LAB-3 Preliminary

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

artunsel@gmail.com,

karahanmehmet13@gmail.com

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 4, 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.]

For a given control system whose block diagram is given as

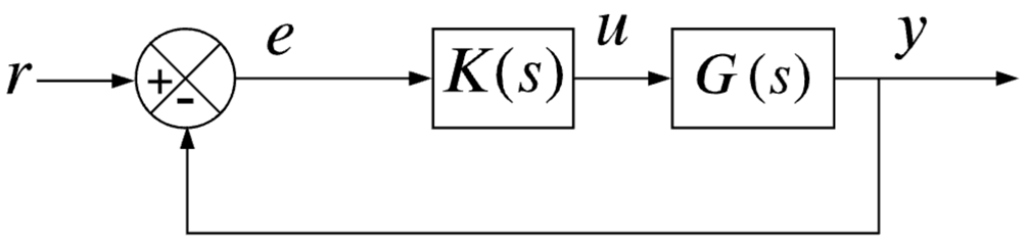


Figure 1: Block Diagram

Table 1: The block terms

plant	Controller	Open-loop TF	Closed-loop TF	Reference-to-Error TF
$G = \frac{1}{s+1}$	$K = k_1 + k_2 \frac{1}{s}$	$L = GK$	$T_{yr} = \frac{L}{1+L}$	$T_{er} = \frac{1}{1+L}$

Part-1

Find the $\boxed{L}$ (open-loop transfer function) expression dependent on k1 and k2.

[you can use matlab-symbolic-toolbox to obtain the expression]

<table>
<tr><th>Matlab code</th><th>Matlab output</th></tr>
<tr><td><pre>syms s k1 k2

G_s=1/(s+1)

K_s=k1+k2/s;

open_loop_tf=K_s*G_s;
open_loop_tf=simplifyFraction(open_loop_tf,'Expand',true)
pretty(open_loop_tf)</pre></td><td><pre>open_loop_tf =

(k2 + k1*s)/(s^2 + s)

k2 + k1 s

   2
  s + s</pre></td></tr>
</table>

[Note: “simplify” is a matlab-command to simplify the symbolic expression]

[Note: “simplifyFraction” is a matlab-command to simplify the fractional symbolic expression]

[Note: “pretty” is a matlab-command to display the symbolic expression in a way that is easy to read]

Using this matlab script, it can be seen that

$$L = \frac{s[k_1] + [k_2]}{s^2[1] + s[1]}$$

Part-2

Find the $\boxed{T_{yr}}$ (closed-loop transfer function) expression dependent on k1 and k2.

[you can use matlab-symbolic-toolbox to obtain the expression]

Matlab code	Matlab output

<pre>syms s k1 k2
 	
G_s=1/(s+1)
 	
K_s=k1+k2/s;
 	
open_loop_tf=K_s*G_s;
open_loop_tf=simplifyFraction(open_loop_tf,'Expand',true)
T_yr=open_loop_tf/(1+open_loop_tf);
T_yr=simplifyFraction(T_yr,'Expand',true)
pretty(T_yr)</pre>
	<pre>T_yr =
	
	(k2 + k1*s)/(k2 + s + k1*s + s^2)
	
	      k2 + k1 s
	------------------- 	
	                  2
	k2 + s + k1 s + s</pre>

Using this matlab script it can be seen that

$$T_{yr} = \frac{s[k_1] + [k_2]}{s^2[1] + s[k_1 + 1] + [k_2]}$$

Part-3

Find the $\boxed{T_{er}}$ (reference-to-error transfer function) expression dependent on k1 and k2. [you can use matlab-symbolic-toolbox to obtain the expression]

Matlab code	Matlab output

<pre>syms s k1 k2
 	
G_s=1/(s+1)
% G_s=1/((s+1)*(s+2))
 	
