Universal Controller Design Using Arm Controller

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***Abstract*— In this paper, different control strategies are discussed and design of universal (process) controller on ARM embedded platform is proposed. The same controller support feedback, cascade, ratio and feed forward control strategy. The LPC2148 kit (ARM7 controller) is used for the application which has many features which are also discussed in the paper. MODBUS RTU protocol is used for communication. GUI is developed in Wonderware In touch (SCADA) software. Keil µvision 4 IDE is used for programming ARM controller.**

Keywords- Feedback controller, Cascade controller, feed forward controller, Ratio controller.

I. INTRODUCTION

In industrial process control loops, proportional-integral-derivative is extensively used to optimize process by desired control action. PID controller is still used widely in presence of fuzzy, adaptive and many more advance control techniques. More than 90% of all control loops are PID [1]. PID controller is like a heart of feedback loop because of simple and effective structure. The PID algorithm is simple and used in many feedback loops. Different forms of PID algorithm like interacting and non-interacting, set-point weighting, standard form, classical form, parallel form are used as per control action demand [2].

In industry, there are different kinds of control loops strategies such as cascade control loop, feedback control loop, feed forward control loop and ratio control loop are being implemented. Different control loop has its own significances. A feedback controller with PID algorithm is extensively used in the industries as mentioned earlier. Feed forward control laws are also used in control system, sometimes used together with feedback control loop in order to deal with unstable plant models, exogenous disturbances, and model uncertainties e.g. Power system, medical engineering, vibration and noise control[3][4]. Here proposed Universal controller support different control loops like cascade control loop, feedback control loop, feed forward control loop, ratio control loop, embedded on single controller platform. Universal controller supports different control actions like P, PI, PID. Universal controller can be implemented to control different process variables like temperature, level, flow, pressure.

LPC 2148 kit with 16-bit/32-bit ARM7TDMI-S microcontroller is used to implement Universal controller. Graphical user interface (GUI) is developed in wonder ware in-touch software. MODBUS network management protocol is proposed for communication which plays a pivotal role for establishment of such kind of system.

II. FEEDBACK CONTROL SYSTEM

A feedback loop measures a process variable and sends the measurement to a controller for comparison to set point. If the process variable is not at set point, control action is taken to return the process variable to set point. In feedback loop a transmitter measures the temperature of a fluid and, if necessary, opens or closes a hot steam valve to adjust the fluid's temperature. Feedback loops are commonly used in the process control industry. The advantage of a feedback loop is that it directly controls the desired process variable. The disadvantage to feedback loops is that the process variable must leave set point for action to be taken. Feedback control loop is shown in Fig. 1[7] [9].

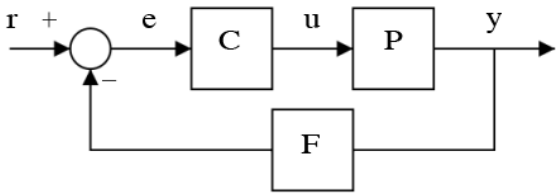

Fig. 1 Feedback control system

III. CASCADE CONTROL SYSTEM

Cascade control is shown in fig. 2[5] is a multi loop Control scheme commonly used in process. Cascade control is built up by nesting the control loops. Where inner loop control the secondary variable and outer loop control the output or control variable. A large part of the disturbance is eliminated by the inner loop. The remaining error is eliminated at a slower rate through the action of the outer

loop. Cascade control technique is used to reduce effect of load disturbance. Inner loop is always faster than outer loop to eliminate effect of disturbance before its affect to control variable. Cascade control is reducing both maximum deviations and integral error of disturbance response [6].

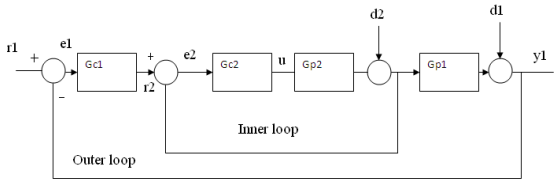

Fig. 2 Cascade control system

IV. Feed Foraward Control System

Feed forward control is a control system that anticipates load disturbances and controls them before they can impact the process variable. For feed forward control to work, the user must have a mathematical understanding of how the manipulated variables will impact the process variable. An advantage of feed forward control is that error is prevented, rather than corrected. However, it is difficult to account for all possible load disturbances in a system through feed forward control. Factors such as outside temperature, build up in pipes, consistency of raw materials, humidity, and moisture content can all become load disturbances and cannot always be effectively accounted for in a feed forward system [4].Feed forward control loop is shown in Fig. 3[7].

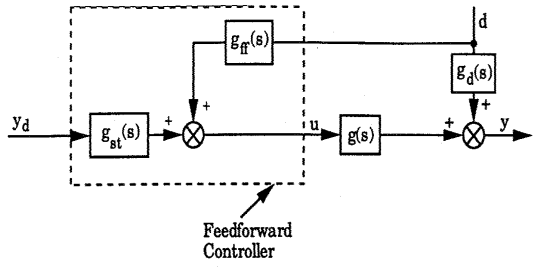

Fig. 3 Feed forward control system

In general, feed forward systems should be used in cases where the controlled variable has the potential of being a major load disturbance on the process variable ultimately being controlled. The added complexity and expense of feed forward control may not be equal to the benefits of increased control in the case of a variable that causes only a small load disturbance [5].

