Q - An AC generator supplies an rms voltage of 5.00 V to an *RC* circuit. At a frequency of 20.0 kHz the rms current in the circuit is 37.0 mA; at a frequency of 30.0 kHz the rms current is 50.0 mA. What are the values of *R* and *C* in this circuit?

Answer:

The impedance of a RC circuit is given by $Z = \sqrt{R^2 + (1/C\omega)^2}$ which depends on $\omega = 2\pi n$.

Now $\omega_1 = 2\pi n_1 = 2\pi$ x 20000 = 125660 rad/s
and $\omega_2 = 2\pi n_2 = 2\pi$ x 30000 = 188400 rad/s

The rms current is given by I = V/Z hence Z = V/I gives
$R + (1/C\omega)^2 = V/I$

For first case $Z_1^2 = R^2 + (1/C\omega_1)^2 = (5 / 37x10^{-3})2 = 18260$.....(1)
and for second $Z_2^2 = R^2 + (1/C\omega_2)^2 = (5 / 50x10\text{-}3)2 = 10000$..... (2)

Subtracting the two equations

$(1/C)^2*(1/\omega_1^2 - 1/\omega_2^2) = 8260$
Or $(1/C)^2*(1/4\pi^2 n_1^2 - 1/4\pi n_2^2) = 8260$
Or $(1/2\pi C)^2 * (1/n_1^2 - 1/n_2^2) = 8260$
Or $(1/2\pi C)^2 * 1.3889*10^{-9} = 8260$
Or $(1/2\pi C)^2 = (8260/1.3889)*10^9 = 5.95*10^{12}$
Or $2\pi C = 4.098*10^{-7}$
Gives $C = 6.52 \times 10^{-8}$ F = **65.2 nF**

Substituting in eq (2) we get

$R^2 = 10000 - (1/C\omega_2)^2$
Or $R^2 = 10000 - (1/65.2*10\text{-}9*188400)^2$
Or $R^2 = 10000 - 6627 = 3373$
Gives R = **58 Ω**