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1907019

Machines Exam - 3

(1) Given,

No. of poles of PMAC motor = 2.

$K_t = K_e = 0.75$ in MKS

$L_s = 25\ mH = 0.025\ H.$

$R_s = 0.25\ \Omega$

$J_m = 0.03\ kgm^2$

$J_L = 0.05\ kgm^2$

$J_{eq} = 0.08\ kgm^2$

$T_L = 2\ Nm$; $T_{em} = 7\ Nm$; $\omega_{m,final} = 2000\ rpm$

$\Rightarrow \omega_f = 2000 \times \frac{2\pi}{60}$ rad/sec

$= 209.43 \approx 210$ rad/sec.

$\therefore \omega_m(t) = \frac{1}{J_{eq}}(T_{em} - T_L)\, t.$

$= \frac{5t}{0.08} = 62.5\, t$ rad/sec.

$t = \frac{209.43}{62.5}$

$= \frac{210}{63}$

$\boxed{t = 3.33\ sec}$

$\theta_{is}(t) = \frac{P}{2}\theta_m(t) + \frac{\pi}{2}$

$= -\frac{\pi}{2} + \int_0^t \omega_m(t)\, dt + \frac{\pi}{2}$

$= -\frac{\pi}{2} + 62.5\left(\frac{t^2}{2}\right) + \frac{\pi}{2}$

$\boxed{\theta_{is}(t) = 31.25\, t^2}$

$\cancel{I_a(t)} = \cancel{\frac{2}{3} I_s(t)} \ast \cancel{\frac{2}{3}} \frac{T_{em}}{K_T} = \frac{2}{3} \cdot \frac{7}{0.75}$

$\Rightarrow I_a(t) =$

$$I_a(t) = \frac{2}{3} I_s(t) \cdot \cos \theta_{is}(t)$$

$$= \frac{2}{3} \times \frac{T_{em}}{K_T} \cdot \cos \theta_{is}(t)$$

$$= \frac{2}{3} \times \frac{7}{0.75} \times \cos(31.25\, t^2)$$

$$\Rightarrow \boxed{I_a(t) = 6.23 \times \cos(31.25\, t^2)}$$

$$\therefore \frac{d}{dt} I_a(t) = 6.23 \cdot \frac{d}{dt} \cos(31.25\, t^2)$$

$$= 6.23\,(-31.25 \times t \times \sin(31.25\, t^2))$$

$$\boxed{\frac{d}{dt} I_a(t) = -389.3 \times t \times \sin(31.25\, t^2)}$$

$$V_a(t) = \left[K_T \cdot \omega(t) \cdot \cos \theta_{is}(t)\right] + \left[I_a(t) \cdot R_a\right] + \left[L_s \cdot \frac{d}{dt} I_a(t)\right]$$

$$= \left[0.75 \times 62.5 \times t \times \cos(31.25\, t^2)\right] + \left[0.25 \times 6.23 \times \cos(31.25\, t^2)\right]$$

$$+ \left[0.025 \times (-389.3) \times t \times \sin(31.25\, t^2)\right]$$

$$V_a(t) = 46.87 \times t \times \cos(31.25\, t^2) + 1.55 \cos(31.25\, t^2)$$

$$- 9.73 \times t \times \sin(31.25\, t^2)$$

Program

```
n=0: 0.01 : 3.35;
t=n.^1;

% program for speed %

w=62.5*t;
figure(1)
plot(t,w)
ylabel('speed W(t)')
xlabel('time (t)')

% program for Angle %

a=31.25*(t.^2);
figure(2)
plot(t,a)
ylabel('angle')
xlabel('time (t)')

% program for Current %

c=6.23*cos(31.25*(t.^2));
figure(3)
plot(t,c)
ylabel('current Ia(t)')
xlabel('time (t)')


% equation for Ea  %

p=46.87*t;
q=cos(31.25*(t.^2));
D=diag(q);
r=p*D;


% equation for Ls * derivative of Ia(t) %

e=-9.73*t;
f=sin(31.25*(t.^2));
G=diag(f);
h=e*G;


% equation for voltage,v %

v=r+h+cos(31.25*(t.^2));
figure(4)
plot(t,v)
xlabel('time (t)')
ylabel('voltage (V)')
```

