

# Analysis Parameter PID with the Root Locus Theory by used M-file Mat Lab

A. Kraisontronlertphop , S. Gunpanich, *Member, IAENG*

**Abstract**—This paper presents the program M-file with Mat lab for PID parameter by root locus technique. The program can be used with other transfer function of any plant. The characteristics of the M-file can be defined for transfer function, percent overshoot and settling time to study the responding of this theory, the simulink Mat lab will be used to simulate the parameter set by M-file.

**Index**—MAT LAB, Root locus, Transfer function, Percent overshoot, Simulink, Settling time.

## I. INTRODUCTION

There are various control theories that are being used significantly. However PID control system is still widely used and accepted in the process industries. Especially, the section that requires temperature control, which is the typical application of PID controller.

The root locus plot was introduced for the design of feedback control systems by Evans in 1948 [1] and since then has become a standard and commonly used tool in control system education and practice.

Undergraduate control systems textbooks still give emphasis to root locus plotting[2]–[3], and research papers present computational methods, computer implementations [4], [5], and new approaches [8],[9]for the root locus method. The method is an essential design and analysis tool in most of the control system software [6], [7].

Several methods can be used to study parameters of PID controller. However, this paper presents root locus theory that requires m-file MAT LAB program to determine the parameters' control. M-file program can be configured to transfer functions of system, percent over shoot and settling time. Furthermore, PID parameters that receive from m-file program can be checked from by examining results of the Pole on the top of Z-Plane. Moreover, the simulation of simulink mat lab's response system can be checked PID parameters as well.

In finding control parameters, the obtained results can be

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A. Kraisontronlertphop Author is with the Graduate school, Dept. of Instrumentation and Control Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, 10520 (e-mail: warin\_mut@hotmail.com).

S. Gulphanich Author is with the Graduate school, Dept. of Instrumentation and Control Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, 10520 (e-mail: kgsuphan1960@hotmail.com).

controlled in various systems according to programmers. Consequently, M-file program is one of many methods that can show parameters and response system for study PID control theories.

## II. PID METHOD WITH M-FILE MAT LAB PROCEDURE

In order to design the M-file program, PID control is the main theory that needs to be apply first in this paper. Finally, the Root locus method is required to determine various parameters close loop pole and location of the system in z-plane. The following figure is the designed program procedures.

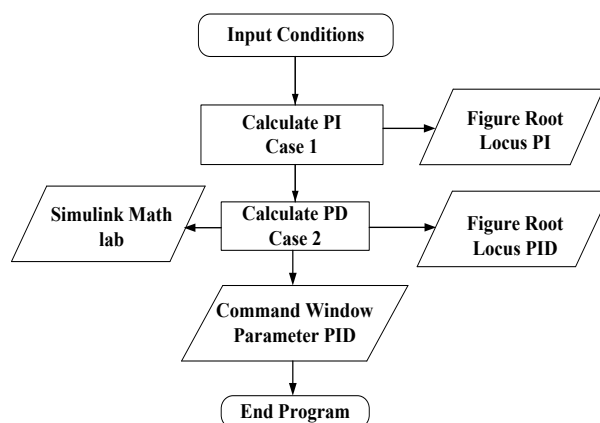


Fig1. M-file Flow Chart Calculate System.

Fig 1, Shows the process of the m-file. There are three Input conditions. Firstly, it is the value of the transfer function. Secondly, the percentage of overshoot which can be configured to start at 0% to 100% according to designer's desires. The final parameter is the settling time which is the identification of a time period. These three parameters will determine the response of the procedure. Moreover, it can find controlled parameter which are Kp, Ki, Kd. This calculation process divides in twoprocedures which are PI calculation and then use the result form the PI to calculate PD as follow.

Input Conditions: Enter the parameter into program with m-file transfer function (tf), percent overshoot (%OS), and the settling time (ts) for default in the procedure.

