09365061 Principle of Automatic Control (2) (Spring Semester 2013-2014)
Practical Report and Group Presentation Assessment Sheet

Students should work in groups and accomplish the following tasks:
(1) Solve the practical problem by using Matlab and Simulink.
(2) Prepare a practical report with the detail of your experiment procedure such as the Matlab code, Simulink block diagram design and parameter setting. Provide your experimental results and analyze the result theoretically.
(3) Give a group presentation in English. In the presentation, you should demonstrate your program, present and analyze your experimental result. And you will also be asked some questions. Student who absent from the group presentation will be given ZERO mark for the group presentation session.

Group No.	Student ID	Name	Contribution %	Signature	Final Mark	
					Report	Oral
6	11121027	Yue Yue	40%			
	11121187	Xiao Zixuan	30%			
	11121153	Xu Yueming	30%			

Practical Report Criteria/Grade	**0 - 3**	**4 - 6**	**7**
Group member should solve the practical problem together. Give a practical report with the detail of your experiment procedure such as the Matlab code, Simulink block diagram design and parameter setting. Provide the experimental results and analyze the result theoretically.	More than 50% of work incorrect. And not so neat work.	More than 75% of the work correct. Generally neat work	More than 90% of the work correct. Very neat and systematic work.

Group Presentation Criteria/Grade	**0 - 3**	**4 - 6**	**7**
Give a group presentation in English. The presentation can be divided into a couple of individual parts. And each member can make a presentation for one part. In the presentation, you should demonstrate your program, present and analyze your experimental result. And you will also be asked some questions.	Fail in demonstrating 50%+ programs. Give incorrect answers to 50%+ questions. The oral presentation is NOT given in English or the spoken English can be hardly understood.	Successfully demonstrate 75%+ programs. Give correct answer to 75%+ questions. And the oral presentation is given in English and easy to understand in most cases.	Successfully demonstrate 90%+ programs. Give correct answer to 90%+ questions. And the oral presentation is given in English and easy to understand.

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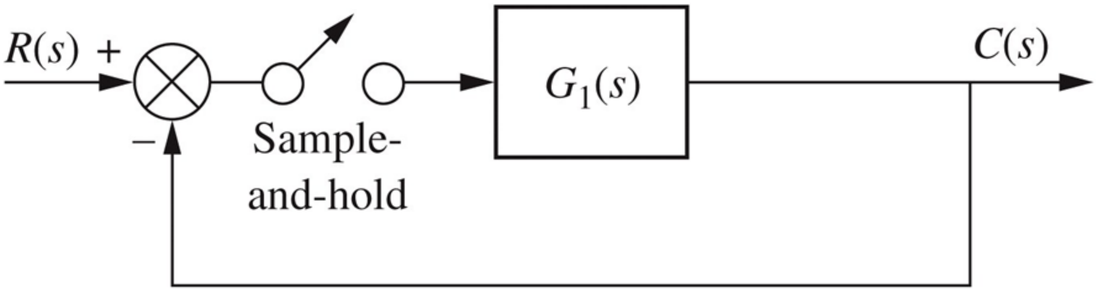
Group No.	Student ID	Name	Signature
6	11121027	Yue Yue	
	11121187	Xiao Zixuan	
	11121153	Xu Yueming	

Write a MATLAB program that can be used to find the range of sampling time, *T*, for stability. The program will be used for systems of the type represented in the following figure and should meet the following requirements:

a. MATLAB will convert $G_1(s)$ cascaded with a sample-and-hold to $G(z)$.

b. The program will calculate the z-plane roots of the closed-loop system for a range of *T* and determine the value of *T*, if any, below which the system will be stable. MATLAB will display this value of *T* along with the z-plane poles of the closed-loop transfer function.

c. Test the program on $G_1(s) = \dfrac{10(s+7)}{(s+1)(s+3)(s+4)(s+5)}$



Part I Theoretical Analysis

To begin with, we will clarify that we are discussing the definition of stability in the digital control system through z-plane. We could recall that in the s-plane,the region of stability is the left half-plane.If the transfer function,G(s),is transformed into a sampled-data transfer function,G(z), the region of stability on the z-plane can be evaluated from the definition,

$$z = e^{Ts} = e^{T(\alpha + j\omega)} = e^{\alpha T}(\cos\omega T + j\sin\omega T) = e^{\alpha T}\angle\omega T$$

Thus ,each region of the s-plane can be mapped into a corresponding region on the z-plane.The points which are in the right half plane of s-plane will be outside the unit circle,the points belonging to the left half plane of the s-plane are inside the unit circle in the z-plane,the points on the $j\omega$-axis will be on the unit circle.