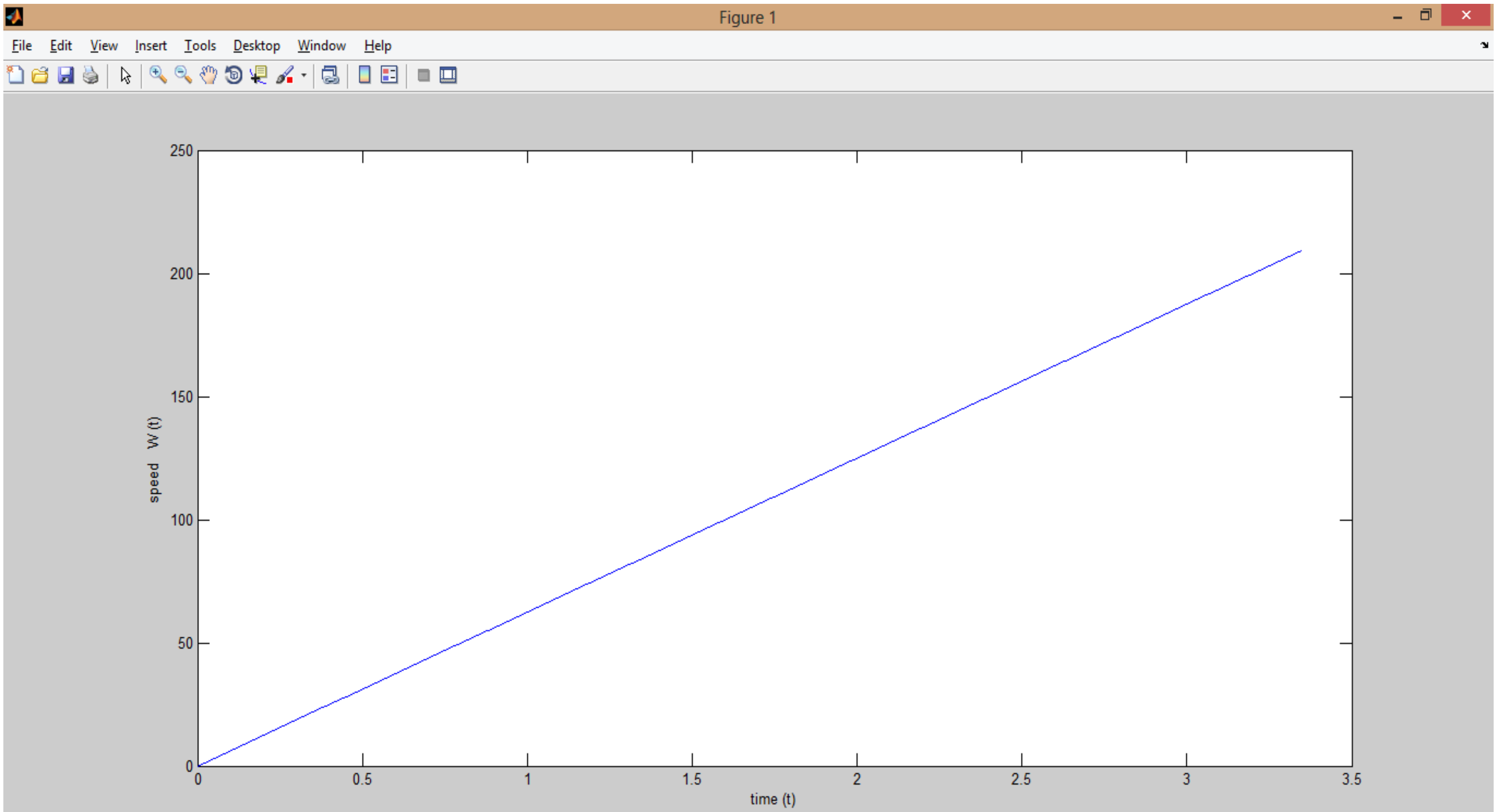


Fig-1: Speed (vs) Time

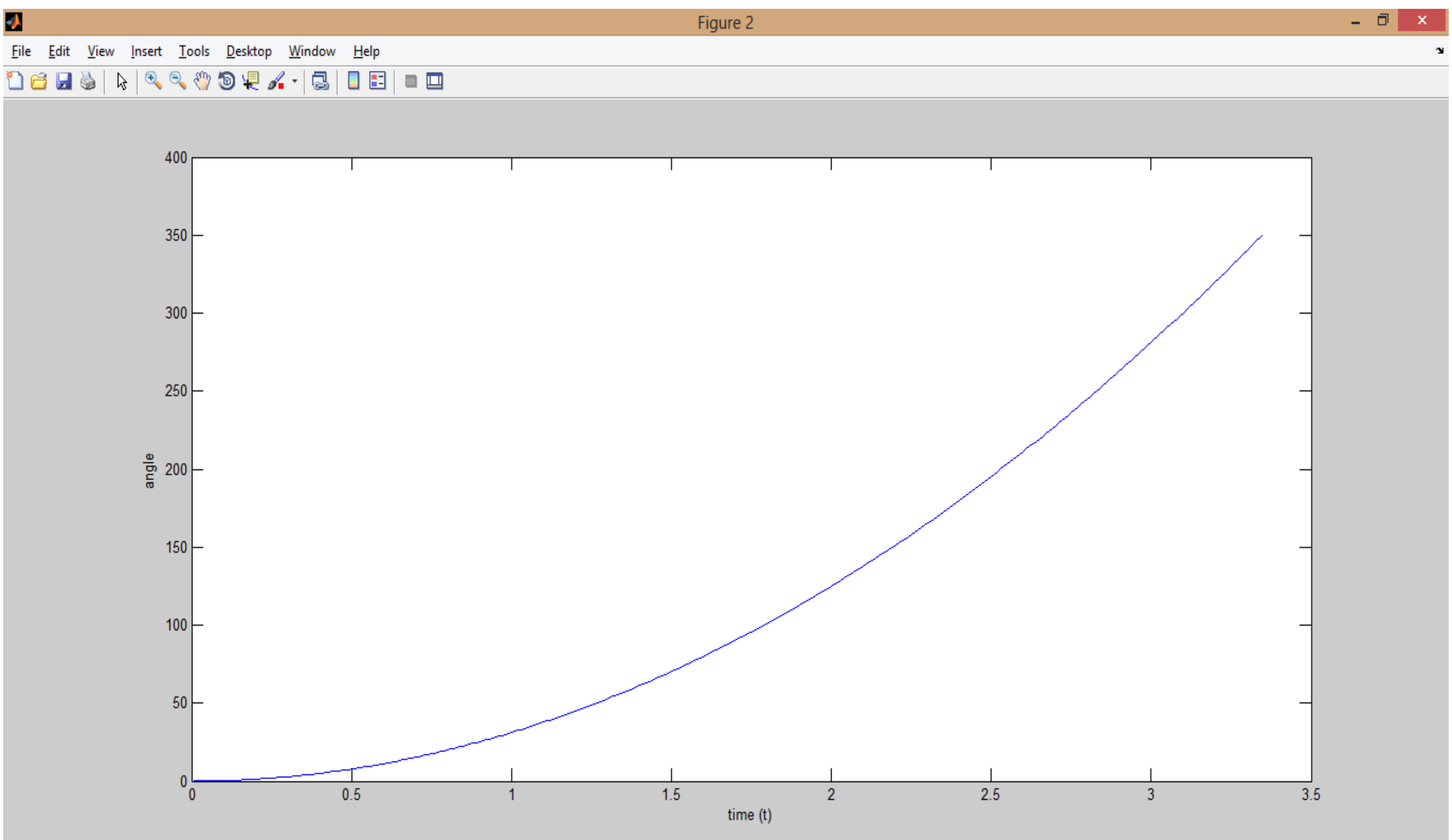


Fig-2: position (vs) Time

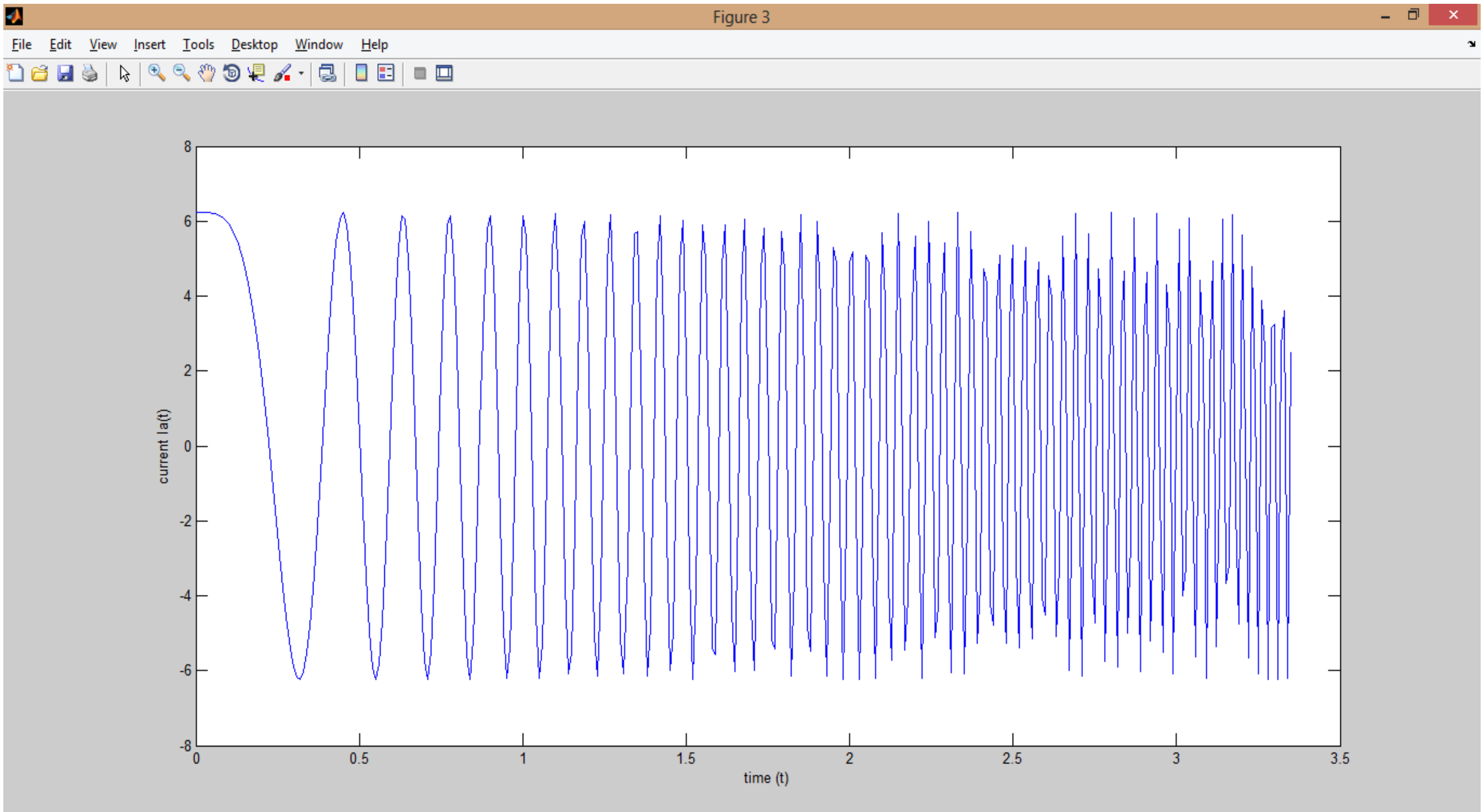


Fig-3: Current (vs) time

