4–3 A three-phase Y-connected 50-Hz two-pole synchronous machine has a stator with 2000 turns of wire per phase. What rotor flux would be required to produce a terminal (line-to-line) voltage of 6 kV?

- Modified to 60 Hz and 2200 turns of wire per phase.

Per (2-11), $V_T = V_{LL} = \sqrt{3}\ V_\phi$ for a Y-connection.

So, the phase voltage (i.e., per coil) is $V_\phi = 6000 / \sqrt{3} \Rightarrow V_\phi = 3464.1016\ (V_{rms})$.

Use (4-39), $E_A = \sqrt{2}\,\pi\, N_C\, \phi\, f$

where N_C is the turns of wire, ϕ is the magnetic flux (Wb) of the rotor, and f is the electrical frequency (Hz) to get the voltage for one pair of slots, i.e., one coil.

Noting $E_A = V_\phi$ (no load) and solving for the magnetic flux, we get

$$\phi = \frac{E_A}{\sqrt{2}\,\pi\, N_C\, f} = \frac{3464.1016}{\sqrt{2}\,\pi\,(2200)\,60} \quad \Rightarrow \quad \underline{\boldsymbol{\phi = 0.0059068\ (\text{Wb}) = 5.907\ (\text{mWb})}}.$$