Modelling Transfer Function of a Control System

Aim:- To model a transfer function of a given control system using the given parameters.

Apparatus:- PC loaded with MATLAB.

Theory:-

The transfer function of a control system is a powerful tool to analyse and design a control system

→ It is the ratio of the laplace transform of the systems output to the laplace transform of its input, with all initial conditions set to zero.

→ It acts like a block/box that summarizes how the system reacts to different input signals.

→ It contains poles and zeros which are specific value in complex plane where the transfer function becomes undefined and zero respectively.

→ It facilitates the analysis of system behaviour, including stability, transient response and frequency response, by allowing engineers to design controllers that meet specific performance requirements

→ Transfer functions are essential for modeling complex systems, allowing engineers to understand and simulate system dynamics before implementing control strategies

Calculations :-

Step response $Y(s) = \frac{1}{s} H(s)$ where $H(s)$ = transfer function

(i) $H(s) = \frac{100(s+2)}{(s+1)(s+5)}$

$Y(s) = \frac{100(s+2)}{s(s+1)(s+5)}$

$Y(\infty) = \lim_{s \to 0} s \cdot Y(s)$ (final value theorem)

$= \lim_{s \to 0} \frac{100(s+2)}{(s+1)(s+5)}$

$= \frac{(100)(2)}{5} = 40$

$\tau = \frac{4.72}{5} = 0.94\,s$ (From step plot)

$\frac{-1}{\text{Dominant pole}} = \frac{-1}{-1} = 1 \approx \tau$

(ii) $H(s) = \frac{100(s+2)}{(s+3)(s+5)}$

$Y(s) = \frac{100(s+2)}{s(s+3)(s+5)}$

$Y(\infty) = \lim_{s \to 0} s \cdot Y(s)$ (FVT)

$= \left. \frac{100(s+2)}{s(s+3)(s+5)} \right|_{s=0}$

$= \frac{40}{3}$

(iii) $H(s) = \frac{100(s+2)}{(s+4)(s+5)}$

$Y(s) = \frac{100(s+2)}{s(s+4)(s+5)}$

$Y(\infty) = \lim_{s \to 0} s \cdot Y(s)$ (Final value theorem)

$= \lim_{s \to 0} \frac{100(s+2)}{(s+4)(s+5)}$

$= \frac{200}{20} = 10$

$\tau = \frac{1.73}{5}\,s$ (From step response)

$= \frac{-1}{\text{Dominant pole}} = \frac{-1}{-4} = 0.25 \approx \tau$

(iv) $H(s) = \frac{100(s+2)}{(s+5)(s+10)}$

$Y(s) = \frac{100(s+2)}{s(s+5)(s+10)}$

$Y(\infty) = \lim_{s \to 0} s \cdot Y(s)$ (Final value theorem)

$= \lim_{s \to 0} \frac{100(s+2)}{(s+5)(s+10)}$

$= \frac{200}{(5)(10)} = 4$

$\tau = \frac{1.12}{5} = 0.22\,s$ (From step plot)

$= \frac{-1}{\text{Dominant pole}} = \frac{-1}{-5} = 0.25\,s \approx \tau$

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Code:-

```
clc;
clear;
close all;
% Let's declare 4 transfer functions in 4 different formats
% Taking input from command window
num= input ('enter numerator:');
den = input ('enter denominator:');
g1 = tf (num, den);
% direct method
 s=tf('s');
 g2 = (100*s+200)/(s^2+8*s+15);
% zpk format
 g3= zpk (-2,[-4. -5], 100);
 g4 = zpk (-2,[-5 -10],100);

% finding pole zero plot
figure(1);
subplot (2,2,1);
pzmap(g1);
title('1602-21-735-117');
grid on;
```

```
subplot(2,2,2);
pzmap(g2);
title('1602-21-735-117');
grid on;
subplot(2,2,3);
pzmap(g3);
title('1602-21-735-117');
grid on;
subplot(2,2,4);
pzmap(g4);
title('1602-21-735-117');
grid on;
% finding the step response of the above transfer functions
figure(2);
subplot(2,2,1);
stepplot(g1);
title('1602-21-735-117');
grid on;
subplot(2,2,2);
stepplot(g2);
title('1602-21-735-117');
grid on;
```

```
subplot(2,2,3);
subplot(g3);
title('1602-21-735-117');
grid on;
subplot(2,2,4);
stepplot(g4);
title('1602-21-735-117');
grid on;
```

Observation:-

→ As the pole of the system are negative the step response is reaching a stable value over a period of time, but if there is a positive pole the system becomes unstable.

→ $\tau = \frac{-1}{\text{dominant pole}}$ where τ = time constant of the system

Result:-

Transfer function for a given system is modelled in different ways using MATLAB.