S-17.3020 Transient phenomena in electrical machines, examination 14.12.2007 at 13-16.

1. a) Explain briefly, which reference frames are suitable for the analysis of induction machine, and which are preferred for synchronous machine, why?

   b) List the four simplifications, which are usually applied when modelling the rotating electrical machines using space vector theory.

   c) Write the general space-vector expressions for voltage and magnetic flux linkage of the stator and rotor windings in stator reference frame.

   d) Rewrite the equations of part c) using **two-axis** model in reference frame of your choice (except the stator reference frame).

   e) Define the transformation from three-phase stator quantities (e.g. stator phase currents) to two-axis (two-phase) quantities in stationary reference frame.

2. a) Equation for the instantaneous power is $p = ui$. Verify that the instantaneous power of a three-phase winding can be expressed as $p = 3/2\ \mathrm{Re}\ \{\underline{u}^* \underline{i}\}$, where $\underline{u}$ and $\underline{i}$ are space vectors.

   b) Write the energy balance equation for an electrical machine and explain how the total electrical energy W_{elec} fed to the machine is utilised.

3. 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 ($\underline{u}_r = 0$).

   b) Using the equivalent circuit developed in a) and neglecting resistances of the stator and rotor windings, solve the steady-state stator current.

4. 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.

   You can assume that the rotor angular velocity remains constant after the switch-off, and all the needed parameters of the motor are known.

5. a) What are the basic concepts of small-signal analysis, what is it used for?

   b) Derive a small-signal model for a salient-pole synchronous machine. Equations for stator and rotor voltages on q-axis are not needed, only those for d-axis voltages and the equation of motion.