University of Jordan	Faculty of Engineering & Technology	Electrical Engineering Department
EE471: Electrical [redacted]ines II	First Exam — Second Semester 2016-2017	07/03/2017 — Time: 1 Hour

Student Name: [redacted] **Student ID** [redacted] **Serial #:** 30

Grade: 19 /20

37/40

Question # 1 (10 Points)

Select the correct answer and fill it in the following Table.

9/10

Q #	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Answer	a	d	a	c	b	c	d	d	c	b
Q #	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**
Answer	b	c	b	d	d	a	a	d	b	c

1.1 A synchronous generator on open-circuit generates 400 V at 50 Hz when the field current is 4.0 A. Neglecting saturation, the open-circuit EMF when the frequency is 25 Hz and the field current is 2.0 A will be

$E = 4.44 f N \phi K_w$ $\frac{E_2}{E_1} = \frac{25 \times 2}{50 \times 4}$

(a.) 100 V. b. 400 V. c. 800 V d. 1600 V.

1.2 A 50-Hz synchronous generator will run at the greatest possible speed if it is wound for

a. 8 poles. b. 6 poles. c. 4 poles. (d) 2 poles.

1.3 If the field of a synchronous generator is over excited, the power factor will be

(a.) lagging b. leading c. unity d. more than unity

1.4 The voltage regulation of a synchronous generator having 0.75 lagging *pf* load, no-load induced EMF voltage of 2400 V and rated terminal voltage of 3000 V is

a. +25.0% b. -20.0% c. +20.0% d. -25.0%

1.5 At a particular instant a turbo alternator is generating 80 MW at 0.8 power factor lagging. Now if the steam supply valve to the steam turbine is further opened and the excitation is not changed

a. the speed of the alternator will increase but kW delivered will remain unchanged
(b.) the speed of the alternator will increase and kW delivered will also increase
(c.) the speed of the alternator will remain unchanged but it can meet more kW demand
d. the speed of the alternator will remain unchanged but it will deliver more kVA.

1.6 A synchronous generator connected to infinite bus-bars has at constant full-load, 100% excitation and unity pf. On increasing the excitation only, the armature current will have ...

a. leading PF with under-excitation
b. leading PF with over excitation
(c.) lagging PF with over excitation
d. no change of PF

1.7 If the excitation of a synchronous generator is increased with the load remained unchanged, then

a. the excitation voltage increases.
b. the maximum developed power increases.
c. the reactive power increases.
d. all of the above.

1.8 An alternator is delivering rated current at rated voltage and 0.8 PF lagging case. If it is required to deliver rated current at rated voltage and 0.8 PF leading, the required excitation will be

a. less. b. more. c. more or less. d. the same.

1.9 As load power factor of a synchronous generator becomes more *leading*, the value of generated voltage E_a required to give rated terminal voltage

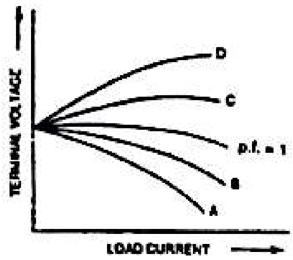
a. increase b. remains unchanged c. decreases d. varies with rotor speed

1.10 As the speed of an alternator increases

a. the frequency decreases
b. the frequency increases
c. the frequency remains constant but PF decreases
d. none of the above

1.11 Load characteristic curves for an alternator are shown. The curves are drawn for 0.8 PF lagging, 0.8 PF leading, 0.7 PF leading and 0.9 PF lagging. Which curve represents the characteristics for 0.8 PF leading?

a. curve A b. curve B c. curve C d. curve D



1.12 The effective rms phase voltage of one phase of an alternator having 240 turns per phase, frequency of 60 Hz and flux per pole of 20.8 mWb will be

a. 332.5 V b. 665 V c. 1330 V d. 2660 V

1.13 A 3-phase Δ-connected synchronous generator is tested in order to determine its effective armature resistance using DC resistance test. If the DC current and voltage results are I_{dc}=100 A and V_{dc}= 40 V, the armature DC resistance R_{dc} will be

a. 0.2 Ω b. 0.6 Ω c. 0.9 Ω d. 0.66 Ω

1.14 A 3-phase, 6600-V, Y-connected synchronous generator has X_s = 8 Ω and its armature resistance R_a is negligible. If the induced voltage is adjusted to 8000 Vat 0.8 PF lagging, the maximum power developed P_d is… .

a. 5.28 MW b. 19.8 MW c. 6.6 MW d. 15.84 MW

1.15 For successful connection of a synchronous generator to an infinite bus system (Grid) using three-lamp method, the following condition(s) must be satisfied:

a. equal voltage magnitudes and phases of the running and incoming generators
b. equal phase sequence of the running and incoming generators
c. equal frequency of the running and incoming generators
d. All of the above

