EN3143: Electronic Control Systems

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Index Number: 180066F **Exercise Number:** 3

Problem 1

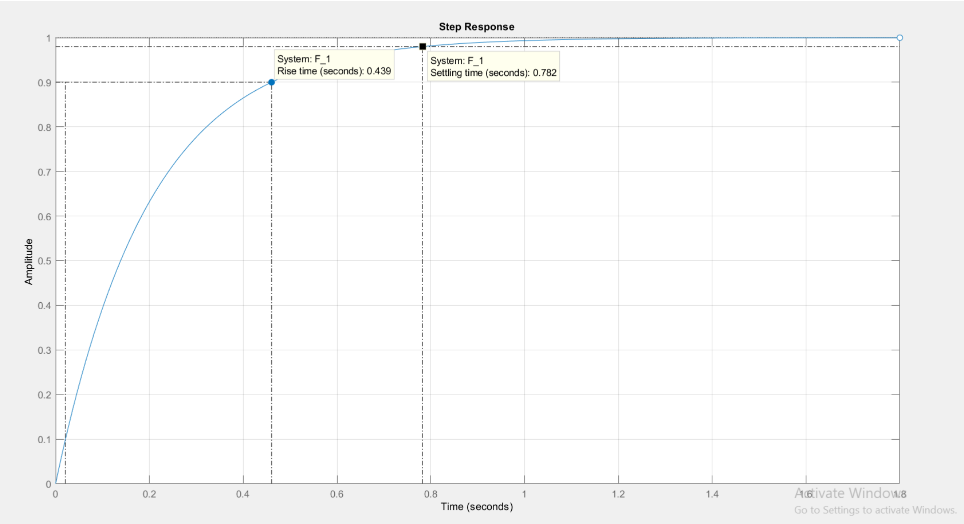

Figure 1: MATLAB plot for step response of the transfer function $\frac{5}{s+5}$

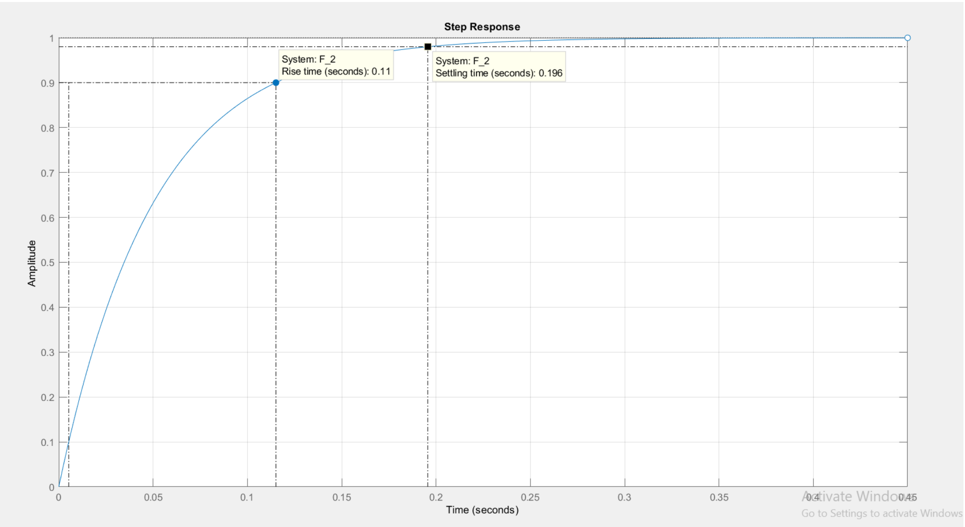

Figure 2: MATLAB plot for step response of the transfer function $\frac{20}{s+20}$

Problem 2

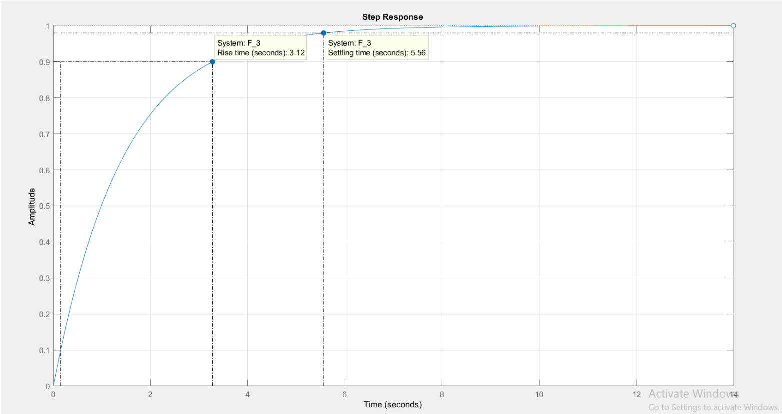

Figure 3: MATLAB plot for step response of the transfer function $\frac{1}{1.422s+1}$

