ELECENG 2CF3: Assignment 4

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Exercise #1: Transient 1ST Degree Circuit

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

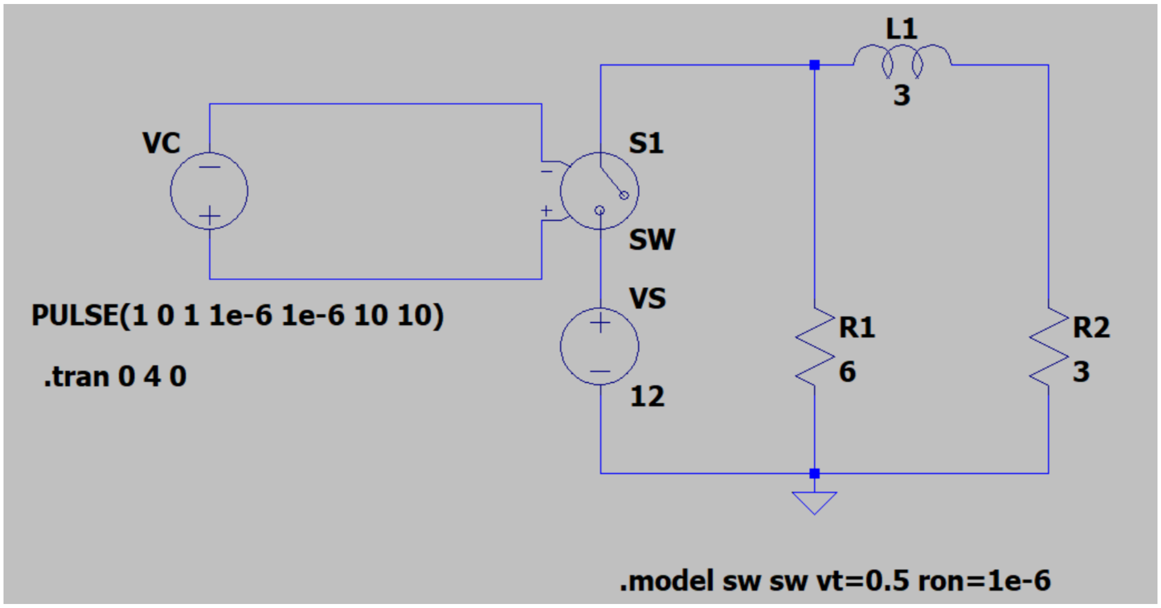


Figure 1: Complete schematic of Transient 1ST Degree Circuit

2. **Include the complete netlist.**

```
* C:\Users\gurle\Downloads\Exercise1.asc
R2 N002 0 3
R1 N001 0 6
L1 N001 N002 3
VS N005 0 12
S1 N001 N005 N004 N003 SW
VC N004 N003 PULSE(1 0 1 1e-6 1e-6 10 10)
.model sw sw vt=0.5 ron=1e-6
.tran 0 4 0
.backanno
.end
```

