Problem 6:

Given, =; = ;

where = 1.53, T = 0.0254, β = 0.9789, = 0.7836, = 55.7616

= ;

= ,

Now,

=

= (

Putting the given values

= () (55.7616) (0.7836)

= (1.53) () (55.7616) (0.7836)

Now, separating the basic terms form = ( the asymptotic calculation of is shown below

1. For , | | = 20log ()

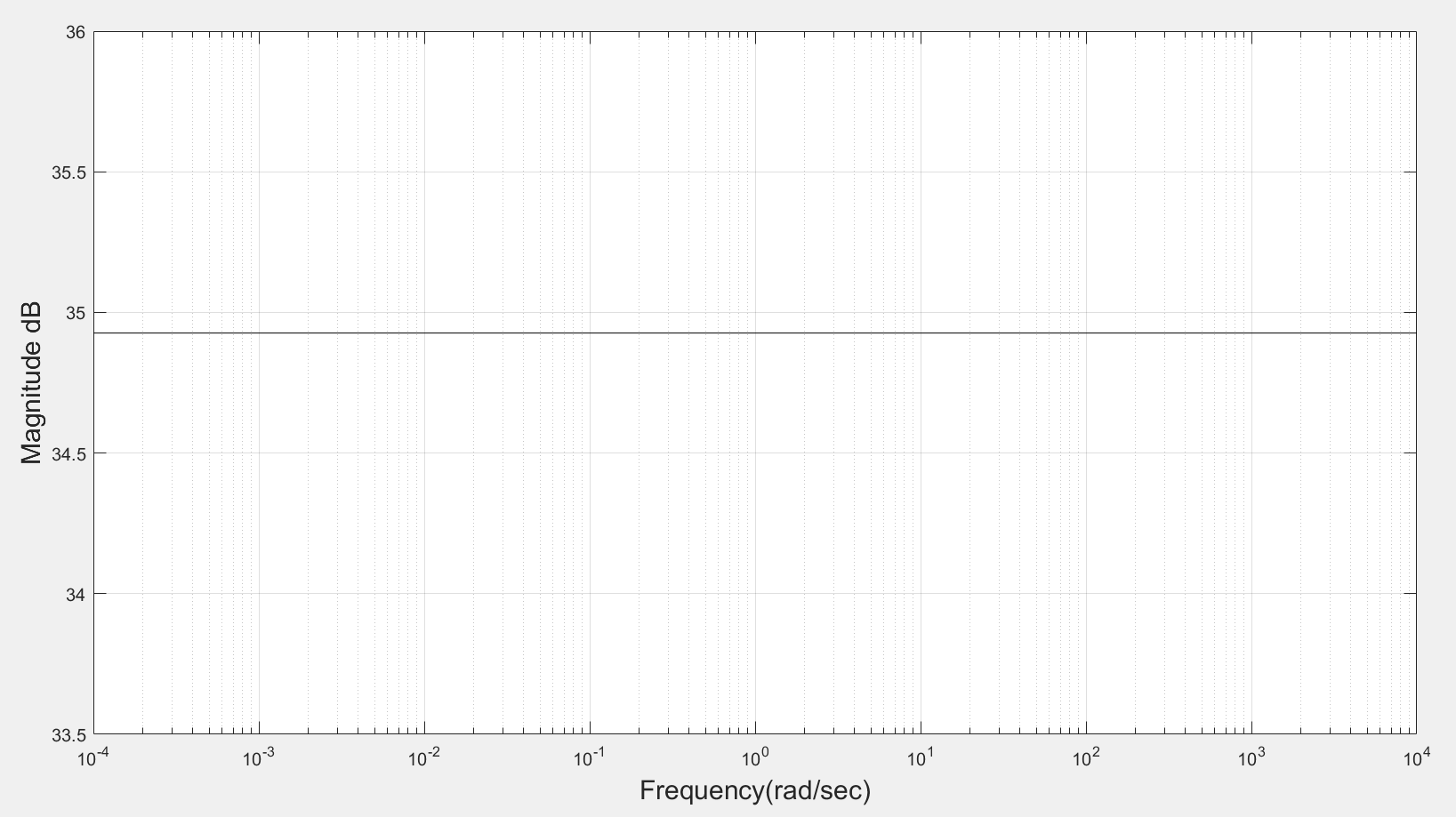


Figure 1: Asymptotic magnitude bode plot for constant gain,

1. For , |)| = 20log ()

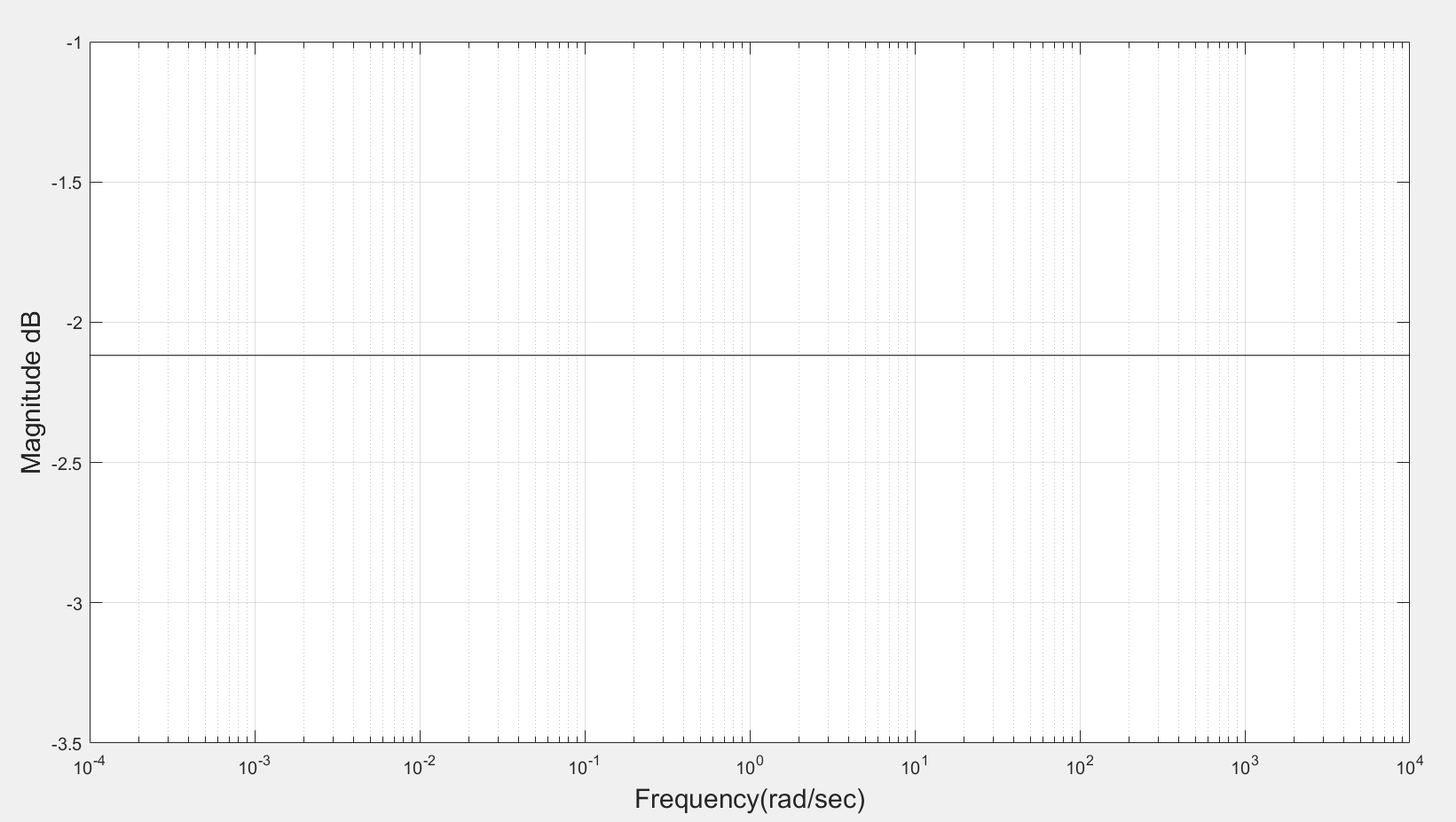


Figure 2: Asymptotic magnitude bode plot for constant gain,

1. For , |)| = 20log ()

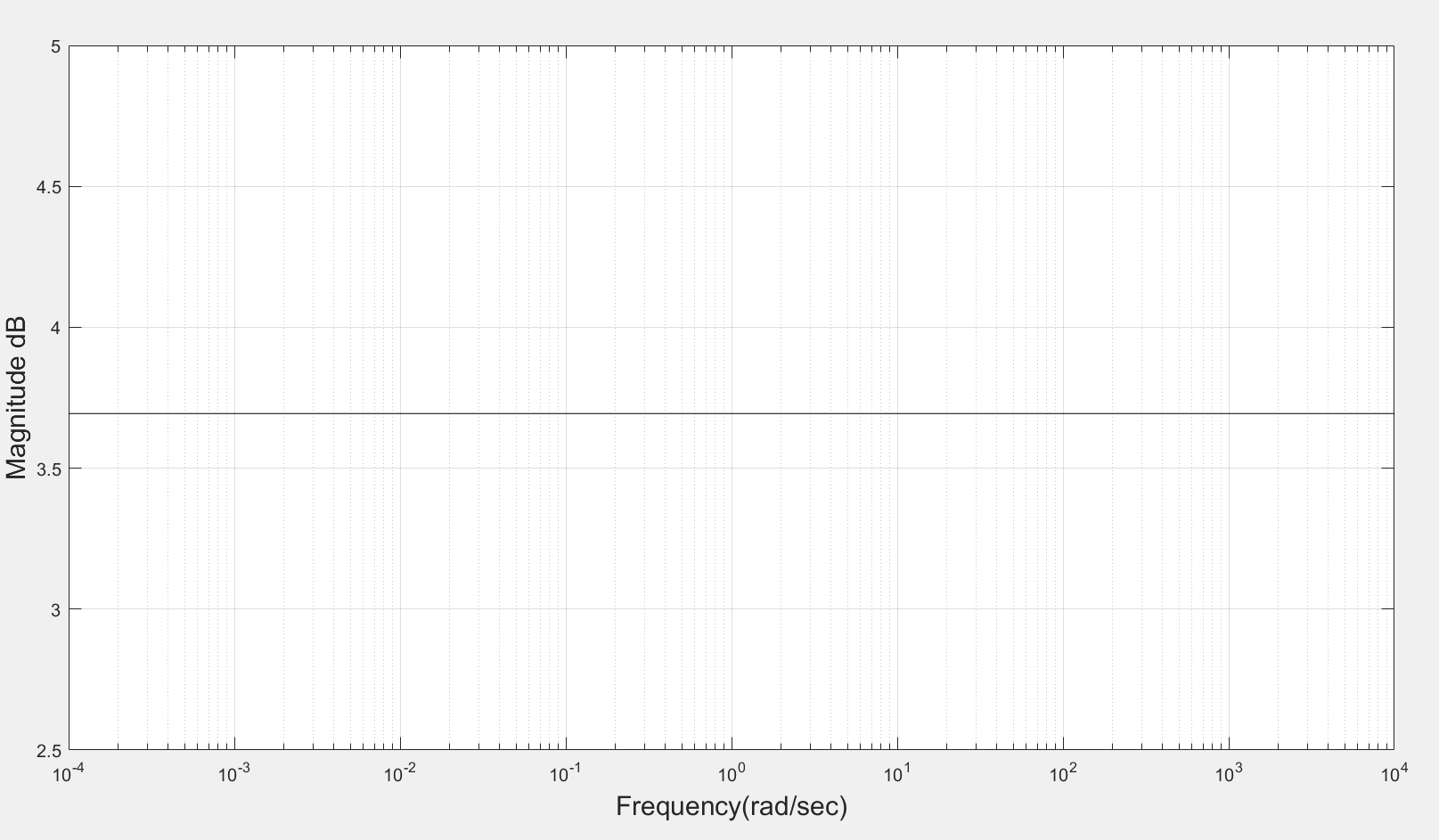


Figure 3: Asymptotic magnitude bode plot for constant gain,

1. For, (

Fractional zero transfer function is given by =…... (1)

Put s = jω, in equation (1) results into =…… (2)

Magnitude in dB is given by | | dB = 20log ( )

**Calculation procedure**

==

Applying De Moivre’s theorem in above equation we get

= …… (3)

Put equation (3) in (2) we get

=+

= +

Magnitude, || =

=

Now, Magnitude in dB, |) | dB = 20log

In the sum }, dominates at lower frequencies whereas dominates at higher frequencies.

For approximation we consider = .We obtain corner frequency, =

Now, following approximation of magnitude is obtained:

1. For ω ≤ , | | dB = 20log = 20log||
2. For ω >, || dB = 20log= 20βlog ω

**Procedure**

* Compute the corner frequency = and locate the point at magnitude 20log||.
* Draw a slope 0 dB/decade for ω ≤ and a line with slope 20β dB/decade for ω>