Obtained values for performance specifications using MATLAB implementation (Code is attached in Appendix) :

- Settling Time = 5.56s
- Rise Time = 3.12s
- Time Constant = 1.39s

Obtained values for performance specifications using solved equations (Calculations are shown in the latter part of the document):

- Settling Time = 5.688s
- Rise Time = 3.1284s
- Time Constant = 1.422s

Problem 3

When $M = 1$,

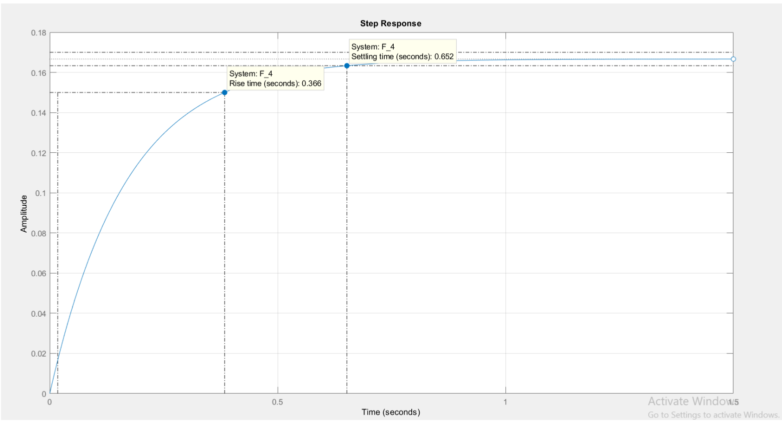

Figure 4: MATLAB plot for step response of the transfer function $\frac{1}{s+6}$ when $M = 1$

Obtained values for performance specifications using MATLAB implementation (Code is attached in Appendix):

- Settling Time = 0.652s
- Rise Time = 0.366s
- Time Constant = 0.163s

Obtained values for performance specifications using solved equations (Calculations are shown in the latter part of the document):

- Settling Time = 0.667s
- Rise Time = 0.367s
- Time Constant = 0.167s

When $M = 2$,

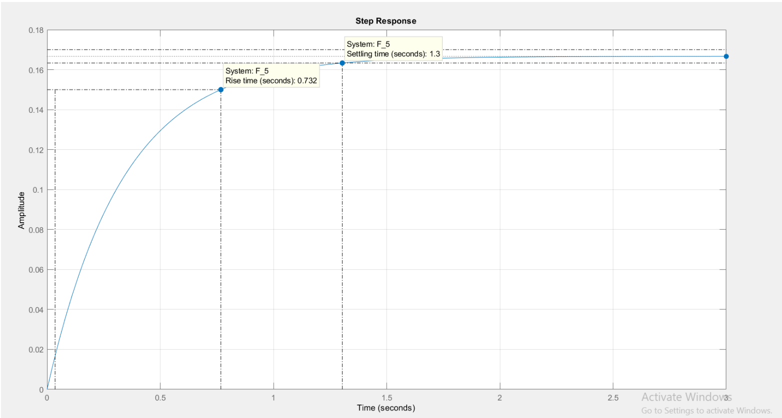

Figure 5: MATLAB plot for step response of the transfer function $\frac{1}{2s+6}$ when $M = 2$

Obtained values for performance specifications using MATLAB implementation (Code is attached in Appendix) :

- Settling Time = 1.3s
- Rise Time = 0.732s
- Time Constant = 0.325s

Obtained values for performance specifications using solved equations (Calculations are shown in the latter part of the document):

- Settling Time = 1.333s
- Rise Time = 0.733s
- Time Constant = 0.333s

Appendix: MATLAB Implementation

```
clc;
close all;
%Problem1
num = [5];
den = [1 5];
F_1= tf(num, den)
stepplot(F_1); %plot step response of the transfer function

num = [20];
den = [1 20];
F_2= tf(num, den)
stepplot(F_2); %plot step response of the transfer function

%Problem2
num = [1];
den = [1.422 1];
F_3= tf(num, den)
stepplot(F_3); %plot step response of the transfer function

%Problem3
%When M=1
num = [1];
den = [1 6];
F_4= tf(num, den)
stepplot(F_4); %plot step response of the transfer function

%When M=2
num = [1];
den = [2 6];
F_5= tf(num, den)
stepplot(F_5); %plot step response of the transfer function
```