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

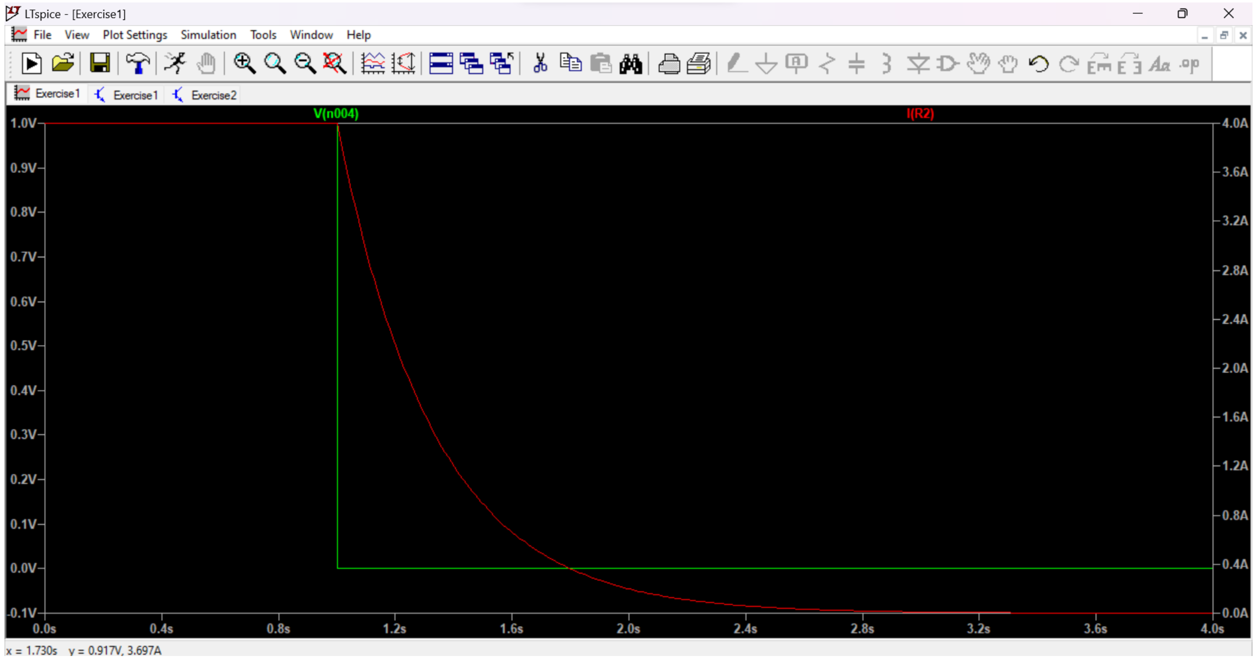
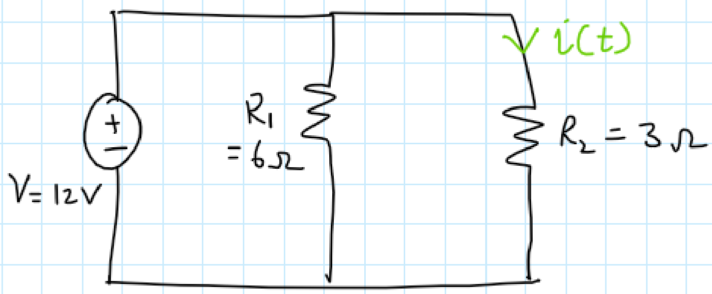


Figure 2: Simulation plots for $V_C(t)$ and $i(t)$

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

$i(0_-) = ?$



$$R_p = \frac{(6\Omega)(3\Omega)}{(6+3)\Omega} = \frac{18}{9} = 2\Omega$$

$$I_T = \frac{12V}{2\Omega} = 6A$$

$$i(0_-) = \frac{6\Omega}{(6+3)\Omega} \times I_T = \frac{6\Omega}{9\Omega}(6)$$

$$= 4A$$

$$\boxed{i(0_-) = 4A}$$

S-domain circuit

$R = 6\Omega + 3\Omega = 9\Omega$

$L = \tilde{V}_L(s) = sL\tilde{I}(s) - Li(0_-) = 3s\tilde{I}(s) - 12$

KVL in the loop

$9\tilde{I}(s) + 3s\tilde{I}(s) - 12 = 0$

$\tilde{I}(s)\left[9 + 3s\right] = 12$

$\tilde{I}(s) = \frac{12}{3(s+3)} = \frac{4}{s+3}$

$\mathcal{L}^{-1}\left(\tilde{I}(s)\right) = 4\mathcal{L}^{-1}\left(\frac{1}{s+3}\right)$

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

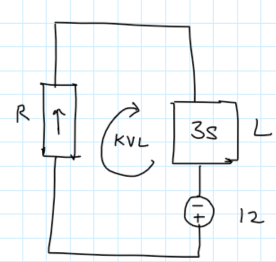


Figure 3: Analytical solution for i(t) based on the Laplace Transform

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

```
clear all; close all;
t = linspace(0, 4, 1001);
i = 4*exp(-3*t);
figure;
plot(t, i);
grid on;
title('Current through Inductor in Exercise 1');
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
```

