ELEC ENG 2CF3

Assignment 4
Laplace Transform in Circuit Analysis

Areeba Irfan - irfana20 - 400378045

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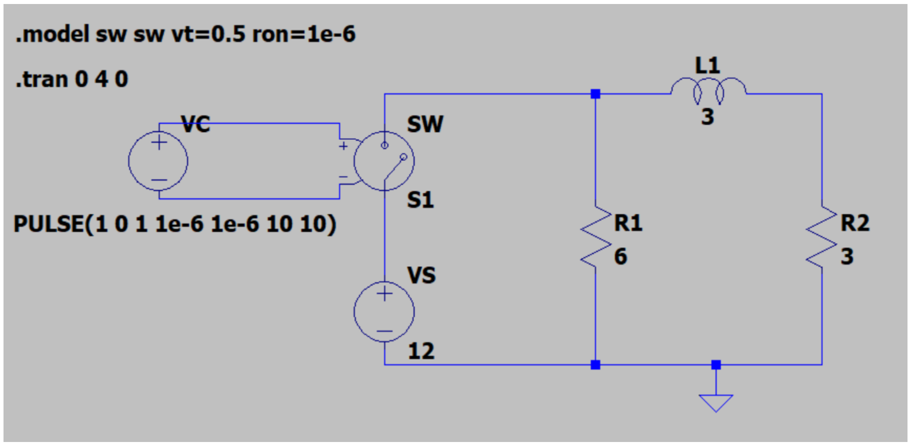
EXERCISE 1: TRANSIENT 1^{ST} DEGREE CIRCUIT

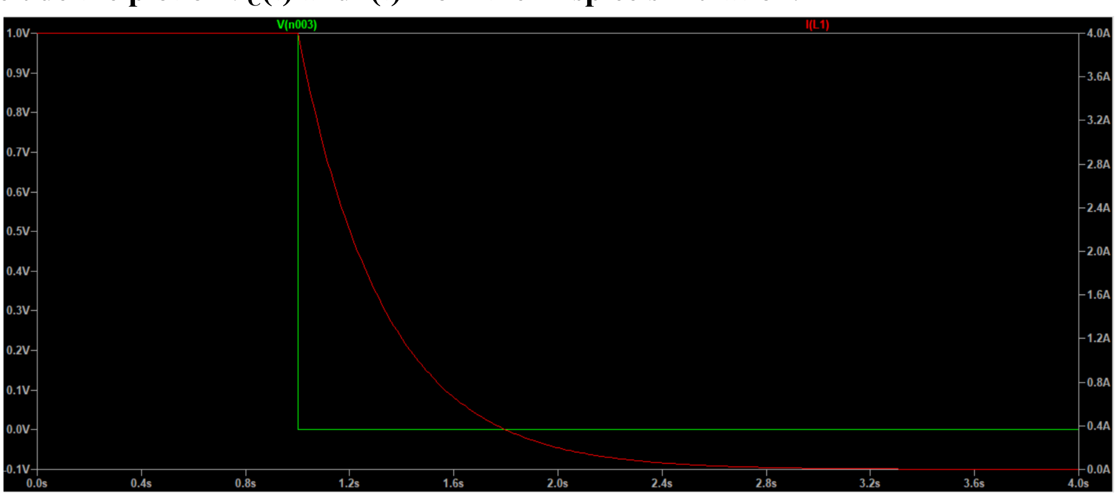
1. Include the complete schematic (screenshot or image export)



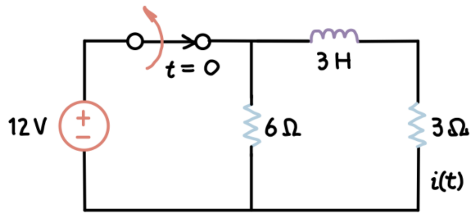
2. Include the complete netlist (View→SPICE Netlist)

```
* C:\Users\Areeba\Desktop\winter 2023\2EI4\Draft2.asc
VC N003 N004 PULSE(1 0 1 1e-6 1e-6 10 10)
S1 N005 N001 N003 N004 SW
VS N005 0 12
R1 N001 0 6
R2 N002 0 3
L1 N001 N002 3
.backanno
.end
```

