S-17.162 Advanced Course in Electromechanics
Examination 8.8.2005 at 13 – 16 o'clock, Room I 256.

= S-17.3020

1. Explain briefly:
   a) what is the four-winding basic machine,
   b) what does present the space vector of a three-phase current,
   c) what are the free oscillations,
   d) what is an operational inductance of a synchronous machine and
   e) what is a state-space presentation of a differential equation.

2. There is a symmetric three-phase winding in the stator of an electrical machine. The rotor is cylindrical without any windings. Because of a sinusoidal flux-density distribution in the air-gap, the mutual inductances between the stator windings are $M = L_h \cos\gamma$, where γ the angle between the magnetic axis of the windings. The leakage inductance of the winding is $L_{\sigma s}$. Based on the definition of a space vector, derive the flux equation

$$\underline{\psi}_s^s = (L_{\sigma s} + L_m)\,\underline{i}_s^s$$

and simultaneously, an equation for the magnetisation inductance L_m. The stator currents are arbitrary but there is no zero-component in the currents.

3. a) Describe the transient process that occurs in switching-off of a squirrel-cage induction motor that has been running at no-load.

   b) Calculate the voltage induced in a phase winding after the switch-off. The speed is supposed to be constant. The space vector of stator voltage was $\underline{u}_s^s = \hat{u}e^{j\phi}$ at the moment of switch-off.

4. A permanent magnet synchronous motor is driving a gas turbine at its rated power ($U = U_n$, $I = I_n$, $\cos\phi = 1$, $T = T_n$, $\Omega = \omega_n/p$) when it is suddenly disconnected from the voltage supply. Derive an equation giving the stator voltage after the disconnection. The machine has no damper winding. The parameters of the stator winding are R_s, $L_d = L_q$. The torque of the turbine is proportional to the second power of the rotation speed, and the common moment of inertia of the system is J.

   Instruction: After the disconnection, the permanent magnets in the rotor produce a constant flux, the amplitude of which can be calculated from the rated values. The frequency of the flux in the stator changes according to the equation of motion. All the losses of the electrical motor are assumed to be zero.

5. a) Transform the voltage and flux equations of an induction motor, which are originally presented using space vectors, to the form obtained by assuming small variations in the values of the variables

   b) What is the effect of a small change in the stator voltage on currents of a machine running at the rated load.

   (Assumption: The speed remains constant, i.e. the change in the speed can be neglected)