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MATLAB Simulation for Control System

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Abstract: This paper presents the MATLAB simulation of control system and discusses open loop and closed loop properties of control system. In this paper we start with transfer function of control system and their pole zero plots to frequency response through MATLAB simulation coding. This paper also explains time domain and frequency domain response of control system to different-different input, frequency domain analysis three techniques like root locus, bode plot and nyquist plot are discussed. It is thus important to learn first how to generate transfer function and then applied MATLAB commands to them to applicable in control system analysis, which are the main objectives of this paper. A secondary objective is to learn the application of some basic MATLAB commands and how to apply them in simple control system problems.

Keywords: Transfer function, Open & Closed loop, Frequency response, MATLAB, Simulink.

I. INTRODUCTION

Control engineering is based on the foundations of feedback theory and linear system analysis, and it generates the concepts of network theory and communication theory. Accordingly, control engineering is not limited to any engineering discipline but is applicable to aeronautical, chemical, mechanical, environmental, civil, and electrical engineering. A control system is an interconnection of components forming a system configuration that will provide a desired system response. The basis for analysis of a system is the foundation provided by linear system, which assumes a cause effect relationship for the components of a system. Main objective of this paper for beginner can easily understand concepts of control system with the help of MATLAB simulation.

II. TRANSFER FUNCTION GENERATION

$$\boldsymbol{G(s) = \frac{4s}{s+5}}$$

MATLAB SCRIPTS

```
a=[4 0];          % numerator coefficient
b=[1 5];          % denominator coefficient
gf=tf(a,b)
>>Transfer function:
      4 s
      -----
      s + 5
```

$$\boldsymbol{G(s) = \frac{2s+5}{2s^2+3s+2}}$$

MATLAB SCRIPTS

```
a=[2 5];          % numerator coefficient
b=[2 3 2];        % denominator coefficient
gf=tf(a,b)
>>Transfer function:
      2 s + 5
  ---------------
  2 s^2 + 3 s + 2
```

III. POLE & ZEROS PLOT

$$\boldsymbol{G(s) = \frac{s-2}{s+5}}$$

MATLAB SCRIPTS

```
G= tf([1 -2],[1 5]);
pzmap(G)
```

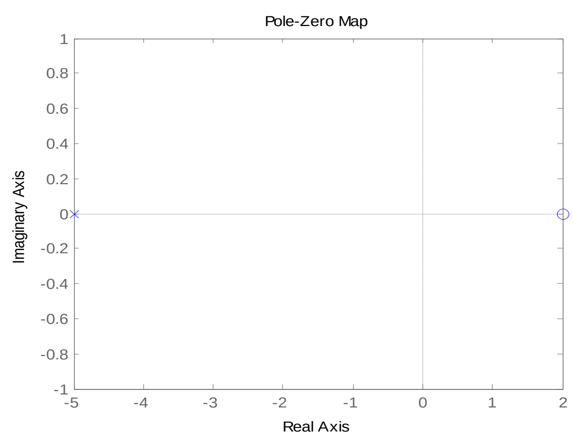

Fig. 1. Pole zeros plot for transfer function

$$\boldsymbol{G(s) = \frac{2s+5}{2s^2+3s+2}}$$

MATLAB SCRIPTS

```
G= tf([2 5],[2 3 2]);
pzmap(G)
```

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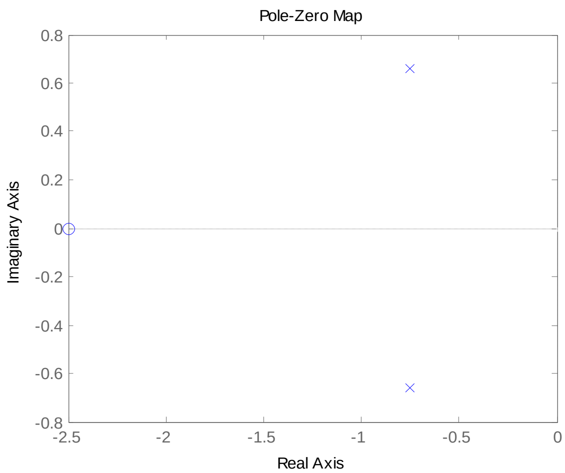

