CONTROL SYSTEM LAB REPORTS

LAB 05

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LAB 05

Task 01:

We have found the range of K on which the system is stable, the range is K<1386 then the system is stable.

The solution of Routh stability criteria , Lab # 05

Task NO 01:

Consider following closed loop transfer function:

$$T(s) = \frac{K}{s^3 + 18s^2 + 77s + K}$$

Using Routh stability criterion, determine range of K for stability.

Solution:

We take

$$s^3 + 18s^2 + 77s + K = 0$$

Routh Matrix:-

$$\begin{array}{c|ccc} s^3 & 1 & 77 & 0 \\ s^2 & 18 & K & 0 \\ s^1 & -77 + \frac{K}{8} & & \\ s^0 & & & \end{array}$$

$$b_1 = \frac{-1}{18}\left(18 \times 77 - K\right)$$

$$b_1 = -77 + \frac{K}{8}$$

For Stable System:

$$-77 + \frac{K}{8} > 0$$

$$\frac{K}{8} < 77$$

$K < 77 \times 8$

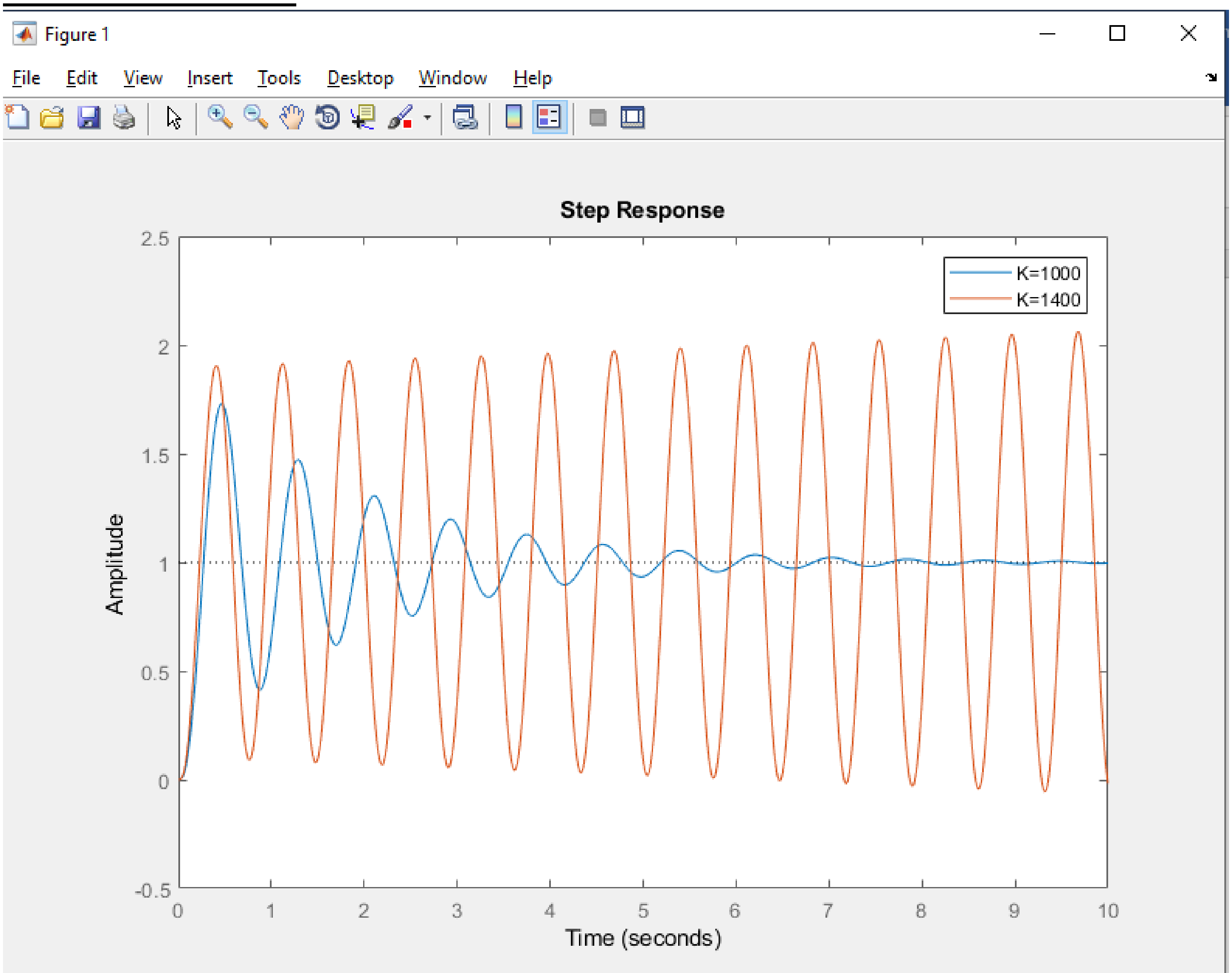
$\boxed{K < 1386}$

For stable system "K" value should be less than 1386.

MATLAB code to check whether our obtained range is correct,

```
s=tf('s');
G= 1/(s^3+18*s^2+77*s)
K1=1000;
step(feedback(K1*G,1),10)
hold on
K2= 1400;
step(feedback(K2*G,1),10)
legend('K=1000','K=1400')
```

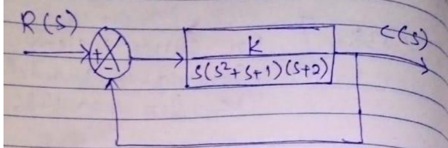
MATLAB RESULT:



TASK 02:

We have found the range of K on which the system is stable, the range is $K<1.5$ then the system is stable and if $K> 1.5$ the system will be unstable and when the $K=1.5$ the system will be marginally stable