K_s=k1+k2/s;
 	
open_loop_tf=K_s*G_s;
open_loop_tf=simplifyFraction(open_loop_tf,'Expand',true)
% pretty(open_loop_tf)
T_yr=open_loop_tf/(1+open_loop_tf);
T_yr=simplifyFraction(T_yr,'Expand',true)
T_er=1/(1+open_loop_tf);
T_er=simplifyFraction(T_er,'Expand',true)
pretty(T_er)</pre>
	<pre>T_er =
	
	(s^2 + s)/(k2 + s + k1*s + s^2)
	
	         2
	        s + s
	------------------- 	
	                  2
	k2 + s + k1 s + s</pre>

Using this matlab script it can be seen that

$$T_{er} = \frac{s^2[1] + s[1]}{s^2[1] + s[k_1 + 1] + [k_2]}$$

Part-4

Find a k1 and k2 such that $\boxed{T_{yr}}$ is stable.

[you can generate random k1 and k2 values and then check the stability of the $\boxed{T_{yr}}$ system using "isstable" matlab command, or the roots of the characteristic Equation]

Matlab code

```
syms s k1 k2

G_s=1/(s+1)
K_s=k1+k2/s;

open_loop_tf=K_s*G_s;
open_loop_tf=simplifyFraction(open_loop_tf,'Expand',true)
T_yr=open_loop_tf/(1+open_loop_tf);
T_yr=simplifyFraction(T_yr,'Expand',true)
T_er=1/(1+open_loop_tf);
T_er=simplifyFraction(T_er,'Expand',true)

[Num1,Den1] = numden(T_yr) % "numden" fcn gets the numerator and denominator of a
%given rational-function
% [C,T] = coeffs(p,vars)
[Coeffs1,Term1] = coeffs(Den1,s)

while(true)
    % stay in this loop till u find a (k1,k2) values s.t. closed-loop is stable
    k1_val = randi([-10,10],1,1)    % pick a random integer between [-10,10]
    k2_val = randi([-10,10],1,1)    % pick a random integer between [-10,10]
    % Coeffs1_val=subs(Coeffs1,{k1,k2}, {1,2})    % subs 1 for k1, subs 2 for k2
    Coeffs1_val=subs(Coeffs1,{k1,k2}, {k1_val,k2_val})
    % subs k1_val for k1, subs k2_val for k2
    Coeffs1_val=double(Coeffs1_val)
    % "Coeffs1_val" is "sym" type, to make it "double" use double() fcn
    roots_1=roots(Coeffs1_val)
    % compute the roots of the "Characteristic equation",
    % use the coefficients of the "characteristic polynomial"
    if all(real(roots_1)<0)
        disp('stable closed-loop dynamics');
        k1_val
        k2_val
        break;
    else
        disp('unstable closed-loop dynamics');
    end
end
```

Matlab code output

```
k1_val =

     7
```

```
k2_val =

     8
```

Note: in this given matlab script the matlab-commands you may not be familiar with are listed as

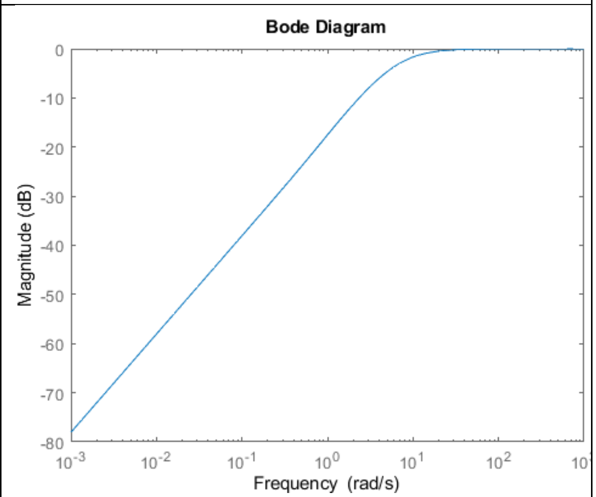
1) `simplifyFraction`
2) `numden`
3) `coeffs`
4) `randi`
5) `subs`
6) `double`
7) `roots`
8) `all`
9) `real`

