Problem 1:

Given, P(s) =; C(s) = ;

where K = 0.55, T = 62, α = 0.1578, β = 1.0148, = 98.11268, = 15.2864, = 1.1625

C(s) = = (1 + + ) = ( + ) ()

L(s) = P(S)C(s)

= ( ( + ) ()

Putting the given values

L(s) = ()( + ) ()

Now separating all the basic terms from L(s) = ( ( + ) (), the asymptotic calculation of (, ( + ) and (), is shown below

1. For , |T(jω)| = 20log ()

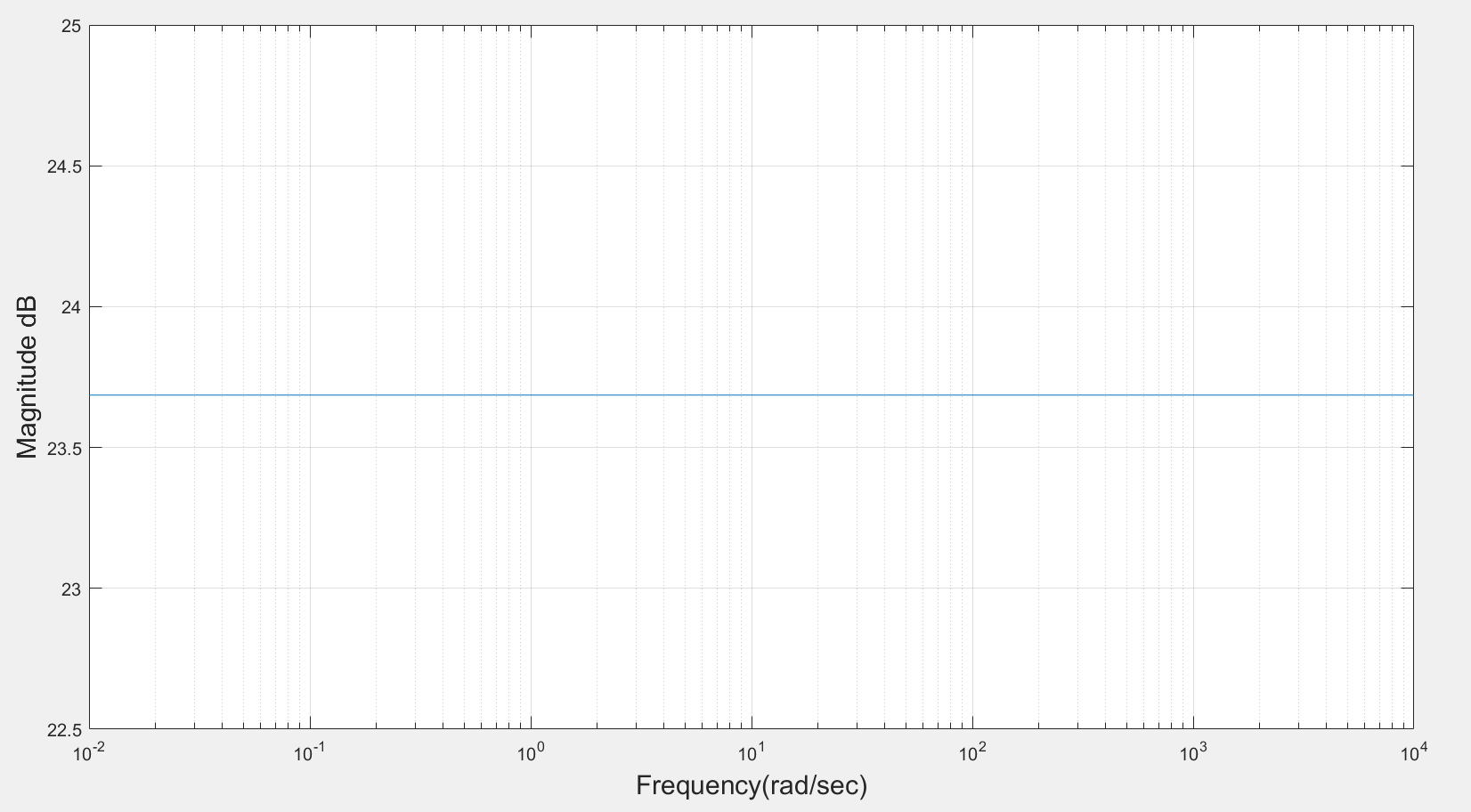


Figure 1: Asymptotic magnitude bode plot for constant gain,

1. For , |T(jω)| = 20log ()

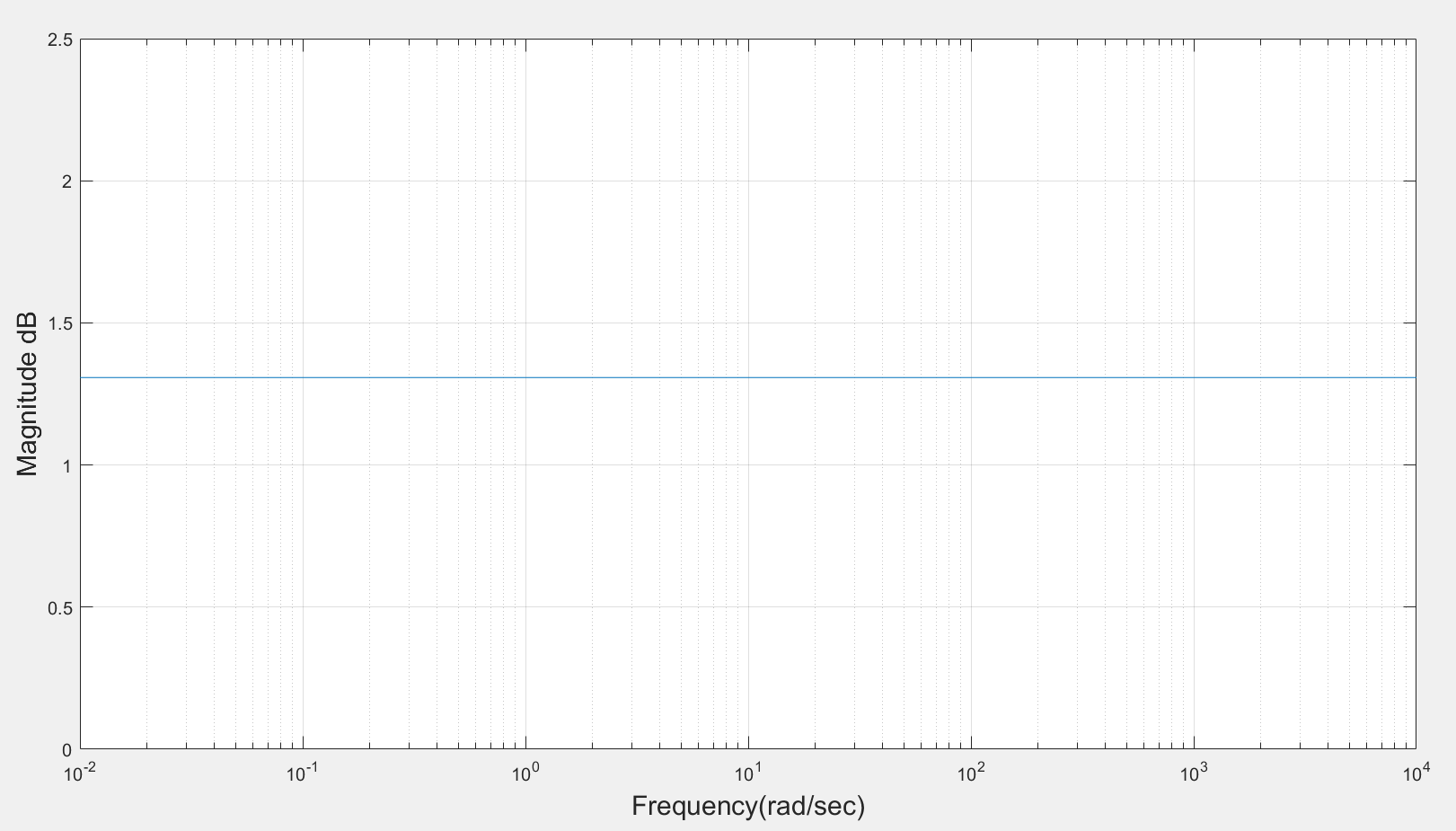


Figure 2: Asymptotic magnitude bode plot for constant gain,

1. For K, |T(jω)| = 20log (K)

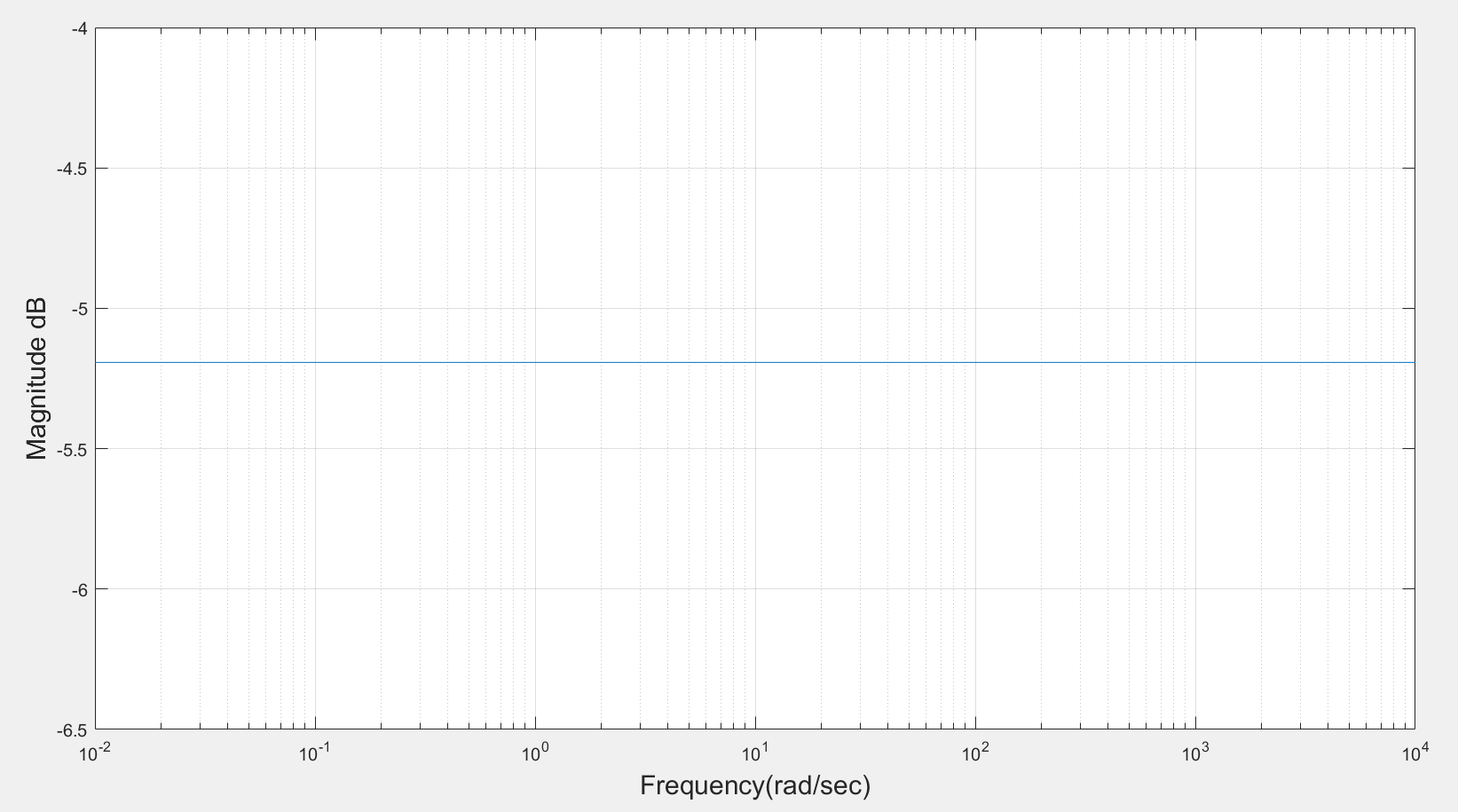


Figure 3: Asymptotic magnitude bode plot for constant gain, K

1. For ( + ),

T(s) = ( + ) ……….. (1)

Put s = jω, in equation (1) results into T(s) = {( + }……. (2)

**Calculation procedure**

**= .**

= . = .

Applying De Moivre’s theorem in above equation we get

. …… (3)

Again, =. …… (4)

Put equation (3) and (4) in (2) we get

T(jω) = + j ) + ( + j ) +

= + ) + (j + j )

Magnitude,

|T(jω) | =

=

=

Magnitude in dB |T(jω) | dB = 20log

In the sum , dominates at lower frequencies whereas dominates at higher frequencies. For approximation we consider = . Now, we obtain corner frequency, =.

Following approximation of magnitude is obtained:

1. For ω ≤ , |T(jω) | dB = 20log||.
2. For ω >, |T(jω) | dB = 20(α+β) log 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 20(α+β) dB/decade for

