

19AIE 104 -INTRODUCTION TO ELECTRICAL ENGINEERING

Name: Rohith ND (21631)

QUESTIONS:

1. For the circuit containing a battery of voltage $V_b = 10$ volt, a resistor with resistance $R = 5$ ohm and an inductor with inductance $L = 1$ H, plot the voltage across the inductor.

Solution:

$$V_b = 10V; \quad R = 5 \, \Omega; \quad L = 1H; \quad V_L = ?$$

$$V_b = I \cdot R + L \frac{di}{dt} \quad ; \quad V_R(0) = 0$$

$$V_L = L \frac{di}{dt}$$

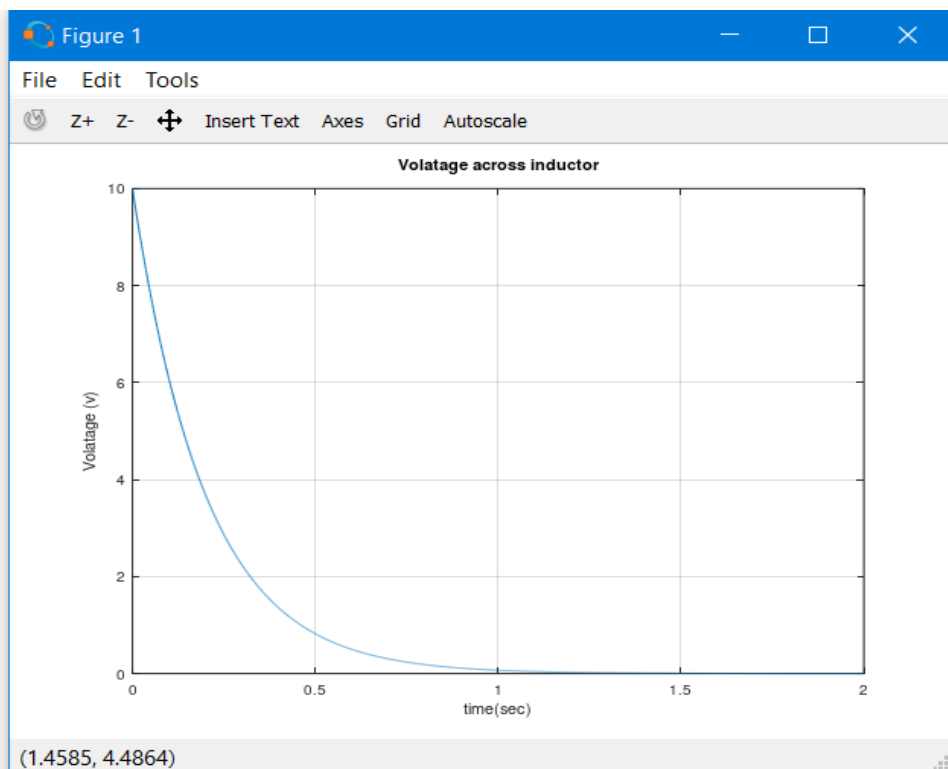
$$V_b = I \cdot R + L \frac{di}{dt} \Rightarrow 10 = 0 + L \frac{di}{dt}$$

$$V_L = L \frac{di}{dt} = 10 \, V$$

Thus the voltage across inductor is 10V at initial (i.e), at $t = 0$.

Matlab:

```
1 clc;
2 clear all;
3 close all;
4
5 R=5;
6 L=1;
7 Vb=10;
8 delt = 0.001;
9 time_constant = L/R;
10
11 T= 10*time_constant;
12 i(1)=0;
13
14 t=0:delt:T;
15
16 A=-R*t/L;
17 for n=1:(length(t)-1)
18 %i(n+1)= i(n)+(delt*((-i(n)*R)+Vb)/L);
19 vl=Vb*exp(A);
20 end
21 plot(t,vl);
22 title('Volatage across inductor');
23 xlabel('time(sec)');
24 ylabel('Volatage (v)');
25 grid('on');
26
27
```



2. Suppose at time $t = 2$ in the previous problem the battery is taken out of the circuit and replaced with a wire. Plot the current for the next 2 seconds.

Solution:

$T = 2$ seconds ; $V_b = 10V$; $R = 5 \Omega$; $L = 1H$;
 $V_L = 10V$

$$I = I_0(1 - e^{\frac{-\tau}{T}})$$

$$\tau = \frac{L}{R} \Rightarrow \frac{1}{5} = 0.2 \text{ s}$$

After battery is removed

$$I = 2 * (1 - e^{\frac{0.2}{2}})$$

$$= 2 * (1 - e^{-0.1})$$

$$= 2 * (1 - \frac{1}{e^{0.1}})$$

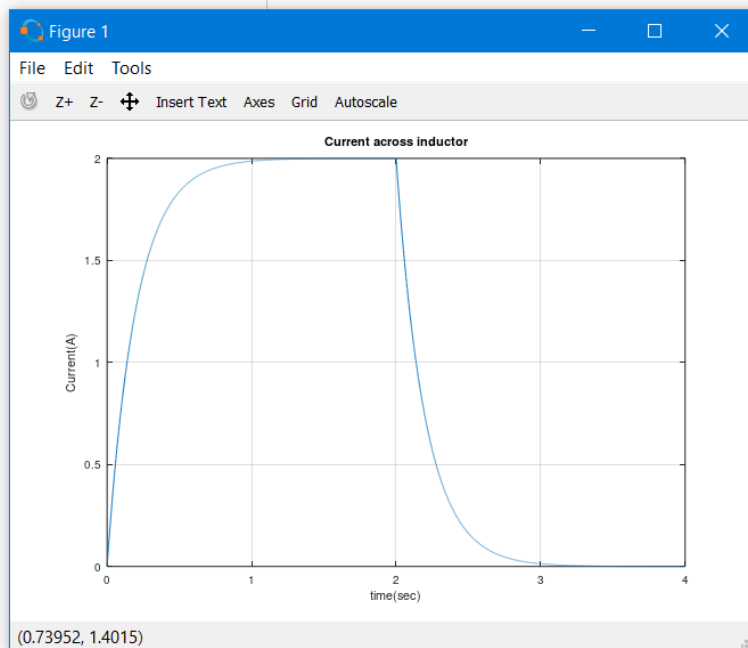
$$= 2 * (1 - 0.904)$$

$$= 2 * 0.096 \Rightarrow 0.192 \text{ A}$$

Thus the current is 0.192A

Matlab:

```
1 clc;
2 clear all;
3 close all;
4 R=5;
5 L=1;
6 Vb=10;
7 delt = 0.001;
8 T=2;
9 t=0:delt:T;
10 t1=t;
11 i(1)=0;
12 for n=1:(length(t)-1)
13 i(n+1)= i(n)+(delt*((-i(n)*R)+Vb)/L));
14 end
15 i1=i;
16 i(1)=i(end-1);
17 Vb=0;
18 T=4;
19 t=2:delt:T;
20 t2=t;
21 for n=1:(length(t)-1)
22 i(n+1)=i(n)+(delt*((-i(n)*R)+Vb)/L));
23 end
24 i2=i;
25 t3=[t1 t2];
26 i3=[i1 i2];
27
28 plot(t3,i3);
29 title('Current across inductor');
30 xlabel('time(sec) ');
31 ylabel('Current (A) ');
32 grid('on');
```



3. For the circuit containing a battery of voltage $V_B = 15$ volts, a resistor with resistance R ohms, and an inductor with inductance $L = 5$ henry, the circuit reaches the steady state at 0.25 seconds.

Determine the resistance R . What is the maximum current in the circuit?

Solution:

$$V_b = 15\text{v}; R = R \Omega; L = 5 \text{ H}; T = 0.25 \text{ s}$$

$$I_{\max} = \frac{V_b}{R}$$

$$5 \tau = 0.25 \text{ [steady state]}$$

$$\tau = 0.05 \text{ s}$$

$$\tau = \frac{L}{R}$$

$$R = \frac{L}{\tau} \Rightarrow \frac{5}{0.05} = 100 \Omega$$

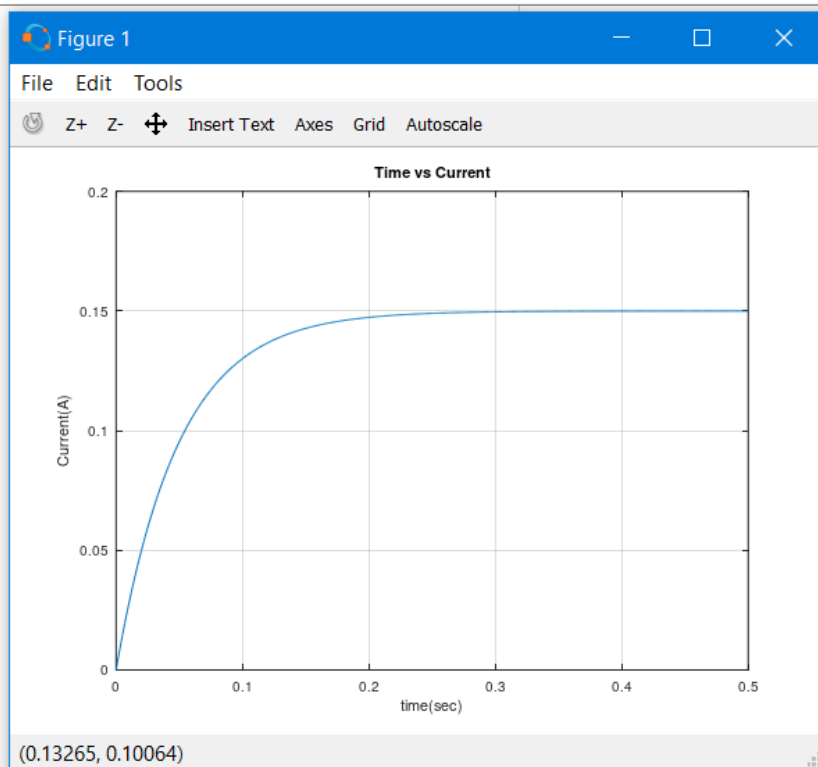
$$I_{\max} = \frac{V_b}{R} \Rightarrow \frac{15}{100}$$

$$I_{\max} = 0.15 \text{ A}$$

The Resistance is 100Ω and the maximum current is 0.15A.

Matlab:

```
1 clc;
2 clear all;
3 close all;
4
5 R=100;
6 L=5;
7 Vb=15;
8 delt = 0.001;
9
10 time_constant = L/R;
11
12 T= 10*time_constant;
13 i(1)=0;
14
15 t=0:delt:T;
16
17 for n=1:(length(t)-1)
18     i(n+1)= i(n)+(delt*((-i(n)*R)+Vb)/L));
19     %vl=Vb-vr;
20 end
21
22 plot(t,i);
23 title('Time vs Current');
24 xlabel('time(sec)');
25 ylabel('Current(A)');
26 grid('on');
27
```



4. For the above circuit (given in Q.No.3), plot the voltage across the resistor and the inductor.

Solution:

$$V_L = L \frac{di}{dt} ; V_b = 15V; L = 5H$$

$$V_R = I * R ; t = 0 s$$

$$V_R = 0.15 * 100 = 5 V$$

$$V_b = V_R + L \frac{di}{dt} \text{ (OR)}$$

$$V_L = V_b * \left(e^{-\frac{Rt}{L}} \right)$$

$$V_L = 15 * \left(e^{-\frac{100*0}{5}} \right)$$

$$V_L = 15 * e^0$$

$$V_L = 15 v$$

Matlab:

(voltage across inductor)

```
clc;
clear all;
close all;

R=100;
L=5;
Vb=15;
delt = 0.001;
time_constant = L/R;

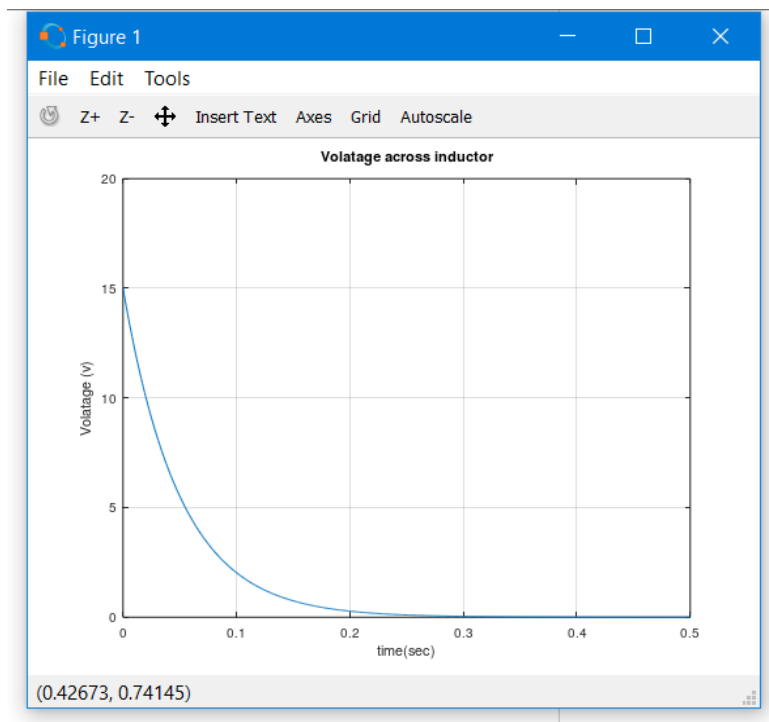
T= 10*time_constant;
i(1)=0;

t=0:delt:T;

A=-R*t/L;

vl=Vb*exp(A) ;

plot(t,vl);
title('Volatage across inductor');
xlabel('time(sec)');
ylabel('Volatage (v)');
grid('on');
```

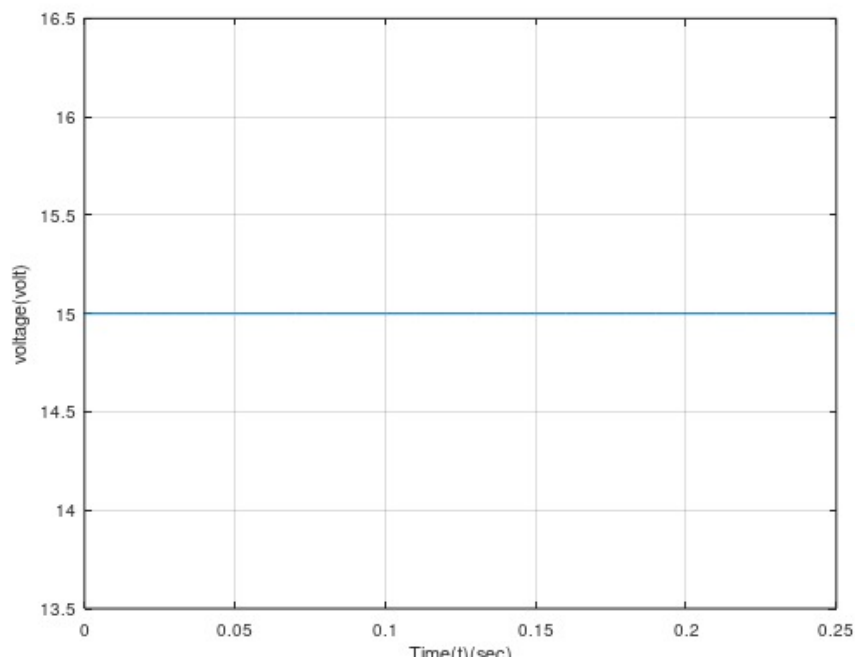


(voltage across resistor)

```
clc;
clear all;
close all;
Vb=15;
R=100;
T=0.25;
i=0.15;
delt=0.01;
L=5;
t=0:delt:T;
for n=1:(length(t)-1)
    i(n+1)=i(n)+(delt*((-i(n)*R)+Vb)/L);
end
VR=i*R;
plot(t,VR);
grid('on');
xlabel('Time(t) (sec)');
ylabel('voltage(volt)');
```

File Edit Tools

🔄 Z+ Z- 🔍 Insert Text Axes Grid Autoscale



5. The steady state of the circuit must be 10 times higher than the steady state obtained in Q.No.3. Determine the resistance R. What's the relation between the resistance and the steady state for the fixed inductance?

Solution:

$5 \tau_3 = \text{steady state (3}^{\text{rd}} \text{ question)}$

$5 \tau_5 = \text{steady state (3}^{\text{th}} \text{ question)}$

$$5 \tau_3 = 0.25 \text{ s}$$

$$10 * 5 \tau_3 = 5 \tau_5$$

$$\tau_5 = \frac{2.5}{5} = 0.5 \text{ s}$$

$$R = \frac{L}{\tau} \Rightarrow R = \frac{5}{0.5}$$

$$R = 10 \Omega$$

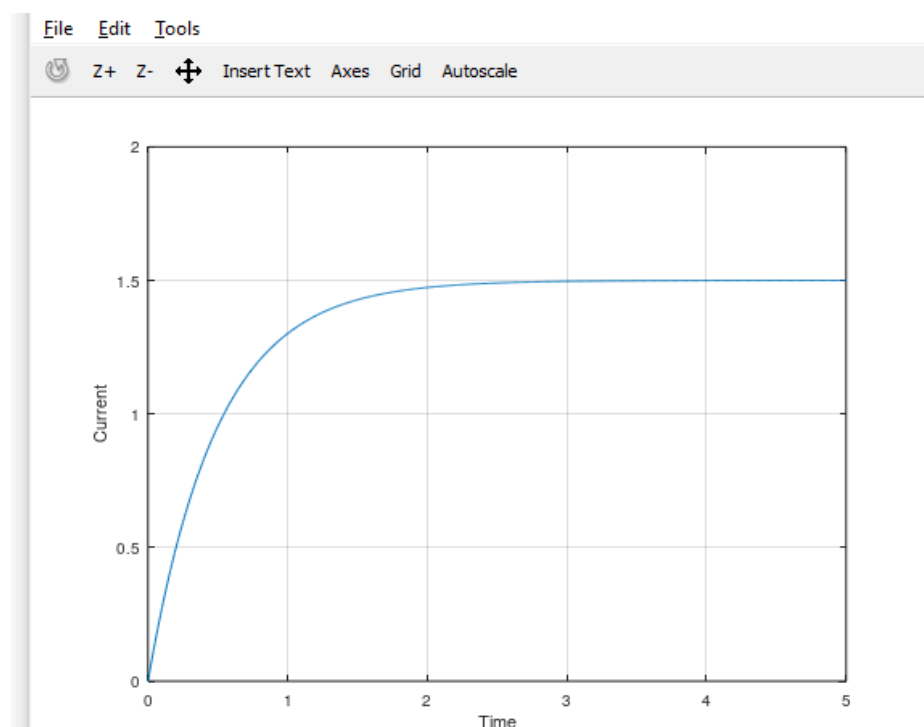
$L = \text{Fixed ; } 5 \tau = \text{steady state}$

$$5 \tau = \frac{L}{R} \Rightarrow 5 \tau \propto \frac{1}{R}$$

Steady state is inversely proportional to resistance

Matlab:

```
O_3.m x
1 clc;
2 clear all;
3 close all;
4
5 Vb=15;
6 R=10;
7 L=5;
8 delt=0.01;
9 time_constant=L/R;
0 T=10*time_constant;
1
2 t=0:delt:T;
3
4 i(1)=0;
5
6 for n=1:(length(t)-1)
7     i(n+1)=i(n)+(delt*((-i(n)*R)+Vb)/L);
8 end
9
0 plot(t,i);
1 grid('on');
2 xlabel('Time');
3 ylabel('Current');
4
5
```



6. What is the maximum current in the circuit designed in Q.No.5. Plot the voltage across the resistor and the inductor.

Solution:

$$V_b = 15\text{V}; R = 10\ \Omega; L = 5\text{ H}; t = 0\text{ s}$$

$$I_{\max} = \frac{V_b}{R}$$

$$R = \frac{L}{\tau} \Rightarrow \frac{5}{0.05} = 100\ \Omega$$

$$I_{\max} = \frac{V_b}{R} \Rightarrow \frac{15}{10}$$

$$I_{\max} = 1.5\text{ A}$$

The maximum current is 0.15A.

$$V_L = V_b * \left(e^{\frac{-Rt}{L}} \right)$$

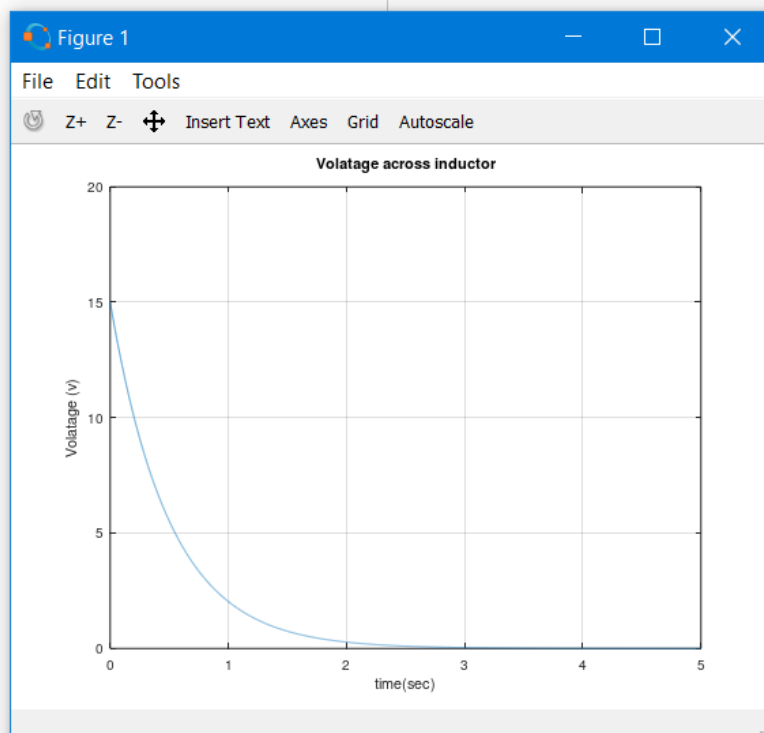
$$V_L = 15 * \left(e^{\frac{-10*0}{5}} \right)$$

$$V_L = 15 * e^0$$

$$V_L = 15\text{ V}$$

Matlab:(Voltage across inductor)

```
1 clc;
2 clear all;
3 close all;
4
5 R=10;
6 L=5;
7 Vb=15;
8 delt = 0.001;
9 time_constant = L/R;
10
11 T= 10*time_constant;
12
13 t=0:delt:T;
14
15 A=-R*t/L;
16 for n=1:(length(t)-1)
17 %i(n+1)= i(n)+(delt*((-i(n)*R)+Vb)/L);
18 vl=Vb*exp(A);
19 end
20
21
22 plot(t,vl);
23 title('Volatage across inductor');
24 xlabel('time(sec)');
25 ylabel('Volatage (v)');
26 grid('on');
27
28
```



(Voltage across resistor)

```
1 clc;
2 clear all;
3 close all;
4
5 R=10;
6 L=5;
7 Vb=15;
8 delt = 0.001;
9 T=2;
10
11 i(1)=0;
12 t=0:delt:T;
13
14 for n=1:(length(t)-1)
15     i(n+1)= i(n)+(delt*((-i(n)*R)+Vb)/L);
16 end
17 Vr= i*R;
18 Vl = Vb - Vr;
19 figure;
20 plot(t,Vl);
21 title('Voltage across resistor');
22 xlabel('time(sec)');
23 ylabel('Voltage(v)');
24 grid('on');
```