Fig. 2. Pole zeros plot for transfer function

IV. UNIT STEP RESPONSE OF SYSTEM

A. Unit Step Response for First order system

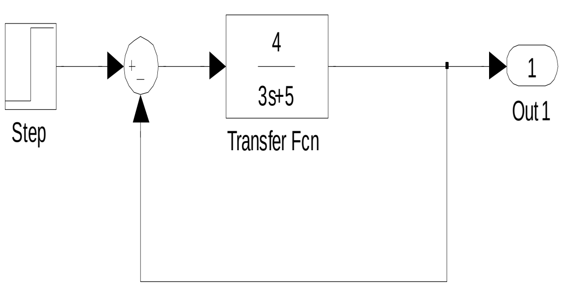

Fig. 3. Simulink model for first order system

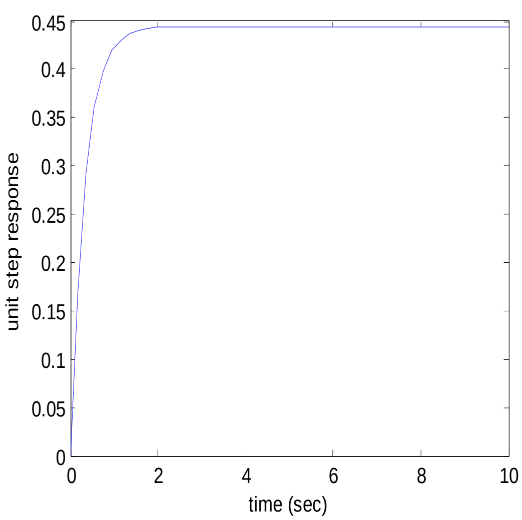

Fig. 4. Unit step response for first order system

B. Unit Step Response for Second order system

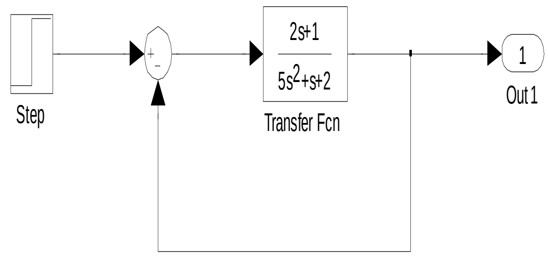

Fig. 5. Simulink model for second order system

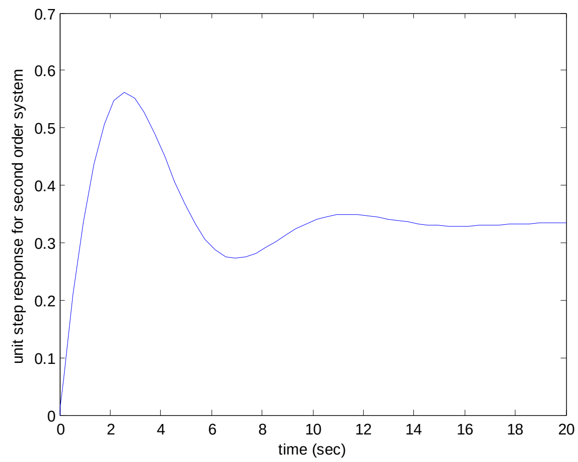

Fig. 6. Unit step response for second order system

V. P,PI & PID CONTROLLER RESPONSE

A. Without Any Controller Response

Let the transfer function of system

$$\boldsymbol{G(s)} = \frac{\mathbf{1}}{\mathbf{s^2 + 10s + 20}}$$

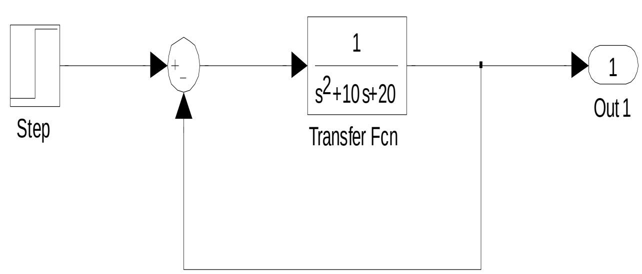

Fig. 7. Simulink model for without any controller

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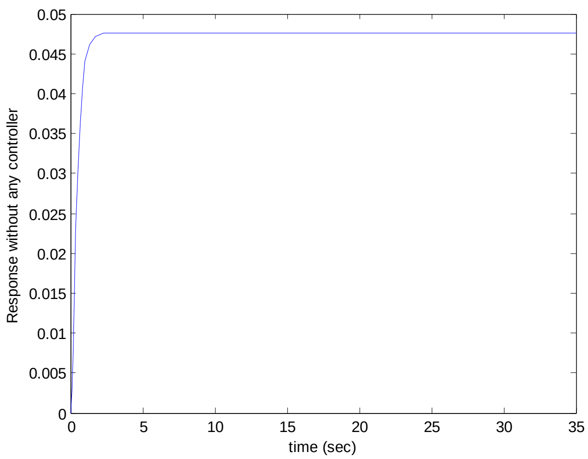