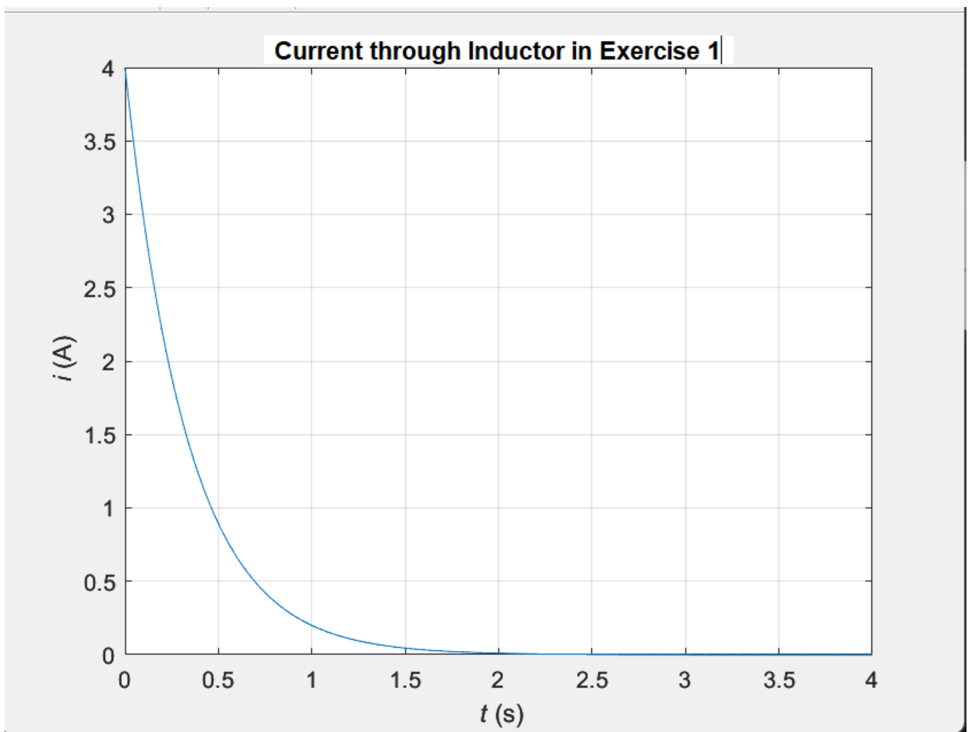


Figure 4: MATLAB plot of the theoretical result

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

Yes, the simulation results agree with the MATLAB plot of the theoretical result. This is proven by the trend of both graphs. They both are decreasing functions starting from 4 A and going to 0 A. This shows that both results agree with each other.

