Answer on Question 59467, Physics, Electric Circuits

Question:

A 1000 turns coil of cross-sectional area $30\ cm^2$ rotates at a frequency of $120\ Hz$ in a magnetic field $0.1\ T$. Calculate the peak value of the induced emf:

A) $\mathcal{E}_{peak} = 346.4\ V$

B) $\mathcal{E}_{peak} = 112.3\ V$

C) $\mathcal{E}_{peak} = 97.6\ V$

D) $\mathcal{E}_{peak} = 226.2\ V$

Solution:

Let's use the Faraday's law and find the emf generated between the ends of the coil:

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d(NBAcos\theta)}{dt},$$

here, $\mathcal{E}$ is the emf generated between the ends of the coil, Φ_B is the magnetic flux through the coil, N is the number of turns of the coil, B is the magnetic field, A is the cross-sectional area of the coil, θ is the angle between the magnetic field and the normal to the plane of the coil.

Since $\theta = \omega t$, we get:

$$\mathcal{E} = -\frac{d(NBAcos\omega t)}{dt} = -NBA\frac{d(cos\omega t)}{dt} = -NBA\omega sin\omega t.$$

The peak value of the emf induced in the coil when $\theta = \omega t = 90^{\circ}$, so that the coil is in the plane of the magnetic field:

$$\mathcal{E}_{peak} = NBA\omega,$$

here, ω is the angular frequency with which the coil rotates in a magnetic field.

Let's also recall the relationship between the angular frequency (measured in rad/s) and the ordinary frequency (measured in Hz):

$$\omega = 2\pi f,$$

here, ω is the angular frequency, f is the ordinary frequency.

So, we get:

$$\omega = 2\pi f = 2\pi \cdot 120\ s^{-1} = 754\ \frac{rad}{s}.$$

Finally, substituting ω into the formula for $\mathcal{E}_{peak}$, we can calculate the peak value of the induced emf:

$$\mathcal{E}_{peak} = NBA\omega = 1000\ turns \cdot 0.1\ T \cdot 3 \cdot 10^{-3}\ m^2 \cdot 754\ \frac{rad}{s} = 226.2\ V.$$

Answer:

D) $\mathcal{E}_{peak} = 226.2\ V$