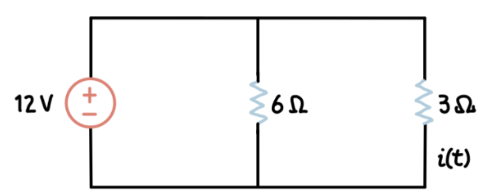
3. Include the plot of $V_C(t)$ and i(t) from the LTspice simulation.



4. Include your analytical solution for i(t) based on the Laplace transform



@ t < 0



determine the transient current through the inductor $i_L(t)$

$i(0^-) = \frac{12V}{3\Omega}$ $\boxed{i(0^-) = 4A}$

$= 4A$

apply KVL $(t > 0)$

$I(s)[3 + 6 + 3s] = 12$

$I(s)[9 + 3s] = 12$

$I(s) = \frac{12}{9 + 3s}$

$= \frac{4}{s + 3}$ $\boxed{I(s) = \frac{4}{s + 3}}$

Laplace Transformation:

$L^{-1}\{I(s)\}$

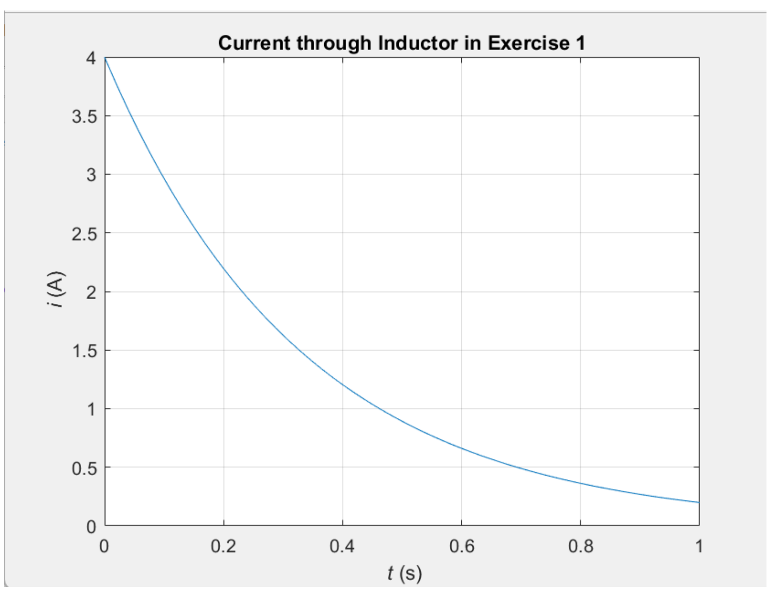
$= L^{-1}\left\{\frac{4}{s+3}\right\}$

$= 4L^{-1}\left\{\frac{1}{s+3}\right\}$

$= 4e^{-3t}$

$\boxed{I(s) = 4e^{-3t}}$

5. Include the MATLAB source code and plot in your PDF report



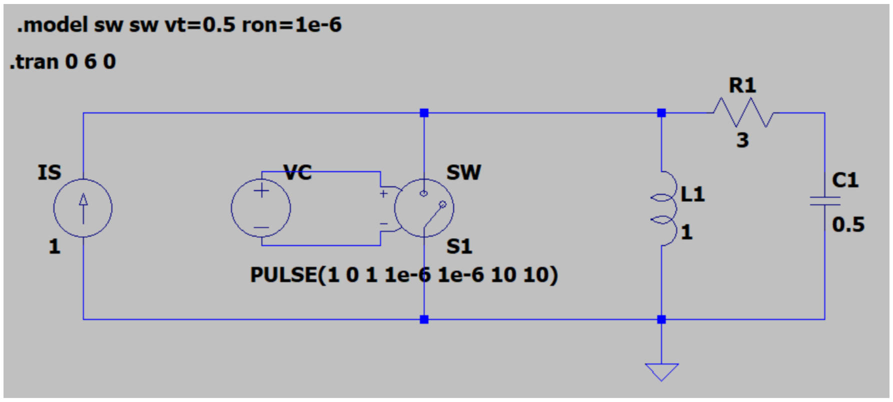
```
>> clear all; close all; % clean up memory and close all open plot windows
t = linspace(0, 1, 1001); % vector of time samples where function is calculated
i = 4*exp(-3*t); % change this to the function i(t) you found from Laplace analysis
figure;
plot(t, i);
