



# PID Controller – A Survey

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**ABSTRACT:** This paper concentrates on the work done on the PID control system especially on time delaying systems like network control systems. The different works which have already been done are summarized here like gain margin, phase margin methods. The absolute focal point on time delayed system are the delays induced by network and the packet losses. This survey paper covers the study on such methods that compensates these terms.

**KEYWORDS:** Robust PID control, Network Delayed Systems, gain- phase margin, Tuning Parameters, a survey.

## I. INTRODUCTION

PID controllers are the most popular controller system used in industries; robust PID controller gives more robust output than classical PID controller. Their parameters are tuned according to the instability and delay induced by networked system and creates a safety margin in terms of phase and gain margins. When PID controllers work in communication network its parameters are difficult to tune using classical methods, this is due to delays produced by the network. Despite of increasing the use of PID (almost 60-80 years) there are hundreds of publications on control delayed processes collected by author (O'Dwyer 2003a). Various methods are adopted by various authors like fuzzy control, adaptive control, neural control and optimal control techniques are discussed in this survey. Iserman(1989) suggested that the controller implementation is done only when medium order processes are in consideration and controller parameter settings must be done using tuning rules.

## II. TUNNING PARAMETERS AND COMMON METHODS

In PID controller there are some parameters that that are used for tuning methods and methods as well that are proposed by various researchers practically and theoretically and they can be summarized as follows:

### A. Tuning Parameters

Various research papers defines various terms that are used to stabilize or set the system to near stabilized condition, these terms are the tuning parameters. The basic parameter that defines the characteristics of PID controller can be written as:

$$PID(s, k) = (KI + KP s + KDs^2) / s (1 + TRs) \text{ ----(1)}$$

$$G(s, L, q) = [A(s, q) / R(s, q)] e^{-sL} \text{ ----(2)}$$

where  $K = (KI, KP, KD)^T$  are the controller parameters.

$L$  and  $R$  = plants parameters ( $L > 0$ )

The characteristic function of the loop:-

$$P(s, k, L, q) = (KI + KP s + KDs^2) A(s, q) + s (1 + TRs) R(s, q) e^{-sL}$$

Some researchers like Hohenbitchler and Ziegler- Nichols uses gain and phase margins to find the stability regions.

### B. Common Methods

Tuning rules are originally based on controller parameters and originally proposed by ziegler and Nichols (1942), they uses the tangent method to determine the parameters. The graphical methods are also proposed by shinsky in 2001 and Hay by 1998. Another tuning rule can be named as "Ultimate Cycling Tuning Rule" that can be formed by gains of



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controller and period of oscillation period at ultimate frequency; such model is firstly proposed in 1942 by ziegler-nichols. The other model that is based on gain and phase margin in IPD form was given by KOOKOS et al. 1999.

Tuning rules that are based on direct synthesis uses frequency domain techniques. HO and Xu 1998 WANG and CAI 2002 describe such system for stable and unstable systems. In fine tuning the individual values of  $k_p$ ,  $k_i$ , and  $k_d$  are fine-tuned until acceptable output obtained. Some other methods that are studied by the researchers are "chin, hornes and reswick method", "lambda tuning technique", "direct tuning methods".

Iterative methods can be used as manual tuning which is very appropriate method where compensator parameters may be achieved experimentally that's why it is called manual tuning. However, such methods are time consuming and the steps of processes has to follow its stability limit. For time or frequency domains there are alternatively, a graphical or analytical approach is available for tuning of controller. The time domain design can be accomplished by root locus diagrams, but in this method the delayed processes cannot be modeled. The frequency domain approach is typically done using Bode plots technique that makes us to find a desired phase margin. First approximation can be found by the iterative methods which are the desirable controller parameters. All methods that are proposed by researchers follow the two criteria to optimize the result and they are Gain Margin and Phase Margin.

Gain Margin is the amount of gain increases or decreases required to make the loop gain unity at the given frequency (By: mathwork.com) Phase Margin is the difference between the phase response and  $-180^\circ$  when the loop gain is 1.0. The frequency at which the magnitude is 1.0 is called unit gain frequency or gain cross over frequency.

