and the furnace walls are too cool and the temperature falls too low before its fall is arrested, so that the oscillations continue.

Derivative action: The derivative part is concerned with the rate-of-change of the error with time: If the measured variable approaches the set point rapidly,

then the actuator is backed off early to allow it to coast to the required level; conversely if the measured value begins to move rapidly away from the set point, extra effort is applied in proportion to that rapidity to try to maintain it. Derivative action makes a control system behave much more intelligently. On control systems like the tuning of the temperature of a furnace, or perhaps the motion-control of a heavy item like a gun or camera on a moving vehicle, the derivative action of a well-tuned PID controller can allow it to reach and maintain a set point better than most skilled human operators could. If derivative action is over-applied, it can lead to oscillations too. An example would be a PV that increased rapidly towards SP, then halted early and seemed to "shy away" from the set point before rising towards it again.

II. HOW A PID CONTROLLER WORK

The PID controller's job is to maintain the output at a level so that there is no difference (error) between the process variable (PV) and the set point (SP).



In the diagram shown above the valve could be controlling the gas going to a heater, the chilling of a cooler, the pressure in a pipe, the flow through a pipe, the level in a tank, or any other process control system. What the PID controller is looking at is the difference (or "error") between the PV and the SP. It looks at the absolute error and the rate of change of error. Absolute error means -- is there a big difference in the PV and SP or a little difference? Rate of change of error means -- is the difference between the PV or SP getting smaller or larger as time goes on. When there is a "process upset", meaning, when the process variable or the set point quickly changes - the PID controller has to quickly change the output to get the process variable back equal to the set point. If you have a walk-in cooler with a PID controller and someone opens the door and walks in, the temperature (process variable) could rise very quickly. Therefore the PID controller has to increase the cooling (output) to compensate for this temperature rise.

Once the PID controller has the process variable equal to the set point, a good PID controller will not vary the output. You want the output to be very steady (not changing). If the valve is constantly changing, instead of maintaining a constant value, this could cause more wear on the control element. So there are these two contradictory goals. Fast response (fast change in output) when there is a "process upset", but slow response (steady output) when the PV is close to the set point. Note that the output often goes past (over shoots) the steady-state output to get the process back to the set point. For example, a cooler may normally have its cooling valve open 34% to maintain zero degrees (after the cooler has been closed up and the temperature settled down). If someone opens the cooler, walks in, walks around to find something, then walks back out, and then closes the cooler door --the PID controller is freaking out because the temperature may have raised 20 degrees! So it may crank the cooling valve open to 50, 75, or even 100 percent -- to hurry up and cool the cooler back down -- before slowly closing the cooling valve back down to 34 percent.

$$Output = K_p \left[e(t) + \frac{1}{K_i} \int e(t) dt + K_d \frac{de(t)}{dt} \right]$$

The above formula is the classic PID formula. Where 'Kp' is Proportional constant, 'Ki' is Integral constant and 'Kd' is Derivative constant and 'et' is error. The level of fluid in vessel is controlled by using feedback flow scheme.

III. MULTI-LOOP TRAINER KIT (FLOW LOOP)

The loop consists of mainly one flow meter and one final control element to regulate and control the flow through loop. To make the process real time work and remotely operable, signals from transducer and output to control valve is connected to computer via. Input Output card. Above mentioned loop is a part of Trainer kit

