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Control of Pressure Process Using Infineon Microcontroller

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Abstract: The main objective of this paper is to design a cost effective controller for real time implementation of pressure process using Infineon micro controller (SAB 80C517A). Model Identification is performed and it is found to be First Order Plus Dead Time Process (FOPDT). The performance measure is tabulated for different parameter and it is found that Proportional (P) controller is suitable for controlling the process. *Copyright © 2007 IFSA.*

Keywords: Real time, Pressure process, Microcontroller, Model Identification and Controller

1. Introduction

There are several methods for measurement and control of pressure process. The function of a feedback control system is to ensure that the closed loop system has desirable dynamic and steady state response characteristics. In typical control applications, it is not possible to achieve all of these goals simultaneously because they involve inherent conflicts and tradeoffs. The tradeoffs must balance two important objectives performance and robustness. Starting with these requirements, it is seen that the plant being a simple one, a sophisticated control system is not necessary for our purpose. Hence, conventional controllers are chosen. The PID controller is a very simple controller, but the major drawback is that there is no analytical way of finding the optimal set of parameters (Kp, τ_i, τ_d). But, empirical methods such as Ziegler-Nichols tuning and Cohen-Coons method can be used for the tuning. Since, it is required to build an embedded control system, discrete forms of P, PI, PD and PID controllers are required.

Sundaresan and Krishnaswamy (1978) have discussed the method obtaining first plus dead time model for a process using the reaction curve for a unit step change give to the process in open loop. From the response curve of the process to various step changes at different operating points and discuss the limitation of PI controller in this process. Somani et al. (1992) have proposed an analytical tuning formula for PI controller for a FOPDT process in open loop .Chidambaram and Padma Sree (2003) have proposed a simple method PI, PD and PID controller settings for an integrating plus dead-time transfer function model. The method is based on matching the coefficients of corresponding powers of s in the numerator and that in the denominator of the closed-loop transfer function for a servo problem. Skogestad (2003) has present an analytic rules for PID controller tuning that are simple and still result in good closed-loop behavior. A two-step procedure is proposed for deriving PID settings for typical process control applications. Any higher model is approximated to first order plus dead time model using half rule. Then PID controller is designed for the first order model using SIMC method. Koivo and Reijonen (2004) have suggested an optimization tuning of PID controllers for time varying, including state-dependent delays is discussed. The approach used in the paper is simulation and optimization. The plant can be nonlinear, but the results are easier to compare with classical results for constant delay case, when the dynamics is linear and of first order. In fact, iterative feedback tuning could he applied for real systems instead of simulation.

In this study, a cost effective real time implementation of pressure process using Infineon micro controller is performed and tested.

2. Design of PID Controller

A Proportional-Integral-Derivative controller (PID controller) is a common feedback loop component in industrial control systems. The controller takes a measured value from a process or other apparatus and compares it with a reference set point value. The difference (or "error" signal) is then used to adjust some input to the process in order to bring the process-measured value back to its desired set point. Unlike simpler controllers, the PID can adjust process outputs based on the history and rate of change of the error signal, which gives more accurate and stable control. The schematic of the traditional PID controller is shown in Fig.1.

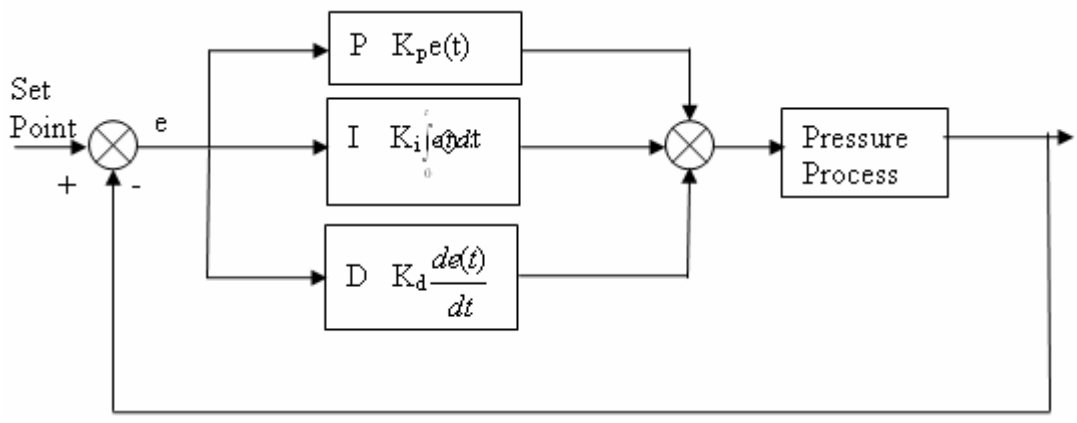

Fig. 1. Block diagram of a traditional PID controller.

