MT240_NR_8_2_1 RLC Circuit

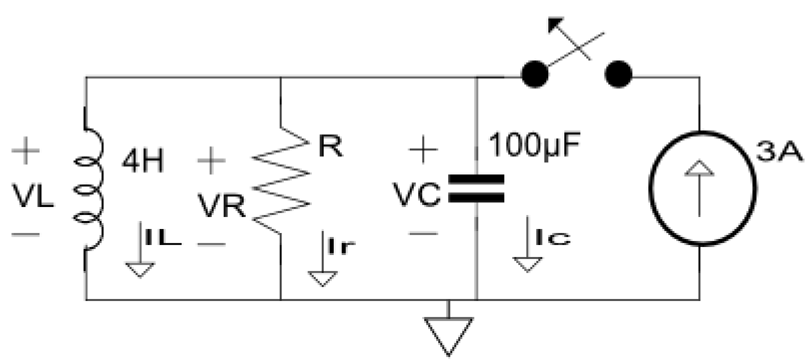
Table of Contents

Title

Last Updated 2/22/2016

Description

```
You have a parallel RLC circuit as shown in the image below.
The current source has a value of 3A, the capacitor 100uF,
the inductor 4H, and a potentiometer (R) can assume values
from 70 Ohms to 1070 Ohms with increments of 200 Ohms.
Assume that the switch has been closed for a long time
before opening it at t = 0s.
```



Exercise

1. Calculate the current through the inductor as a function of time from t = 0s to t = 1s with time steps of 10ms for every resistor value. See the section **Useful Information** for help.

2. Plot the current through the inductor as a function of time for all values of R.

Questions

1. How does resistance affect the current? Why? Hint, think back to the MATLAB assignment mt240_nr_7_2_1_nat_tesp_rc_circuit.

Useful Information

```
For the purposes of this assignment we will work
with the natural response of an over-damped circuit
modeled by
```

$$A_1e^{s_1t} + A_2e^{s_2t}$$

$$\alpha = \frac{1}{2RC}$$

$$\omega_o = \frac{1}{\sqrt{LC}}$$

$$s^2 + \alpha s + \omega_o^2 \; Characteristic\ Equation$$

$$s_1, s_2 = \; roots\ of\ the\ Characteristic\ Equation$$

$$x(0) = A_1 + A_2$$

$$\frac{dx}{dt(0)} = A_1s_1 + A_2s_2$$

Roots

```
MATLAB has a built in command called roots. It
takes in a polynomial and returns the roots of
the polynomial. For example consider the polynomial
```

$$x^2 + 6x + 9 = 0$$

```
To find the roots of the polynomial I would use
the roots command.
```

```
r = roots([1 6 9])
```

```
Note that the most right digit has an order of 0,
the middle digit has an order of 1 and the left
most digit has an order of 2. The command computes
the roots of the polynomial and stores them in r.
```

Finding A1 and A2

```
After using the roots command to find s1 and s2,
we can set up a matrix to solve for A1 and A2.
Don't you just love matrices by now!

We begin by using the two systems of equations stated earlier.
```

$$x(0) = A_1 + A_2$$

$$\frac{dx}{dt(0)} = A_1 s_1 + A_2 s_2$$

```
We can put them systems of equations into matrix form.

Matrix S    Matrix A   Matrix D
```

$$\left[\begin{array}{cc} 1 & 1 \\ s_1 & s_2 \end{array} \right] * \left[\begin{array}{c} A_1 \\ A_2 \end{array} \right] = \left[\begin{array}{c} x(0) \\ \frac{dx}{dt(0)} \end{array} \right]$$

```
Solve for matrix B
```

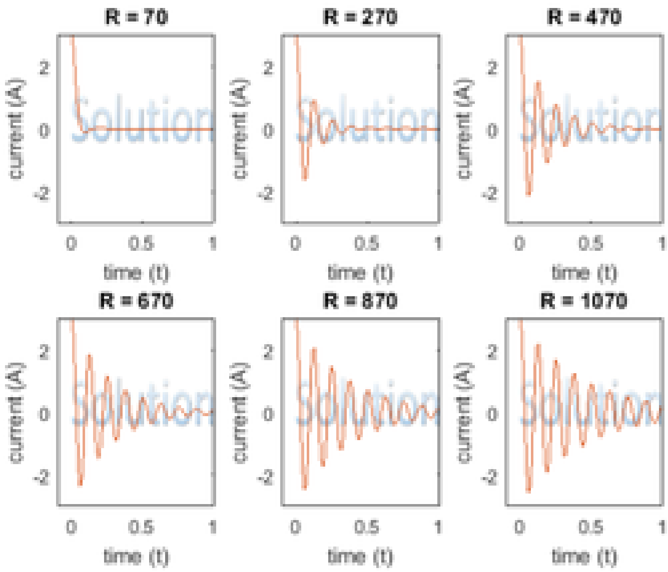
$$\begin{array}{r} SA = D \\ S^{-1}SA = S^{-1}D \\ A = S^{-1}D \\ A_1 = A(1) \\ A_2 = A(2) \end{array}$$

Provided Code

```
% Parameters
C = 100e-6;       % Value of the capacitor, F
L = 4;            % Value of the inductor, H
R = 70:200:1070;  % Resistor values, Ohms
t = 0:.01:1;      % Time array, s

%Initial conditions at t = 0+
VcInit = % INSERT CODE HERE;    % Voltage across the capacitor, V
IcInit = % INSERT CODE HERE;    % Current through the capacitor, A
VrInit = % INSERT CODE HERE;    % Voltage across the resistor, V
IrInit = % INSERT CODE HERE;    % Current through the resistor, A
VlInit = % INSERT CODE HERE;    % Voltage across the inductor, V
IlInit = % INSERT CODE HERE;    % Current through the inductor, A

%Final conditions at t = inf+
VcFinal = % INSERT CODE HERE;   % Voltage across the capacitor
IcFinal = % INSERT CODE HERE;   % Current through the capacitor
```

```
VrFinal = % INSERT CODE HERE;   % Voltage across the resistor
IrFinal = % INSERT CODE HERE;   % Current through the resistor
VlFinal = % INSERT CODE HERE;   % Voltage across the inductor
IlFinal = % INSERT CODE HERE;   % Current through the inductor

% Calculate the derivative
dIdT = VlInit/L;          % The derivative of the
                        % voltage across the capacitor
D = [IlInit;dIdT];        % D matrix

% Calculate coefficients of the characteristic equation
% polynomial
% d^2i/dt + alpha di/dt + omega^2 = 0
% => s^2 + alpha*s + omega^2 = 0
% => a*s^2 + b*s + c = 0
alpha = 1./(2*R*C);
omega = 1/sqrt(L*C);
a = 1;               % s^2 coefficient, has order 2
b = alpha;           % s coefficient, has order 1
c = omega^2;         % last coefficient, has order 0

figure(1);
for m = 1:length(R)       % The for loop goes through all
                        % values of the resistor
r = % INSERT CODE HERE;   % Calculate the roots

S = % INSERT CODE HERE;          % Form the S matrix
Sinv = inv(S);                   % Calculate the inverse of the S
                               % matrix
A = Sinv*D;                    % Calculate the A matrix
A1 = A(1);                       % Grab the coefficients
A2 = A(2);

% Calculate the current through the inductor as
% a function of time.
I = % INSERT CODE HERE;

% Plot the current
subplot(2, 3, m);

plot(t,I);
title(['R = ', int2str(R(m))]);
xlabel('time (t)');
ylabel('current (A)');
axis([-.1 1 -3 3]);
end
```

solution



Published with MATLAB® R2015a