Answer Question #69088 Physics – Electromagnetism

An electric generator comprises a square wire loop of side 100 cm. The loop has 50 turns and is placed in a magnetic field of 0.5T. By what frequency should this loop be rotated in the magnetic field to produce an AC voltage of peak value 250 V?

Solution. According to the Faraday law: the induced emf in a coil is equal to the negative of the rate of change of magnetic flux times the number of turns in the coil. It involves the interaction of charge with magnetic field.

$$E_{mf} = -N\frac{\Delta\Phi}{\Delta t}$$

where $N = 50$ – number of turns, $\Phi = \mathrm{BA}$ – magnetic flux, $B = 0.5T$ – external magnetic field, A – area,.

Considering that the magnetic flux varies with rotation $\Phi = \mathrm{BA}\cos\omega\mathrm{t} = \mathrm{BA}\cos 2\pi\nu\mathrm{t}$, where ν – frequency, t – fixed time. At the specified time according to the Faraday law

$$E_{mf} = -N\frac{\Delta\Phi}{\Delta t} = -N\frac{d\Phi}{dt}$$
$$E_{mf} = NBA2\pi\nu\sin 2\pi\nu\mathrm{t}$$

For the peak value $\sin 2\pi\nu\mathrm{t} = 1$ ($E_{mf} = 250V$). Hence $E_{mf} = NBA2\pi\nu \rightarrow \nu = \frac{E_{mf}}{NBA2\pi}$

According to the condition of problem $\mathrm{A} = 1 \cdot 1 = 1\mathrm{m}^2$(area square wire loop).

$\nu = \frac{250}{50 \cdot 0.5 \cdot 1 \cdot 2\pi} \approx 1.59\mathrm{Hz}$

Answer. 1.59Hz.