The control output given by the PID controller is realized as

$$u(t) = K_c\left[e(t) + \frac{1}{\tau_i}\int_0^t e(t)dt + \tau_d\frac{d(e(t))}{dt}\right] + u_0 \quad (1)$$

For its implementation in a microcontroller, the discrete form of PID controller is used.

$$u[t] = u[t-1] + K_c\left[e[t] - e[t-1] + \frac{1}{\tau_i}e[t] + \tau_d(e[t] - 2e[t-1] + e[t-2])\right]. \quad (2)$$

This has advantages like reduced computation time, lesser memory usage and also, it does not depend on the initial conditions of the system.

3. Process Description

For controlling the pressure of the tank, which is a closed loop process, the interfacing circuit is connected as shown in Fig.2. The output from DAC is in the range 0-5 V. This is converted to current range 4-20 mA and given as input to the I-P converter, whose output is the control signal for the control valve. A C program for acquiring the pressure value every 0.625s and calculating the appropriate control signal depending on the set point is calculated and fed back to the system through a DAC followed by an V-I converter. Simultaneously, the value of pressure and the control signal generated and fed back are stored for further analysis. The same procedure is repeated and values stored by controlling the pressure of the tank using P, PI, PD and PID controllers. The open loop response of the system is performed for simulation and experimental study and it validated with actual model is shown in Fig.3. The comparison of steady state error for simulation and experimental study is ±2%.

Fig. 2. Plant overview.

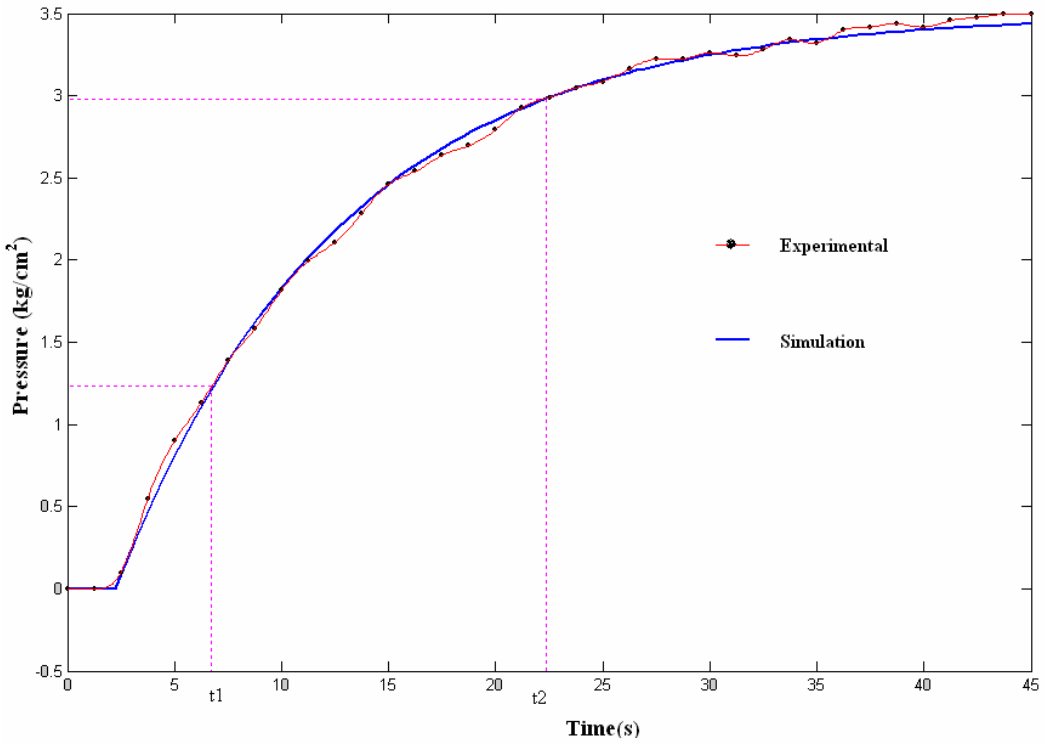

Fig. 3. Plot of transfer function obtained along with step response of the system.

