

1. Answer **briefly**
 - a) What are zero-sequence currents and how to model them using space vectors?
 - b) The torque versus speed characteristic of a self-starting synchronous motor is a sum of three torque components. What are the origins of these components?
 - c) Parameters of which winding(s) define the transient open-circuit time constant T_0' ; subtransient open-circuit time constant T_0'' ? Which time constant is longer?
 - d) Which reference frames are more suitable for the analysis of induction machine, and which are preferred for synchronous machine, why?
 - e) List the four simplifications, which are usually applied when modelling the rotating electrical machines using space vector theory.
2.
 - a) Starting from voltage and magnetic flux linkage equations, develop the equivalent circuit of an induction motor. Use the **stator reference frame** and assume that machine operates in steady state and rotor winding is short-circuited ($u_r = 0$).
 - b) Using the equivalent circuit developed in a) and neglecting resistances of the stator and rotor windings, solve the steady-state stator current.
3. A two-pole synchronous machine is carrying balanced three-phase armature (stator) currents $i_a = \sqrt{2}I \cos(\omega t)$, $i_b = \sqrt{2}I \cos(\omega t - 120^\circ)$ and $i_c = \sqrt{2}I \cos(\omega t + 120^\circ)$. The rotor is rotating at synchronous speed ω , and the rotor direct axis is aligned with the stator phase a axis at time $t = 0$. Find the direct- and quadrature-axis current components (i.e. the d-q-components in the rotor reference frame).
4. Derive a small-signal model for a three-phase induction machine. Use the **stator reference frame**. The small signal model should include the voltage and flux linkage equations and the equation of motion.
5. A squirrel-cage induction motor is running at no load. The stator winding is supplied from a balanced three-phase voltage source. At time instant $t = 0$, stator winding is disconnected from the supply.
 - a) Derive the expression for the space-vector of the stator voltage after the switch-off.
 - b) Describe shortly, how the switch-off affects the magnitude, frequency and phase angle of the stator voltage.Assume that all needed motor parameters are known.