Case1: From close loop transfer function of the value of  $z$  is the close loop pole system is the characteristic equation.

$$1 + KG_{cPD}(z)G_p(z) = 0 \quad (1)$$

With the condition of the magnitude criteria, by the value of  $z$  corresponds to the equation.

$$|KG_{cPD}(z)G_p(z)| = 1 \quad (2)$$

When is the condition of phase condition angle, sum of the system.

$$\sum \alpha_{zeros} - \sum \theta_{poles} = -180 \quad (3)$$

Case2 : The position of the pole of a PI controller in the  $z$  plane is shown at position +1. With the zero appears at  $z = \frac{K_p}{K_I + K_p}$  within the range between 0 and 1, or the unit circle.

Therefore the value of the angle  $\theta_{PI}$  is more than  $\alpha_{PI}$  which is  $\phi$  or  $\theta_{request}$  that can be obtained from

$$\phi = \alpha_{PI} - \theta_{PI} = \theta_{request} \quad (4)$$

Then  $\theta_{request}$  is

$$\theta_{request} = \tan^{-1}\left(\frac{\beta}{\sigma - \alpha}\right) - \tan^{-1}\left(\frac{\beta}{\sigma - 1}\right) \quad (5)$$

Where  $\beta$  is the angle of zero that measures from the angle of the vector which lines from zero ( $z_i$ ) to S points that is a positive angle and an anticlockwise. Moreover, the  $\sigma$  is the position of real axis. When included both values together, it will make the pole PID controller appears in  $z$ - plane (The pole has two positions at 0 and +1). The point of zero appears in two positions at the equation.

$$z = \frac{(K_p + 2K_D) \pm \sqrt{K_p^2 - 4K_D K_I}}{2(K_p + K_I + K_D)} \quad (6)$$

From the above process, we are able to determine the parameters  $K_p, K_i, K_D$ , also check value of the pole, check value of the and zero and the angle in  $z$ -plane. The Mat lab command window can be used to check the all parameters. We can exam the results by simulated process response of the parameters by using  $K_p, K_i, K_d$  that obtains from the process shown in Figure 1. In this paper, the parameters of m-file is used to test the process. Simulink Mat lab is used to simulate the response and verify the initial conditions weather it matches with the response procedure.

### III. RESULT AND SIMULATE M-FILE MAT LAB

In this research, we use a temperature model to study for finding the transfer function. The open loop is necessary to test the process for determining the characteristics equation. After that mat lab program is used to analyze and compared the characteristic equation between the open loop result and simulate mat lab.

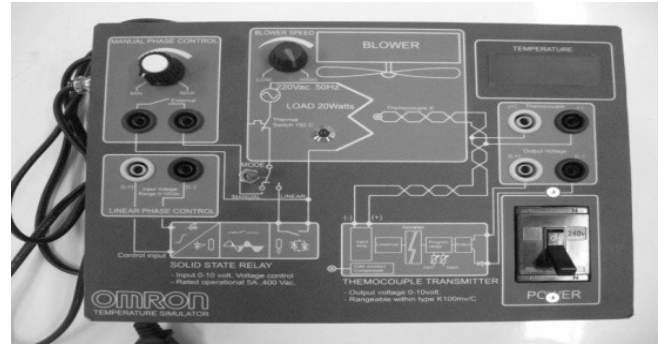


Fig 2 Temperature Simulation.

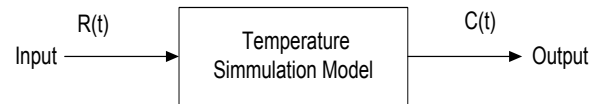


Figure 3 shows the testing to find the Open Loop Transfer Function.

From Fig 3 we use of the open loop result to find out the characteristics equation process. Mat lab application is used to figure the value of the transfer function, by using simulate mat lab as shown in Fig 4.1(a) and 4.1(b). Simulink program is used to determine the characteristics equation process in fig 4.1(a). In this Fig 4.1(b) is the characteristics equation by comparing between the open loop process and simulink program. As a result, the characteristics of the both curves have very similar trends and directions in fig 4.1(b).

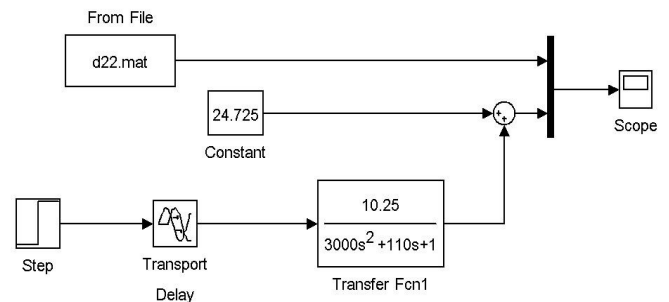


Figure 4.1(a) procedure simulate transfer function.

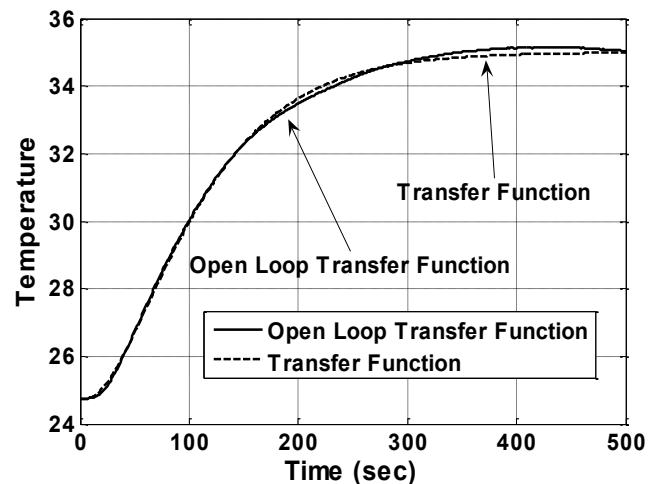


Fig 4.1(b) result simulate transfer function.

The result that shown fig 4.1(b) is the transfer function of system from equation 7.

$$G(S) = \frac{10.25}{3000s^2 + 100s + 110} \quad (7)$$

Result procedure m-file : The transfer function of procedure can be simulated by parameter PID. The pole is shown on z-plane in the root locus theory. The Equation 7 is used to initial configuration of m-file by giving the percent overshoot equal to 0.01 and settling time equal to 320 seconds (the three parameters can be changed) in this paper.

```
close all
clear
clc
sysc = tf(10.25,[3000 110 1]); //transfer function//
OS = 0.1; //percent overshoot//
ts_old = 300; //settling time//
```

Example Source Code initial condition by M-file.

This m-file default result can make the pole to place on root locus theory as shown in fig 5.

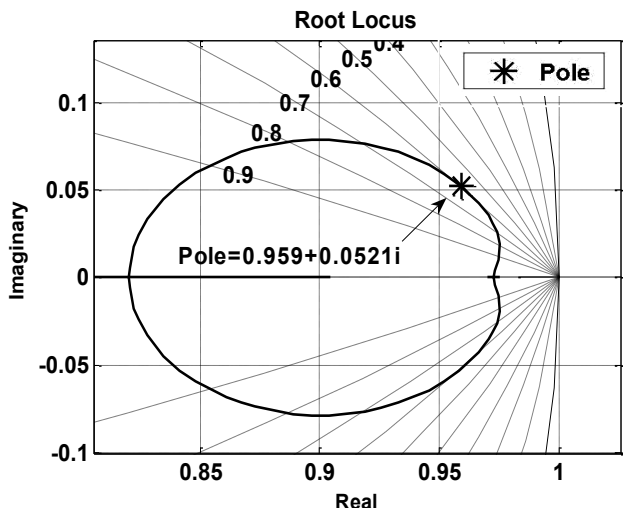


Fig 5. Pole position (0.959+0.0521i) on root locus.

The results of pole (pole position=0.959+0.0521i) on root locus can find out parameters of PID control. The math lab work space presents the parameters  $K_p=0.6367$ ,  $K_i=0.0093$ ,  $K_d=5.1969$ .

Result Simulink Math lab: In Figure 1, the m-file program will send parameters  $K_p$ ,  $K_i$  and  $K_d$  to simulink math lab by increasing the transfer function in equations 7 as shown Fig 6.

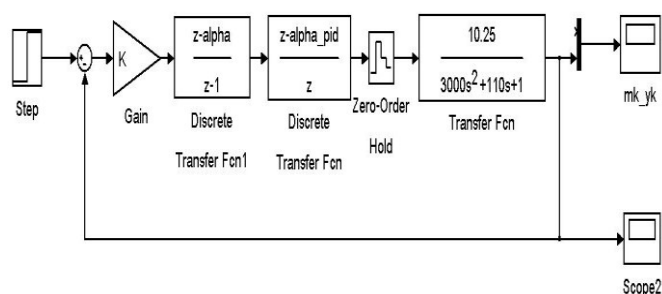


Fig 6. Process PID control Simulink.

In Fig 6, the simulated response of process by using M-file initial value program as follow, set point =1, overshoot=1%, settling time= 300 sec. As a result, we will receive the response of the procedure as shown in Fig 7(a), (b).

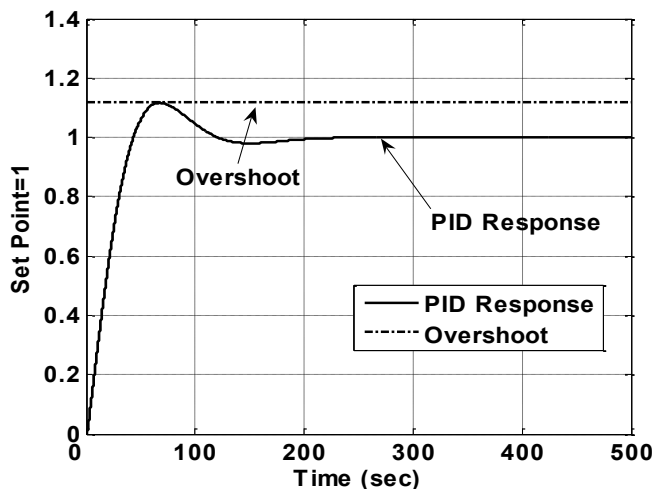


Fig. 7(a).Processes responds PID Set Point = 1.

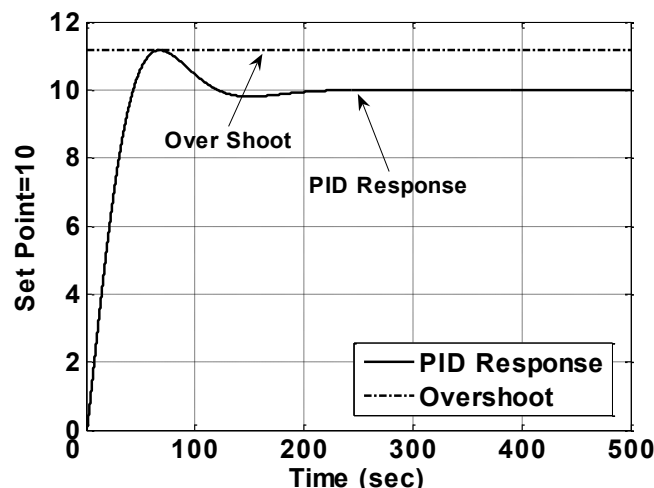


Fig. 7(b).Processes responds PID Set Point = 10.

#### IV. CONCLUSION

The results that obtained from experiment, the m-file Math lab program is another method that can be used to study the response of PID control. The root locus theory is necessary to observe the pole position of in the z-plane. Moreover, the pole value is needed to find out the parameters PID control. The simulink math lab can be used to simulate the response weather it follows the initial condition. We can adjust transfer function, percent overshoot and settling time to study and observe procedure responding.

The m-file is also another technique to determine the parameters  $K_p$ ,  $K_i$ , and  $K_d$ . As a result, based on the initial conditions specified in the m-file, the response of the process is shown in Fig 7.

Consequently, the users can used the m-file program to determine the response system. By configuring percent overshoot, settling time and the transfer function, we can figure the parameters that can be used to control actions.

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