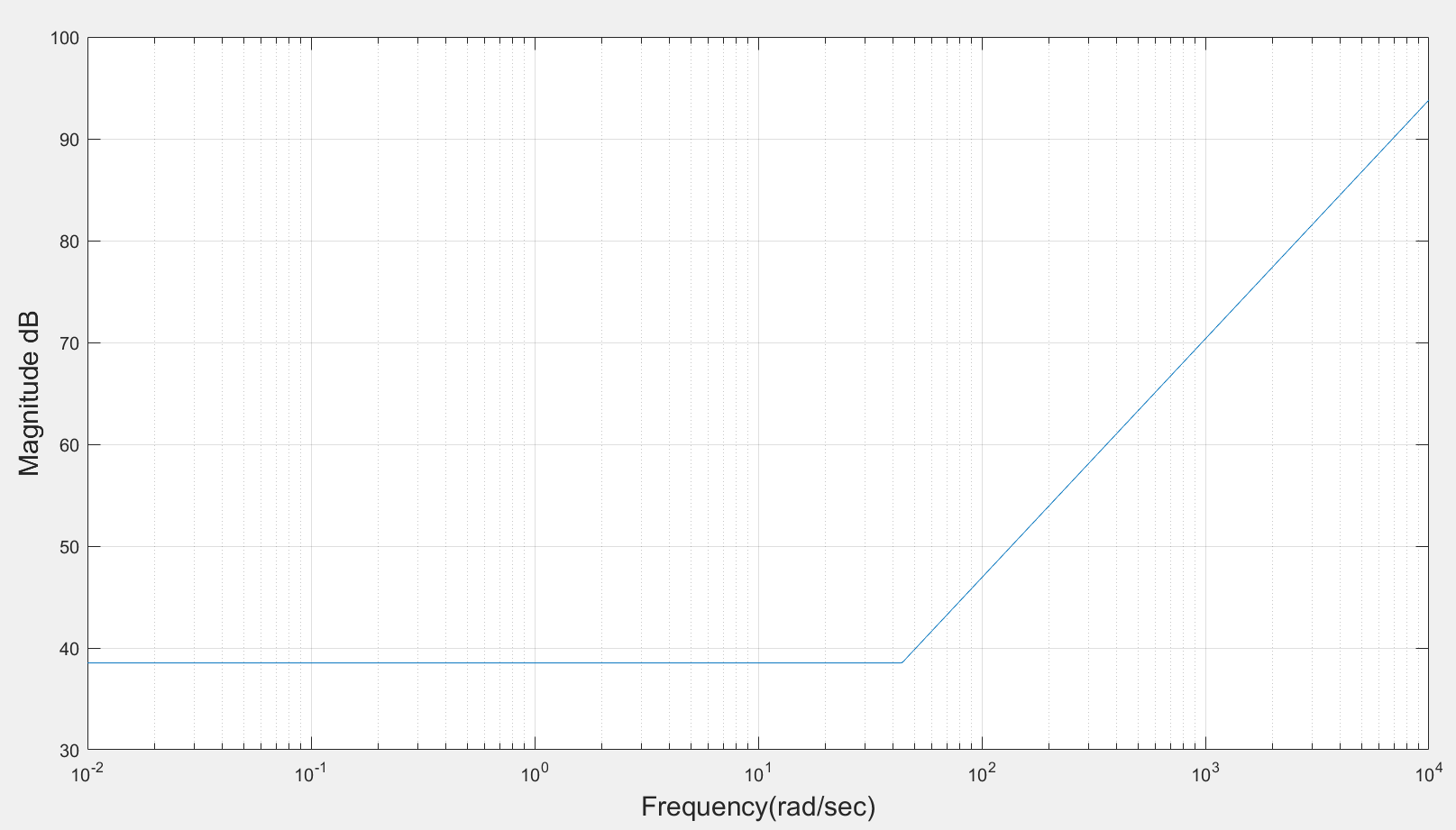


Figure 4: Asymptotic magnitude bode plot for ( + )

1. For,

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

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

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

**Calculation procedure**

==

Applying De Moivre’s theorem in above equation we get

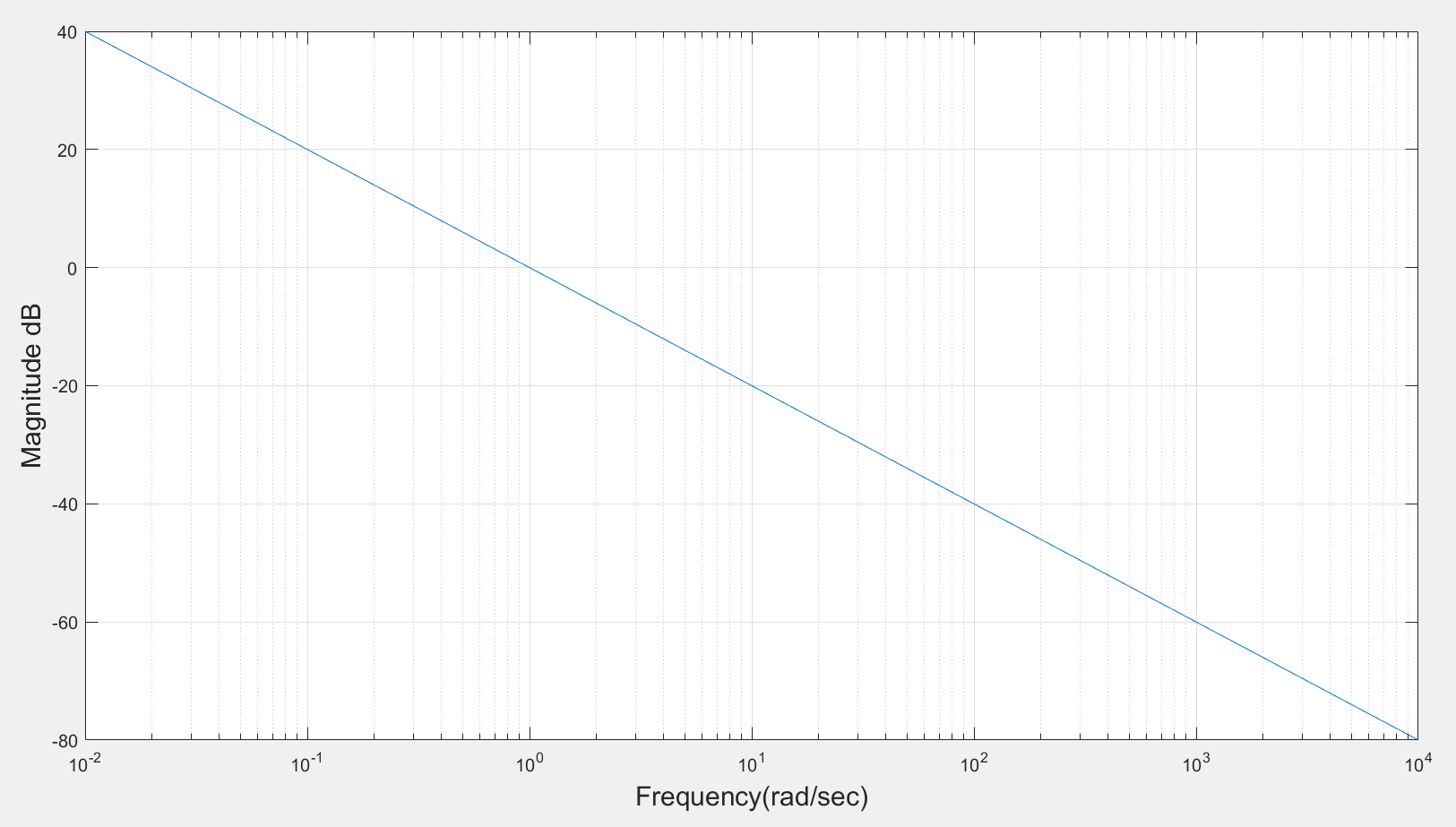
= . …… (3)