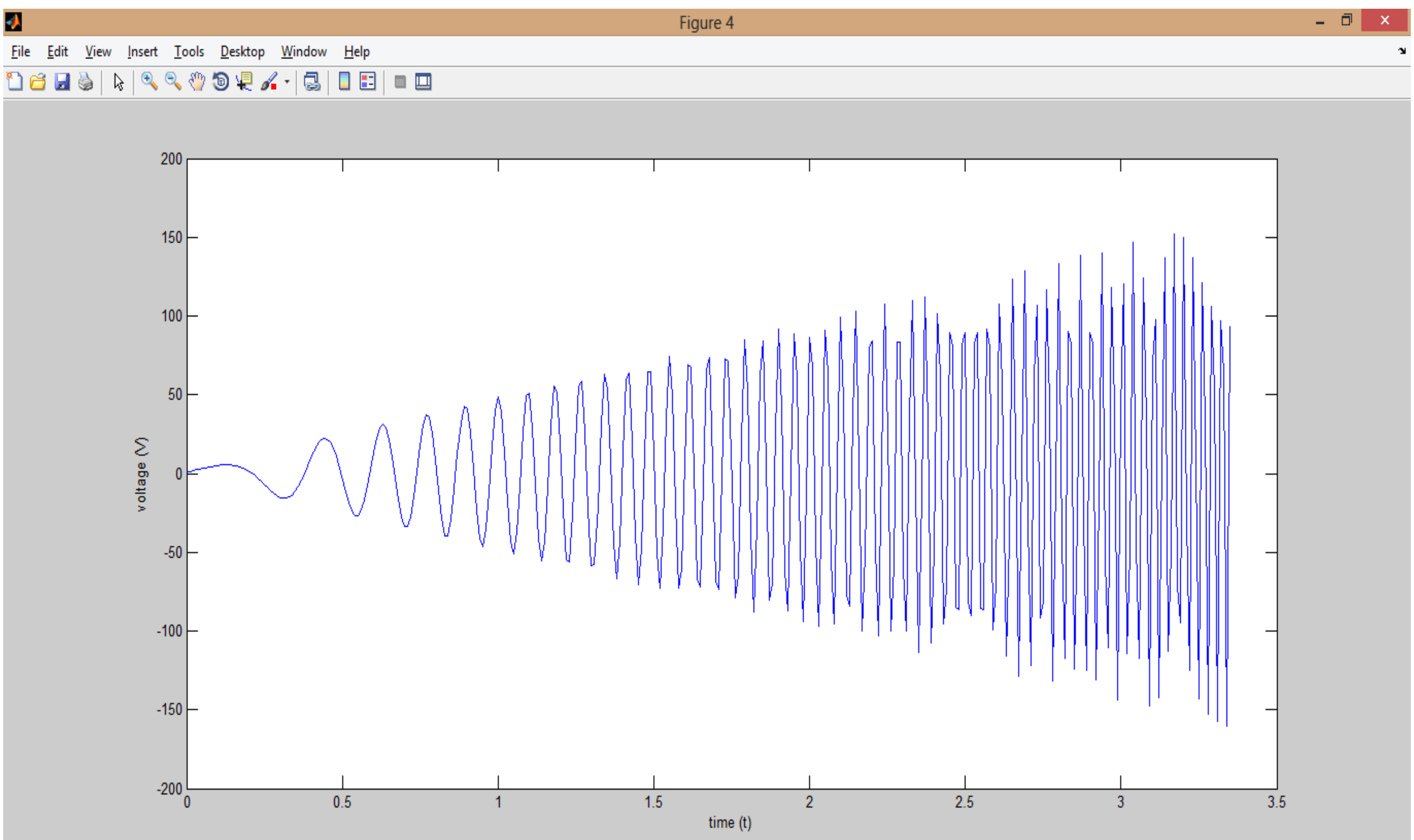


Fig-4: Voltage (vs) time

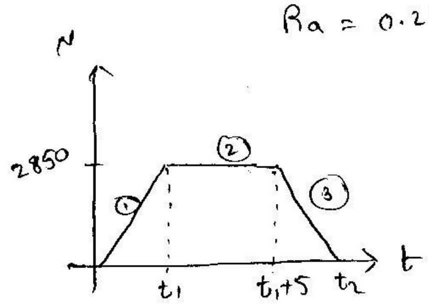
(2) Given, Torque is Proportional to speed.

and $T_L = 3$ N-m when $w = 2850$ rpm

also, $J_L = 0.05$, $J_m = 0.03$ (kgm^2) ; $La = 0$.