### III. LITERATURE REVIEW

N. Hohenbichler<sup>1</sup>, J. Ackermann<sup>2</sup>, Synthesis of Robust PID Controllers For Time Delay Systems. This paper develops a PID tuning method based on the parameter space approach. So far, in the synthesis step is extended to time delay systems, but important results for the practical application are still missing. Also, the analysis step is not developed in the literature and results have not been compared with existing tuning methods. The parameter space approach is used to solve the problem in two main steps. In the controller synthesis step, we compute the stable (either Hurwitz) region in the space of controller parameters  $k$  for several representatives out of  $Q$  (usually the vertices). A candidate for a robust controller  $k$  is chosen from the intersection of stable regions. The second step, the control loop analysis, is applied to test the robust stability for the continuum of all values in  $Q$ . Now we compute the stable region in the space of plant parameters with fixed controller. If  $Q$  lies entirely in the stable region, then a solution of the problem is found. Yifei YANG et al presented a Robust Stability Regions of PID Parameters for Uncertainty Systems with Time Delay Using D-partition Technique. A method is introduced for ending gains for all proportional integral derivation (PID) controllers that satisfy a robust performance constraint for a given transfer function of any order with time-delay by using the frequency response. Vipul B. Patel et al in this paper implementation of All digital PID controller using Field Programmable Gate array (FPGA) is presented. Nowadays embedded control applications requires low power and fast acting PID controllers with a closed loop performance using less resources, resulting in cost reduction. In digital PID controller error signal is generated by using comparator which is analog in nature. Antsaklis, P., and Baillieul, J., 2004 in "Special Issue on Networked Control Systems," describes the problems of the real time data mining that are associated with large scale, real time data fission for heterogeneous and distributed arrays of sensors and distributed control and the communication for peer to peer network to manage device node drop-outs, the spatially distributed arrays of RF networked sensors, the and network reconfiguration strategies among others as well as how to compensate the output.

Tipsuwan, Y., and Chow, M.Y., 2003 provided the survey on various delays on "Control methodologies in networked control systems," on discrete time model methodology, fuzzy logic modulation, closed loop control system over a data network with different application and NCS configurations. Tipsuwan and Chow on "Control methodologies in networked control systems," gives an enhanced method on existing networked traffic method based on gain scheduling approach over IP networks. Chow, M.Y., and Tipsuwan, Y., 2003, in their article "Gain Adaptation of Networked DC Motor Controllers Based on QOS Variations," give two methods. In part I a partial adaptation method to tune the controller parameters for the fuzzy logic modulator was given and numerical simulation of a network-based controlled DC motor is used to illustrate the effectiveness of the proposed scheme over a direct PI controller parameter tuning. In part II the full adaptive fuzzy modulation (AFM), method adopted where the consequent parameters and membership functions parameters are tuned for further enhancement in the performance of the system. A self tuning Fuzzy



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Controller with first and second level controllers was designed by the various authors to control a NCS with the presence of delay and packet losses.

Branicky, M.S., Phillips, S.M., and Zhang, W., 2000, give their study results in “Stability of NCS’s: Explicit Analysis of Delay,” where an NCS model containing a clock driven sensors and event-driven controller and actuators are studied with timings. The relationship between the rate of sampling and delay induced by network were analyzed using stability region plot and using hybrid systems technique the NCS stability was analyzed. Lee, K.C., and Lee, S., 2002, describes in his article “Implementation of Networked Control System using a Profibus –DP Network,” that NCS for motor speed control can be implemented by using a Profibus –DP Network for the performance evaluation as well as he proposed a modified traditional design method for PID controller that reduces the effects of network delays on the actual system. The two methods are compared in terms of settling time and maximum overshoots of Cohen Coon method & Ziegler – Nichols method and then they were used to design the PID controllers.

Work studies the performance of IMC tuning for PID controller with other tuning algorithms for PID controller like Cohen–Coon, Chin, Hrones and Reswicl (CHR). The algorithms are analyzed for performance measures such as time response characteristics, integral error criteria and robustness. Computational methods for determining the set of all stabilizing controllers, of a given order and structure, for linear time invariant delay free systems are reported in the literature (Saadaoui&Ozguler, 2005; Silva, 2005). In this line of research, the main objective is to compute the stabilizing regions in the parameter space of simple controllers since stabilization is a first and essential step in any design problem. Once the set of all controllers of a given order and structure is determined, further design criteria can be added. To this end, several approaches are employed, among which extensions of the Hermite- Biehler.

## IV.CONCLUSION

This paper presents a brief review of recent researches and their techniques for optimizing the output of PID control system in network delayed systems. The diversity of researches done by various researchers have summarized and studied in this paper.

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