grid on;
title('Current through Inductor in Exercise 1');
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
>>
```

6. Does the LTspice simulation result agree with the MATLAB plot of the theoretical result? Justify your answer

The LTspice simulation result agrees with the MATLAB plot of the theoretical result, indicating that the simulation accurately models the behavior of the circuit. When the switch is closed, the inductor acts as a voltage source until it is completely discharged. Both graphs display this as it shows the current going from 4A to 0A over time.

EXERCISE 2: TRANSIENT 2ND DEGREE CIRCUIT

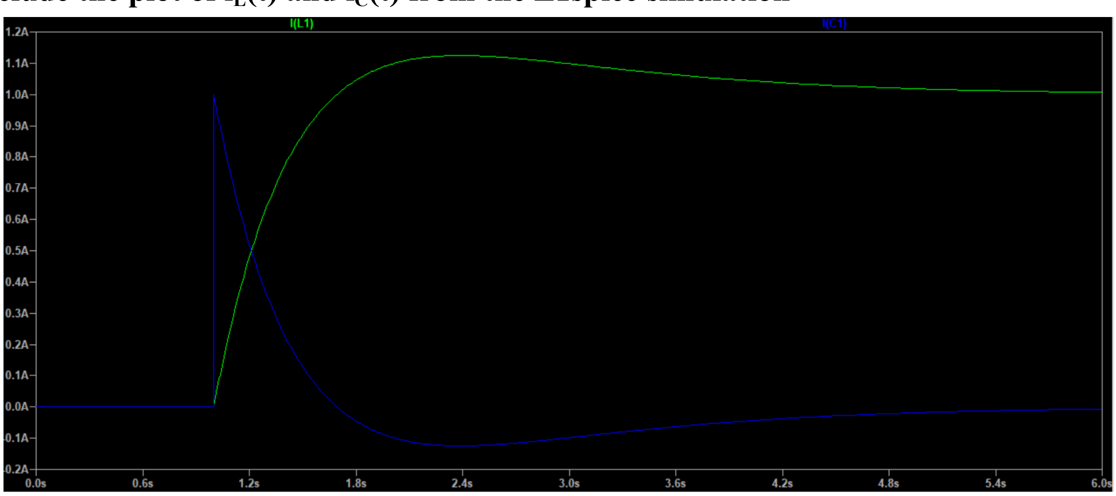
1. Include the complete schematic (screenshot or image export)



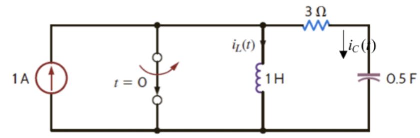
2. Include the complete netlist (View→SPICE Netlist)

```
* C:\Users\Areeba\Desktop\winter 2023\2EI4\Draft3.asc
IS 0 N001 I
VC N003 N004 PULSE(1 0 1 1e-6 1e-6 10 10)
S1 0 N001 N003 N004 SW
L1 0 N001 1
C1 N002 0 0.5
R1 N002 N001 3
.model sw sw vt=0.5 ron=1e-6
.tran 0 6 0
.backanno
.end
```