Exercise #2: Transient 2^{ND} Degree Circuit

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

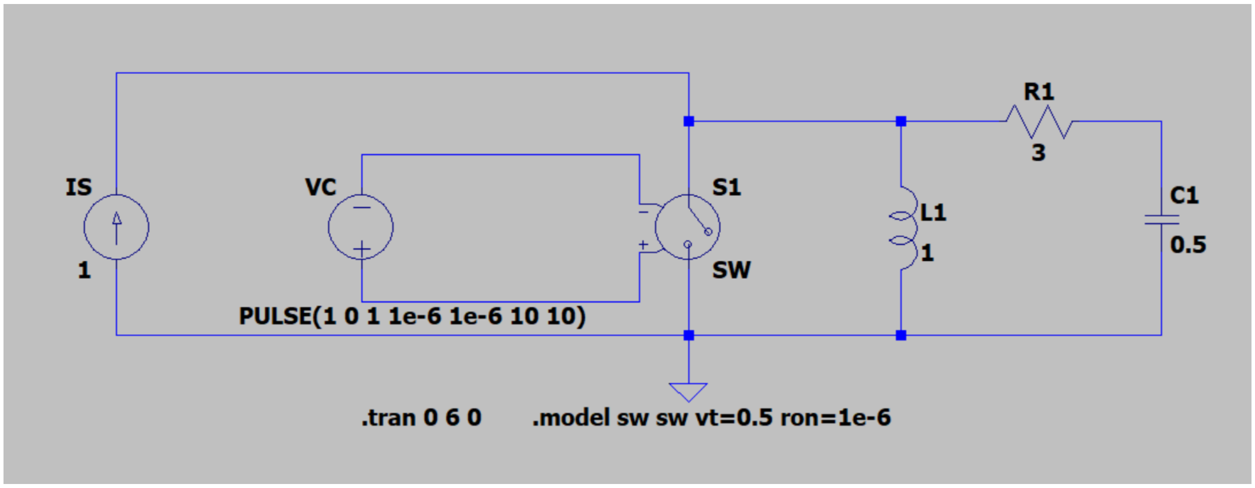


Figure 5: Complete schematic of Transient 2^{ND} Degree Circuit

2. **Include the complete netlist.**

```
* C:\Users\gurle\Downloads\Exercise2.asc
C1 N002 0 0.5
R1 N002 N001 3
L1 N001 0 1
S1 N001 0 N004 N003 SW
IS 0 N001 1
VC N004 N003 PULSE(1 0 1 1e-6 1e-6 10 10)
.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.**

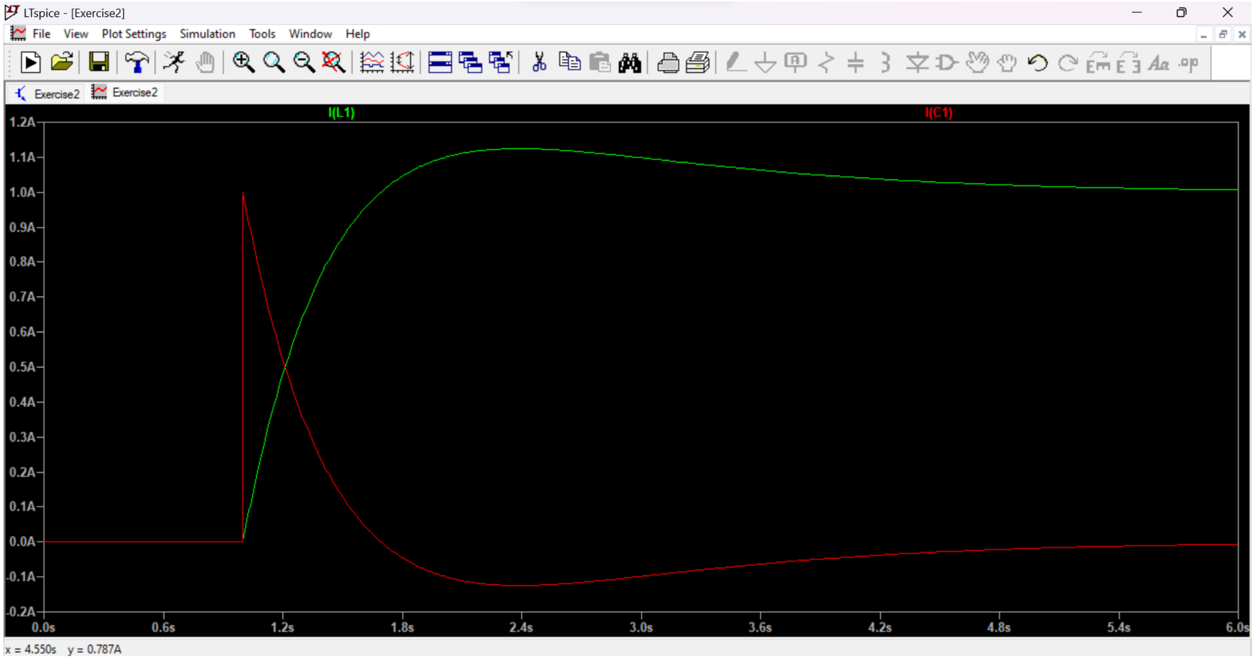


Figure 6: Simulation plots for $i_L(t)$ and $i_C(t)$

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

At $t = 0^-$

$$i_c(0^-) = 1\text{ A} \quad — \text{ (1)}$$

$$i_L(0^-) = 0\text{ A} \quad — \text{ (2)}$$

Add (1) & (2)

$$i_c(0^-) + i_L(0^-) = 1\text{A}$$

$$i_L(t) = 1 - i_c(t) \quad — \text{ (3)}$$

$$\frac{1}{C}\int i_c(t)\,dt - L\frac{di_L(t)}{dt} + R i_c(t) = 0 \quad \text{— (4)}$$

Sub (3) in (4)

$$\frac{1}{C}\int i_c(t)\,dt - L\frac{d}{dt}\left(1 - i_c(t)\right) + R i_c(t) = 0$$

$$\frac{1}{0.5}\int i_c(t)\,dt - \frac{d}{dt}\left(1 - i_c(t)\right) + 3 i_c(t) = 0$$

$$2\mathcal{L}\left[\int i_c(t)\,dt\right] + \mathcal{L}\left[\frac{di_c(t)}{dt}\right] + 3\mathcal{L}\left[i_c(t)\right] = \mathcal{L}[0]$$

$$\frac{2}{s} I_c(s) + s I_c(s) - 1 + 3 I_c(s) = 0$$

$$I_c(s)\left[\frac{2}{s} + s + 3\right] = 1$$

$$I_c(s) = \frac{s}{s^2 + 3s + 2}$$

$$\frac{s}{(s+1)(s+2)} = \frac{k_1}{s+1} + \frac{k_2}{s+2}$$

$$s = k_1(s+2) + k_2(s+1)$$

When $s = -1$ $\quad k_1 = -1$

When $s = -2$ $\quad k_2 = 2$

$$I_c(s) = \frac{-1}{s+1} + \frac{2}{s+2}$$

$$\boxed{i_c(t) = -e^{-t} + 2e^{-2t}}$$

$$i_L(t) = 1 - i_c(t) = 1 - \left[-e^{-t} + 2e^{-2t}\right]$$

$$\boxed{i_L(t) = 1 + e^{-t} - 2e^{-2t}}$$

Figure 7: Analytical solutions for $i_L(t)$ and $i_C(t)$ based on the Laplace Transform

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