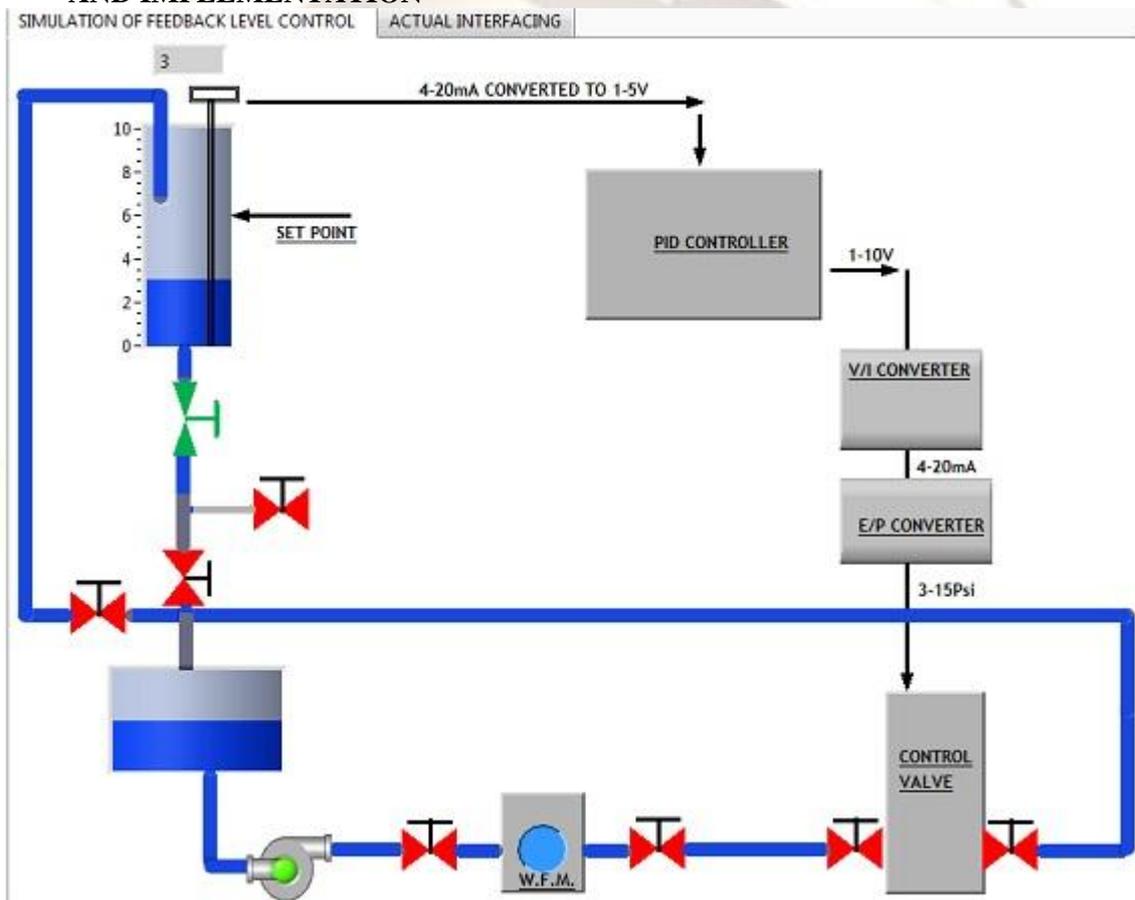


The vital requirement to achieve project objective is NI LabVIEW 7.1 Front panel is the GUI wherein the operator sets the PID input parameters as per the requirements along with various graphical and pictorial representations of the process. And the block diagram executes the PID algorithm.

Front panel:

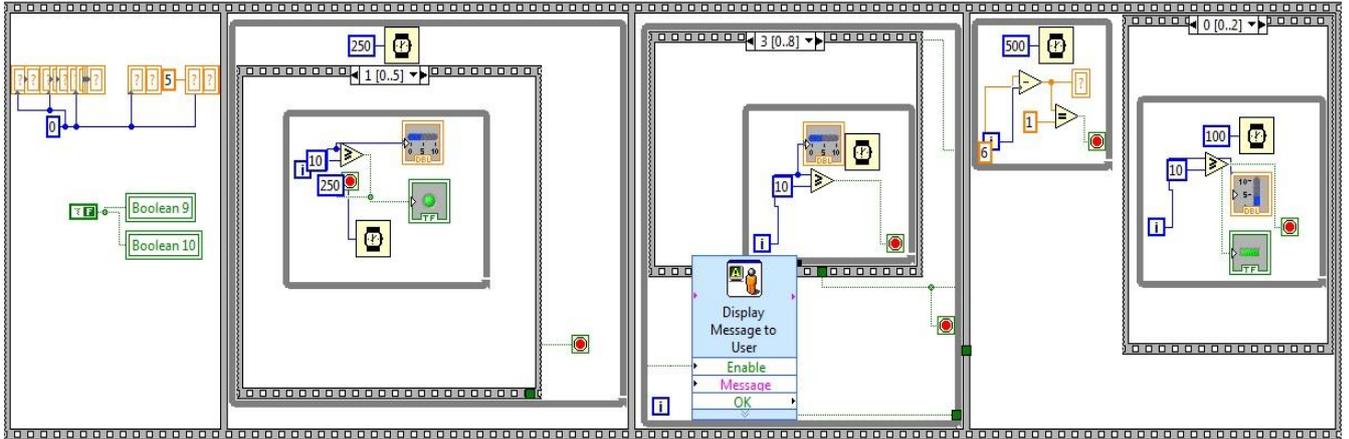
The front panel designed for the project consists of a 'Table selector' which selects 'SIMULATION' and 'ACTUAL INTERFACING'. The simulation simulates the feedback loop of level control of the multiloop trainer kit. The actual interfacing inputs the PID parameters. PID output which proportionate the required current to operate I/P converter which indirectly operates the control valve.