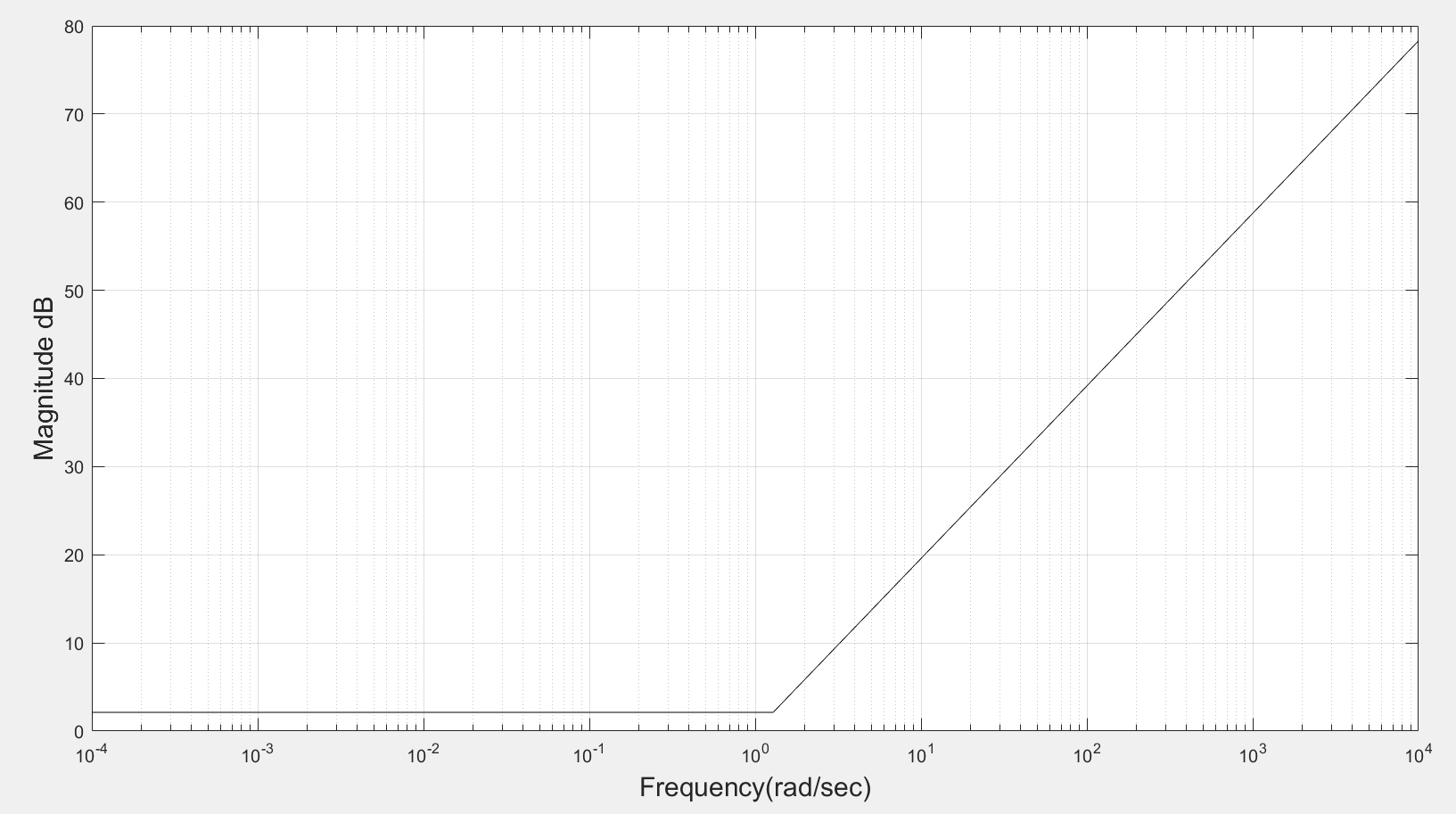


Figure 4: Asymptotic magnitude bode plot for (

1. For,

Fractional zero transfer function is given by =…… (1)

Put s = jω, in equation (1) results into = ……. (2)

Magnitude in dB is given by dB= -20logω

**Calculation procedure**

= =

Put equation (3) in (2) we get

=

Magnitude, |) | = = =

Magnitude in dB is given by |T(jω) | dB= -20logω.