Part-5

For the k1 and k2 values that you determined in the previous part, plot the frequency response for $\boxed{T_{er}}$. [you can use “bode” matlab command to obtain a frequency response]

Matlab code [this code is run after the code given in the previous part]	Matlab code output

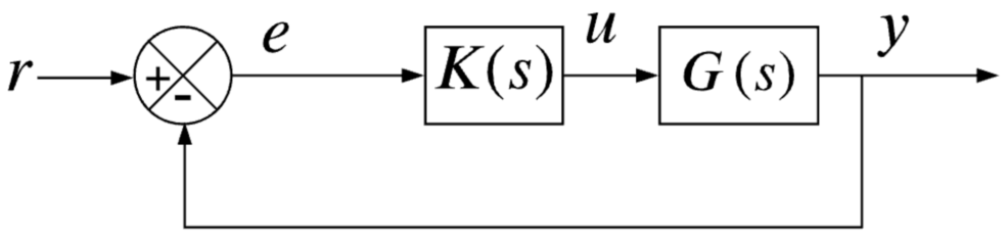
```
%% now that we have (k1,k2) s.t.
%closed-loop dyns are stable, check |Tzw(jw)|
T_er=1/(1+open_loop_tf);
T_er=simplifyFraction(T_er,'Expand',true)
pretty(T_er)
% T_er_val=subs(T_er,{k1,k2}, {1,2})
T_er_val=subs(T_er,{k1,k2}, {k1_val,k2_val})
T_er_val=simplifyFraction(T_er_val,'Expand',tru
e)
pretty(T_er_val)

[Num1,Den1] = numden(T_er_val)
Num1=expand(Num1)+1;
Den1=expand(Den1)+1;
[Num_Coeffs,Term1] = coeffs(Num1,s)
Num_Coeffs(end)=Num_Coeffs(end)-1;
[Den_Coeffs,Term1] = coeffs(Den1,s)
Den_Coeffs(end)=Den_Coeffs(end)-1;
Num_Coeffs=double(Num_Coeffs)
Den_Coeffs=double(Den_Coeffs)
Tzw=tf(Num_Coeffs,Den_Coeffs)
% i named "T_er" as "Tzw"
bodemag(Tzw,{1e-3,1e3});
% plot the frequency respose
set(gcf,'color',[1,1,1]);
% this is to make the background color "white"
```



Bode plot of $T_{er}(s)$ transfer function

Problem-2

For a given control system whose block diagram is given as



plant	Controller	Open-loop TF	Closed-loop TF	Reference-to-Error TF
$G = \frac{1}{(s+1)(s+2)}$	$K = k_1 + k_2 \frac{1}{s}$	$L = GK$	$T_{yr} = \frac{L}{1+L}$	$T_{er} = \frac{1}{1+L}$

Part-1

Find the $\boxed{L}$ (open-loop transfer function) expression dependent on k1 and k2. [you can use matlab-symbolic-toolbox to obtain the expression]

Part-2

Find the $\boxed{T_{yr}}$ (closed-loop transfer function) expression dependent on k1 and k2. [you can use matlab-symbolic-toolbox to obtain the expression]

Part-3

Find the $\boxed{T_{er}}$ (reference-to-error transfer function) expression dependent on k1 and k2. [you can use matlab-symbolic-toolbox to obtain the expression]

Part-4

Find a k1 and k2 such that $\boxed{T_{yr}}$ is stable. [you can generate random k1 and k2 values and then check the stability of the $\boxed{T_{yr}}$ system using "isstable" matlab command]

Part-5

For the k1 and k2 values that you determined in the previous part, plot the frequency response for $\boxed{T_{er}}$. [you can use "bode" matlab command to obtain a frequency response]

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 5th Ed", Ogata K., 2010, Prentice Hall [2] "Linear Systems Theory 2nd 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.