IV. SOFTWARE CONFIGURATION AND IMPLEMENTATION



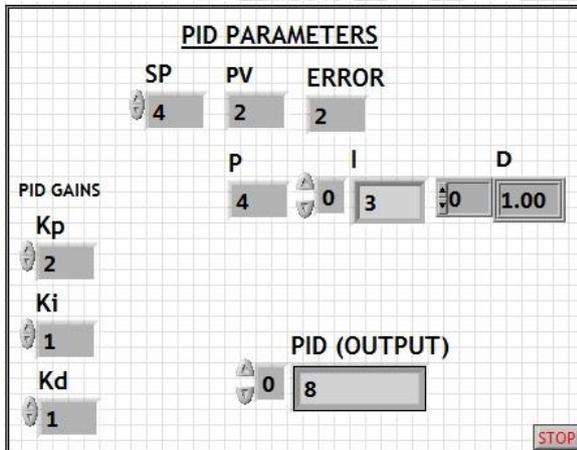
The above screen shot depicts the simulation of feedback level control loop of Multi-loop trainer

kit. The sequential logic for the simulation is as follows:



The vital functions used are Case structure, while loops, timing functions, Booleans indication control valves, Arithmetic, Dialogue generator etc.

This figure is the screen shot of the front panel of the designed PID controller.



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PID input parameters:

Proportional gain (Kp): It's the gain constant for 'P' mode

Integral gain (Ki): It's the gain constant for 'I' mode

Derivative gain (Kd): Used for 'D' mode

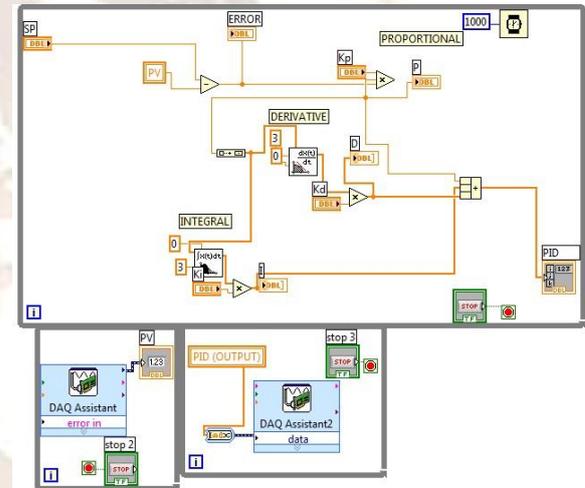
Set point(SP): It is the target value that the PID will aim to reach

V. BENEFITS OF THE APPLICATION

This project replaces the conventional PID instrument with a virtual controller. It saves time of manufacturing of instrument. Since the PID logic can be designed on LabVIEW in a very short period, as the manufacturing of instrument requires plenty of skills which cannot be implemented in a short span of time. Practically this application needs no maintenance and very easy to upgrade. Whereas instruments require timely maintenance and their up-gradations is very difficult.

Process value (PV): It's the output transmitted by the level sensor.

Block Diagram: It is the place where the algorithm executes.



The above block diagram is the logic of designed PID controller. The input that is the PV is accepted by the DAQ card using DAQ assist. And the PID output is fed to the DAQ card using another DAQ assist. This output is then converted to current signal using V to I converter designed by using Op-Amps.

In addition to the industrial applications, the educational importance is noteworthy. It boosts academic interaction with latest technology. Students can put one step forward than curriculum.

VI. CONCLUSION

The experimental investigations in NI LabVIEW show that the new system developed would be highly flexible and easy in controlling the level. This new system will create a new era in the field of Process Automation.

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