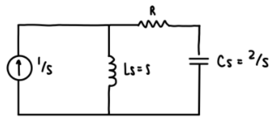
3. Include the plot of $i_L(t)$ and $i_C(t)$ from the LTspice simulation



4. Include your analytical solution for $i_L(t)$ and $i_C(t)$ based on the Laplace transform



$t > 0$



I_L (inductor):

current division:

$$I_L(s) = 1/s \left[\frac{R + 2/s}{s + R + 2/s}\right]$$

$$= 1/s \left[\frac{3 + 2/s}{s + 3 + 2/s}\right]$$

Laplace transformation

$$L^{-1}\{I_L(s)\}$$

$$\rightarrow L^{-}\left\{\frac{3 + 2/s}{s + 3 + 2/s}\right\} = 1 + e^{-t} - 2e^{-2t}$$

I_C (capacitor):

current division:

$$I_C(s) = 1/s \cdot \left[\frac{s}{R + s/2 + s}\right]$$

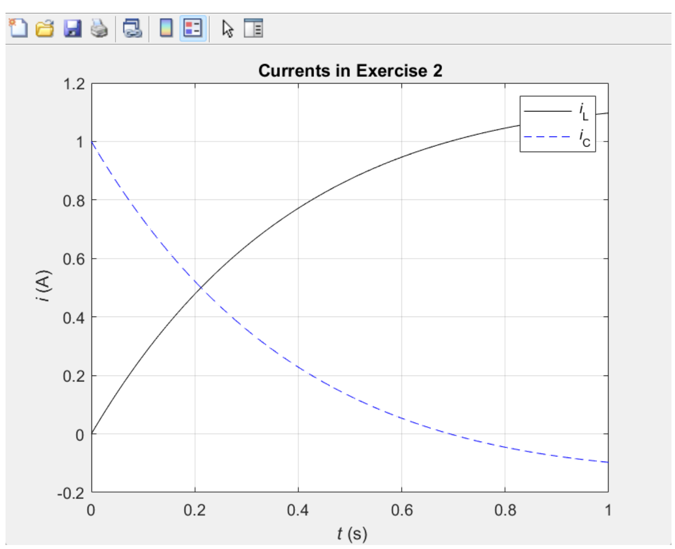
$$= 1/s \cdot \left[\frac{s}{3 + s/2 + s}\right]$$

Laplace transformation

$$L^{-}\{I_C(s)\}$$

$$\rightarrow L^{-}\left\{\frac{s}{3 + s/2 + s}\right\} = -e^{-t} + 2e^{-2t}$$

5. Include the MATLAB source code and plot in your PDF report



```
clear all; close all; % clean up memory and close all open plot windows
t = linspace(0, 1, 1001); % vector of time samples where function is calculated
i = 4*exp(-3*t); % change this to the function i(t) you found from Laplace analysis
figure;
plot(t, i);
grid on;
title('Current through Inductor in Exercise 1');
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
clear all; close all;
t = linspace(0, 1, 1001);
iL = 1+exp(-t)-2*exp(-2*t); % change this to the function iL(t) you found from Laplace
analysis
iC = -exp(-t)+2*exp(-2*t); % change this to the function iC(t) you found from Laplace
analysis
figure;
plot(t, iL,'-k') % plot curve in solid black line
hold on;
plot(t, iC,'--b') % plot curve in dash blue line
hold off;
grid on;
legend('{\it i}_L','{\it i}_C')
title('Currents in Exercise 2')
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
>>
```

6. Does the LTspice simulation result agree with the MATLAB plot of the theoretical result? Justify your answer.

The LTspice simulation result agrees with the MATLAB plot of the theoretical result, indicating that the simulation accurately models the behavior of the circuit. When the switch is closed, the inductor acts as a voltage source until it is completely discharged while the capacitor charges. This can be seen in both graphs as the current in the inductor decreases and the capacitor's increases overtime.