Fig. 8. Unit step response without any controller

Steady State error (e_{ss}) = 0.965
Rise Time ≡ 3 second

B. P CONTROLLER RESPONSE (K_P =10)

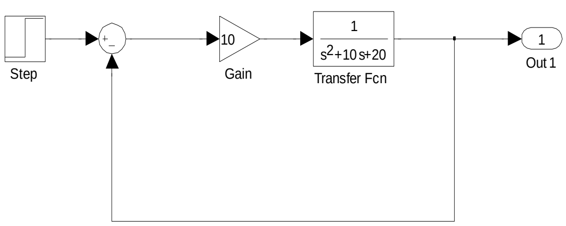

Fig. 9. Simulink model for with P controller

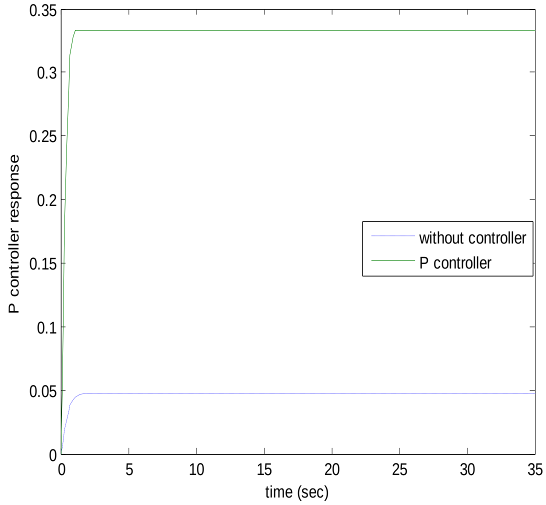

Fig. 10. Unit step response with P controller

Steady State error (e_{ss}), Rise Time decreased compare to without controller.

C. P-I CONTROLLER RESPONSE (K_P =100, K_I= 100)

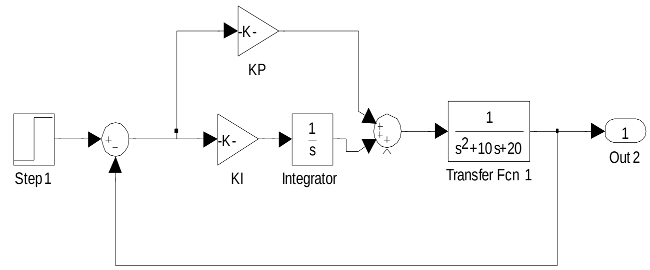

Fig. 11. Simulink model for with PI controller

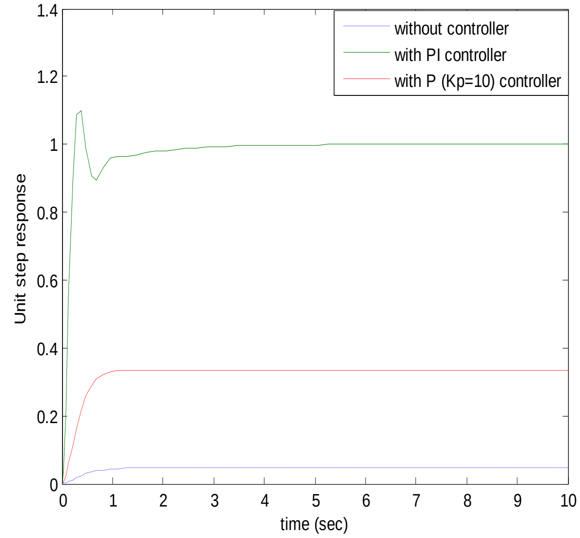

Fig. 12. Unit step response with PI controller

Steady State error (e_{ss}), Rise Time decreased compare to P controller.

D. P-I-D CONTROLLER RESPONSE (K_P =100, K_I= 100 K_d = 10)

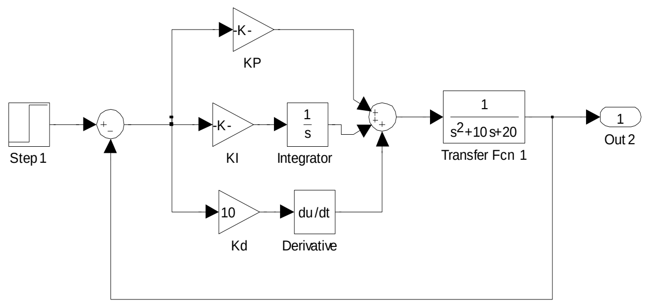

Fig. 13. Simulink model for with PID controller

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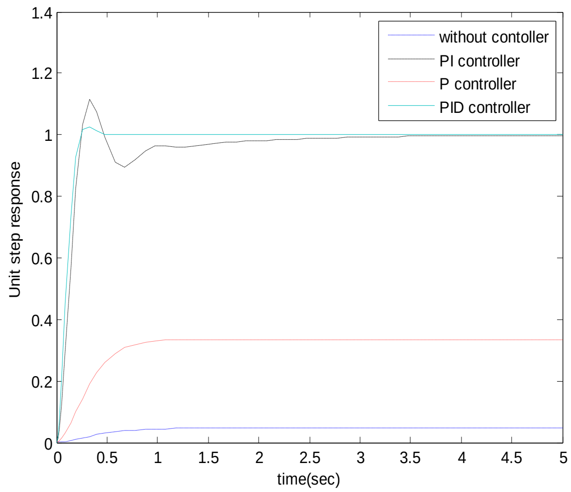