The solution of Routh stability criteria, Lab# 05 Task # 02



Find range of K, that will cause system to be stable, unstable and marginally stable.

Solution:

First we find closed loop transfer function of gain;

$$G(S) = \frac{K}{S(S^2+S+1)(S+2)}$$

As we know that

$$T(S) = \frac{G(S)}{1+G(S)H(S)}$$

Here we have unity feedback, So $H(S) = 1$

$$T(S) = \frac{G(S)}{1+G(S)(1)}$$

Taking G(S).

$$G(S) = \frac{K}{S(S^2+S+1)(S+2)}$$

$$= \frac{K}{S(S^3+2S^2+S^2+2S+S+2)}$$

$$= \frac{K}{S(S^3+3S^2+3S+2)}$$

$$G(S) = \frac{K}{S^4+3S^3+3S^2+2S}$$

putting values in T(S)

$$T(S) = \frac{K/S^4+3S^3+3S^2+2S}{1+\frac{K}{S^4+3S^3+3S^2+2S}}$$

$$T(S) = \frac{K/\cancel{S^4+3S^3+3S^2+2S} \times \cancel{S^4+3S^3+3S^2+2S}}{S^4+3S^3+3S^2+2S+K}$$

$$\boxed{T(S) = \frac{K}{S^4+3S^3+3S^2+2S+K}}$$

Which is the closed loop transfer function.

By Characteristic Equation

$$S^4+3S^3+3S^2+2S+K=0$$

By Routh Matrix

S^4	1	3	K
S^3	3	2	0
S^2	$\frac{7}{3}$	K	0
S^1	$\frac{-9K+2}{7}$	0	
S^0			

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$\cancel{C_4}$

$$c_1 = -\frac{3}{7}\left(3K - \frac{14}{3}\right)$$

$$c_1 = -\frac{9K}{7} + 2$$

Hence

$$\boxed{K < 1.5}$$

for stable system.

When $K = 1.5$
system will marginal stable.

When $K > 1.5$
System will be unstable.

