*Journal of Information & Communication Technology*
Vol. 8, No. 2, (Fall 2014) 25-30

# Root Loctus Technique For Stabilty Analysis of Control System And To Set Parameters of Controller in Robotic Application.

**Chandan Lal ***

**Dr. Ather Raza Syed ***

## ABSTRACT

In this paper the root locus technique is used for stability analysis of the control system. It gives the trajectory of poles which plays an important role in transient and steady-state response of the system. This method helps to adjust controller parameters to satisfy the required specification even in the presence of noisy atmosphere. Time delay is another factor which affects the performance of the system. These systems are also analyzed using MATLAB.

**Keywords :** Root locus, Stability, Transient response, Steady state error, Poles, S-plane and Control systems.

* The material presented by the authors does not necessarily portray the viewpoint of the editors and the management of the Institute of Business and Technology (IBT) or Karachi Institute of Power Engineering.

*Chandan Lal : chandan.lal@fuuast.edu.pk
*Dr. Ather Raza Syed : akhter@fuuast.edu.pk

## 1. Introduction:

In the field of robotics the role of control systems and their stability is very important. The objective of control systems is to control physical variable to achieve required dynamic response (steady state error and transient response) and to make system stable even in transient disturbance [1].

The root locus is one of the methods to analyze stability and dynamic behavior of control systems [1]. It is a graphical method which shows the trajectory of poles of closed loop systems in complex plane. All the characteristics of the system, depends on the location of poles in s-plane [2]. It is also observed in control systems that due some processing delay, system may become unstable. Delayed transfer function of the system can be written as:

$$G(s) = e^{-s\grave{e}} \quad (1)$$

Where "s" is a complex variable and è is phase shift [3]. To achieve main objectives of control system, including percent overshoot, settling time and steady state error, we have to select parameters of controller on the basis of root locus to get optimal response. The current paper presents stability analysis of open loop and closed loop systems with and without controller using MATLAB and SIMULINK. The next section of this paper introduces control system for robotic applications including overview and performance parameters of controller under investigation. Section 3 is focused on simulations to investigate stability of the control system by varying conditions. Results and discussions are presented in section 4 which is followed by conclusion in section 5.

## 2. Control System for Robotic Applications

In general, closed loop control systems are employed in robotic applications. However, open loop systems are also considered for comparative analysis of stability using root locus technique in both configurations [9]. This intended work is based on simulations in MATLAB for which control system's overview and performance parameters are discussed in this section.

### 2.1. Control System Overview

The overall block diagram of the control system under investigation is presented in Fig.1 in which plant represents dc motor [6]. Dc motor is the part of overall control system and manipulator is operated by multiple motors such that one motor is used at each axis [8]. The motor is controlled by Proportional, Derivative, Integral or combination of them depends upon desired performance and accuracy [3]. System's output is continuously measured and compared by comparator with reference value. The difference is applied to controller for desired response.

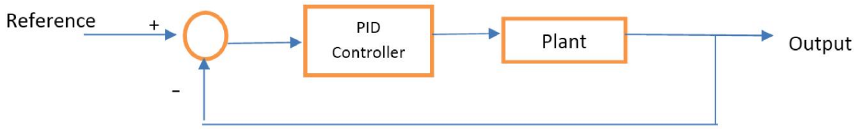


**Fig.1. Overall Control System Block Diagram**

It is clarified from Fig.1 that PID controller is placed for which parameters are required to be controlled in a careful manner [7]. The details about such parameters are discussed in section 2.2.

2.2. Performance Parameters of Controller

The controller play main role in stability and performance of the control system [4]. Mainly PID controller as shown in Fig.2.It is used when the plant is continuous or it is difficult to find mathematical model of system.

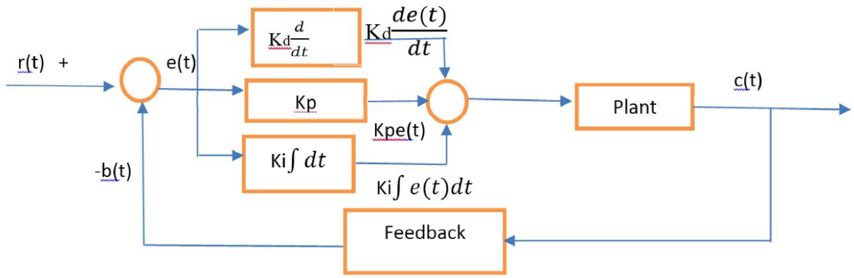


**Fig.2. PID control System**

$$cpid(t) = Kpe(t) + Ki \int e(t)\, d(t) + Kd\ \frac{de(t)}{dt} \qquad (2)$$

$$\frac{C_{pid(s)}}{E(s)} = Kp + Ki\frac{1}{s} + Kd\ s \qquad (3)$$

The values of settling time, overshoot and steady state error will change when the values of gain parameters ( $K_p$, $K_d$, $K_i$) are changed [5]. The output of PID of controller is given in equation (2) and its transfer function in equation (3).

