LAB-4 Preliminary

Please follow the instructions in the document and mail your pdf-files to the TA of your section

artunsel@gmail.com,

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Please name your pdf files as in the given example file:

Mehmet-Ali-Demir-111211102-lab-1-preliminary-G-3.pdf

Mehmet-Ali-Demir-111211102-lab-1-labreport-G-3.pdf

ALSO STATE YOUR SECTION in the E-MAIL, [there are 3 sections]

section-1 TA: Mehmet Karahan,

section-2 TA: Mehmet Karahan,

section-3 TA: Artun Sel.

PLEASE READ "Important Rules" section at the end of this document before submitting your document.

THE DEADLINE: Friday, November 11, 2022, 20:00.

WARNING: Any work submitted at any time within the first 24 hours following the published submission deadline will receive a penalty of 10% of the maximum amount of marks available. Any work submitted at any time between 24 hours and up to 48 hours late will receive a deduction of 20% of the marks available.

Contents

Problem 1

[This problem is given as an example. Analyze this problem then try to solve Problem-2.]

Task 1

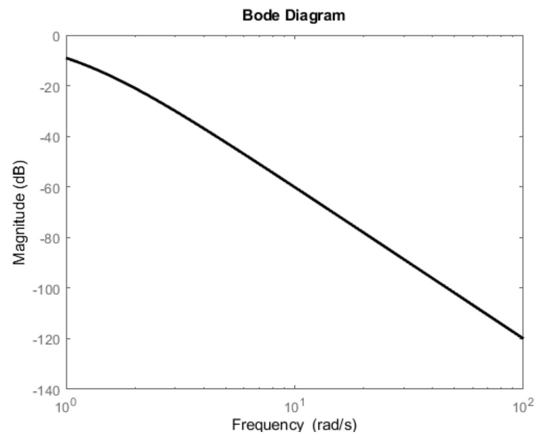
For a given TF, plot the Bode Diagram using matlab's 'bodemag' function.

$$G_1 = \frac{1}{(s+p_1)(s+p_2)(s+p_3)}, p_1 = 1, p_2 = 1, p_3 = 1$$

The matlab code for this task

```
clear all,close all,clc;
%%

p1=1
p2=1
p3=1

Plant=tf([1],conv(conv([1,p1],[1,p2]),[1,p3]))

bodemag(Plant,{1,1e2});
obj1=gca;
obj1.Children(1).Children.Color=[0,0,0];
obj1.Children(1).Children.LineWidth= 2;
obj1.Children(1).Children.LineStyle= '-';

% setfield(gcf,'Color',[1,1,1]);
obj2=gcf
obj2.Color=[1,1,1]
```

The code output



Task 2

Consider the case where the parameters take values between a defined range. For this case, discretize the range for each parameter and plot the bode diagram for each discretization point.

$$p_{1_{nom}} = 1, p_{2_{nom}} = 1, p_{3_{nom}} = 1$$

$p_1 \in [p_{1_{nom}} - 0.1, p_{1_{nom}} + 0.1]$	$p_2 \in [p_{2_{nom}} - 0.1, p_{2_{nom}} + 0.1]$	$p_3 \in [p_{3_{nom}} - 0.1, p_{3_{nom}} + 0.1]$

and

$p_{1_{vec}} = linspace(\boxed{p_{1_{nom}} - 0.1}, \boxed{p_{1_{nom}} + 0.1}, 10)$	$p_{2_{vec}} = linspace(\boxed{p_{2_{nom}} - 0.1}, \boxed{p_{2_{nom}} + 0.1}, 10)$	$p_{3_{vec}} = linspace(\boxed{p_{3_{nom}} - 0.1}, \boxed{p_{3_{nom}} + 0.1}, 10)$

The algorithm to plot the bode diagram for a plant with parameter uncertainty

For $p_{1_{temp}} \in p_{1_{vec}}$

  For $p_{2_{temp}} \in p_{2_{vec}}$

    For $p_{3_{temp}} \in p_{3_{vec}}$

      Plot the bode diagram of $\boxed{G_{1_{temp}} = \frac{1}{(s+p_{1_{temp}})(s+p_{2_{temp}})(s+p_{3_{temp}})}}$