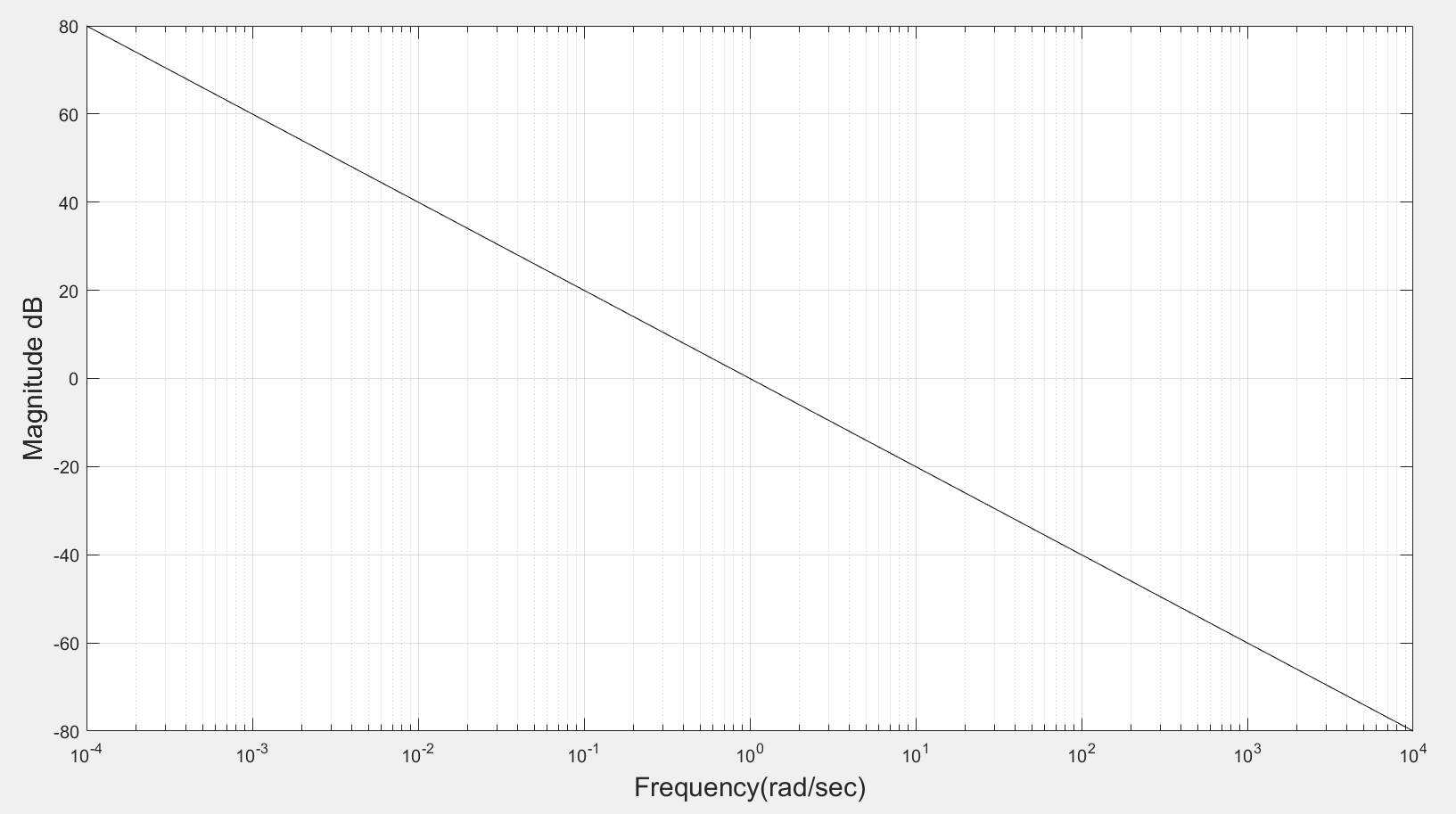


Figure 5: Asymptotic magnitude bode plot for

1. For , putting T = 0.0.0254

= now put s=jω

=--------(a)

Now,

= = ………. (b)

Putting (b) in (a)

= =

Magnitude, || =

=

=

Now, Magnitude in dB, || dB = -20log

For approximation we consider = .We obtain corner frequency, =.

