Q3. (a)

Given system,

```
%Create VCM Plant Model
%Note:  This model is from "Design and testing of track-following
%controllers for dual-state servo systems with PZT actuated suspensions" by
%Li and Horowitz, Microsystem Technologies, 2002
Gv = 10;  %DC Gain
Gv1 = tf((2*pi*135)^2,[1 2*0.1*2*pi*135 (2*pi*135)^2]);
Gv2 = tf((2*pi*5500)^2,[1 2*0.03*2*pi*5500 (2*pi*5500)^2]);
Gv3 = tf((2*pi*8640)^2,[1 2*0.05*2*pi*8640 (2*pi*8640)^2]);
Gv4 = 7300^2/7650^2*tf([1 2*.015*2*pi*7650 (2*pi*7650)^2],[1 2*.03*2*pi*7300 (2*pi*7300)^2]);
VCM = Gv*Gv1*Gv2*Gv3*Gv4;

Gp = 0.1;  %DC gain
Gp1 = tf((2*pi*8460)^2,[1 2*0.01*2*pi*8460 (2*pi*8460)^2]);
Gp2 = 5500^2/5650^2*tf([1 2*.03*2*pi*5650 (2*pi*5650)^2],[1 2*.03*2*pi*5500 (2*pi*5500)^2]);
Gp3 = 7300^2/7650^2*tf([1 2*.015*2*pi*7650 (2*pi*7650)^2],[1 2*.03*2*pi*7300 (2*pi*7300)^2]);
Gp4 = 8070^2/8250^2*tf([1 2*.02*2*pi*8250 (2*pi*8250)^2],[1 2*.015*2*pi*8070 (2*pi*8070)^2]);
Gp5 = 10650^2/10530^2*tf([1 2*.015*2*pi*10530 (2*pi*10530)^2],[1 2*.01*2*pi*10650 (2*pi*10650)^
PZT = Gp*Gp1*Gp2*Gp3*Gp4*Gp5;
```

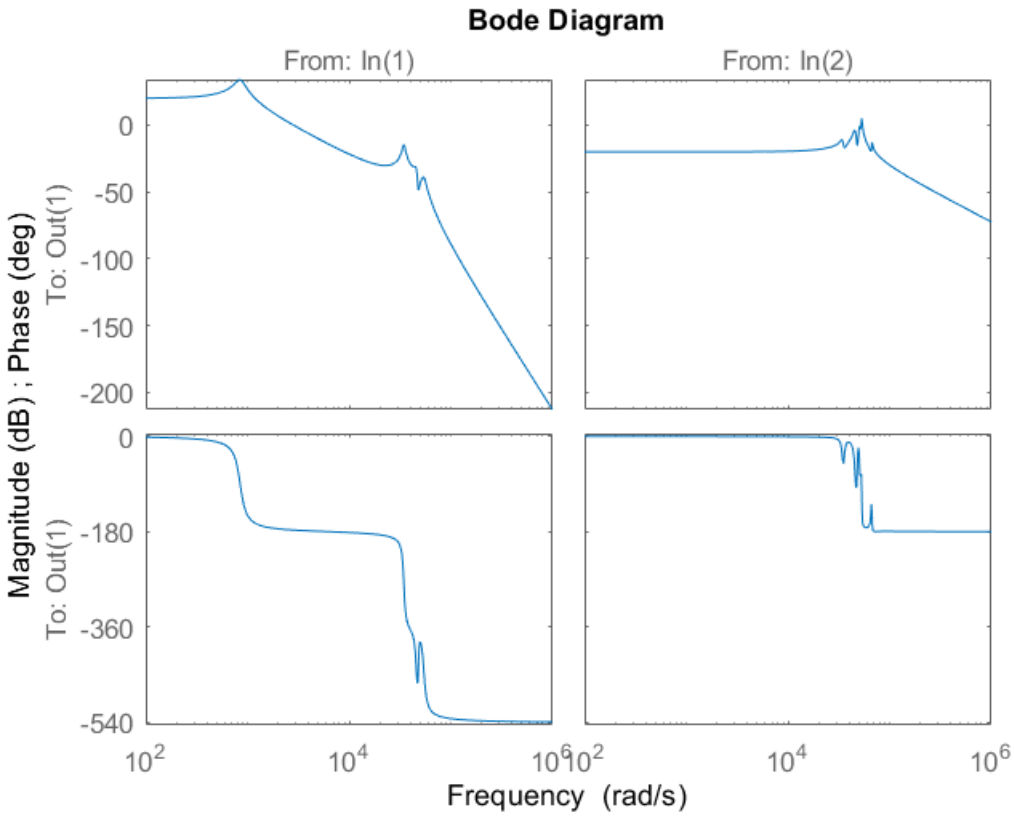
Create a DISO model

```
G = [VCM,PZT]
```

```
G =

  From input 1 to output:

                              2.306e25 s^2 + 3.325e28 s + 5.327e34

  ---------------------------------------------------------------------------------------------

  s^8 + 1.042e04 s^7 + 6.279e09 s^6 + 4.088e13 s^5 + 1.23e19 s^4 + 3.829e22 s^3 + 7.419e27 s^2

                                                                          + 1.282e30 s + 5.327e33


  From input 2 to output:

  2.386e08 s^8 + 1.821e12 s^7 + 2.543e18 s^6 + 1.453e22 s^5 + 9.549e27 s^4 + 3.65e31 s^3

                                                              + 1.497e37 s^2 + 2.893e40 s + 8.173e45

  ---------------------------------------------------------------------------------------------

  s^10 + 8748 s^9 + 1.32e10 s^8 + 9.411e13 s^7 + 6.675e19 s^6 + 3.637e23 s^5 + 1.616e29 s^4

                                          + 5.985e32 s^3 + 1.868e38 s^2 + 3.523e41 s + 8.173e46


Continuous-time transfer function.
```

Bode plot of the diso model

```
bode(G)
```



Q3. (b)

Initialize transfer function and the weight parameters as done in Q2 (a), (c)

```
s = tf('s');
Wu_V = 1/100;
Wu_P = 1/10;
Wu = [Wu_V 0;0 Wu_P];
GAM = 10;
BW = 3000*2*pi;
BW_step = 25;
M = 10^(6/20);
A = 1000;
```

Optimization loop

```
while GAM>1
    Wp = (s/sqrt(M)+BW)^2/(s+BW/sqrt(A))^2;
    Wt = makeweight(0.5,5*BW,1000);
    [K,CL,GAM,info] = mixsyn(G,Wp,Wu,Wt);
    BW = BW - BW_step;
end
```

Gamma Value

```
GAM
```

```
GAM = 0.9985
```

Semsitivity function

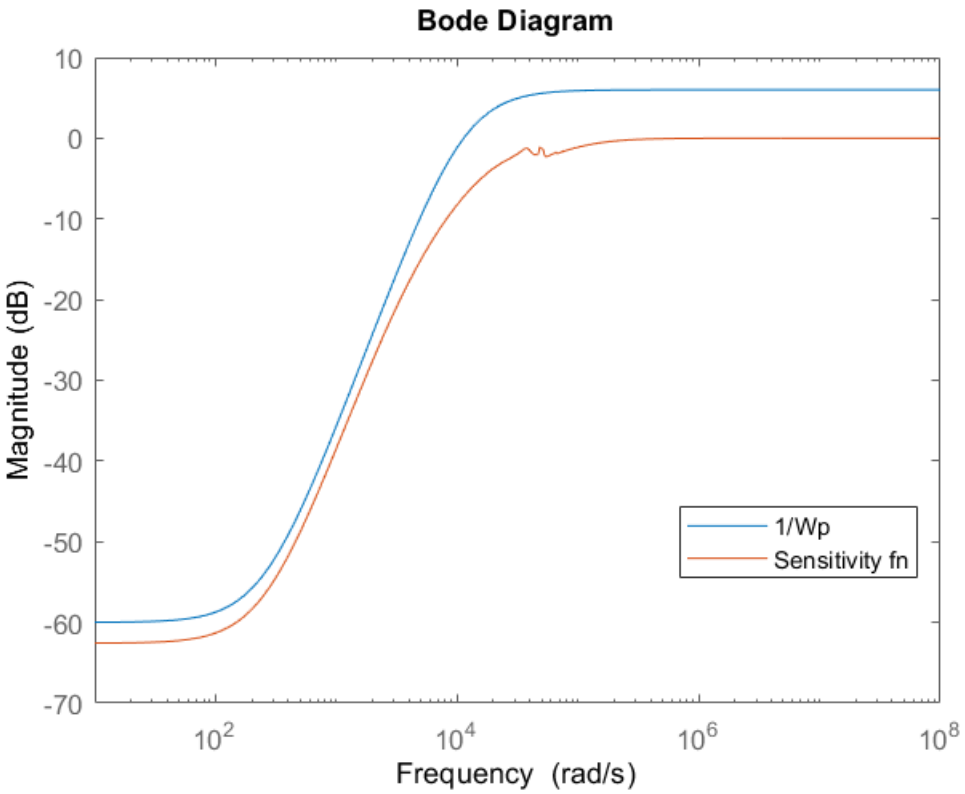
```