V. Ratio Control System

For Imagine a process in which an acid must be diluted with water in the proportion two parts water to one part acid. If a tank has an acid supply on one side of a mixing vessel and a water supply on the other, a control system could be developed to control the ratio of acid to water, even though the water supply itself may not be controlled. [7]This type of control system is called ratio control. Ratio control is used in many applications. Ratio control might be used where a continuous process is going on and an additive is being put into the flow. Ratio control loop are shown in Fig 4. [8]

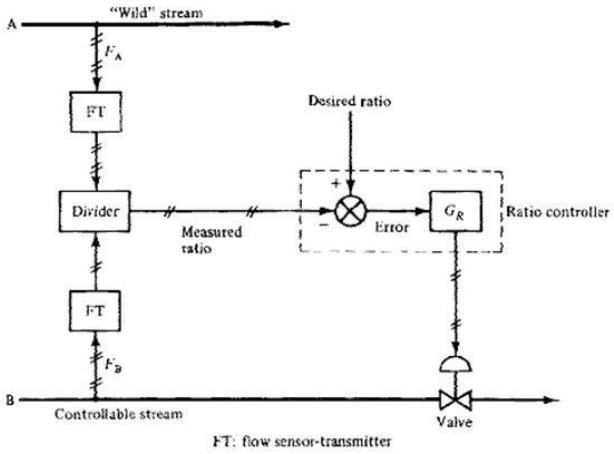

Fig. 4 Ratio control system

System Hardware

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. [11] For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. So this ARM controller kit is selected for implemented universal controller. LPC 2148 kit is shown in fig.5. [11]

For practical testing and result verification, Apex make level control kit is used.

Fig. 5 LPC 2148

VI. SYSTEM SOFTWARE

To developed graphical user interface for universal controller, Wonder ware In touch (SCADA) is proposed to used. At present work, primary GUI is developed for feed forward control scheme as shown in fig.6.

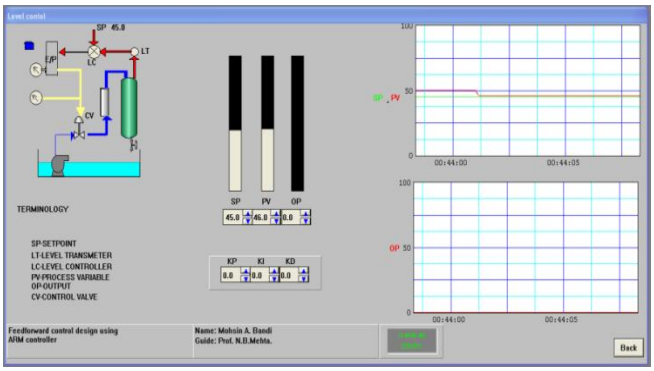

Fig. 6 Graphical User Interface

It shows process mimic diagram. Value for set point, process variable, and control output is shown in GUI. Real time trend is also shown in GUI. Value for KP, KI, and KD is given directly by GUI.

The LPC2148 microcontroller is supported by various commercially available IDEs for compiling and debugging of code. Keil is widely used IDE for LPC family of microcontroller. The Keil µvision 4 IDE is window based software development platform that combines robust editor, project manager and make facility [12].

VII. SIMULATION RESULT

In present work, simple PID algorithm is developed. Real-time input is compared with set point send by user and PID algorithm calculates the output according to the error.

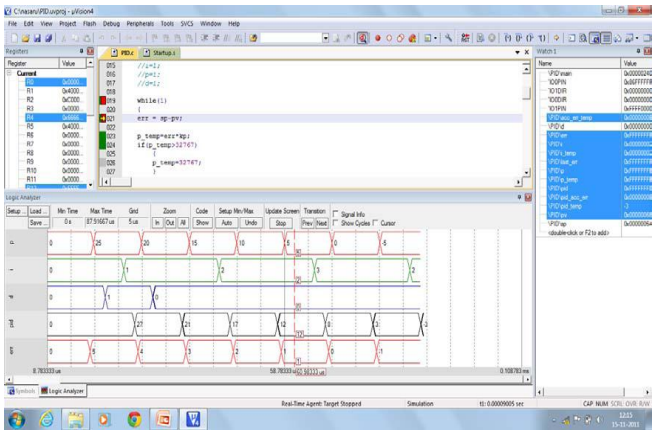

Fig. 7 Simulation result for simple PID algorithm.

Here fig.7 shows the waveform value of P, value of I , value of , value of PID, and value of error. Waveform can be seen in logic analyzer in Keil. From waveform we can say that error would be removed by tune the parameter like P, I, D.

Algorithm for cascade, ratio is developed. feed forward is under development.

VIII. CONCLUTION

In this paper, different types of control strategy are discussed. From above paper it is to be concluded that different control laws have their own advantages. So by implementing all these control loops on single arm controller, system becomes simpler and cost effective. Due to the generic design, the device also can be reused in many different industrial applications with the same features. It is easy to implements Universal controllers using the arm controller. Arm controllers work as the heart of the system LPC2148 or family IC can be used. Communication of the system is through MODBUS protocol, and GUI using SCADA tool.

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