Fig. 14. Unit step response with PID controller

Steady State error (e_{ss}), Rise Time decreased compare to PI controller.

VI. FREQUENCY RESPONSE OF TRANSFER FUNCTION

A. Root Locus of System

$$G(s) = \frac{2s+5}{2s^2+3s+2}$$

MATLAB SCRIPTS
G = tf([2 5],[2 3 2]);
rlocus(G)
>>

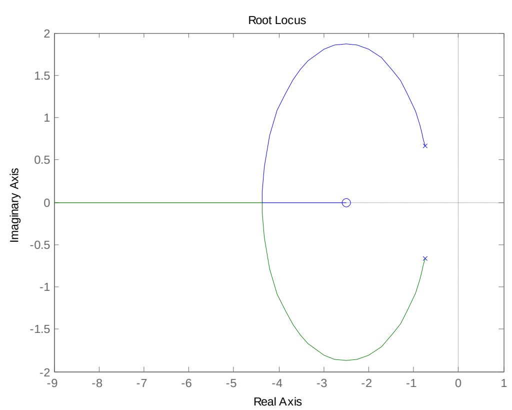

Fig. 15. Root locus of system

B. Bode Plot of System

$$G(s) = \frac{1}{s^2+10s+20}$$

MATLAB SCRIPTS
G = tf([1],[1 10 20]);
bode(G)
>>

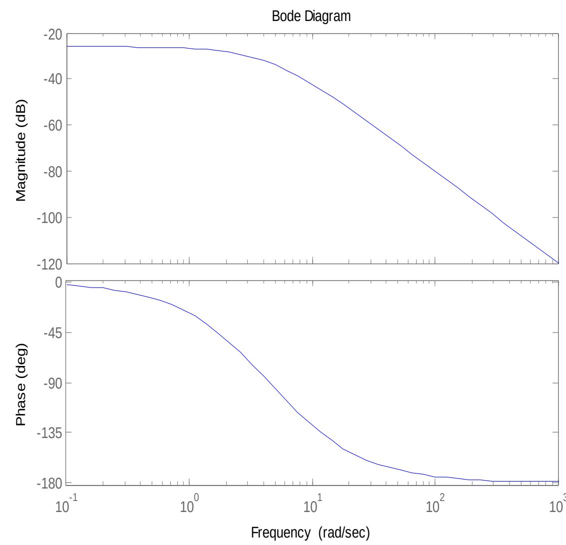

Fig. 16. Bode plot of system

C. Bode Plot of System

$$G(s) = \frac{4s}{s+5}$$

MATLAB SCRIPTS
G = tf([4],[1 5]);
nyquist (G)
>>

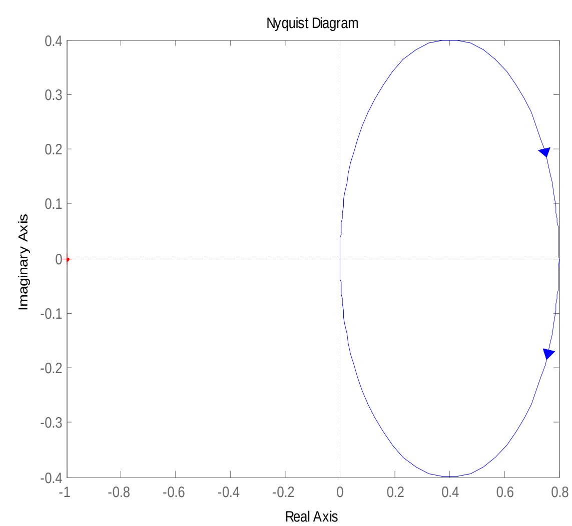

Fig. 17. Nyquist plot of system

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VII. CONCLUSION

This paper helps lots of beginner those who are interested to learn Control system with MATLAB programming, because this paper start with basic control system concept programming and goes to various mathematical operations, frequency domain analysis programming. Main features of this paper unit step response of various controller.

REFERENCES

[1] Online resources like www.google.com
[2] Online resources like www.mathwork.com
[3] Online Books, Notes.