Put equation (3) in (2) we get

T(jω) =

Magnitude, |T(jω) | = =

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

Figure 5: Asymptotic magnitude bode plot for

1. For , putting T = 62

T(s) = now put s=jω

T(jω) =--------(a)

Now,

= = ………. (b)

Putting (b) in (a)

T(jω) = =

Magnitude, |T(jω) | =

=

=

Now, Magnitude in dB, |T(jω) | 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 ≤ , |T(jω) | dB = -20log = -20log|1|.
2. For ω >, |T(jω) | dB = -20log= -20log ()

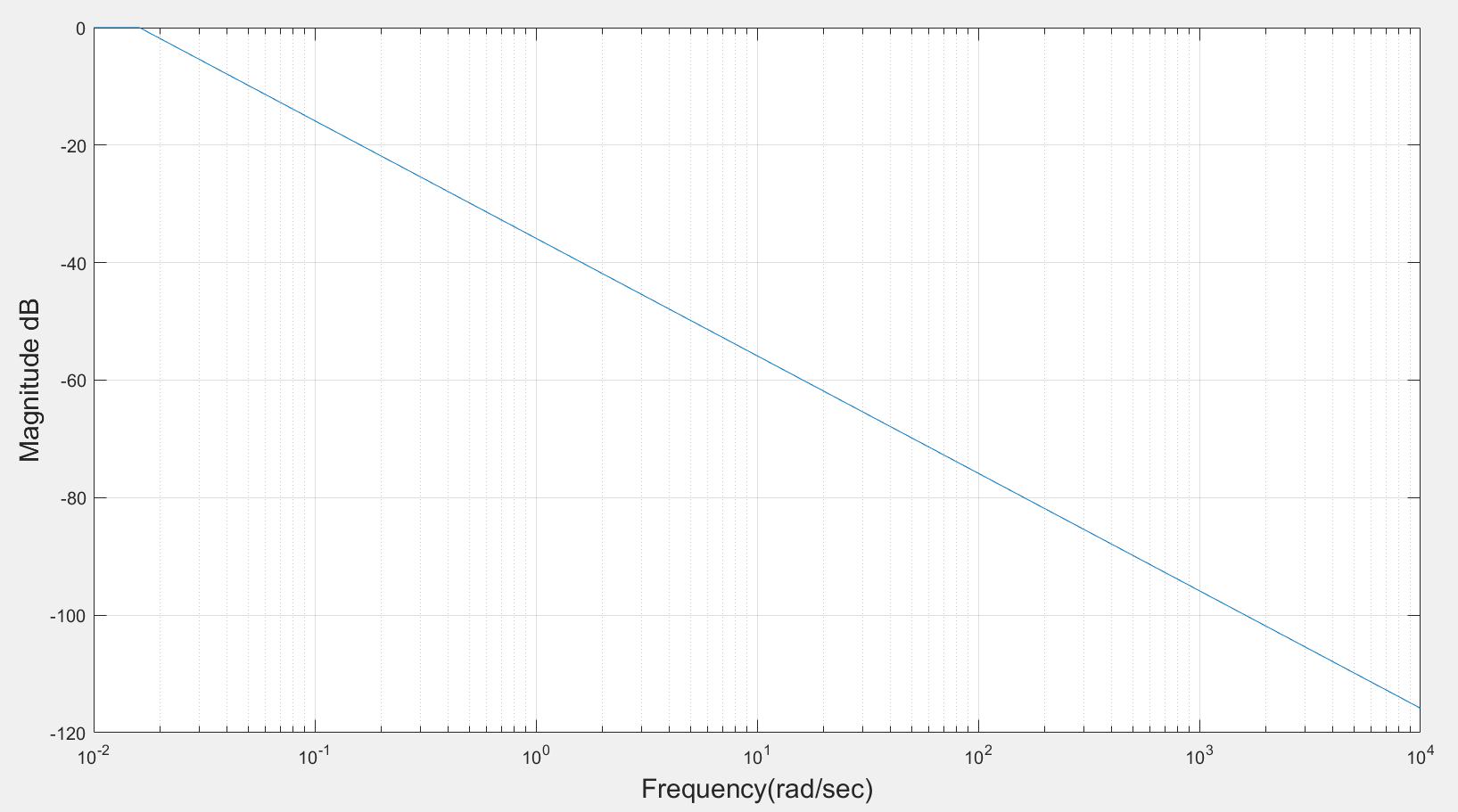


Figure 6: Asymptotic magnitude bode plot for

1. L(s) is composed of basic terms, by adding the asymptotic plot of (, ( + ) and (one can find asymptotic plot for L(s)

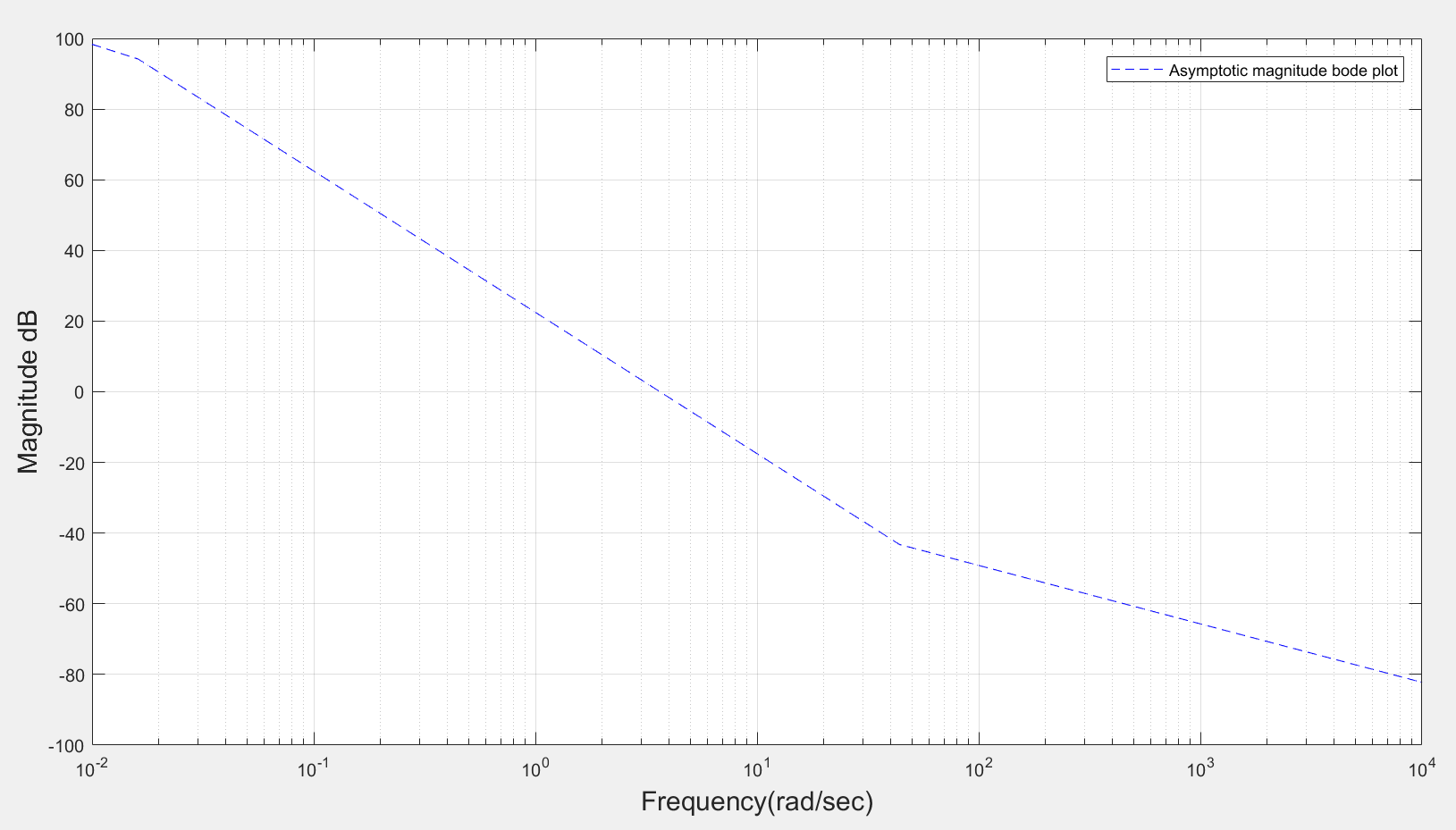


Figure 7: Asymptotic magnitude bode plot for L(s)