```
clear all; close all;
```

```
t = linspace(0, 6, 1001);
iL = 1-2*exp(-2*t)+exp(-t);
iC = 2*exp(-2*t)-exp(-t);
figure;
plot(t, iL,'-k')
hold on;
plot(t, iC,'--b')
hold off;
grid on;
legend('{\it i}_L','{\it i}_C')
title('Currents in Exercise 2')
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
```

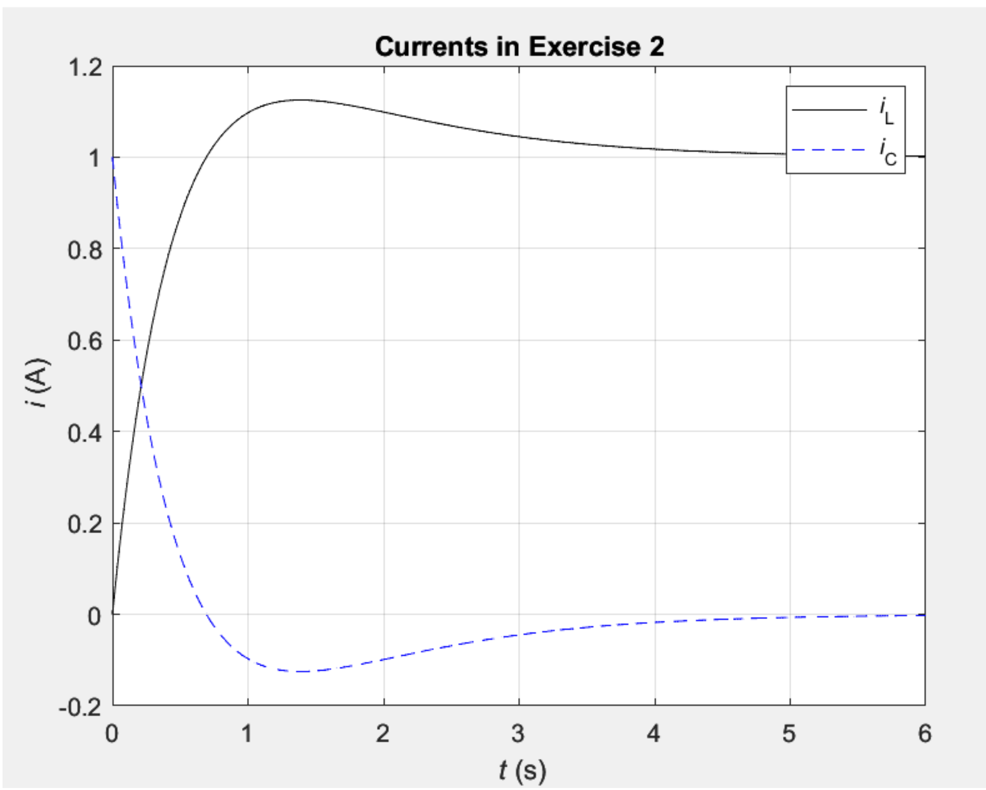


Figure 8: MATLAB plot of the theoretical result

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

   Yes, the results of the LTspice simulation agree with the MATLAB plot of the theoretical result. This could again be seen from the trend of both graphs. In both plots, the current in the inductor experiences a steep rise in the beginning and then it begins to flatten.

Additionally, the capacitor current is a decreasing function in both graphs which again show that both simulation results match each other.