4. Real Time Implementation

Design of Microcontroller Using Infineon 80C517A

The SAB 80C517A is a high-end microcontroller in the Siemens ACMOS technology and based on SAB 8051 8-bit microcontroller family. ACMOS is a technology, which combines high-speed, and density characteristics with low-power consumption and dissipation. It is a superset of the high-end microcontroller SAB 80C517. While maintaining all architectural and operational characteristics of the SAB 80C517 the SAB 80C517A incorporates more on-chip RAM as well as some enhancements in the compare capture unit. Also the operating frequency is higher than that of the SAB 80C517. It is based on the well-known industry standard 8051 architecture; a great number of enhancements and new peripheral features extended capabilities to meet the extensive requirements of new applications.

Sundaresan and Krishnaswamy (S and K) method is used to model the system as a first order system with time delay as given in equation 3. This method avoids use of the point of inflection construction entirely to estimate the time delay. It is proposed that two times, t1 and t2, can be estimated from a step response curve, corresponding to the 35.3% and 85.3% response times, respectively. The time delay and time constant are then estimated from the following equations:

$$G(s) = \frac{5.37e^{-2.248s}}{10.45s+1} \tag{3}$$

$$\theta = 1.3t_1 - 0.29t_2$$
$$\tau = 0.67(t_2 - t_1)$$

These values of q and t approximately minimize the difference between the measured response and the model, based on a correlation for many data sets.

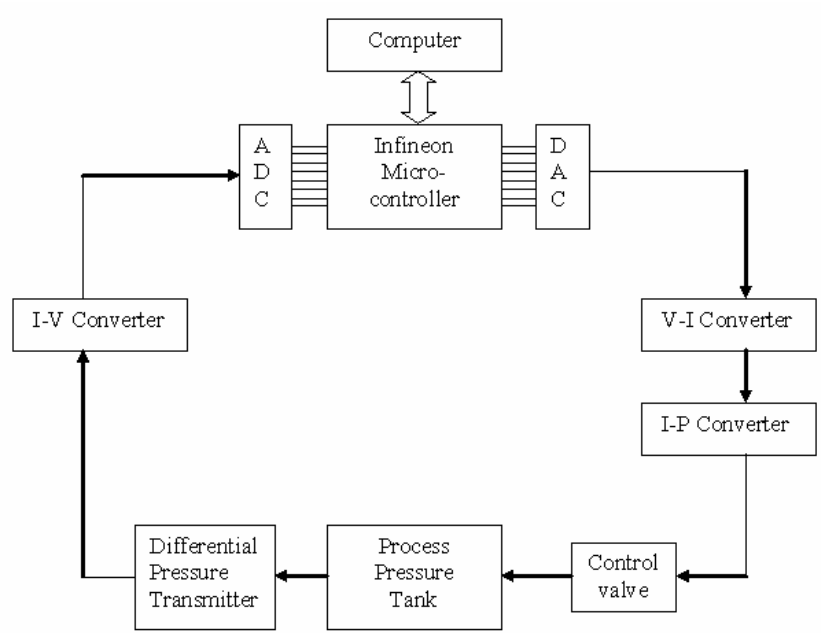

Fig. 4. Interfacing circuit for controlling the pressure set-up.

The real time interfacing circuit is shown in Fig.4. Here, the C code for acquiring the input parameters i.e. DP, VP and temperature and sending to the Infenion Microcontroller AT89C51 using PC is written using Keil Cross-Compiler which gives the corresponding Hex code. The Hex cod is directly downloaded to SAB 80C517A microcontroller using serial port of the PC. In the target the C code is developed for receiving the multiple data sent by the PC and processing them using Model and PI control algorithm to calculate the Air Flow Rate (m^3/hour.) and its control. The input parameters are converted into the standard (0 to 5V) range using appropriate Signal Conditioning units. The signals of standard value are given as time-multiplexed inputs to the ADC that converts each of its analog input into the corresponding digital output. Normalizing the system inputs in the range (0 to 5V) and the output (air flow rate) in the range (0 to 5V).The acquired input data is substituted in the Model which gives air flow rate in (m^3/hr) Error is calculated based on measured flow rate and desired flow rate, and the controller output is attained by PI algorithm. The controller output from the Microcontroller is fed to DAC, the corresponding signal is given to V to I converter, which in turns operate the control valve position by employing the I to P converter. A C program for acquiring the pressure value every 0.625s and calculating the appropriate control signal depending on the set point is calculated and fed back to the system through a DAC followed by an V-I converter. Simultaneously, the value of pressure and the control signal generated and fed back are stored for further analysis.

