KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

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EE 360

MAJOR EXAM # 2

December 26, 2005

5:00 - 7:00 pm

Key Solution

Section:

Student Name:

Student I.D.#

Serial #

Question # 1	
Question # 2	
Question # 3	
Question # 4	
Total	

Q. 1) A three-phase 69 kV feeder is connected to a three-phase load rated at 1000 kVA and 4.16 kV through a **three identical single-phase ideal** transformers. Specfiy the voltage, current, (at both sides) and kVA ratings of each transformer when they are connected as

(a) wye-wye.
(b) wye-delta.
(c) delta-wye.
(d) delta-delta.

(25 Marks)

Solution:

$S_{Load} = 1000$ kVA

$V_{2L} = 4.16$ kV

$$I_{2L} = \frac{1000}{\sqrt{3}(4.16)} = 138.8 \text{ A}$$

Connection	$\mathbf{V_{1ph}}$ **(kV)**	$\mathbf{I_{1ph}}$ **(A)**	$\mathbf{kVA_1}$	$\mathbf{V_{2ph}}$ **(kV)**	$\mathbf{I_{2ph}}$ **(A)**	$\mathbf{kVA_2}$
wye-wye	40	8.33	333.3	2.4	138.8	333.3
wye-delta	40	8.33	333.3	4.16	80.1	333.3
delta-wye	69	4.83	333.3	2.4	138.8	333.3
delta-delta	69	4.83	333.3	4.16	80.1	333.3

Q. 2) A 20 hp, 240 V, 4-pole, 1700 rpm, DC shunt motor has armature and field resistances of 0.2 Ohm and 240 Ohm, respectively. The efficiency of the motor at rated operating condition is 88%. Determine the following:

(a) the rotational losses.
(b) the induced voltage.
(c) the mechanical developed power.
(d) the shaft torque.

(25 Marks)

Solution:

(a) P_{out} =(20) (746) = 14, 920 W

$$P_{in} = \frac{14{,}920}{0.88} = 16{,}954.5 \text{ W}$$

$$I_t = \frac{16{,}954.5}{240} = 70.64 \text{ A}$$

$$I_f = \frac{240}{240} = 1 \text{ A}$$

$I_a = 70.64 - 1 = 69.64$ A

$P_{cu} = (0.2)\,(69.64)^2 + (240)\,(1)^2 = 1210$ W

$P_{\text{rotational losses}} = 16{,}954.5 - 14{,}920 - 1210 = 824.5$ W

(b) $E_a = 240 - (0.2)\,(69.64) = 226.1$ V

(c) $P_{dev} = (226.1)\,(69.64) = 15{,}746$ W

(d) $w_m = \frac{2\pi(1700)}{60} = 178$ rad/sec

$$T_{out} = \frac{14{,}920}{178} = 83.8 \text{ N-m}$$

Q. 3) A 3-phase, 60 Hz, 6-pole, Y-connected synchronous generator has a synchronous reactance of 4 Ohm and a terminal voltage of 2300 V. The field current is adjusted so that the excitation voltage is 2300 V at a power (torque) angle of 15^o . Neglect the armature resistance and rotational losses,

(a) determine the stator current.
(b) determine the power factor.
(c) determine the output power.
(d) determine the torque required to drive the machine.
(e) is the machine supplying or absorbing reactive power.

(25 Marks)

Solution:

$$V_t = \frac{2300}{\sqrt{3}} = 1327.9 \angle 0^o \text{ V}$$

$$E_a = \frac{2300}{\sqrt{3}} \angle 15^o = 1327.9 \angle 15^o \text{ V}$$

(a) $$I_a = \frac{1327.9\angle 15^o - 1327.9\angle 0^o}{j4} = 86.7 \angle 7.5^o$$

(b) PF = $\cos 7.5^o$ = 0.991 Leading

(c) $$P_{out} = \frac{3(1327.9)(1327.9)}{4} \sin 15^o = 342.28 \text{ kW}$$

(d) $$n_s = \frac{(120)(60)}{6} = 1200 \text{ rpm}$$

$$w_m = \frac{2\pi(1200)}{60} = 125.7 \text{ rad/sec}$$

$$T_{shaft} = \frac{342.28}{125.7} = 2.72 \text{ kN-m}$$

(e) The machine is absorbing reactive power.

Q. 4) A 6-pole, 50-Hz, polyphase induction motor drives a rated load at 950 rpm. Find

(a) the speed of the stator magnetic field with respect to the stator.
(b) the speed of the stator magnetic field with respect to the rotor.
(c) the speed of the rotor magnetic field with respect to the stator.
(d) the speed of the rotor magnetic field with respect to the rotor.
(e) the speed of the rotor with respect to the stator.

(25 Marks)

Solution:

$$n_s = \frac{(120)(50)}{6} = 1000 \text{ rpm}$$

$n_m = 950$ rpm

(a) The speed of the stator magnetic field with respect to the stator is 1000 rpm.

(b) The speed of the stator magnetic field with respect to the rotor is 50 rpm.

(c) The speed of the rotor magnetic field with respect to the stator is 1000 rpm.

(d) The speed of the rotor magnetic field with respect to the rotor is 50 rpm.

(e) The speed of the rotor with respect to the stator is 950 rpm.