In this paper root locus method is used for stability and performance of proportional and PID controllers.

## 3. Simulation Based Stability and Performance Analysis

In the light of PID transfer function in equation (3) and plant described in previous section, the stability and performance of dc motor is analyzed using MATLAB.

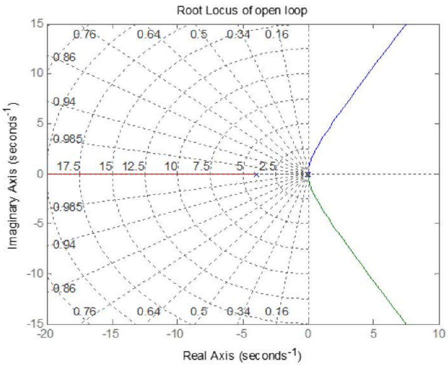


Fig.3 (a)

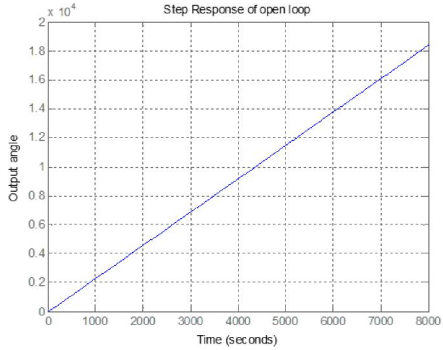


Fig.3 (b)

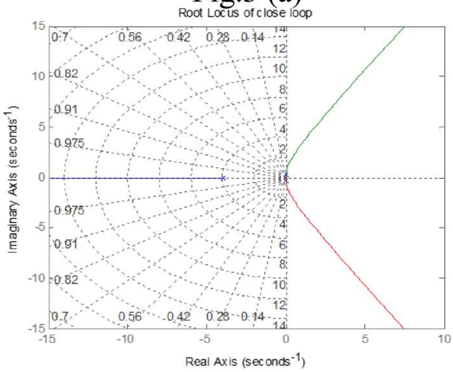


Fig.4 (a)

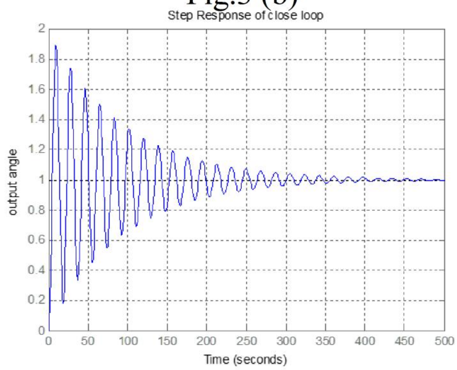


Fig.4 (b)

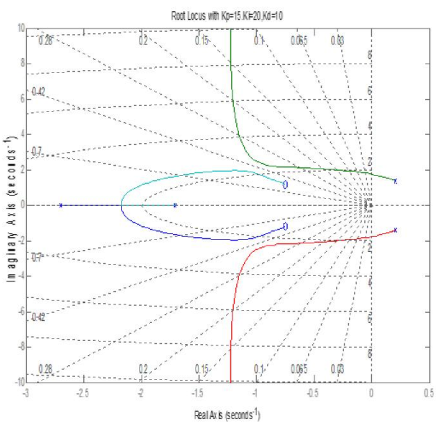


Fig.5 (a)

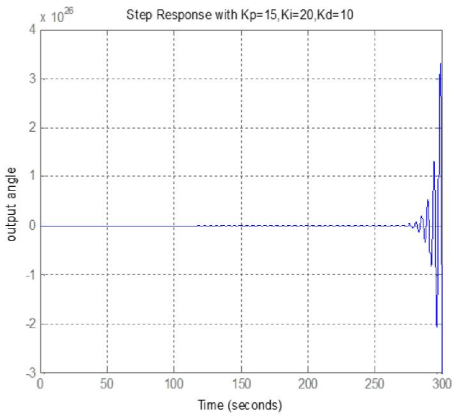


Fig.5 (b)

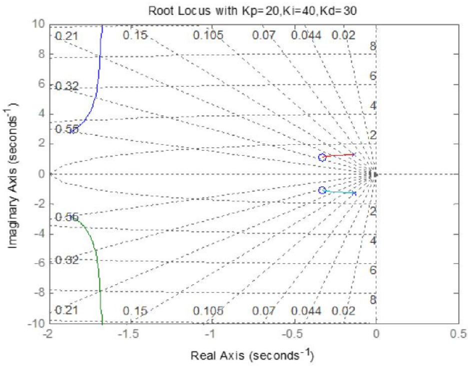


Fig.6 (a)

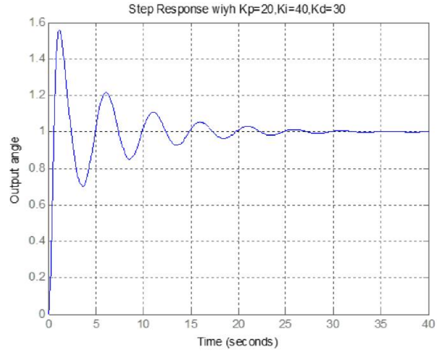


Fig.6 (b)

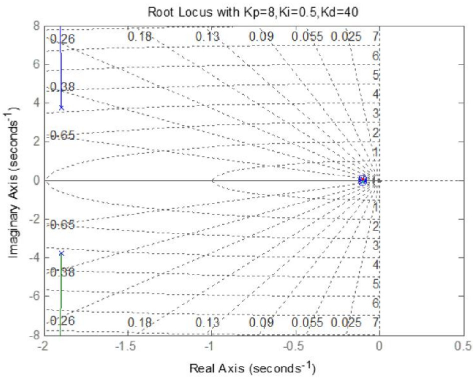


Fig.7 (a)

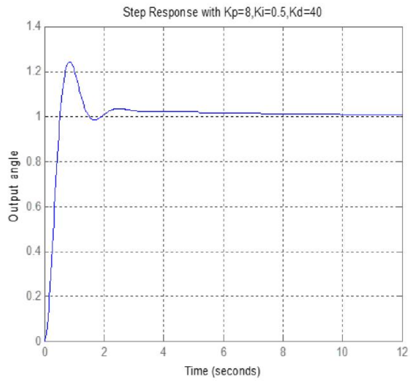


Fig.7 (b)

## 4. Results and Discussions:

Simulation performed on open loop, closed loop with proportional controller, closed loop with PID controller with different gain values. On the basis of root locus and step response given in Fig.3 to Fig.7 it is clear that if any single pole of the system lies on right half s-plane, the system will become unstable. By setting gain parameters of controller we can get stable system with desired response. If we increase these gain parameters the overall effect on dynamic response is given in Table.1

**Table.1**

| Parameters Increases | Rise Time | Overshoot | Settling Time | Steady State error |
|---|---|---|---|---|
| $K_p$ | Decrease | Increase | Small | Decrease |
| $K_i$ | Decrease | Increase | Increase | Eliminate |
| $K_d$ | small | decrease | Decrease | small |

## 5. Conclusion

The root locus method for stability analysis and setting controller parameters is introduced for control systems in robotics. Simulation results verify that the location of poles of a closed loop system play an important role in stability and overall dynamic performance of the control system. For stability all the poles must lie on left half s-plane. By combining three controllers we get a system which has acceptable performance. The desired angular position of armature controlled dc motor can be achieved by tuning three gains of PID controller [10]. The stability and gain parameter setting can be done with rltool and sisotool of MATLAB.

## 6. References

[1] N. S. Nise, Control Systems Engineering (6th Edition), John Wiley and Sons Inc., New York, 2010.

[2] Richard C. Dorf and Robert H. Bishop., Modern Control Systems, 12th edition, Prentice Hall. 2010.

[3] Mann GKI,Hu BG, & Gosine RG. (2001). "Time-domain based design and analysis of new PID tuning rules". IEE Proceedings-Applied Control Theory, 148(3), 251–261.

[4] Sipahi, R., Niculescu, S., Abdallah, C., & Michiels, W. (2011). Stability and stabilization of systems with time delay: limitations and opportunities. IEEE Control Systems Magazine, 31(1), 38–53.

[5] Stefani, R. T., Shahian, B., Savant, C. J., & Hostetter, G. H. (2002).Design of feedback systems. New York, NY: Oxford University Press.

[6] A. S. Othman, "Proportional Integral and Derivative Control of Brushless DC Motor," European Journal of Scientific Research, Vol. 35 No. 2 (2009), pp. 198-203.

[7] K.H. Ang and G. Chong,and Y.Lee, "PID control system analysis, design and technology", IEEE transactions on Control Systems Tech., vol. 13, no. 4, pp. 559-576, July 2005.

[8] J.C. Basilio and S.R. Matos,"Design of PI and PID controllers with transient performance, specification, IEEE Transaction on Education", vol. 45, no. 4, pp. 364-370, Nov. 2002.

[9] H. Alasooly, "Control of DC motor using different control strategies", global journal of technology and optimization, volum 2 , 2011

[10] A. O'Dwyer, "PI and PID controller tuning rules: an overview and personal perspective", in The IET Irish Signals and Systems Conference, Dublin, Jun. 28-30, 2006, pp. 161-166.