Now, following approximation of magnitude is obtained:

1. For ω ≤ , |) | dB = -20log = -20log|1|.
2. For ω >, || dB = -20log= -20log (0.0254ω)

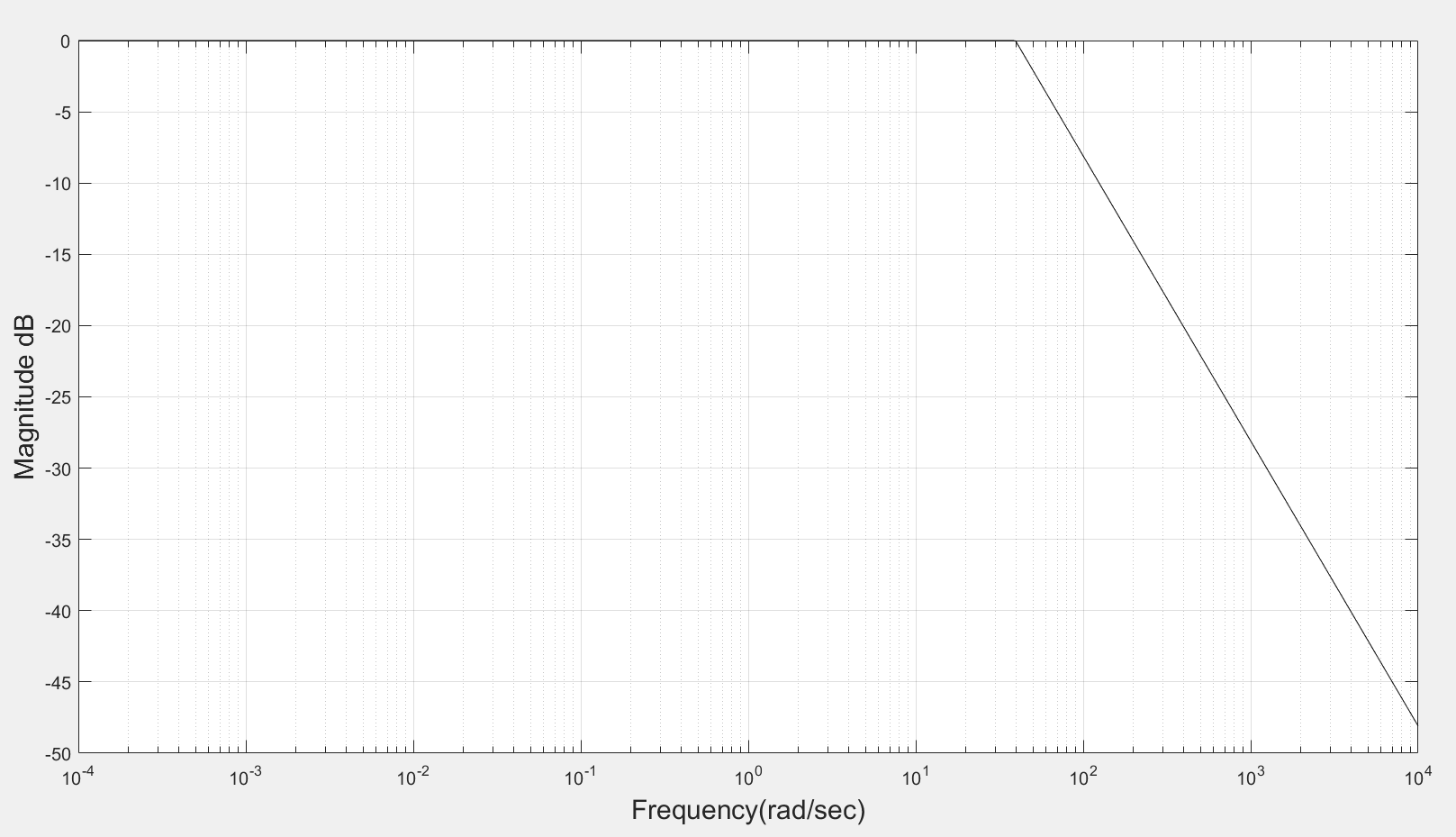


Figure 6: Asymptotic magnitude bode plot for

1. is composed of basic terms, by adding the asymptotic plot of ( one can find asymptotic plot for