5. Results and Discussions

The value of pressure of the tank is calculated and plotted for analysis. The time domain parameters such as rise time, steady state error are calculated and are shown in Table 1.The control system study on pressure process is studied and the model is identified to be FOPDT.

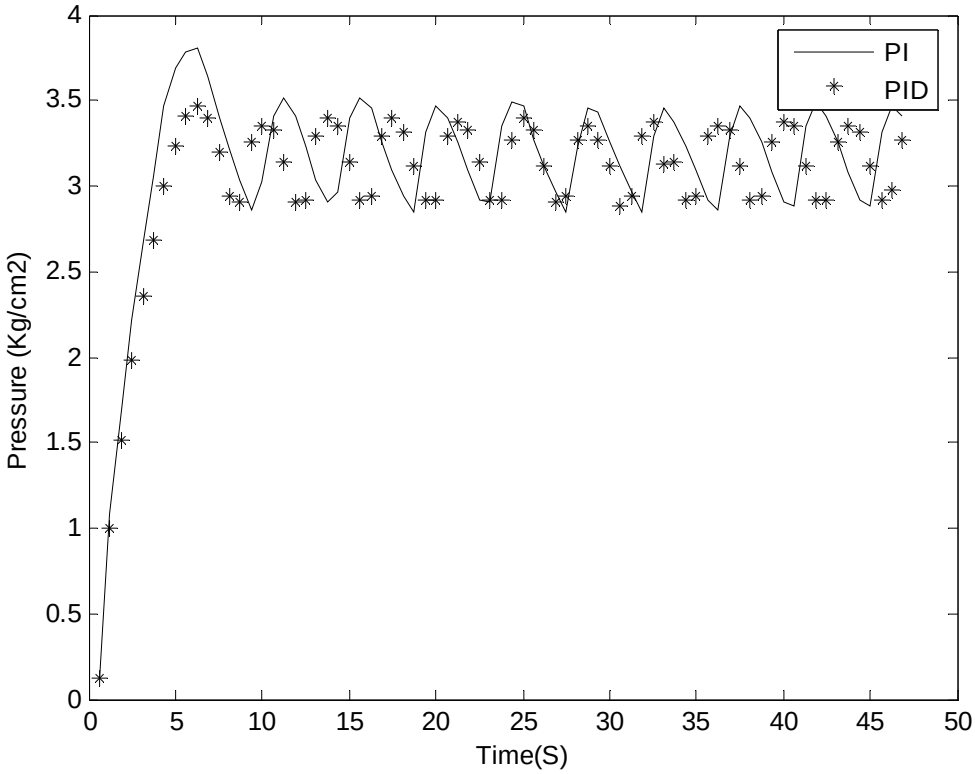

Fig. 5. Response of system controlled with PI and PID controller.