Figure 6: MATLAB implementation for Problem 1, Problem 2 and Problem 3

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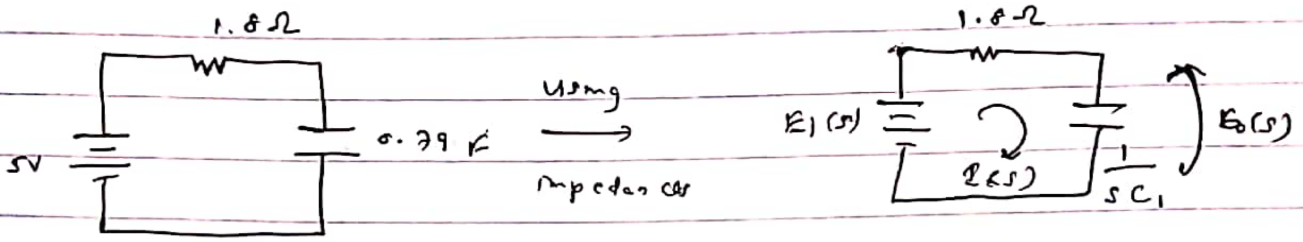
MATLAB Exercise 03

(2)



Using KVL ; $E_i(s) = I(s) \times \left[1.8 + \frac{1}{s \times 0.79} \right]$ — (1)

$E_o(s) = I(s) \times \frac{1}{s \times 0.79}$ — (2)

Therefore ; $\frac{E_o(s)}{E_i(s)} = \frac{\frac{1}{s \times 0.79}}{1.8 + \frac{1}{0.79s}} = \frac{\frac{1}{0.79s} \times 0.79s}{1.8 \times 0.79s + 1}$

$TF = \frac{1}{1 + 1.422s} = \frac{0.703235}{s + 0.703235}$

Therefore, (First order sys)

Time constant ; $T = \frac{1}{0.703235} = 1.422\ s$

Rise Time ; $T_r = 2.2T = 3.1284\ s$

Settling Time , $T_s = 4T = 5.688\ s$

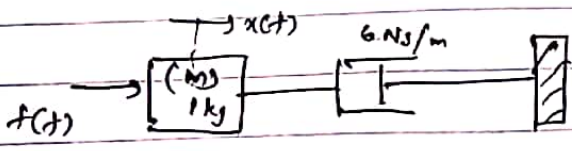
At steady state,

$V_c(\infty) = 5V$

$\therefore\ V_c(t) = 5(1 - e^{-0.703t})$

$t \geq 0$

(3)



$f(t) - 6(\dot{x}(t)) = M\ddot{x}(t)$ — (1)

$F(s) = [s^2M + 6s]\,X(s)$

$\frac{X(s)}{F(s)} = \frac{1}{s(Ms+6)} = \frac{1}{s} \cdot \frac{1}{Ms+6}$

When $M = 1$, $\frac{X(s)}{F(s)} = \frac{1}{s} \cdot \frac{1}{s+6}$

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When $M = 1$; $\frac{X(s)}{F(s)} = \frac{1}{s(s+6)}$

From ①; $f(t) = 6\dot{x}(t) + M\ddot{x}(t)$.

If $\dot{x}(t) = y(t)$, assuming zero initial conditions,

$\ddot{x}(t) = \dot{y}(t)$,

Therefore; $f(t) = 6y(t) + M\dot{y}(t)$

taking laplace, $F(s) = 6Y(s) + MsY(s)$

$$\frac{Y(s)}{F(s)} = \frac{1}{6 + Ms} \quad \text{— ②}$$

When $M = 1$, $\frac{Y(s)}{F(s)} = \frac{1}{s+6} = \frac{1}{6} \cdot \frac{6}{s+6}$

$T = \frac{1}{6} = 0.167\ s$

$T_s = 4/6 = 0.667\ s$

$T_r = 2.2 \times 1/6 = 0.367\ s$

② $\Rightarrow$ $\frac{Y(s)}{F(s)} = \frac{1/M}{6/M + s}$ $\Rightarrow$ $T = \frac{1}{6/M} = M/6$

$T_s = 4T = 0.667M$

$T_r = 2.2T = 0.367M$

$M = 2$; $T = 1/3 = 0.333\ s$

$T_s = 4/3 = 1.333\ s$

$T_r = 2.2T = 0.733\ s$