MIT International Journal of Electrical and Instrumentation Engineering, *Vol. 2, No. 2, Aug. 2012, pp. (65-69)*
ISSN 2230-7656 (c) MIT Publications

New Techniques of PID Controller Tuning of a DC Motor—Development of a Toolbox

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ABSTRACT

The Proportional Integral Derivative (PID) controllers have been widely used and the trend is continued. There are many new methods and approaches for tuning which can provide improved performance. In this paper we present the development of a PID toolbox with a choice of fourteen methods for P, PI and PID controller tuning, few state of the art PID controllers tuning methods and a case study of dc motor speed control (set point tracking & disturbance rejection).The results of extensive simulations covering classical methods including Ziegler-Nichols (ZN) tuning, ZN step response tuning, Cohen-Coon tuning, the Wang–Juang–Chan (WJC) tuning, Chien–Hrones–Reswick (CHR) PID tuning have led to determine the optimum choice for tuning. Finally a toolbox structure has been developed to provide a user friendly package capable of providing PID controller for models of various configurations including those with dead time and guidelines, to suit the specified process performance.

Keywords: dc drives, PID controller, tracking control, regulatory control, MATLAB.

I. INTRODUCTION

The PID controllers is well known to the control engineers and these have been the dominating form of feedback control in process control and industrial applications. About 94% of all control loops are in the category of PID. Out of these most common is PI controller, as derivative action is not more commonly employed. The major strength of PID controllers is also due to its capability to handle practical issues of actuator saturation and integral wind-up.

These controllers have received largely renewed interest from researchers and theoreticians during the last decade [1-10] and references contained therein. This has been possible due to developments in automatic tuning and increased use of model predictive control approaches. Many researchers use Ziegler- Nichols tuning rules as bench mark, as it is well known method though there are many superior methods of tuning available, which can also provide automatic tuning with largely improved performance of process. Now it is most simple computationally and has low requirement on plant knowledge. One of the intentions is to demonstrate that it is indeed so and there is need to rethink over the selection of bench mark.Now with the advancement in digital technology and developments in automatic control a wide range of choices arealso available. The interest in PI and PID controls has received stimulation with efficient and powerful software packages, and hardware modules. Now-a-days the effort is focused on integration of all available techniques in the form of software tool, to implement the relatively best strategy for any type of given problem. This has led to facility of on demand tuning and research forwards to still better approach for PID controller tuning.

Each method has some advantages and limitations in terms of optimization objectives, computational needs, and plant model assumptions and at times these are in conflict to make a fair comparison difficult.

This paper presents a few state- of- the art PID controllers that will have a bearing on the future applications and brings out the fact that PID controller will be of continued use with features of computation based fast tuning, for improved performance.

In this paper, the next section details the development of PID toolbox; in section three the transfer function of separately excited dc motor has been developed. Five conventional methods are described in the fourth section-ZN ferq response, ZN step response, Cohen-Coon method, WJC method and CHR method. Several other approaches have been used in the toolbox but not included in the paper for reasons of brevity. In section five, representative simulation results are presented for case study of dc motor speed control for both tracking and regulatory problems. The conclusions are presented at the end, to focus on the faith being strengthened on the PID controllers for online tuning through a simple, efficient and effective approach.

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II. DEVELOPMENT OF PID TOOLBOX

Software is user friendly, and reminders provide overview and simple instructions on the screen to guide the user who may not be familiar with the intricacies of MATLAB.

The software provides P, PI and PID controller tunings by classical and advanced methods. The suitability of each method has been tested by simulations of given process with PID controller in the conventional mode for a number of examples in each case. Figure 1 shows the flow chart for toolbox. Figure 2 shows the overview or tuning method selection menu which appears at starting. The toolbox can tune the systems which are up to the order of the five. The system function can be enter in various form i.e. polynomial form, pole-zero form and state space form. Various performance measures are provided by the toolbox such as rise time, % overshoot (OS), % undershoot, peak, peak time, settling time etc. Also the step response provided by the toolbox for each method and for both type of problem (tracking and regulatory).