In all,a digital control system is stable if all poles of the closed-loop transfer function, T(z), are inside the unit circle on the z-plane.It is unstable if any pole is outside the unit circle and/or there are poles of multiplicity greater than one on the unit circle.And the system is marginally stable if poles of multiplicity one are on the unit circle and all other poles are inside the unit circle.

Based on the fundamental above ,for the system given,first we should calculate the z transfer function T(z):

$$G(s)=10\frac{(1-e^{-Ts})(s+7)}{s(s+1)(s+3)(s+4)(s+5)}=10(1-e^{-Ts})\frac{(s+7)}{s(s+1)(s+3)(s+4)(s+5)}$$

$$=10(1-e^{-Ts})[\frac{7s}{60}-\frac{1}{4(s+1)}+\frac{1}{3(s+3)}-\frac{1}{4(s+4)}+\frac{1}{20(s+5)}]$$

Taking the z-transform,

$$G(z)=\frac{10(z-1)}{z}[\frac{7z}{60(z-1)}-\frac{z}{4(z-e^{-T})}+\frac{z}{3(z-e^{-3T})}-\frac{z}{4(z-e^{-4T})}+\frac{z}{20(z-e^{-5T})}]$$

Using the equation $T(z)=\frac{G(z)}{1+G(z)}$ we could get the closed-loop transfer function,then we should get all the closed-loop poles and let them in the unit circle,we could calculate the range of T should be 0<T<3.366s.

Part II Matlab Program Process

In a similar way ,we could arrange a matlab program to solve this problem.We use a range of the sampling time T into the closed-loop z-transfer function T(z),then we can get all the poles under the different T,we calculate the biggest length of these vectors ,if it is bigger than 1,we could assert that the system is unstable.We use a loop structure to make this program.

Program:

```
num=[10 70]
den=poly([-1 -3 -4 -5 ])
SYSC=tf(num,den);The s-plane transfer function G(s)
for T=0.01:0.0001:10;Set the range of T
SYSD=c2d(SYSC,T,'zoh');Find G(z) assuming G(s) in cascade with z.o.h. and display
Tz=feedback(SYSD, 1);Find T(z)
r=pole(Tz);Get poles for this value of T
rm=max(abs(r));Find pole with maximum vector length for this value of T
if rm>=1;See if pole is outside unit circle.
  Break;Stop if pole is found outside unit circle
End;end if
End;end for
T;display T
r;display the poles
rm;Display vector length of pole
```

Then run the program,we get the result :When T equals to 3.3657s,the biggest length of the vector will be 1,thus there will be poles outside the unit circle, the system will be unstable.So the range of T to ensure the stability of the system should be **0<T<3.3657s**.

```
r =

   -1.0000
   -0.0458
   -0.0001
   -0.0000


rm =

     1.0000


r =

   -1.0000
   -0.0458
   -0.0001
   -0.0000


rm =

     1.0000
```

```
Tz =

      1.08 z^3 + 0.04587 z^2 + 2.656e-06 z + 8.456e-13
  -------------------------------------------------------
  z^4 + 1.046 z^3 + 0.04587 z^2 + 2.656e-06 z + 8.456e-13

Sample time: 3.3657 seconds
Discrete-time transfer function.
```

Part III The Comparison between Theoretical result and Matlab Result

We are going to have a look at the results of the different methods.
Using the method of z-transformation ,we get the range of T to ensure the stability is 0<T<3.366s;
The result from the Matlab program is 0<T<3.3657s.The fractional error is 0.00891%.To sum

up ,the Matlab results tally with the theoretical results.

Part IV Summary

In this practical report,our group has used two kinds of methods to solve the problem of the stability of the digital control system.We have gained the experience of making use of Matlab and the theoretical ways of working out the problem.

In the field of the Principle of Automatic Control,we should combine the two methods together so that we could solve the practical problem easier and faster.