$K_t = K_E = 0.35$ (in MKS) units.

$Ra = 0.25\ \Omega$, $Ia = \pm 12.5$ Amps.



$$w = 2850 \times \frac{2\pi}{60} = 298.45 \text{ rad/sec}$$

Case - ① $t = 0$ to t_1

$$\dot{w} = \frac{1}{J_{eq}}\left(K_T \cdot Ia - \frac{T_{L\,max}}{w_{max}} w\right)$$

$$= \frac{1}{0.08}\left(0.35 \times 12.5 - \frac{3}{298.45} w\right)$$

$$\dot{w} = 54.6 - 0.125w$$

applying laplace Transform, we get

$$W(s) - \underset{0}{W(0)} = \frac{54.6}{s} - 0.125(W)$$

$$W(s + 0.125) = \frac{54.6}{s}$$

$$W = \frac{54.6}{s(s+0.125)}$$

Applying partial fractions

$$\frac{54.6}{s(s+0.125)} = \frac{A}{s} + \frac{B}{s+0.125}$$

$$\Rightarrow 54.6 = A(s+0.125) + Bs$$

Put $s = -0.125$

$$\Rightarrow -0.125B + 0 = 54.6$$

$$\Rightarrow \boxed{B = -436.8}$$

Put $s = 0$

$$\Rightarrow 0 + 0.125A = 54.6$$

$$\Rightarrow \boxed{A = 436.8}$$

$$\therefore W = \frac{436.8}{s} - \frac{436.8}{s+0.125}$$

applying inverse laplace T.F, we get.

$$\boxed{\omega(t) = 436.8\left(1 - e^{-0.125t}\right)}$$

$$\omega_{final} = 298.45$$

$$\Rightarrow 298.45 = 436.8\left(1 - e^{-0.125t}\right)$$

$$\Rightarrow 0.6832 = 1 - e^{-0.125t}$$

$$\Rightarrow -0.125t = -1.149$$

$$\Rightarrow \boxed{t = 9.19 \text{ sec}}$$

$\therefore\ V(t) = E_a + I_a R_a$

$$= 0.35 \times 436.8\left(1 - e^{-0.125t}\right) + (12.5 \times 0.25)$$

$$\boxed{V_1(t) = 155.92 - 152.8\, e^{-0.125\, t}}$$

Case (2)

$$V_a = (K_T \cdot \omega_m) + (12.5 \times 0.25)$$

$$= (0.35 \times 298.45) + (12.5 \times 0.25)$$

$$\Rightarrow \boxed{V_a = 107.58}$$

Case (3) $t_1 + 5$ to t_2 and $I_a = -12.5$

$$\dot{\omega} = \frac{1}{0.08}\left(-12.5 \times 0.35 - \frac{3}{298.45}\omega\right)$$

$$\dot{\omega} = -54.6 - 0.125\,\omega$$

applying laplace T.F

$$W \cdot S - \underset{298.45}{W(0)} + 0.125 W = \frac{-54.6}{S}$$

$$W \cdot S - 298.45 + 0.125 W = \frac{-54.6}{S}$$

$$W(S + 0.125) = 298.45 - \frac{54.6}{S}$$

$$\Rightarrow W = \frac{298.45}{S + 0.125} - \frac{54.6}{S(S + 0.125)}$$

$$w = \frac{298.45}{s+0.125} - \frac{436.8}{s} + \frac{436.8}{(s+0.125)}.$$

from previous problem-a.

$$\Rightarrow \boxed{\omega_2(t) = 735.25\, e^{-0.125t} - 436.8}$$

Here ω_m final $= 0$.