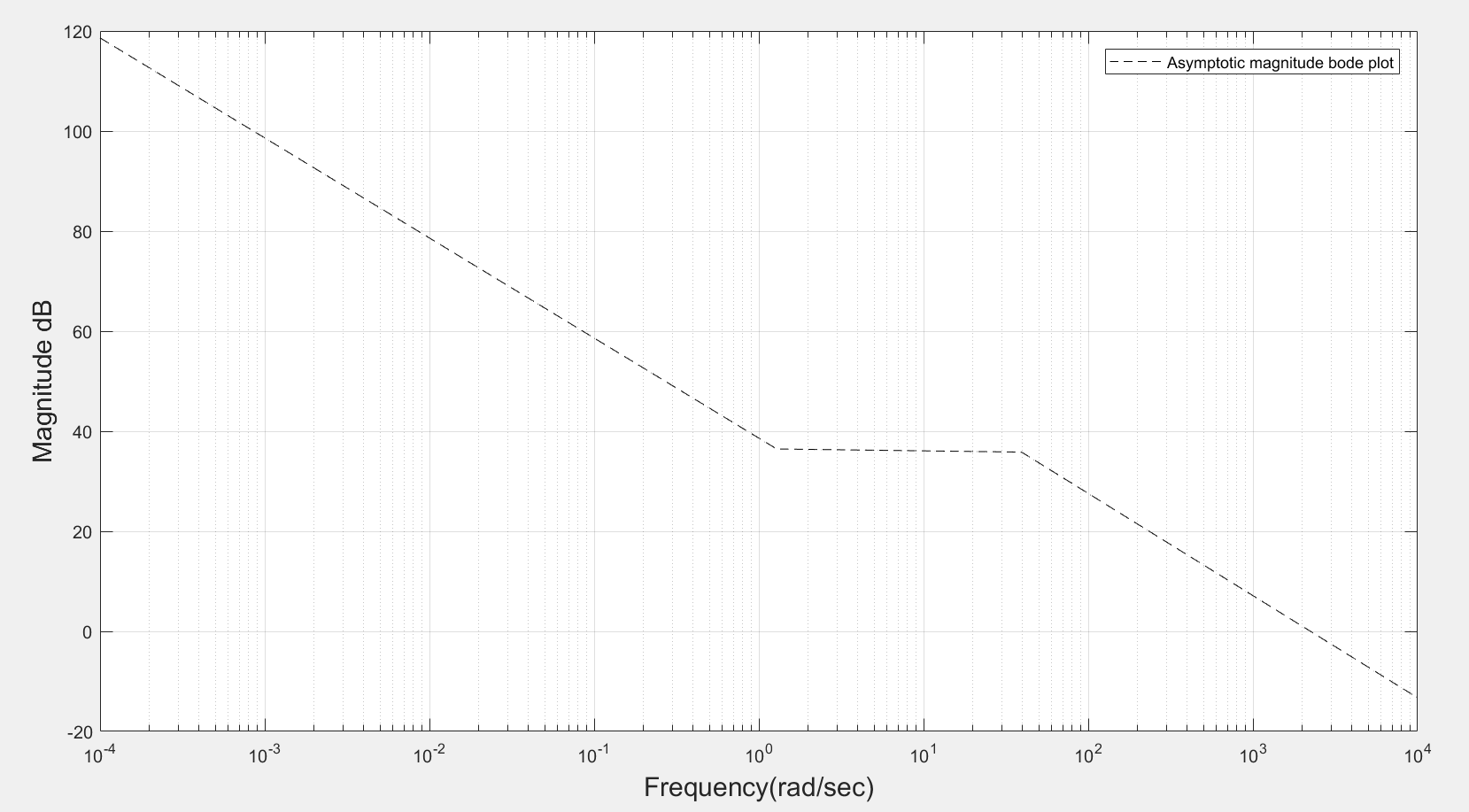


Figure 7: Asymptotic magnitude bode plot for

1. For exact magnitude bode plot of

=

= (

Now,

Magnitude, || = 20log

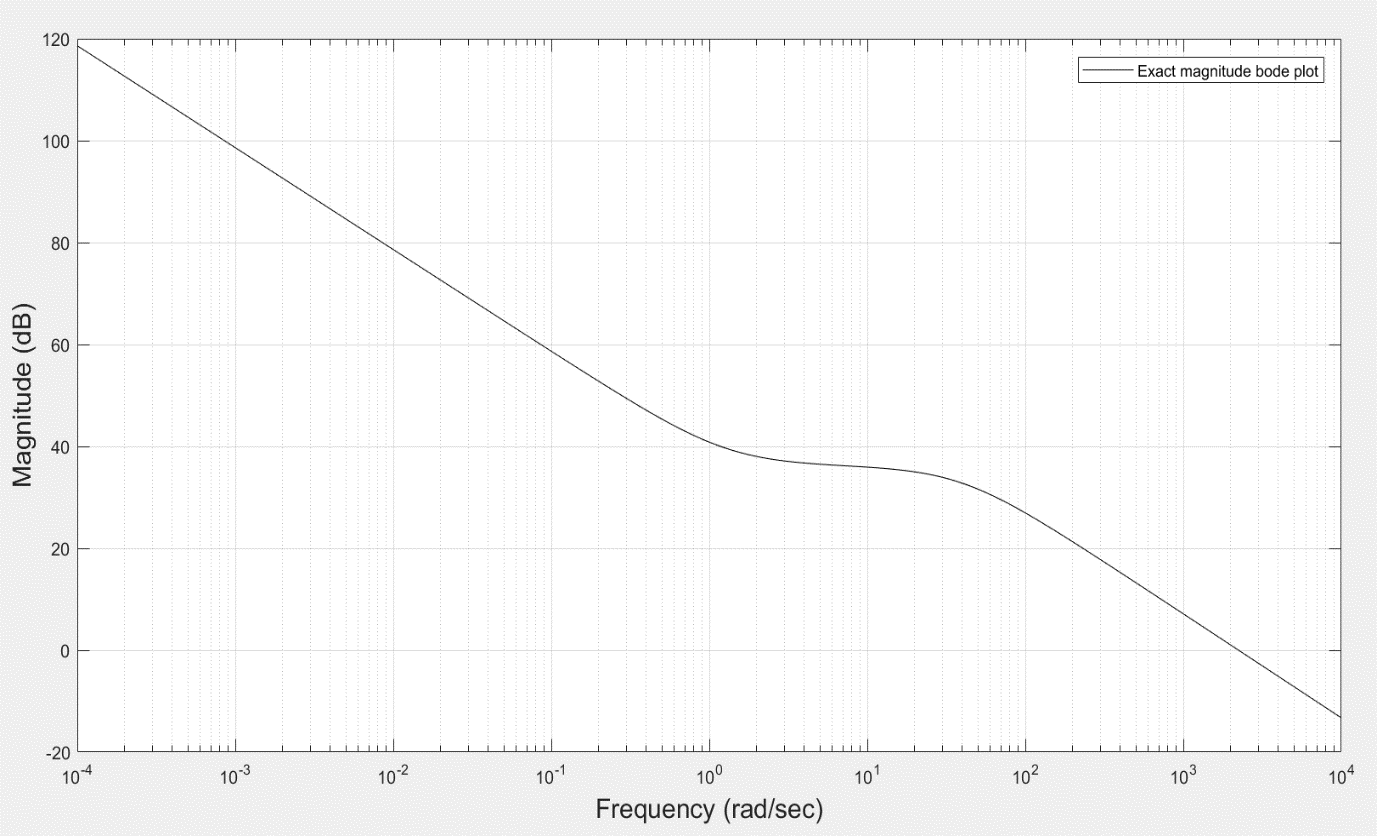


Fig 8: Exact magnitude bode plot for

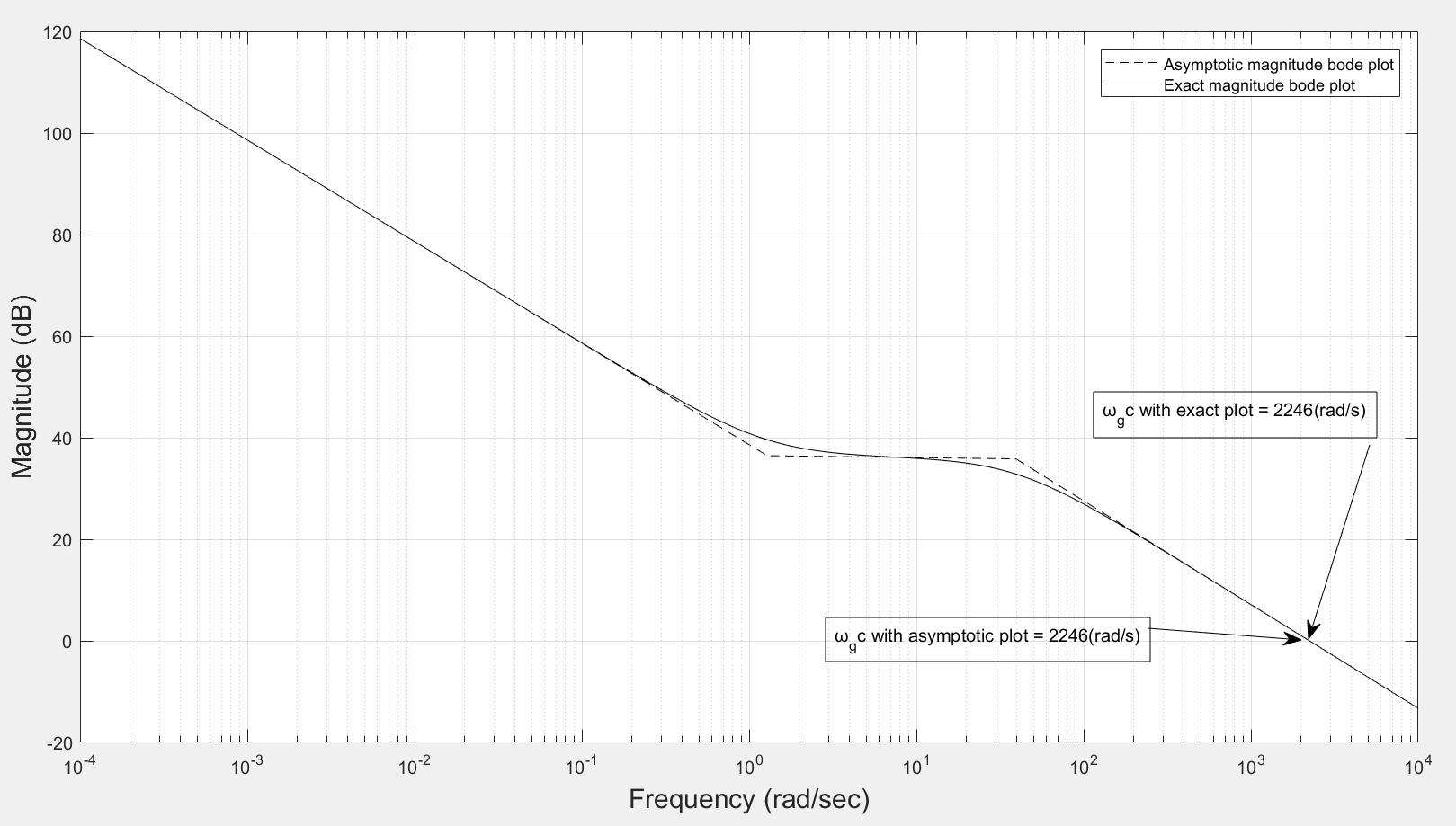


Fig 9: Real and asymptotic magnitude bode plot for

From fig 9, is obtained as

1. for asymptotic = 2246 (rad/sec)
2. for exact plot = 2246(rad/sec)

**Matlab**

clc;

clf;

clear all;

close all;

Kp = 55.7616;

Kd = 0.7836;

beta = 0.9789;

K= 1.53;

T = 0.0254;

Wcr = (abs(1/Kd))^(1/beta);

Wcr1 = (abs(1/0.0254));

w = logspace(-4 , 4, 1000);

mask = w < Wcr;

mask1 = w < Wcr1;

mag1 = 20\*log10(Kp)\*ones(size(w));

mag2 = 20\*log10(Kd)\*ones(size(w));

mag3 = 20\*log10(K)\*ones(size(w));

mag4 = mask.\*(20\*log10(1/Kd)) + (~mask).\*(20\*beta\*log10(w));