R.W

$$-\frac{9K}{7} + 2 > 0$$

$$-9K + 14 > 0$$

$$-9K < -14$$

$$\cancel{K < \frac{14}{9}}$$

$$\boxed{\cancel{K < 2}}$$

$$\boxed{K < \frac{14}{9}}$$

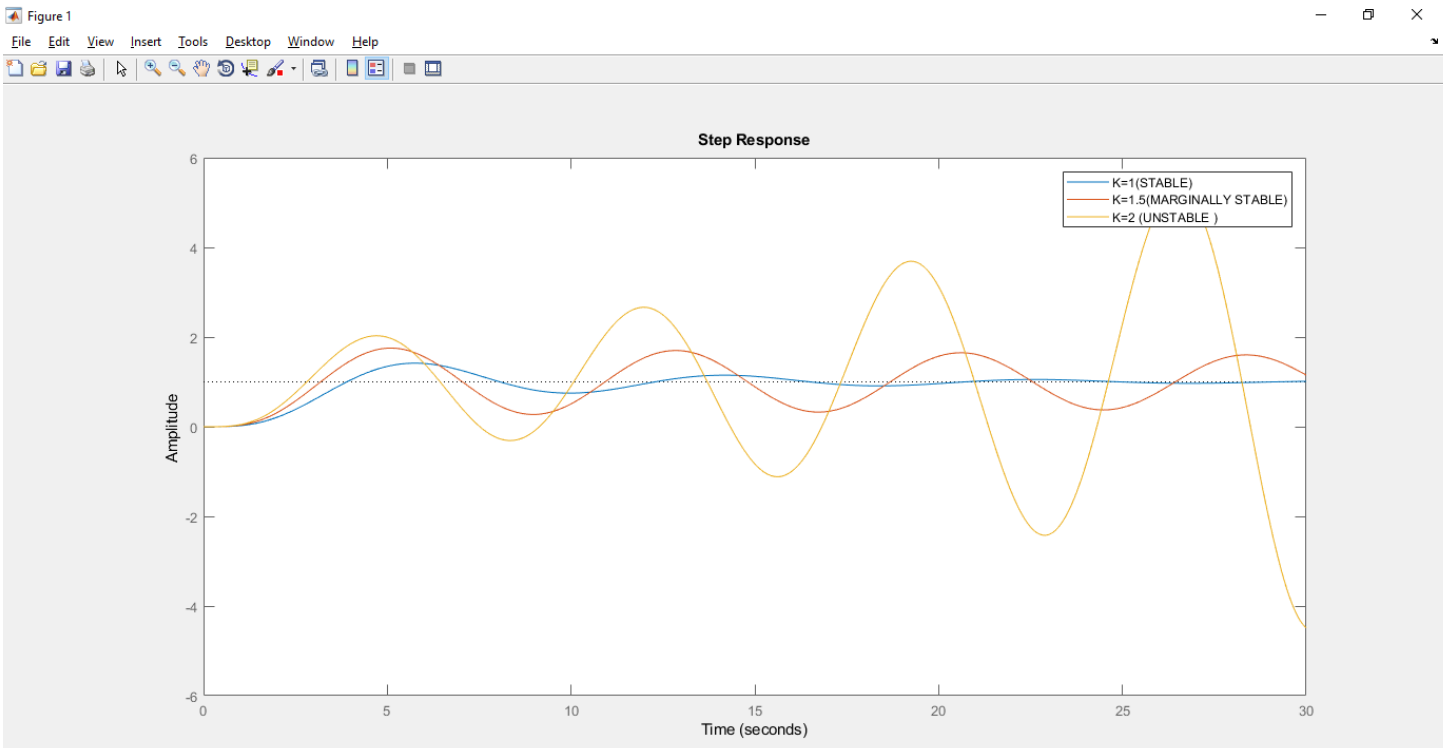
$$K < 1.5$$

MATLAB code to check whether our obtained range is correct,

```
s=tf('s');
G= 1/(s^4+3*s^3+3*s^2+2*s)
K1=0.9;
step(feedback(K1*G,1),50)
```

```
hold on
K2= 5;
step(feedback(K2*G,1),50)
legend('K=2','K=10')
```

MATLAB RESULT:



TASK 03: