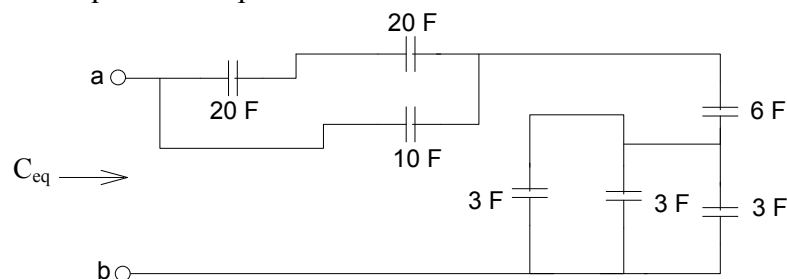


TOPIC

Electricity and Magnetism – Section XI – Question 11

QUESTION

The equivalent capacitance in Farads of the circuit below is most nearly



- (A) 3.051
- (B) 7.320
- (C) 15.00
- (D) 20.00

HINT

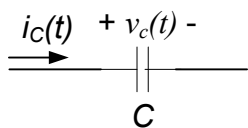
A capacitor is composed of two electrodes ('plates') separated by an electrolyte. The capacitance is directly proportional to electrode surface area, A in m^2 and inversely proportional to the separation distance between the electrodes, d in meters, and ϵ is the permittivity of the electrolyte.

$$C = \frac{A\epsilon}{d}$$

Capacitors store energy (charge) in the form of an electric field; $Q = CV$, where Q is charge in Coulombs, C is capacitance in Farads and V is the voltage drop across the capacitor in volts. The total energy stored in a capacitor is given by:

$$E_C = \frac{1}{2} CV_C^2$$

Given the voltage drop across a capacitor then the current is the derivative of voltage. Hence, given the current then the voltage is the integral of current.



$$i_C(t) = C \frac{dV_C}{dt}$$
$$v_C(t) = v_C(0) + \frac{1}{C} \int_0^t i_C(\tau) d\tau$$

Looking closely to the current through a capacitor, some interesting properties can be concluded about capacitors.

For DC signals ($f = 0\text{Hz}$ and $T = \infty$ seconds)

$$i_C(t) = C \frac{d}{dt} [const] = 0A$$

The capacitor acts like an open circuit. The current is known to be 0A but the voltage drop across the capacitor is unknown and needs to be calculated.

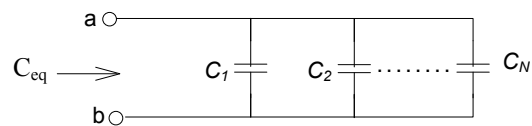
Instantaneous ($dt = 0$ seconds) changes in voltage drop across a capacitor

$$i_C(t) = C \frac{dv_C}{0} = \infty A$$

The voltage drop across a capacitor cannot be changed instantaneously ($dt = 0$ seconds) because that would cause an infinite current. Hence, it is said that $v_C(0+) = v_C(0-)$. Notice that the same cannot be said for the current through a capacitor.

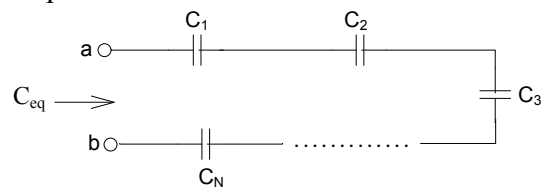
Equivalent Capacitance

Capacitors in Parallel:



$$C_{eq} = C_1 + C_2 + \dots + C_N$$

Capacitors in Series:



$$C_{EQ} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_N}}$$

CONTRIBUTOR

Stelios Ioannou