MT240_NR_7_2_1 Natural Response of RC Circuit

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Title

Last Updated: 2/22/2016

Description

In an RC circuit, the resistor controls the rate at which a capacitor charges or discharges. The larger the resistor, the harder it is to push current through the circuit, and the longer it takes for a capacitor to charge or discharge. In this assignment you will study the affect resistance has on the rate that the capacitor discharges.

You have several 20mF capacitors with an initial voltage of 20V. You design circuits composing of one capacitor and one resistor. Every resistor has a different value, and the resistor values ranges from 1k Ohm to 10k Ohms with a step size of 1k Ohm.

The resistor and capacitor are connected together at t = 0.

Exercise

1. Calculate the time constant ,tau, for every RC circuit. Keep the values of tau in an array.
2. Using the calculated time constant, calculate the voltage across every capacitor as a function of time from t = 0s to t = 1000s. Also, plot the calculated voltages as a function of time in the same figure.
3. Calculate the voltage across every capacitor as a function of tau. Also, plot the calculated voltage as a function of tau in the same figure.

```
Note, do not use any form of loops in order to complete this assignment.
```

Questions

1. How does resistance affect the rate at which a capacitor discharges?

2. Why are the plots the same when plotting voltage as a function of tau?

Useful Information

Time Constant

```
The time constant for a RC circuit is dependent
on the capacitor and the resistor.
```

$$\tau = RC$$

Natural Response

```
The natural response of a RC circuit is when the
capacitor goes from an energized ,charged, state
to an unenergized, uncharged, state. The voltage
natural response can be modeled by the following.
```

$$V(t) = e^{\frac{-t}{\tau}} V_{init}$$

Natural Response as a Function of Tau

```
We have discussed how to model the natural response
of a RC circuit as a function of time. To model it
as a function of tau, the time step must be equal to
tau. For example, assume we have the following time array.
```

$$t = 0 : \tau : 5 * \tau$$

```
Inserting the newly constructed time array into the
previous equation yields.
```

$$V(t) = e^{-\frac{0:\tau:5\tau}{\tau}} V_{init}$$

```
The equation can simplify to
```

$$V(t) = e^{-0:1:5} V_{init}$$

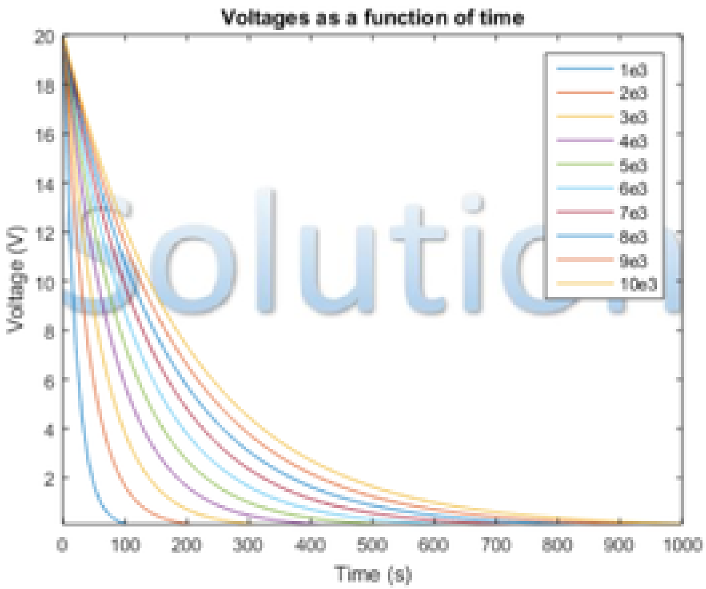
Provided Code

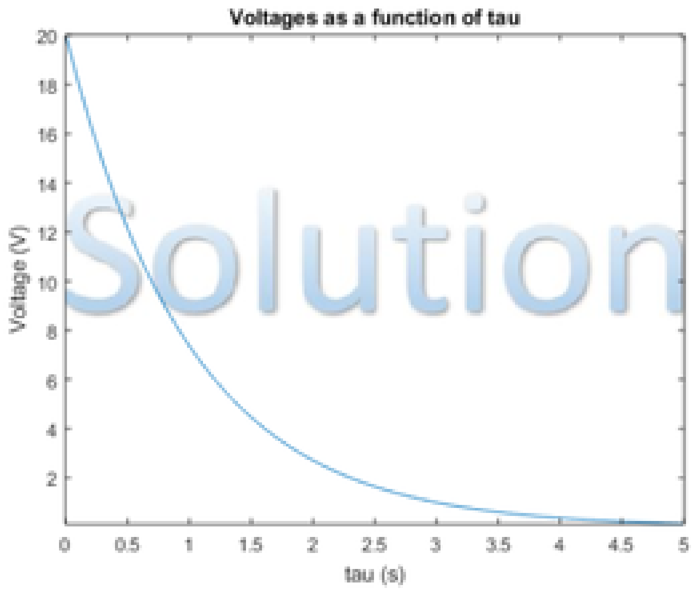
```
Parameters
C = 20e-3;                % The value of the capacitor, C
Vinit = 20;               % Initial voltage across the capacitor
                        % at t = 0s, V
R = 1000:1e3:10e3;        % Variety of resistors, Ohms
time_beg = 0;             % Begin of time array, s
time_step = 10;           % Time step, s
time_end = 1000;          % End of time array, s
t = time_beg:time_step:time_end;  % Time array, s
```

```
tau = # INSERT CODE HERE; % The various time constants, s
t_tau = 0:0.1:5;       % Tau array, s

Vt = #INSERT CODE HERE;     % Voltage as a function of time for
                             % each RC circuit.
Vtau = Vinit*exp(-t_tau);      % Voltage a s function of tau for
                             % each RC circuit.

figure(1)
plot(t,Vt)
title('Voltages as a function of time');
xlabel('Time (s)');
ylabel('Voltage (V)');
legend('1e3','2e3','3e3','4e3','5e3','6e3','7e3','8e3','9e3','10e3');

figure(2);

plot(t_tau,Vtau)
title('Voltages as a function of tau');
xlabel('tau (s)');
ylabel('Voltage (V)');
```

Solution

Parameters





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