1. For exact magnitude bode plot of L(s)

L(s) = P(S)C(s)

= ( ( + ) ()

Now,

Magnitude, |L(jω)| = 20log{

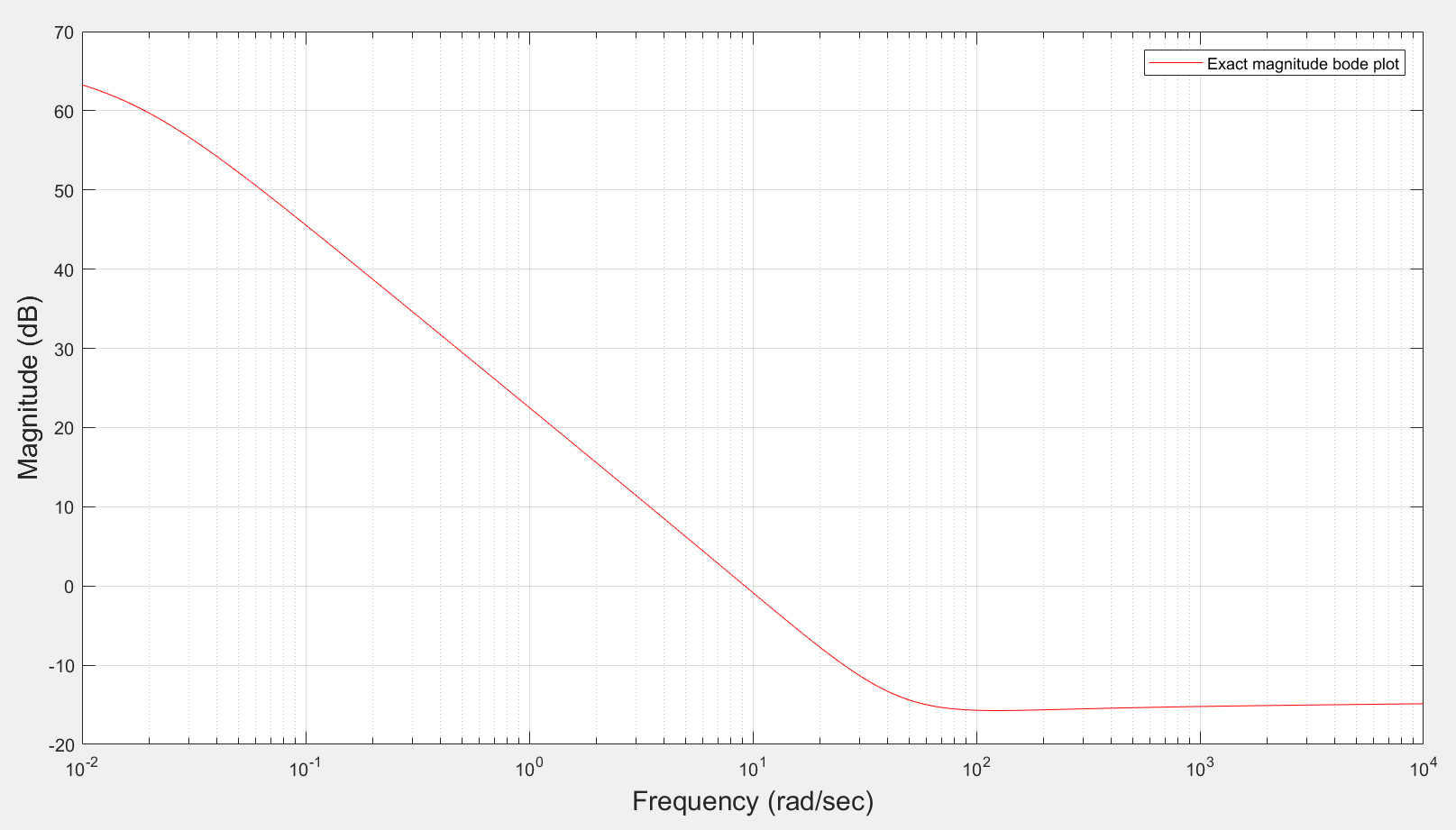


Figure 8: Exact magnitude bode plot for L(s)

