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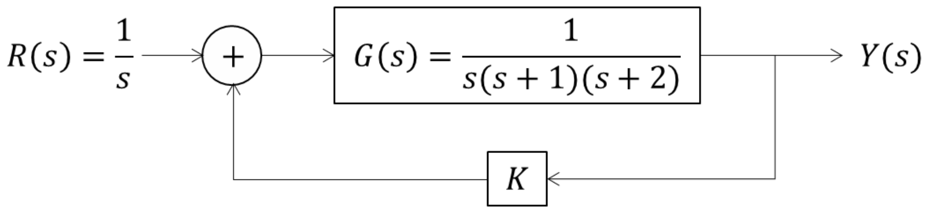
CLASS	**: EE**	
HOMEWORK	**: 5**	



1. See the figure above. Determine the range of K such that the overall system is stable!
2. See the figure above. Determine the value of K such that the overall sistem has no steady-state error!

Answer :

1. The transfer function $H(s)$ with the positive feedback :

$$H(s) = \frac{G(s)}{1 - G(s)K}$$

$$H(s) = \frac{\frac{1}{s(s+1)(s+2)}}{1 - \frac{1}{s(s+1)(s+2)}K}$$

$$H(s) = \frac{1}{s(s+1)(s+2)} \cdot \frac{s(s+1)(s+2)}{s(s+1)(s+2) - K}$$

$$H(s) = \frac{1}{s(s+1)(s+2) - K}$$

$$H(s) = \frac{1}{s^3 + 3s^2 + 2s - K}$$

After the TF found, using Routh-Hurwitz table to determine the value of K

s^3	1	2
s^2	3	$-K$
s^1	$\frac{-\begin{vmatrix}1 & 2\\ 3 & -K\end{vmatrix}}{3} = \frac{K+6}{3}$	$\frac{-\begin{vmatrix}1 & 0\\ 3 & 0\end{vmatrix}}{3} = 0$
s^0	$\frac{-\begin{vmatrix}3 & -K\\ \frac{K+6}{3} & 0\end{vmatrix}}{\frac{K+6}{3}} = -K$	$\frac{-\begin{vmatrix}3 & 0\\ \frac{K+6}{3} & 0\end{vmatrix}}{\frac{K+6}{3}} = 0$

Identify the second columns of Routh-Hurwitz table

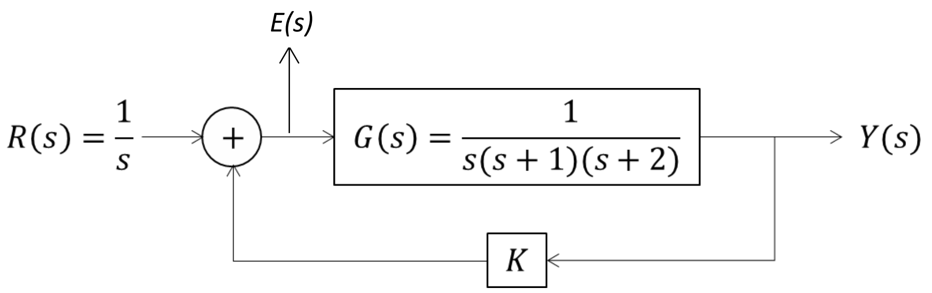
1	
3	
$\frac{K+6}{3}$	$+$
$-K$	$+$

The system have been stable if the value of K is positive, so the third and fourth columns must be greather than 0 so,

$\frac{K+6}{3} > 0\,; K > -6$
$-K > 0\,; 0 > K$

So, range of K is $-6 < K < 0$

2.



Consider the *G(s)* is

$$G(s) = \frac{1}{s(s+1)(s+2)}$$

And *H(s)* is

$$H(s) = K$$

So, $G_e(s)$ is

$$G_e(s) = \frac{G(s)}{1 - G(s)H(s) - G(s)}$$

$$G_e(s) = \frac{\frac{1}{s(s+1)(s+2)}}{1 - \frac{K}{s(s+1)(s+2)} - \frac{1}{s(s+1)(s+2)}}$$

$$G_e(s) = \frac{\frac{1}{s(s+1)(s+2)}}{\frac{s(s+1)(s+2) - K - 1}{s(s+1)(s+2)}}$$

$$G_e(s) = \frac{1}{s(s+1)(s+2)} . \frac{s(s+1)(s+2)}{s(s+1)(s+2) - K - 1}$$

$$G_e(s) = \frac{1}{s(s+1)(s+2) - K - 1}$$

$$G_e(s) = \frac{1}{s^3 + 3s^2 + 2s - K - 1}$$

So, the *E(s)* is

$$E(s) = R(s) + Y(s)$$

$$E(s) = R(s) + G_e(s).E(s)$$

$$E(s)\big(1 - G_e(s)\big) = R(s)$$

$$E(s) = \frac{R(s)}{1 - G_e(s)}$$

$$E(s) = \frac{R(s)}{1 - G_e(s)}$$

\

$$E(s) = \frac{\frac{1}{s}}{1 - \frac{1}{s^3 + 3s^2 + 2s - K - 1}}$$

So, if we want to design the system with no steady state error, $\lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s) = 0$

$$e(\infty) = \lim_{s\to 0} sE(s) = 0$$

$$0 = \lim_{s\to 0} s . \frac{\frac{1}{s}}{1 - \frac{1}{s^3 + 3s^2 + 2s - K - 1}}$$

$$0 = \lim_{s\to 0} \frac{1}{1 - \frac{1}{s^3 + 3s^2 + 2s - K - 1}}$$

$$0 = \frac{1}{1 - \frac{1}{-K - 1}}$$

$$0 = \frac{-K - 1}{-K - 2}$$

$$K = -1$$