Volume 2, Issue 6December 2013

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Software Based Application of Good Gain Method

Md. Imran Hossain Jony

Lecturer, Department of Electrical and Electronic Engineering, City University, Bangladesh

E-mail: jony@yahoo.com

ABSTRACT

A software based application of Good Gain method for tuning PI controller is presented in this paper. The method is applied on a type-0 plant. The exact topology is described here by some figures generated using MATLAB.

Keywords: *PI controller, tuning, closed-loop, good gain, stability robustness.*

1. INTRODUCTION

Good Gain method is used to tune the PI controller and is considered to be the best suited method for tuning this type of controller. The PI (proportional plus integral) controller stems from a PID controller with the D-term (derivative) deactivated. The D-term is often deactivated because it amplifies random (high-frequent) measurement noise causing abrupt variations in the control signal. The PI controller is probably the most frequently used controller function in practical applications.

This tuning method will be applied to the system given below:

GOOD GAIN METHOD ON A TYPE-0 PLANT

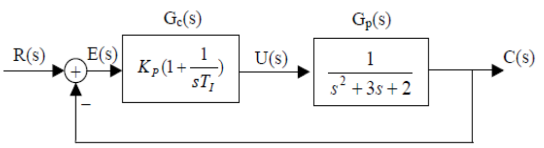

Figure 1

The closed loop transfer function of this system would be:

$$CLTF = \frac{C(s)}{R(s)} = \frac{K_P(s+1/T_I)}{s(s^2+3s+2)+sK_P+K_P/T_I}$$

2. METHODOLOGY

The Good Gain method is applied to the established closed-loop system as we could see from Figure 1. [1]The procedures to tune a controller with Good Gain method are listed below:

1. Bring the process to or close to the normal or specified operation point by adjusting the manual control signal.
2. Ensure that the controller is a P controller with $K_c = 0$ (set T_i = infinity and $T_d = 0$). Switch the controller into automatic mode. Increase K_c until the control loop gets good stability.
3. Read off the time, T_{ou}, from overshoot to undershoot. Calculate the integral time T_i with $T_i = 1.5\ T_{ou}$
4. Because of the introduction of the I-term, the loop with the PI controller in action will probably get reduced stability. To compensate, K_c should be reduced, $K_c = 0.8\ K_{cGG}$.
5. Apply K_c and T_i calculated above to the controller.
6. Finally, check the stability of the control system by changing the set point as a step and concluding about the stability, whether it is acceptable or not.

3. SIMULATION

The closed loop transfer function is simulated through MATLAB putting K_p= 10 and T_i = 20 which yields to figure 2 shown below.

SIMULATED OUTPUT

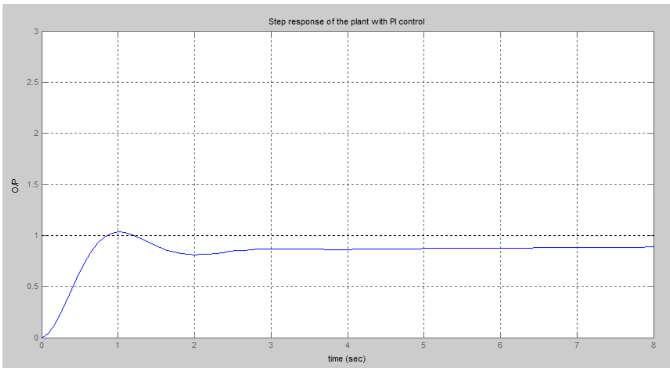

Figure 2

Here from Figure 2, it can be found that T_{ou}=1s.

SIMULATED OUTPUT WITH GOOD GAIN PARAMETER VALUES

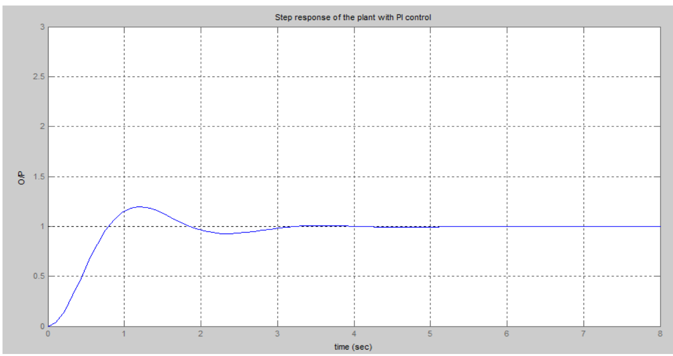

Figure 3

Figure 3 is generated applying the values from the Good Gain method tuning procedures. The values used to generate figure 4 are calculated like below:
$K_p = 0.8\ K_{pGG} = 0.8 \times 10 = 8$
$T_i = 1.5\ T_{ou} = 1.5 \times 1 = 1.5$ s

4. RESULT ANALYSIS

From figure 4 it is clear that there is a slight overshoot and undershoot, which is the most desired case. Therefore, tuning with Good Gain method is proved to be very efficient and probably the best in terms of performance and stability robustness.
The term performance consists of setpoint tracking and disturbance compensation.
(a) Setpoint tracking: The setpoint is changed as a step. IAE (Integral of Absolute Error) index, which is frequently used in the literature to compare different control functions
It is to be noted that the less the IAE value, the better the control performance.
(b) Disturbance compensation: When the system is at steady state with approx. zero control error, the process disturbance is changed as a step.
The term stability robustness consists of gain margin and phase margin.
(a) Gain Margin (GM): [1] Initially, $\Delta K = 1$. For each of the tuning methods, the (ultimate) value ΔK_u that brings the control system to the stability limit is called the gain margin. Therefore,
Gain Margin = ΔK_u
(b) Phase Margin (PM):Initially should be set to zero and then as before.

$$PM\ [\text{deg}] = 360\frac{\Delta\tau_u}{P_{osc}}$$

[2] The following ranges for acceptable values:
GM: In between 4.6 dB to 12 dB
PM: In between 30 degree to 45 degree

[1] There are three important limitations in Good Gain Method as well. These are stated below:
(a) Integrator without delay:One example of such a process is a liquid tank with outflow via a pump and in flow via a pump or valve which is manipulated by the level controller.
(b) Time-constant without time-delay: One example of a time-constant without time-delay system is a liquid tank with outflow via a valve and inflow via a pump or valve which is manipulated by the level controller.
(c) Double-integrator: One example of a double-integrator is a ship at rest.

5. CONCLUSION

This paper presents the applicability of the procedures to tune a PI controller using Good Gain Method on a system. There are two big motivations to choose this good gain method for tuning controllers. These are stated below:
1. It is not required that the control loop has sustained oscillations during the tuning. Instead, the control system is required to have good stability.
2. Improved resulting stability of the control system. It gives better stability than the “one-quarter decay ratio” of Ziegler-Nichols’ method.
In summary, the method appears to be an alternative to the famous Ziegler-Nichols' Ultimate Gain method as for the following advantages:

- Simplicity
- Avoiding severe process upset during the tuning (i.e. avoiding troublesome oscillations)
- Acceptable performance
- Acceptable stability robustness

That’s why it is becoming a very useful and popular tuning method especially for tuning PI controllers.

REFERENCES

[1] F. Haugen. “The Good Gain method for simple experimental tuning of PI controllers”.Modeling, Identification and Control, Vol. 33, No. 4, 2012, pp. 141-152, ISSN 1890-1328.

[2] Seborg, D., Edgar, T., Mellichamp, D. (2004). Process Dynamics and Control, John Wiley and Sons

AUTHOR PROFILE

Md. Imran Hossain Jony received the Bachelor degree in Electrical and Electronic Engineering from Independent University, Bangladesh in 2012. He is now doing his MSc thesis in wireless communication at Islamic University of Technology. Currently, he is a lecturer in the department of Electrical and Electronic Engineering at City University, Bangladesh.

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X