Tampere University of Technology 15.3.2017
Electrical Energy Engineering **DEE-34016 Modeling and Control of Electric Drives**

Jenni Rekola Programmable calculator allowed 5 questions/ á 6 p
Answers in English or in Finnish allowed

1. Propositions

Answer, if the following propositions are true or not true. Correct answer 1p, wrong answer -1p.

a) The rotor structure presented in Fig. 1 is used in salient-pole permanent magnet synchronous machine.

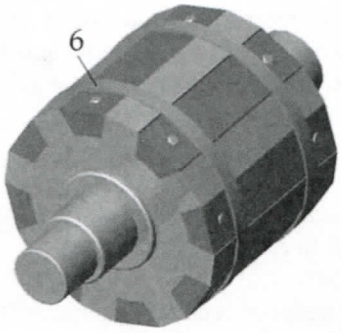

Fig. 1. Rotor

b) Stator resistance value has a major effect to the accuracy of the speed estimation.
c) The modulation method has an effect on the peak value of the common mode voltage pulse.
d) Flux density distribution is assumed sinusoidal in the air gap of a machine when space vector theory is used
e) Stator resistance of a slip-ring machine can be changed
f) PMSM machine is modeled usually in rotor reference frame.

2. DC machine

a) Draw the equivalent circuit of a separately exited DC machine
b) Draw the control block diagram of separately exited DC machine with speed control and shortly explain the figure (2p)
c) What means electrical time constant of DC machine, how it is defined?
d) The load torque of the uncontrolled separately excited machine is decreased step-wisely from its nominal value to 0,5*nominal torque in the nominal operating point. How the rotational speed, armature current and magnetizing current change? Why?
e) The magnetizing voltage of the uncontrolled separately excited DC machine decrease step-wisely from its nominal value to 0,5*nominal voltage when the motor rotates at its nominal speed without the load. How the rotational speed, armature current and magnetizing current change? Why?

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3. Permanent magnet synchronous machine (PMSM)

a) What is the difference in the mechanical structure of salient and non-salient PMSM machines?
b) How the torque production of these two machines differs from each other?
c) How the control method of these two machines differs from each other?
d) What are the benefit/benefits of PMSM compared to induction machine?
e) What are the drawback/drawbacks of PMSM compared to induction machine?
f) The speed reference of the controlled, non-salient PMSM is increased step-wisely from its nominal value to 1.5*nominal speed when the torque reference is nominal. How the produced torque and stator current (d- and q-component) change? Why?

4. Reluctance machine

a) Describe shortly the operation principle of reluctance machine
b) How torque is produced in reluctance machine?
c) How torque is controlled?
d) What are the benefit/benefits of reluctance machine?
e) What are the drawback/drawbacks of reluctance machine?
f) Why the magnetized assisted reluctance machine is used in electric vehicles instead of conventional reluctance machine?

5. Induction machine

a) Explain the operation principle of direct torque control (DTC).
b) Which parameters need to be measured from the motor drive when DTC is used?
c) Why the adaptive motor model is needed in the control system?
d) What are the benefits of DTC compared to scalar (Volts/Hz) control?
e) What are the most important un-idealities which might affect to the operation of the real-world motor drive control system, but which are not usually taken into account in the ideal simulation models?
f) The measured torque and torque reference of an induction machine are shown in Fig. 2. Analyze the differences of FOC and DTC. The switching frequency of FOC is 1.3 kHz and the average switching frequency of DTC is the same.

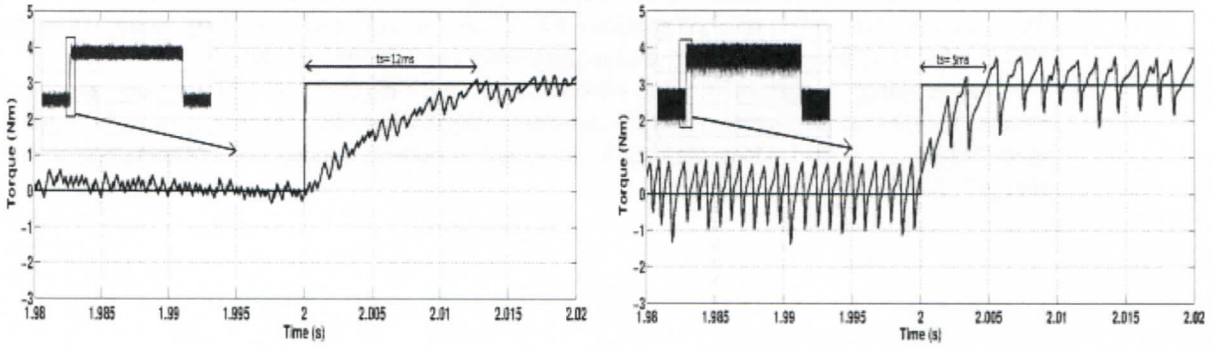

Fig. 2. a) Torque reference and measured torque with FOC (field oriented control i.e. vector control) and b) torque reference and measured torque with DTC