4-2. A three-phase four-pole winding is installed in 12 slots on a stator. There are 40
turns of wire in each slot of the windings. All coils in each phase are connected in
series, and the three phases are connected in Δ. The flux per pole in the machine is
0.060 Wb, and the speed of rotation of the magnetic field is 1800 r/min.

(a) What is the frequency of the voltage produced in this winding?
(b) What are the resulting phase and terminal voltages of this stator?

SOLUTION

(a) The frequency of the voltage produced in this winding is
\[ f_e = \frac{n_m \cdot p}{120} = \frac{(1800 \text{ r/min})(4 \text{ poles})}{120} = 60 \text{ Hz} \]

(b) There are 12 slots on this stator (4 per phase and thus 2 per sub-coil per phase), with a
total of 2 x 40 = 80 turns per phase coil. The total voltage in the two coils of one phase
is therefore
\[ E_A = \sqrt{2 \pi N_C \phi f} = \sqrt{2 \pi (2 \times 40)(0.060 \text{ Wb})(60 \text{ Hz})} = 1280 \text{ V} \]

Since the machine is Δ-connected, \( V_L = V_\phi = 1280 \text{ V} \)

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?

SOLUTION

The phase voltage of this machine should be \( V_\phi = V_L / \sqrt{3} = 3464 \text{ V} \). The induced voltage
per phase in this machine (which is equal to \( V_\phi \) at no-load conditions) is given by the
equation
\[ E_A = \sqrt{2 \pi N_C \phi f} \]
so
\[ \phi = \frac{E_A}{\sqrt{2 \pi N_C f}} = \frac{3464 \text{ V}}{\sqrt{2 \pi (2000 \text{ t})(50 \text{ Hz})}} = 0.0078 \text{ Wb} \]

4-5. If an ac machine has the rotor and stator magnetic fields shown in Figure P4-1 in the
book, what is the direction of the induced torque in the machine? Is the machine acting
as a motor or generator?

SOLUTION

Since \( r_{ind} = k B_R \times B_{net} = k B_R \times B_S \), the induced torque is counterclockwise, in the same
direction of motion. The machine is acting as a motor.