    End

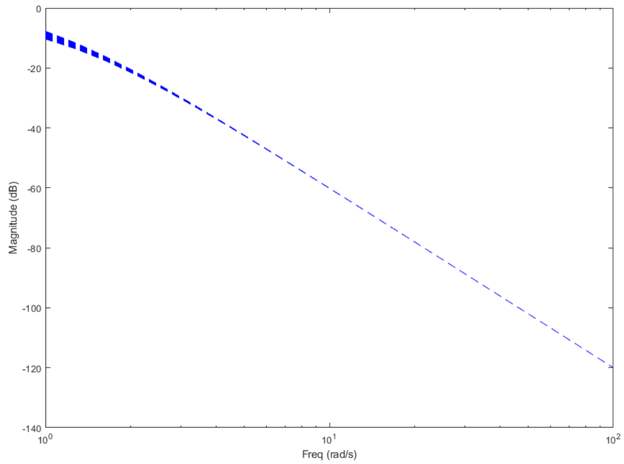
  End

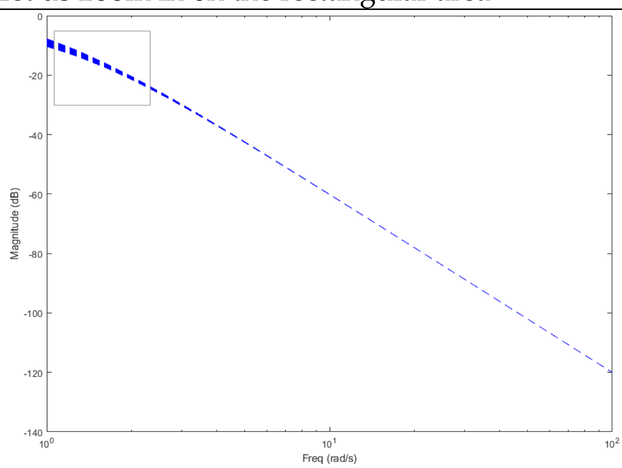
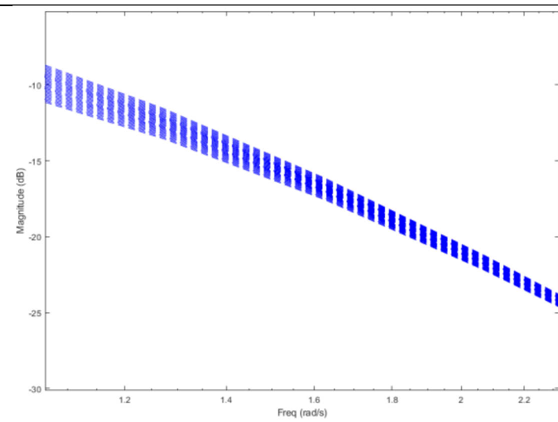
End

The corresponding matlab code for this algorithm is given as

Matlab code

```
clear all,close all,clc;
p1=1
p2=1
p3=1

% p_range=[p_min,p_max]
p1_range=[p1-0.1,p1+0.1]
p2_range=[p2-0.1,p2+0.1]
p3_range=[p3-0.1,p3+0.1]
p1_vec=linspace(p1_range(1),p1_range(2),10);
p2_vec=linspace(p2_range(1),p2_range(2),10);
p3_vec=linspace(p3_range(1),p3_range(2),10);

w_vec=logspace(0,2,20); % w_vec={1e1,1e2}

mag_matrix=zeros(length(p1_vec)*length(p2_vec)*length(p3_vec),...
    length(w_vec));
ii=1;
for i_1=1:1:length(p1_vec)
    for i_2=1:1:length(p2_vec)
        for i_3=1:1:length(p3_vec)
            p1_temp=p1_vec(i_1);
            p2_temp=p2_vec(i_2);
            p3_temp=p3_vec(i_3);
            Plant_temp=tf([1],conv(conv([1,p1_temp],[1,p2_temp]),[1,p3_temp]));

%              [mag,phase,wout] = bode(sys,w)

            [mag,phase,wout] = bode(Plant_temp,w_vec);
mag=squeeze(mag)';
mag_matrix(ii,:)=mag;
ii=ii+1;

        end
    end
end
%% PLOTTING THE BODE DIAGRAMS
for ii=1:1:size(mag_matrix,1)
    semilogx(w_vec,20*log10(mag_matrix(ii,:)),...
        'Color',[0,0,1],...
        'LineStyle','--',...
        'LineWidth',[.5]); hold on;
end
setfield(gcf,'Color',[1,1,1]);
xlabel('Freq (rad/s)');
ylabel('Magnitude (dB)');
```

<table>
<tr><td>The output of the matlab code</td><td></td></tr>
<tr><td>
</td><td>In the figure, there are 10x10x10=1000 bode plots are drawn on top of each other.
Notice:
It can be seen that in the low frequency region the parameter variation has an effect on the magnitude gain.

To see clearly, let us zoom in on the figure.</td></tr>
<tr><td>Let us zoom in on the rectangular area</td><td></td></tr>
<tr><td>
</td><td>

It can be clearly seen that there are many (1000) blue lines each corresponding to a system with given parameter-set.</td></tr>
</table>

Problem 2

Task 1

For a given TF, plot the Bode Diagram using matlab's 'bodemag' function.

$$G_1 = \frac{(s + p_4)}{(s + p_1)(s + p_2)(s + p_3)}, p_1 = 1, p_2 = 1, p_3 = 1, p_4 = 1$$

Task 2

Consider the case where the parameters take values between a defined range. For this case, discretize the range for each parameter and plot the bode diagram for each discretization point.

$$p_{1_{nom}} = 1, p_{2_{nom}} = 1, p_{3_{nom}} = 1, p_{4_{nom}} = 1$$

$p_1 \in [p_{1_{nom}} - 0.1, p_{1_{nom}} + 0.1]$	$p_2 \in [p_{2_{nom}} - 0.1, p_{2_{nom}} + 0.1]$
$p_3 \in [p_{3_{nom}} - 0.1, p_{3_{nom}} + 0.1]$	$p_4 \in [p_{4_{nom}} - 0.1, p_{4_{nom}} + 0.1]$

