MT240_9_9_1 Mesh_Current Method

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Title

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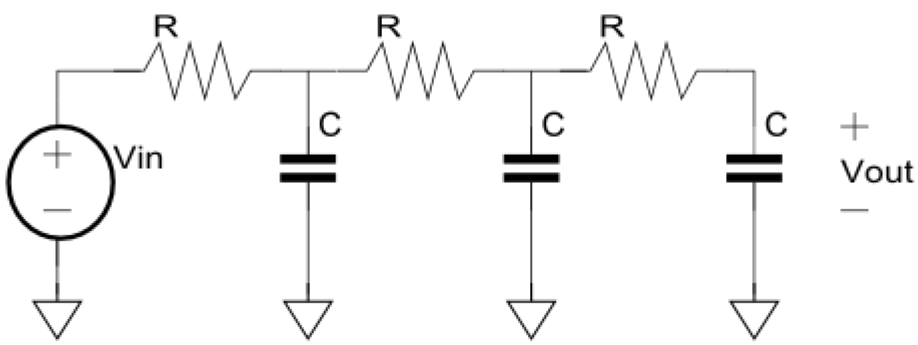
Description

Oscillators can be constructed from op-amps and an RC network. The basic theory is to create a 180 degree phase shift between Vin and Vout. This will cause the op-amp to continuously oscillate in attempt to make both inputs the same voltage level.

Refer to the provided image for this problem.

You want to design a circuit that will oscillate at 40e3 Hz. You only have one resistor value (R = 1e3 ohms), but you have the various capacitors available (C = 1e-9:1e-10:20e-9). You decide to write a program to calculate the angle of Vout in reference to Vin as a function of Capacitance. To simplify calculations, you decide that every capacitor must have the same value. Also, since you are only interested in the phase shift of Vout, assume Vin to have a value of 1 AC



Exercise

1. Label the currents in each small mesh from left to right ia, ib, and ic.

2. Use mesh current method to write a system of equations.

3. Put the systems of equations into matrix form.
4. Solve for ic for every capacitor value. Remember that all three capacitors will have the same value. This means that you should have 191 different values of ic.
5. Calculate Vout for every value of ic.
6. Calculate the phase shift of Vout in Reference to Vin.
7. Plot the phase shift as a function of capacitance using the unwrap command to plot continuous phase.

Questions

1. Approximate the capacitor value that would create a phase shift of 180 degrees.

Useful Information

Warning

Up till now, most of the code and information has been given to you in the MATLAB assignments. Future assignments will require more effort on your part to make sure that you are understanding the MATLAB concepts being demonstrated in these assignments.

System of Equations

```
Your system of equations is provided to you.
```

$$\begin{array}{ccccccc} Vin & = & ia(ZC+R) & + & ib(-ZC) & + & ic(0) \\ 0 & = & ia(-ZC) & + & ib(2*ZC+R) & + & ic(-ZC) \\ 0 & = & ia(0) & + & ib(-ZC) & + & ic(2*ZC+R) \end{array}$$

System of Equations into Matrix Form

```
Your matrices should have the following form. It has been left to you as
an exercise to fill in the matrices using the provided system of
equations.

*Impedances*        *Currents*     *A*
```

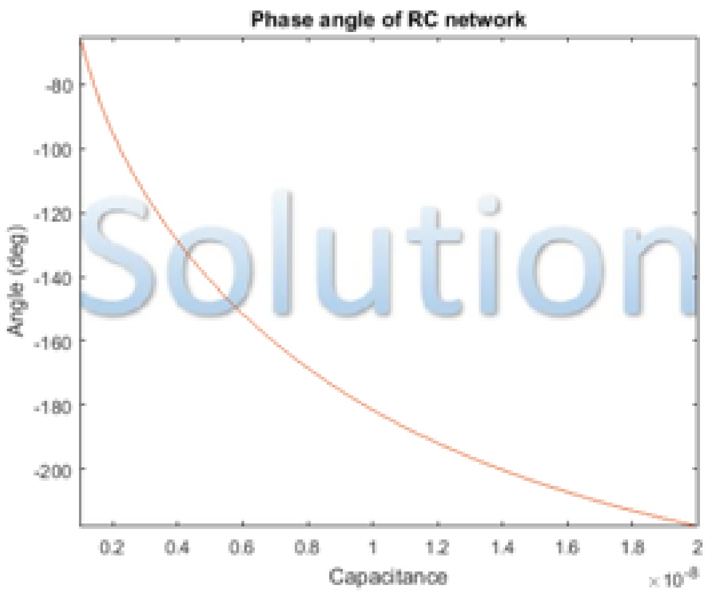
$$\begin{bmatrix} (\ldots) & (\ldots) & (\ldots) \\ (\ldots) & (\ldots) & (\ldots) \\ (\ldots) & (\ldots) & (\ldots) \end{bmatrix} * \begin{bmatrix} ia \\ ib \\ ic \end{bmatrix} = \begin{bmatrix} Vin \\ 0 \\ 0 \end{bmatrix}$$

Provided Code

```
% Parameters
C = 1e-9:1e-10:20e-9;          % Available capacitor values, F
R = 1e3;                       % Resistor, Ohms
w = 2*pi*40e3;                 % Desired operating frequency, rad/s
ZC = 1./(1j*w*C);              % Capacitor impedances, Ohms
Vin = 1;                       % Input voltage, V
ic = zeros(1,length(ZC));      % Allocate space for the array Ic.
```

```
                             % This array will hold the calculated
                             % Ic current values, A

% The matrices have the following form

%                                 Matrices
%                 Impedances                          Currents     A
% | (ZC + R)       (-ZC)              0          |    | ia |    | Vin |
% |  (-ZC)     (ZC + ZC +R)         (-ZC)        | *  | ib | = |  0  |
% |    0           (-ZC)        (ZC +ZC +R)      |    | ic |    |  0  |

A = [Vin;0;0];             % A matrix

% For loop to iterate through every value of C
% Solve for Currents: ia, ib, ic
% Current ic is stored into the array ic
for m = 1:length(ZC)
% Impedance matrix
Impedances = [% INSERT CODE HERE];

Currents = % INSERT CODE HERE;  % Solve for current matrix
ic(m) = Currents(3);      % Store calculated ic into the array ic
end

Vout = % INSERT CODE HERE;            % Calculate Vout. Vout = ic*ZC

Theta = unwrap(angle(Vout))*180/pi;   % Calculate Angle, degrees

% plot
figure(1);
plot(C,Theta);
xlabel('Capacitance');
ylabel('Angle (deg)');
title('Phase angle of RC network');
```

Solution



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