S-17.3020 Transient Phenomena in Electrical Machines

Examination 17/12/2008 at 13 – 16 o'clock, Auditorium S4.

1. Explain briefly, which methods you would use to solve the equations of an asynchronous machine and a synchronous machine, when the
   a) machine is operating in a steady state,
   b) rotation speed stays constant during a transient,
   c) rotation speed is not known beforehand,
   d) operation in a steady state is slightly disturbed,
   e) operation can be described by small oscillations around a steady state?

2. A one-phase transformer is connected to a sinusoidal voltage source $u = \hat{u}\cos\omega t$ at time instant $t = 0$. Derive the differential equations of the primary and secondary currents. Solve the equations assuming that the load of the transformer is zero. The resistance and inductance of the primary winding are R_1 and L_1, and those of the secondary winding R_2 and L_2. The mutual inductance of the windings is L_m.

3. Derive the small-signal space-vector model for a cage induction motor (voltage equations and equation of motion).

4. A permanent-magnet synchronous machine is connected to a symmetric three-phase grid. It rotates at the speed $\omega = \omega_s/p$. The flux produced by the permanent magnets induces an electromotive force E (rms-value) in the phases of the machine. When the unloaded machine is disconnected from the grid, its speed ω starts to decelerate due to the friction and core losses. The friction loss P_f and core loss P_c are

   $$P_f = C_f\omega^3 \quad , \quad P_c = C_h\omega + C_e\omega^2$$

   Derive an equation for the space vector of the stator voltage after the disconnection. There is no damper winding in this machine. The mass of inertia of the rotor is J.

5. A salient pole synchronous motor is started by connecting its stator winding to a three-phase grid. How and from which components is the starting torque produced, and how can we affect the starting torque? Sketch the average torque versus speed curve of a synchronous motor during a slow starting.