And

$p_{1_{vec}} = linspace(\boxed{p_{1_{nom}} - 0.1}, \boxed{p_{1_{nom}} + 0.1}, 10)$	$p_{2_{vec}} = linspace(\boxed{p_{2_{nom}} - 0.1}, \boxed{p_{2_{nom}} + 0.1}, 10)$
$p_{3_{vec}} = linspace\left(\boxed{p_{3_{nom}} - 0.1}, \boxed{p_{3_{nom}} + 0.1}, 10\right)$	$p_{4_{vec}} = linspace\left(\boxed{p_{4_{nom}} - 0.1}, \boxed{p_{4_{nom}} + 0.1}, 10\right)$

The algorithm to plot the bode diagram for a plant with parameter uncertainty
For $p_{1_{temp}} \in p_{1_{vec}}$
For $p_{2_{temp}} \in p_{2_{vec}}$
For $p_{3_{temp}} \in p_{3_{vec}}$
For $p_{4_{temp}} \in p_{4_{vec}}$
Plot the bode diagram of $\boxed{G_{1_{temp}} = \frac{\left(s+p_{4_{temp}}\right)}{\left(s+p_{1_{temp}}\right)\left(s+p_{2_{temp}}\right)\left(s+p_{3_{temp}}\right)}}$
End
End
End
End

Problem 3

Task 1

For a given TF, plot the Bode Diagram using matlab's 'bodemag' function.

$$G_1 = \frac{(s - p_4)}{(s + p_1)(s + p_2)(s + p_3)}, p_1 = 1, p_2 = 1, p_3 = 1, p_4 = 1$$

Task 2

Consider the case where the parameters take values between a defined range. For this case, discretize the range for each parameter and plot the bode diagram for each discretization point.

$$p_{1_{nom}} = 1, p_{2_{nom}} = 1, p_{3_{nom}} = 1, p_{4_{nom}} = 1$$

$p_1 \in [p_{1_{nom}} - 0.1, p_{1_{nom}} + 0.1]$	$p_2 \in [p_{2_{nom}} - 0.1, p_{2_{nom}} + 0.1]$
$p_3 \in [p_{3_{nom}} - 0.1, p_{3_{nom}} + 0.1]$	$p_4 \in [p_{4_{nom}} - 0.1, p_{4_{nom}} + 0.1]$

And

$p_{1_{vec}} = linspace(\boxed{p_{1_{nom}} - 0.1}, \boxed{p_{1_{nom}} + 0.1}, 10)$	$p_{2_{vec}} = linspace(\boxed{p_{2_{nom}} - 0.1}, \boxed{p_{2_{nom}} + 0.1}, 10)$
$p_{3_{vec}} = linspace\left(\boxed{p_{3_{nom}} - 0.1}, \boxed{p_{3_{nom}} + 0.1}, 10\right)$	$p_{4_{vec}} = linspace\left(\boxed{p_{4_{nom}} - 0.1}, \boxed{p_{4_{nom}} + 0.1}, 10\right)$

The algorithm to plot the bode diagram for a plant with parameter uncertainty
For $p_{1_{temp}} \in p_{1_{vec}}$
For $p_{2_{temp}} \in p_{2_{vec}}$
For $p_{3_{temp}} \in p_{3_{vec}}$
For $p_{4_{temp}} \in p_{4_{vec}}$
Plot the bode diagram of $\boxed{G_{1_{temp}} = \frac{(s - p_{4_{temp}})}{(s + p_{1_{temp}})(s + p_{2_{temp}})(s + p_{3_{temp}})}}$
End
End
End
End

Important Rules

The following is the list of the rules that must be followed. The failure of following the rules listed below will be resulted in point-deduction as stated in the table.

No.	Rule	Corresponding point-deduction for the failure of following the rule
01	The document must be mailed to the TA of the section	5 pt.
02	The pdf file must be named as stated at the top of the document	5 pt.
03	The file must be in pdf format	5 pt.
04	Section-name must be stated in the mail that is to be sent to submit the **lab-report** or **preliminary** document	5 pt.
05	The deadline must be met.	10 pt. for each day after the deadline
06	The file must be prepared in digital form. MSword or Latex must be used.	5 pt.
07	All plots must be on a white background and the lines must be clearly visible. The names of the signals in the plot must be stated [either by using legend or by using appropriate Figure Naming such as "Figure 1: (red) input signal, (blue) output signal"]	3 pt.
08	All figures must be numbered.	3 pt.
09	All tables must be numbered.	3 pt.
10	All equations must be numbered.	3 pt.
11	References must be added. Only books are allowed. Do not use internet sources. Example references: [1] "Modern Control Engineering 5^{th} Ed", Ogata K., 2010, Prentice Hall [2] "Linear Systems Theory 2^{nd} Ed", Hespanha J., 2018, Princeton Press	3 pt.
12	Font style must be consistent. Times-New-Roman or Palatino-Linotype must be used. Font size must be 11.	3 pt.
13	Interpret the findings in each task accordingly.	5 pt.