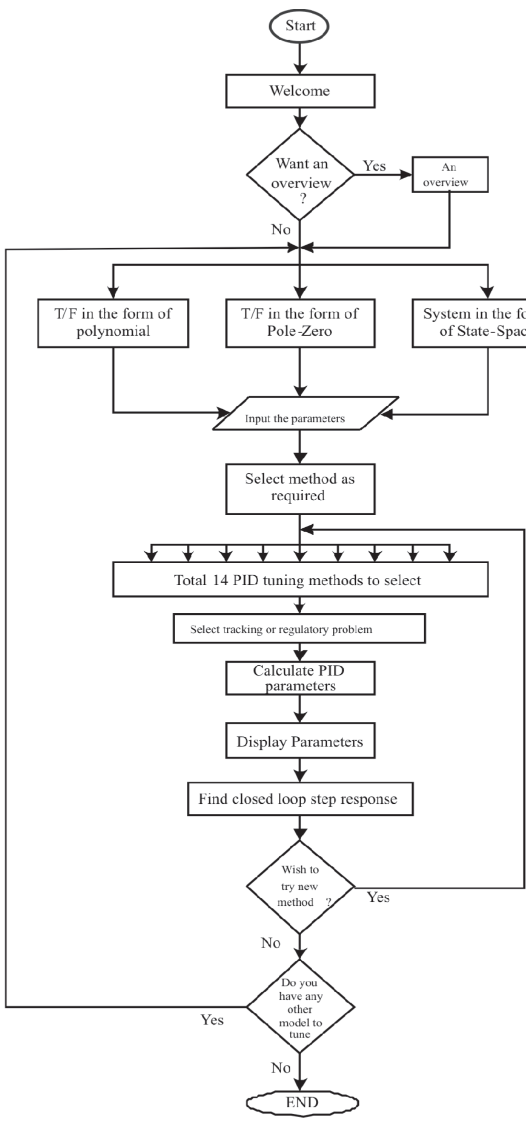

Figure 1: Flow chart for the development of PID toolbox

The toolbox developed includes Ziegler – Nichols frequency response method, ZN step response method, gain and phase margin specifications, magnitude optimum multiple integration method, Internal Model Control (IMC) method, Xumethod, Chien–Hrones–Reswick PID tuning, the Wang–Juang–Chan tuning, Cohen–Coon tuning, refined Ziegler–Nichols tuning, optimum PID controller design, PD and PID parameter setting for IPDT models, PD and PID parameters for FOIPDT models and PID parameter settings for unstable FOPDT models. All these methods appear on the screen as shown in Figure 3.

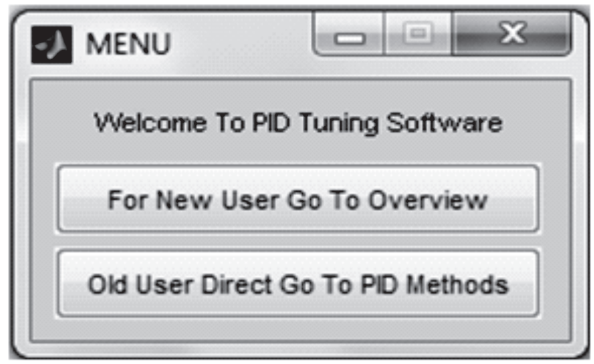

Figure 2: Overview or method selection menu of toolbox

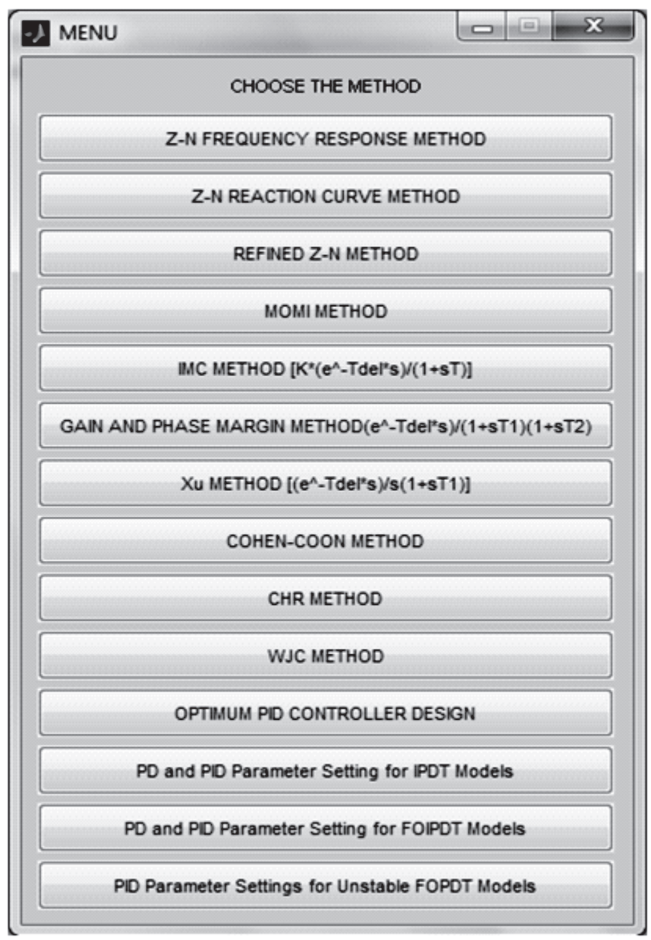

Figure 3: PID tuning methods of toolbox