mag5 = -20\*log10(w);

mag6 = (mask1).\*(-20\*log10(1)) + (~mask1).\*(-20\*log10(0.0254\*w));

combined = mag1 + mag2 + mag3 + mag4 + mag5 + mag6 ;

figure(1);

plot(1,1);

semilogx(w, mag1,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure(2);

plot(1,2);

semilogx(w, mag2,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure(3);

plot(1,3);

semilogx(w, mag3,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure (4);

plot(1,4);

semilogx(w, mag4,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure (5);

plot(1,5);

semilogx(w, mag5,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure (6);

plot(1,6);

semilogx(w, mag6,'Color','black')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

figure(7);

plot(1,7);

semilogx(w, combined,'Color','black','LineStyle','--')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

legend('Asymptotic magnitude bode plot','Location','NorthEast')

plot(1,1);

semilogx(w, combined,'Color','black','LineStyle','--')

xlabel('Frequency(rad/sec)','FontSize', 15);

ylabel('Magnitude dB','FontSize', 15);

grid on;

hold on;

clc;

clear

K = 1.53;

Kp = 55.7616;

Kd = 0.7836;

beta = 0.9789;

T = 0.0254;

w=logspace(-4,4,1000);

Mag=@(w) (20\*log10(abs(sqrt(Kp).^2)) + 20\*log10(abs(sqrt(Kd).^2)) + 20\*log10(abs(sqrt(K).^2)) + 20\*log10(abs(sqrt((i.\*w).^beta + (1/Kd)).^2)) - 20\*log10(abs(sqrt((T\*(i.\*w)) + 1).^2)) - 20\*log10(abs(sqrt(i\*w).^2)));

semilogx(w,Mag(w) ,'Color','black');

hold on;

grid on;

xlabel('Frequency (rad/sec)','FontSize', 15);

ylabel('Magnitude (dB)','FontSize', 15);

legend('Asymptotic magnitude bode plot','Exact magnitude bode plot','Location','NorthEast')