$$\Rightarrow \quad e^{-0.125t} = \frac{436.8}{735.25}$$

$$\Rightarrow \quad 0.594 = e^{-0.125t}$$

$$\Rightarrow \quad \boxed{t = 4.16 \text{ sec}}$$

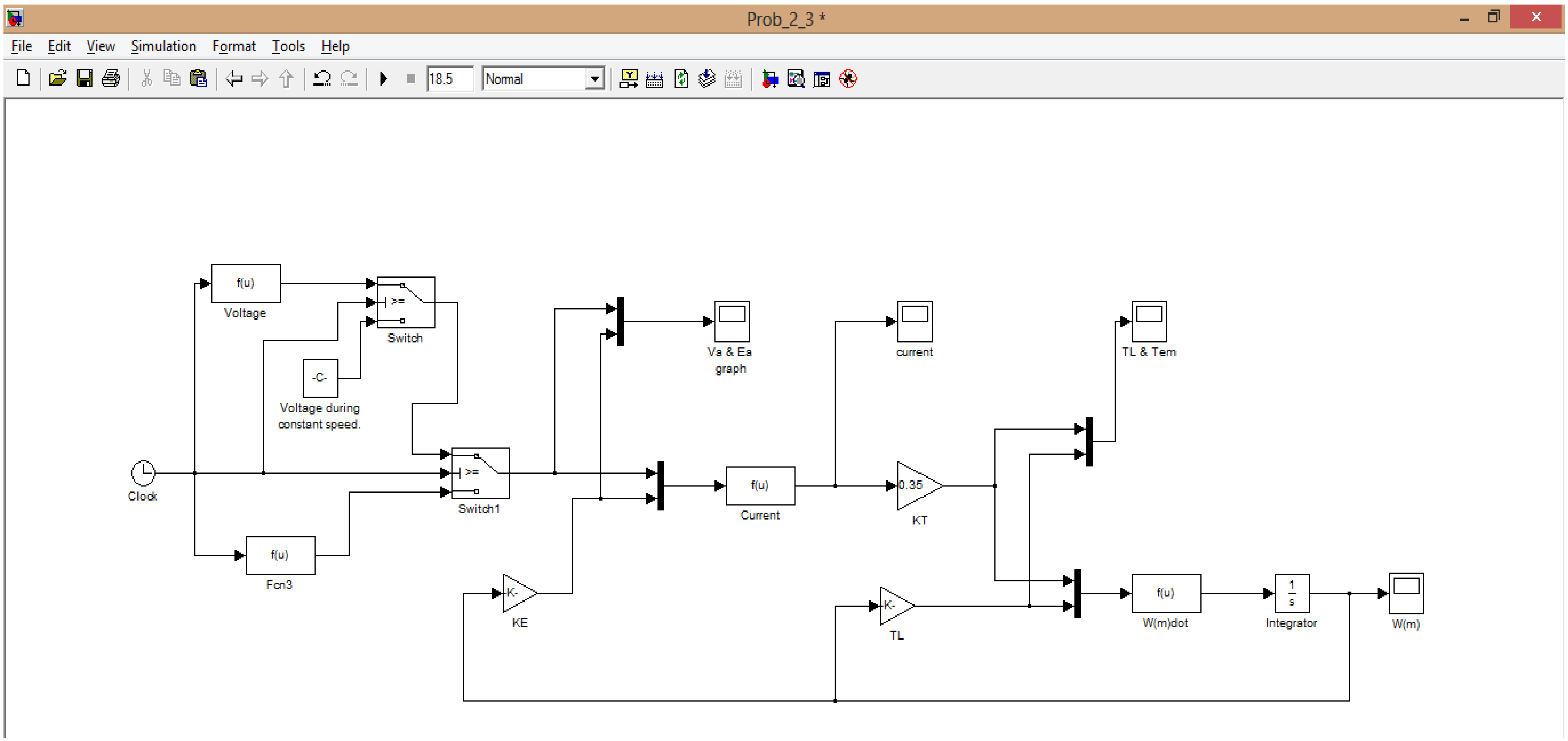
$$\therefore V_2(t) = \left[0.35 \times 735.25 \times e^{-0.125t}\right] - (435.8 \times 0.35) + 3.125$$

$$\therefore \boxed{V_2(t) = 257.3\, e^{-0.125t} - 149.75}$$

When we are plotting the voltage and speed eq we need to shift the time by $(t-14.2)$ sec as the inital time here is 14.2 sec

$$\therefore \boxed{\omega(t) = 735.2\, e^{-0.125(t-14.2)} - 436.8}$$

$$\& \boxed{v(t) = 257.3\, e^{-0.125(t-14.2)} - 149.75}$$



Prob_2_3 *
File Edit View Simulation Format Tools Help
18.5
Normal
f(u)
Voltage
Switch
-C-
Voltage during
constant speed.
Clock
Switch1
f(u)
Fcn3
KE
Va & Ea
graph
f(u)
Current
current
0.35
KT
TL
TL & Tem
f(u)
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1
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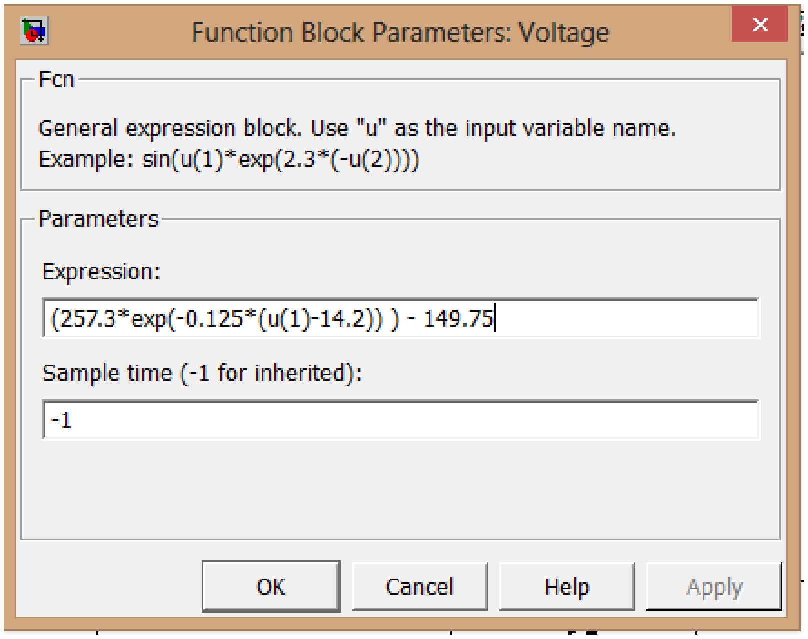
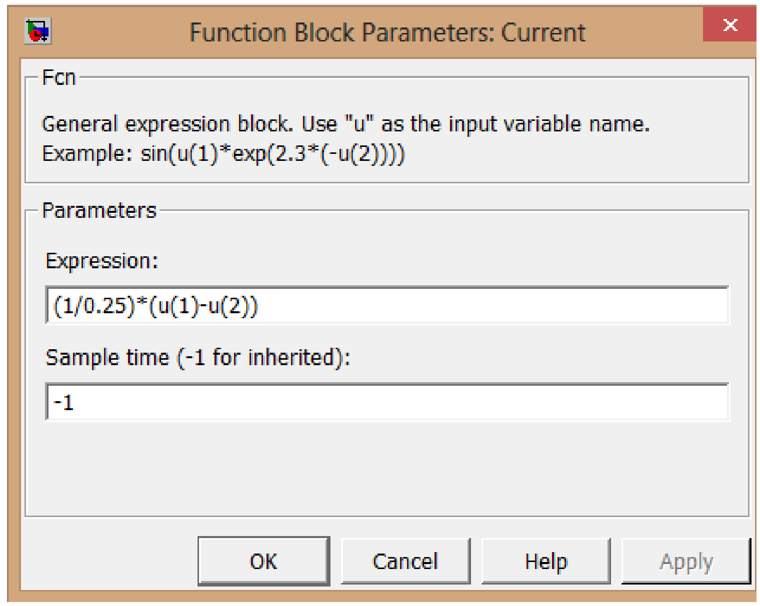
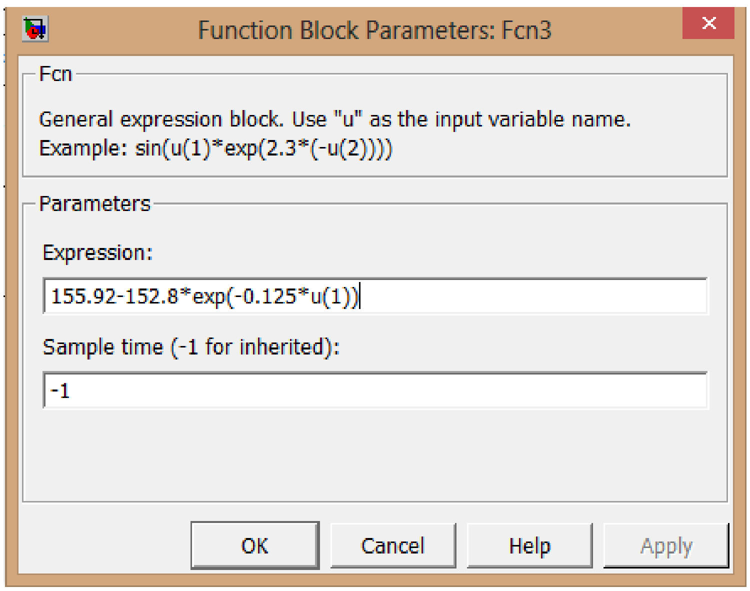
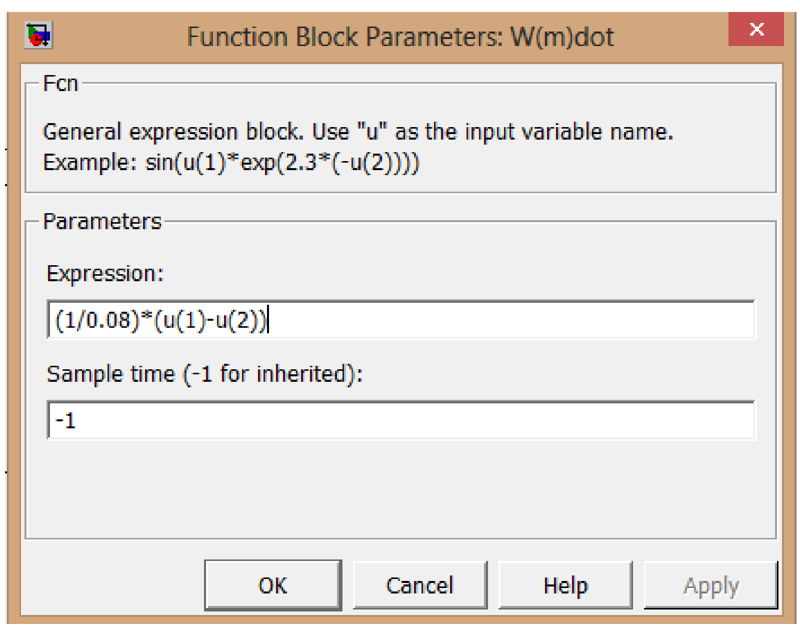
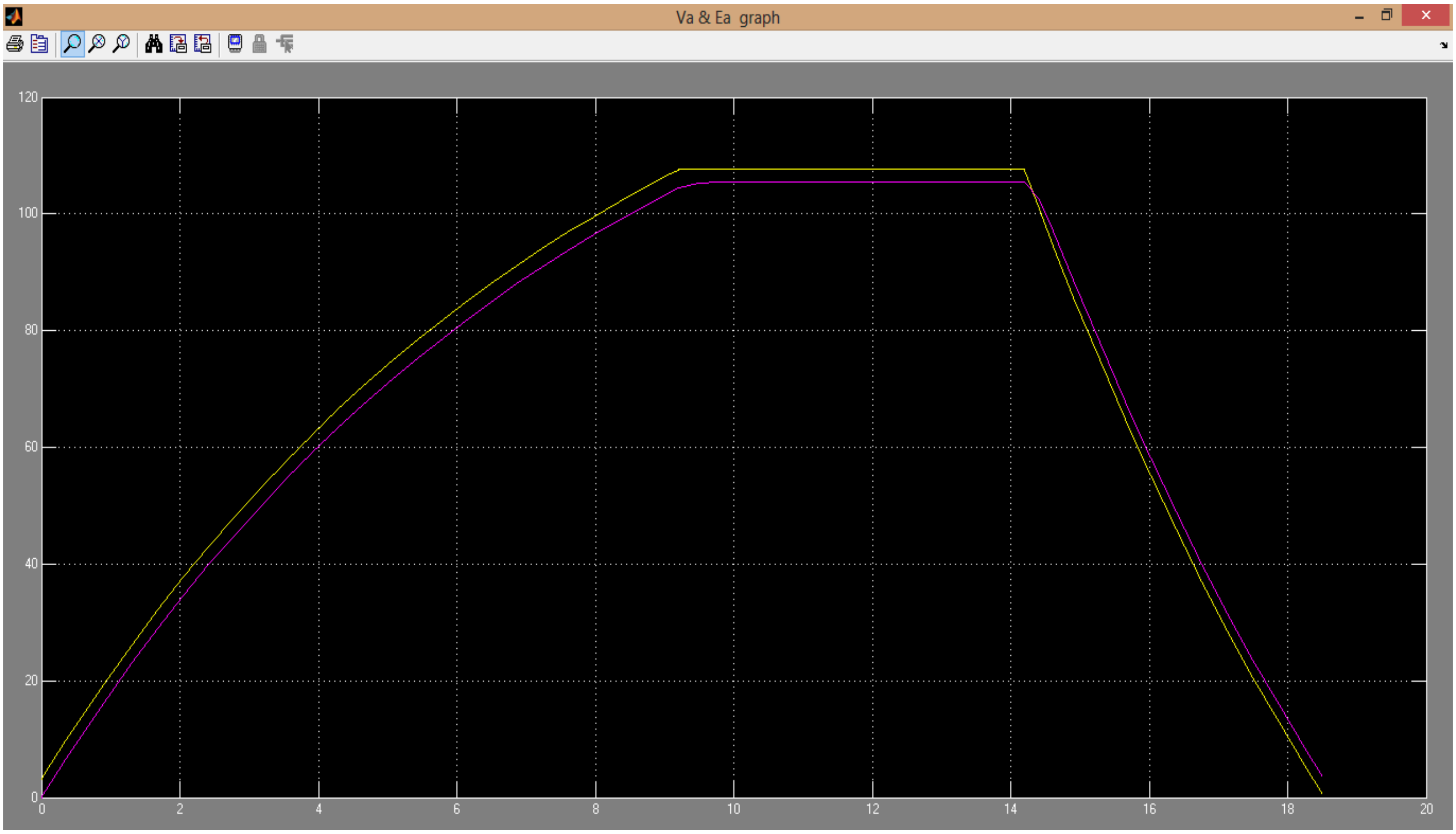
Integrator
W(m)


Function Block Parameters: Voltage
Fcn
General expression block. Use "u" as the input variable name.
Example: sin(u(1)*exp(2.3*(-u(2))))
Parameters
Expression:
(257.3*exp(-0.125*(u(1)-14.2))) - 149.75
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply


Function Block Parameters: Current
Fcn
General expression block. Use "u" as the input variable name.
Example: sin(u(1)*exp(2.3*(-u(2))))
Parameters
Expression:
(1/0.25)*(u(1)-u(2))
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply


Function Block Parameters: Fcn3
Fcn
General expression block. Use "u" as the input variable name.
Example: sin(u(1)*exp(2.3*(-u(2))))
Parameters
Expression:
155.92-152.8*exp(-0.125*u(1))
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply


Function Block Parameters: W(m)dot
Fcn
General expression block. Use "u" as the input variable name.
Example: sin(u(1)*exp(2.3*(-u(2))))
Parameters
Expression:
(1/0.08)*(u(1)-u(2))
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply


Va & Ea graph
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80
60
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0
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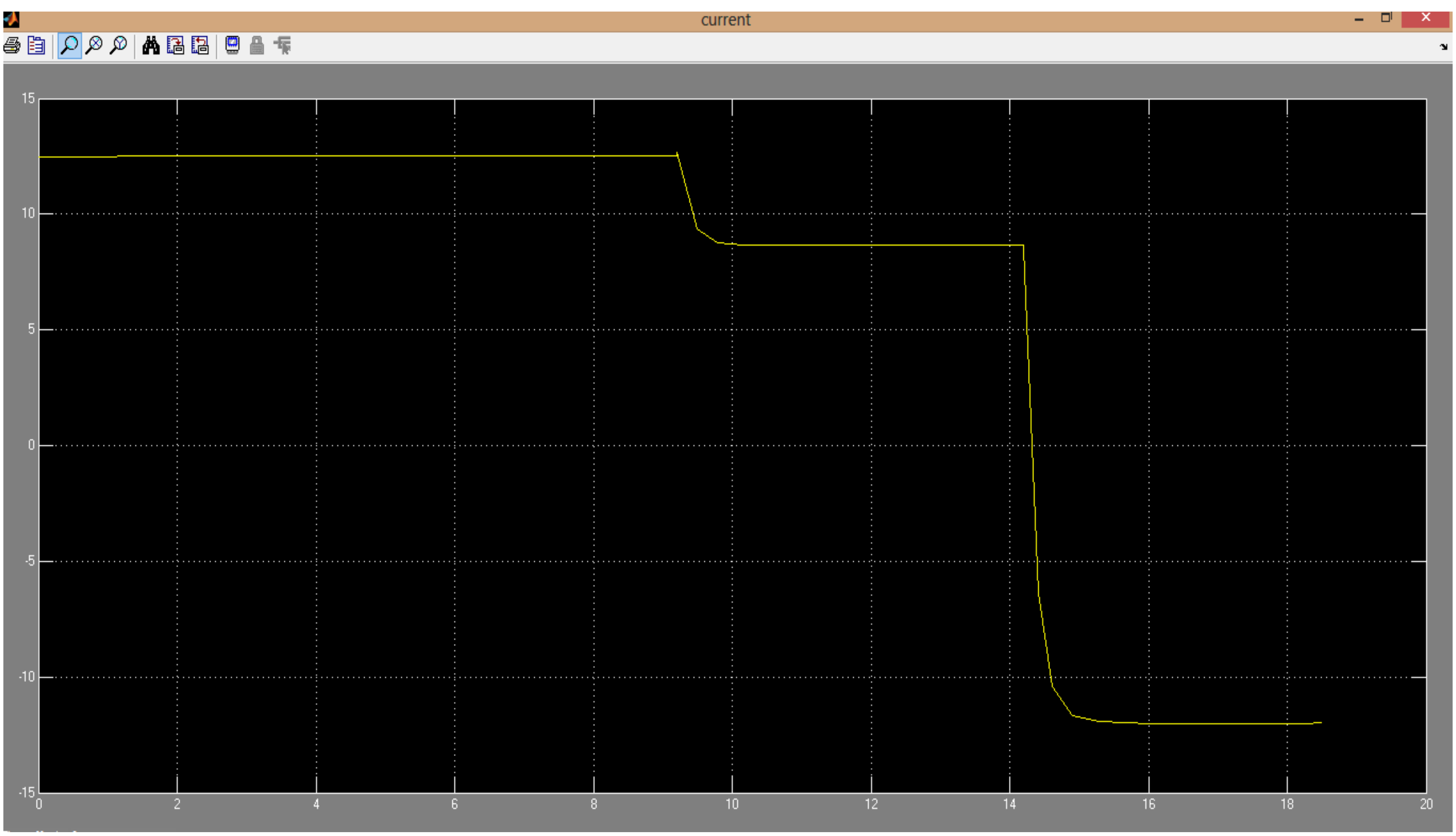
4
6
8
10
12
14
16
18
20


