Electric Circuits

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Overview

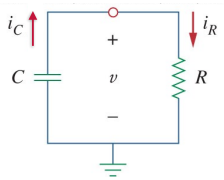
- This chapter examines RC and LC circuits' reaction to switched sources.
- The circuits are referred to as first order circuits.
- Three special functions, the unit step, unit impulse, and unit ramp function are also introduced.
- Both source free and switched sources are examined.

First Order Circuits

- A first order circuit is characterized by a first order differential equation.
- There are two types of first order circuits:
- Resistive capacitive, called RC
- Resistive inductive, called RL
- There are also two ways to excite the circuits:
- Initial conditions
- Independent sources

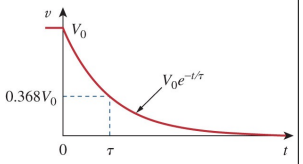
Source Free RC Circuit

- A source free RC circuit occurs when its dc source is suddenly disconnected.
- The energy stored in the capacitor is released to the resistors.
- Consider a series combination of a resistor and a initially charged capacitor as shown:



Natural Response

- The result shows that the voltage response of the RC circuit is an exponential decay of the initial voltage.
- Since this is the response of the circuit without any external applied voltage or current, the response is called the natural response.



Time Constant

- The speed at which the voltage decays can be characterized by how long it takes the voltage to drop to *1/e* of the initial voltage.
- This is called the time constant and is represented by τ.
- By selecting *1/e* as the reference voltage:

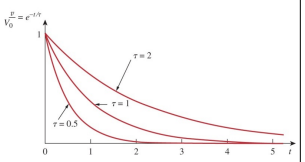
$$\tau = RC$$

- The voltage can thus be expressed as:

$$v(t) = V_0 e^{-t/\tau}$$

Time Constant II

- After five time constants the voltage on the capacitor is less than one percent.
- After five time constants a capacitor is considered to be either fully discharged or charged
- A circuit with a small time constant has a fast response and vice versa.



RC Discharge

- With the voltage known, we can find the current:

$$i_R(t) = \frac{V_0}{R} e^{-t/\tau}$$

- The power dissipated in the resistor is:

$$p(t) = \frac{V_0^2}{R} e^{-2t/\tau}$$

- The energy absorbed by the resistor is:

$$w_R(t) = \frac{1}{2} C V_0^2 \left(1 - e^{-2t/\tau}\right)$$

Source Free RC Circuit Summary

- The key to working with this type of situation is:
- Start with the initial voltage across the capacitor and the time constant.
- With these two items, the voltage as a function of time can be known.
- From the voltage, the current can be known by using the resistance and Ohm's law.
- The resistance of the circuit is often the Thevenin equivalent resistance.

Solved Problem

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