S = inv(eye(1)-G*K);
```

Somplementary sensitivity function

```
T = 1-S;
```

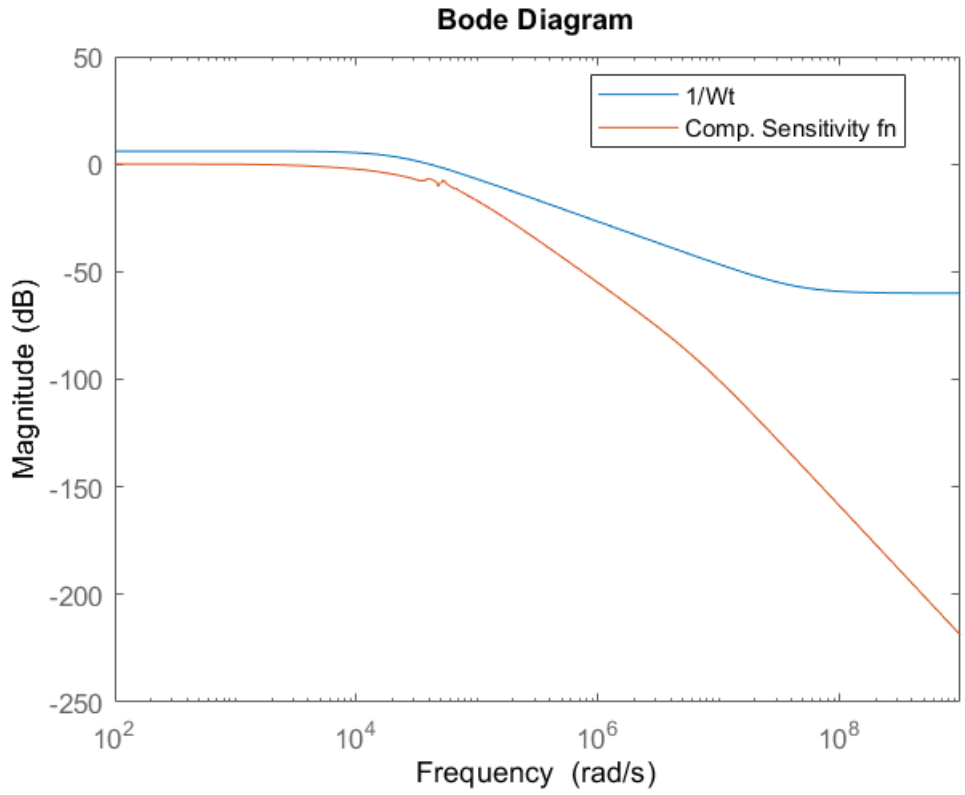
Bode plot of sensitivity funciton

```
bodemag(1/Wp,S)
legend('1/Wp','Sensitivity fn',"Location",'best')
```



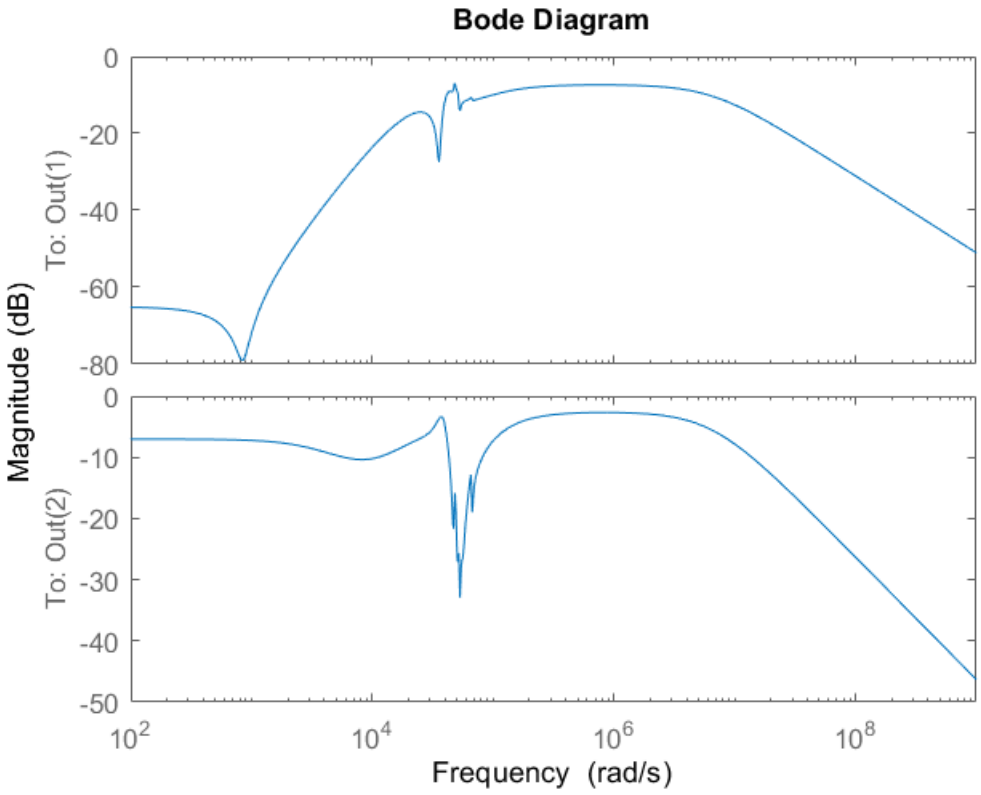
Bode plot of complementary sensitivity funciton

```
bodemag(1/Wt,T)
legend('1/Wt','Comp. Sensitivity fn',"Location",'best')
```



Bode magnitude plot of Wu*K*S

```
bodemag(Wu*K*S)
```


Bode Diagram
Magnitude (dB)
To: Out(1)
To: Out(2)
0
-20
-40
-60
-80
0
-10
-20
-30
-40
-50
10^2
10^4
10^6
10^8
Frequency (rad/s)