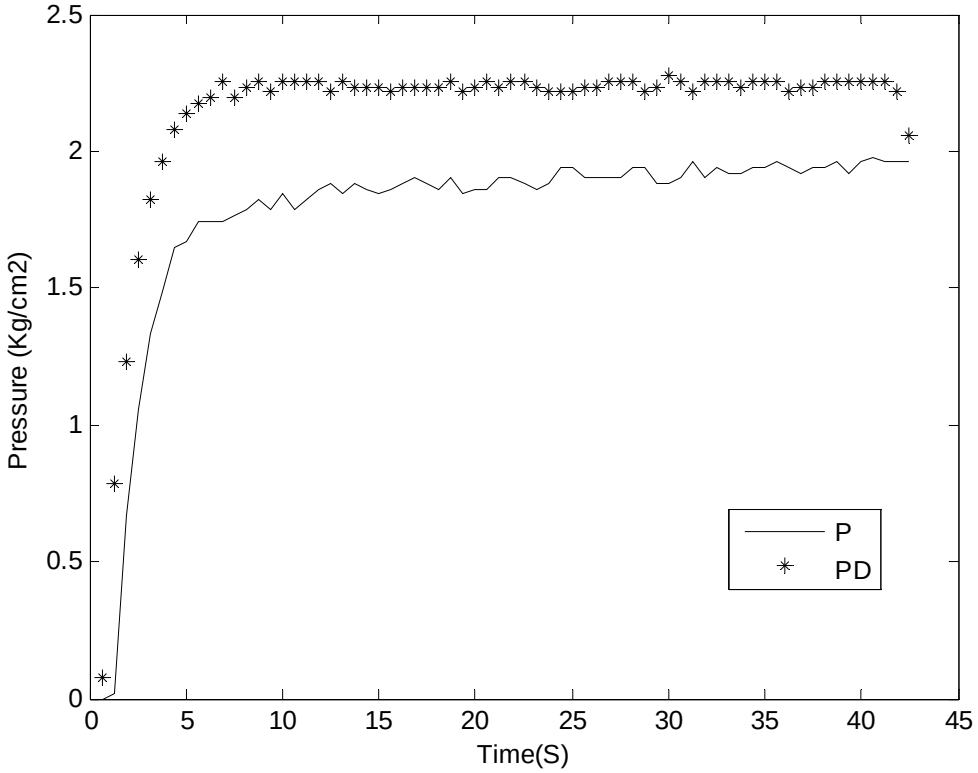

Fig. 6. Response of system controlled with P controller.

Table 1. Time domain parameters calculated for the experimental results.

Controller	Peak overshoot (%)	Peak time(s)	Rise time(s)	Settling time(s)	Steady state error (%)
P	No peaks	-	∞	38.75	2.43
PI	26.8	6.25	3.75	∞	0
PD	No peaks	-	∞	∞	25.44
PID	13.07	6.875	4.375	∞	0

The controller parameters are estimated and calculated for P, PI, PD, PID. The controller design using PI and PID tends to exhibit more peak overshoot and the settling time is not reached which is shown in Fig.5 .Hence for a better controller design error and settling time decides effectiveness in the design. Hence, a P and PD controllers are compared and is shown in Fig.6.For a multiple changes in set point, the P controller tracks the set point effectively, Whereas PD exhibits offset without overshoot. To check the effectiveness of the P controller, the system is perturbed with multiple changes in set point and it is found that the system tracks the set point effectively with no overshoot and better settling time as shown in Fig.7.The P controller design is a suitable control of pressure using cost effective microcontroller.

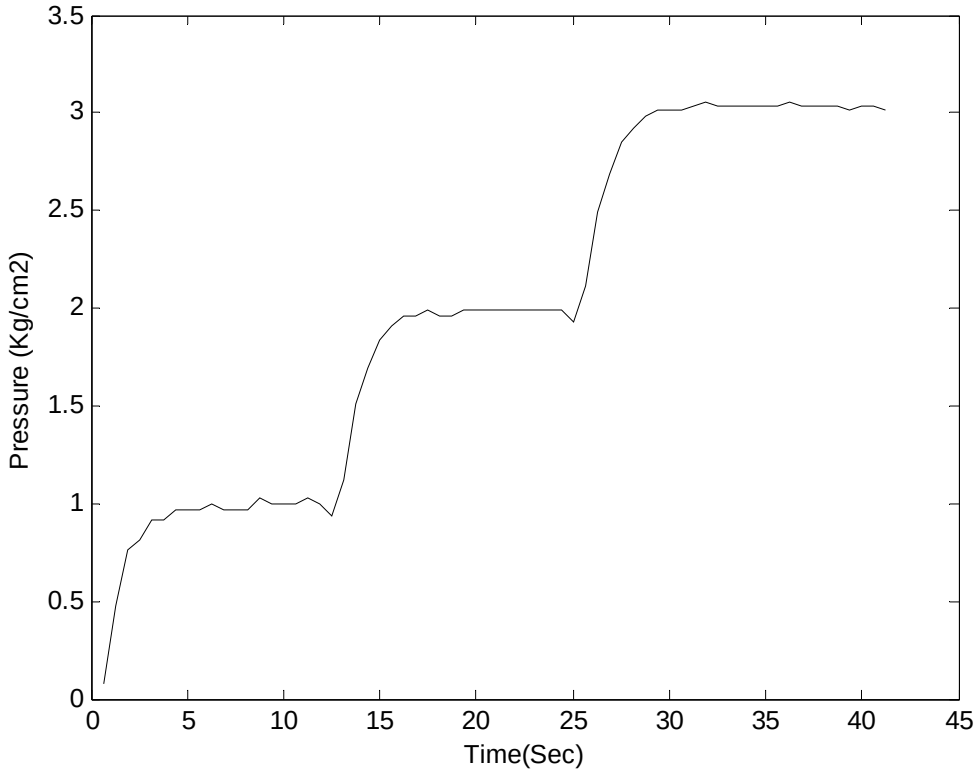

Fig. 7. Response of system controlled with P controller for multiple-step inputs.

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726- 5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

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