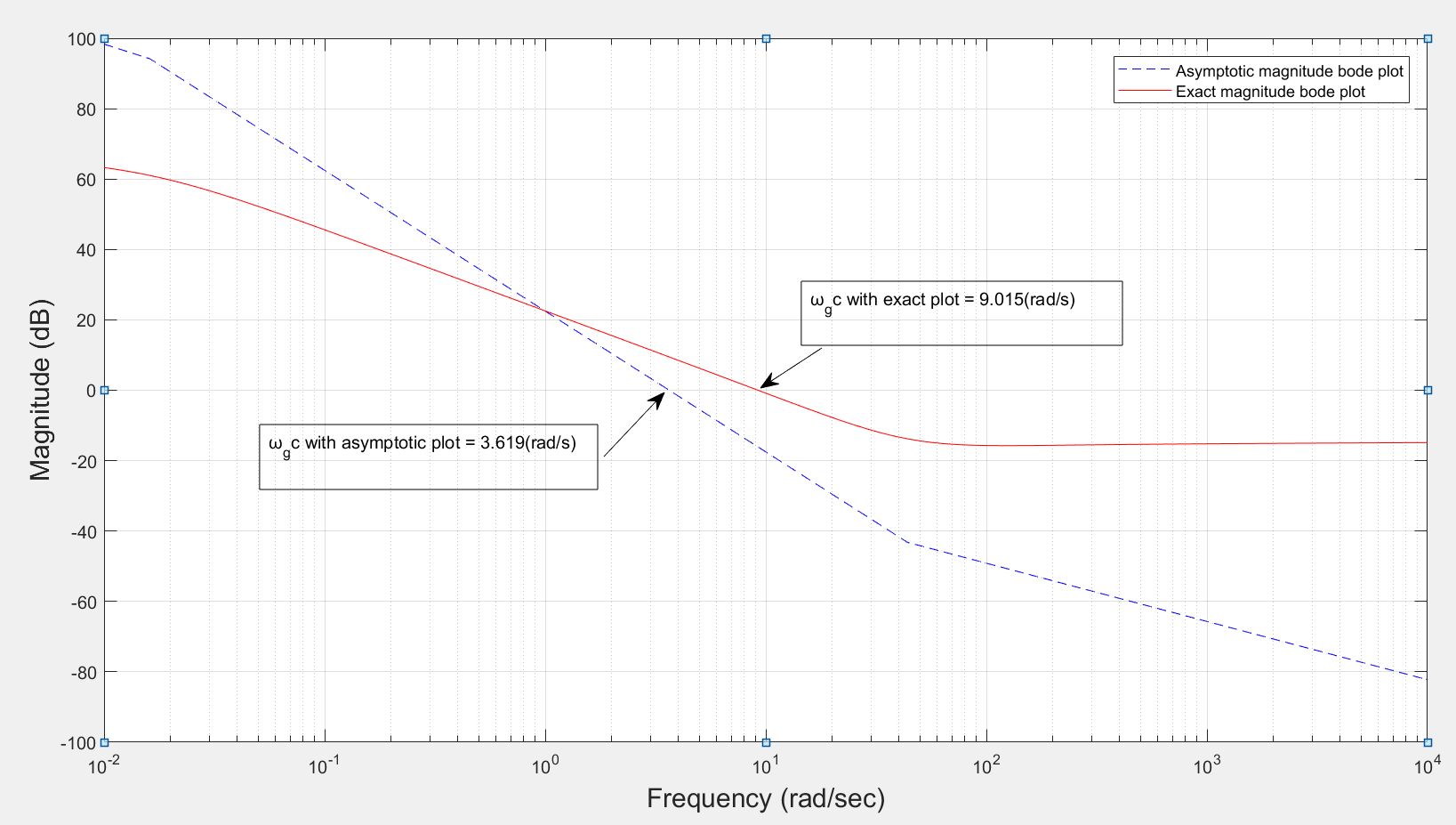


Fig 9: Real and asymptotic magnitude bode plot for L(s)

From fig 9, is obtained as

1. for asymptotic = 3.619(rad/sec)
2. for exact plot = 9.015(rad/sec)

**Matlab**

clc;

clf;

clear all;

close all;

Kp = 15.2864;

Ki = 98.1268;

Kd = 1.1625;

alpha = 0.1578;

beta = 1.0148;

K= 0.55;

T = 62;

Wcr = (abs(Ki/Kd))^(1/(alpha + beta));

Wcr1 = (abs(1/62));

w = logspace(-2 , 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(Ki/Kd)) + (~mask).\*(20\*(alpha + beta)\*log10(w));

mag5 = -20\*log10(w);

mag6 = (mask1).\*(-20\*log10(1)) + (~mask1).\*(-20\*log10(62\*w));

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

figure(1);

plot(1,1);

semilogx(w, mag1)

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

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

grid on;

figure(2);

plot(1,2);

semilogx(w, mag2)

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

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

grid on;

figure(3);

plot(1,3);

semilogx(w, mag3)

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

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

grid on;

figure (4);

plot(1,4);

semilogx(w, mag4)

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

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

grid on;

figure (5);

plot(1,5);

semilogx(w, mag5)

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

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

grid on;

figure (6);

plot(1,6);

semilogx(w, mag6)

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

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

grid on;

figure(7);

plot(1,7);

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

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

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

grid on;

hold on;

clc;

clear

Kp = 15.2864;

Ki = 98.1268;

Kd = 1.1625;

alpha = 0.1578;

beta = 1.0148;

K= 0.55;

T = 62;

w=logspace(-2,4,1000);

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).^(alpha+beta) + ((i.\*w).^alpha)/Kd + (Ki/Kd)).^2)) - 20\*log10(abs(sqrt((T\*(i.\*w)) + 1).^2)) - 20\*log10(abs(sqrt(i\*w).^alpha).^2));

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

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')