current
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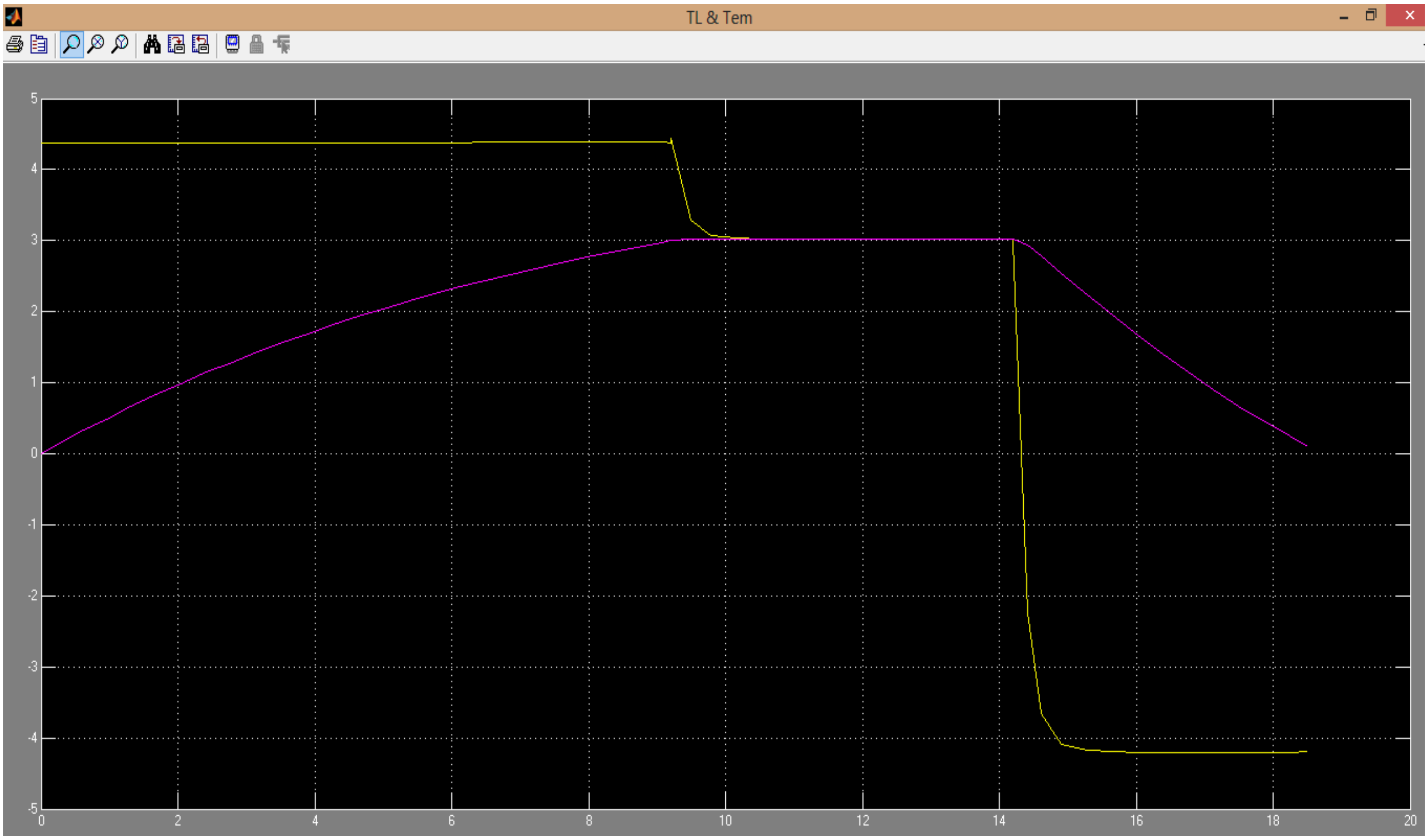

TL & Tem
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
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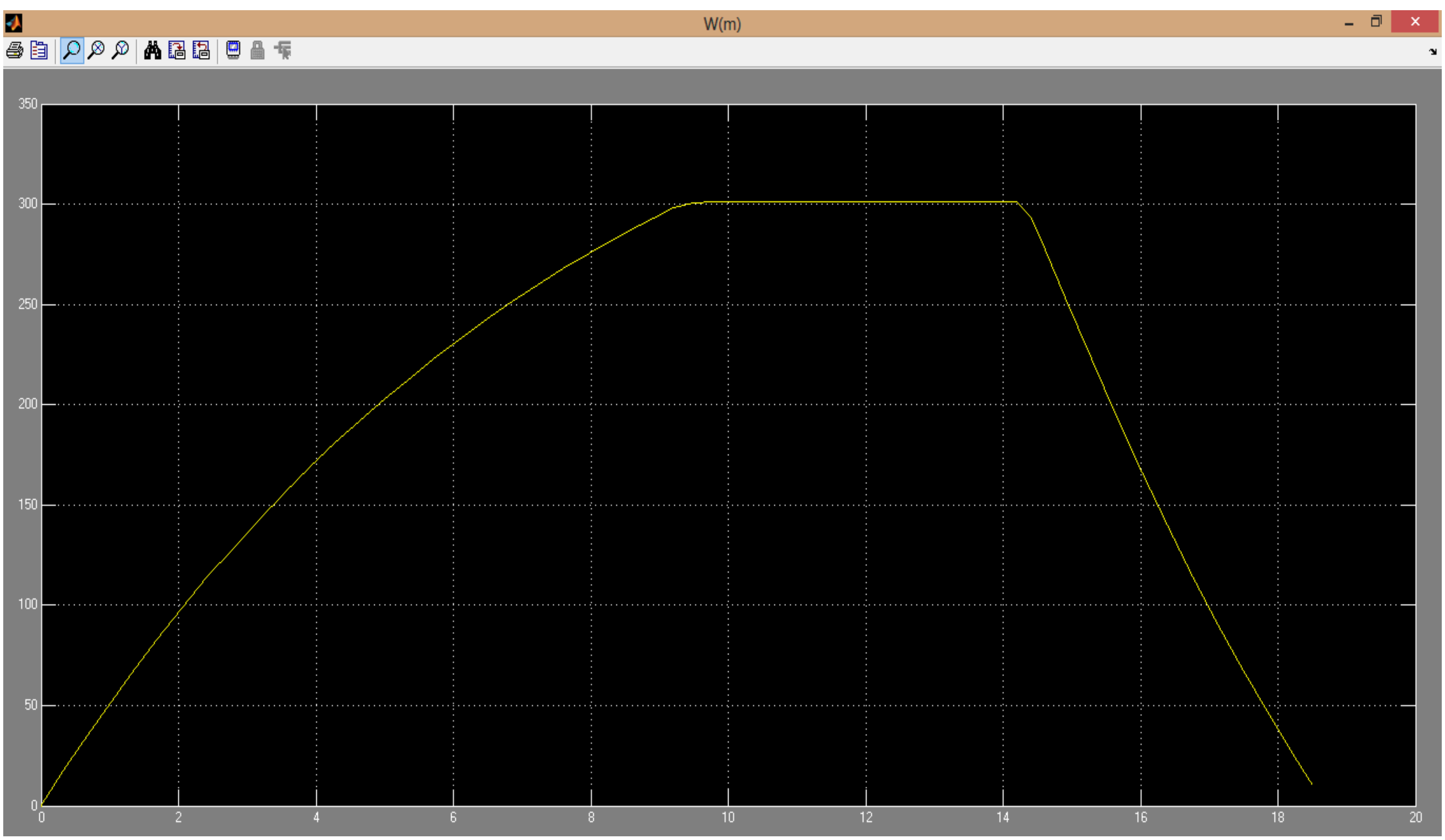
8
10
12
14
16
18
20



W(m)
350
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20