1.16 When two alternators are running in parallel, their KVAR load share is changed by changing their ………… while their kW load share is changed by changing their ………. .

a. excitation, driving torque b. driving torque, excitation c. excitation, excitation d. driving torque, driving torque

1.17 Two alternators A and B are sharing a resistive load (pf=1) equally. Now if the excitation of alternator A is increased, ….. .

a. alternator A will become lagging and alternator B will become leading
b. alternator A will become leading and alternator B will become lagging
c. both alternators will continue to operate on unity power factor
d. both alternators will operate on lagging power factor

1.18 Two synchronous generators $G_1$and G_2 are equally sharing the KVAR of the load while operating in parallel. Keeping the terminal voltage fixed in order to shift part of the KVAR load from G_2 to G_1, ….

a. the field current of G_1 is lowered
b. The field current of G_2 is raised
c. the field current of G_1 is lowered and of G_2 is raised.
d. the field current of G_1 is raised and of G_2 lowered

1.19 The steady-state stability limit of a synchronous generator can be increased by ….

a. an increase in its reactance
b. an increase in the excitation of the machine
c. a decrease in the moment of inertia of the machine
d. an increase in the moment of intertia of the machine

1.20 When a generator designed for operation at 60 Hz is operated at 50 Hz, ….. .

a. kVA rating can be upgraded to (60/50) of the rated value
b. operating voltage must be derated to $(50/60)^2$ of its original value
c. operating voltage must be derated to (50/60) of its original value
d. the generator will not take any load.

Question # 2 (8 Points) $n_s = 3000$

The following readings are taken from the results of open-circuit and short-circuit tests on a three phase, 10 MVA, 12 kV, two pole, 50 Hz, Y-connected cylindrical rotor generator driven at synchronous speed.

$S_{3\phi}$ V_{LL} P f Y-con

7/6

I_f =	180 A	Open-circuit core loss at 12 kV =	75 kW P_{core}
V_{OC} =	12.0 kV LL	Short-circuit load loss at 480 A =	60 kW P_{cu}
I_{sc}	480 A LL	Friction and windage loss =	65 kW $P_{F\&W}$

The generator delivers rated power to a load at 0.8 power factor lagging. If the armature resistance is negligible, calculate: PF, $R_a = 0$

a.	the synchronous reactance X_s.	X_s = 14.43 Ω
b.	the magnitude of the LL generated voltage E_a and power angle δ.	$\lvert E_{aLL}\rvert$ = 21.84 kV δ = 26.5 °
c.	the required field current I_f when the generator delivers its rated load at 0.8 PF lag.	I_f = 4.5 A
d.	the percentage voltage regulation $\%VR$	$\%VR$ = 79 %
e.	the percentage generator's efficiency $\%\eta$	$\%\eta$ = 97.5 %
f.	the mechanical input torque T_{in}	T_{in} = 26.07 kN.m
g.	the maximum developed power P_{dmax}	P_{dmax} = 17.905 MW

(a) $|Z_s| = |X_s| = \frac{12K/\sqrt{3}}{480} = 14.43\ \Omega$

(b) $|I_a| = \frac{10\ MVA}{\sqrt{3} \times 12KV} = 481.125$ $\theta = \angle -36.86$

$\bar{E}_{a\phi} = \frac{12K}{\sqrt{3}} + (481.125\angle -36.86) \times (14.43)j = 17.098 / KV / 18.96 = 12.405 \angle 26.5$ kV

$|E_a|_{LL} = 21.487$ kV

(c)

(d) $\%VR = \frac{21.487 - 12}{12} \times 100\% = 79\%$ $\frac{12.405 - 6.928}{6.928} = 79\%$ very high

(e) $P_{out} = \sqrt{3} \times 12K \times 481.125 \times 0.8 = 7.99$ MW $P_{in} = 7.99M + 75K + 60K + 65K = 8.19$ MW

$\eta = 7.99 / 8.19 = 97.5\%$

(f) $\omega_s = \frac{2\pi}{60} \times n_s = \frac{2\pi}{6} \times 3000 = 314.15$ rad/s $T_{app} = \frac{P_{in}}{\omega_s} = 26.07$ K N.m

(g) $P_{dmax} = \frac{3 \times \frac{12K}{\sqrt{3}} \times 12.405K}{14.43} \sin 90 = 17.905$ MW

Question # 3 (11 Points)

Two identical 3-ph, Y-connected alternators (A and B) are connected in parallel and deliver a total load of 2.5 MW at 11 kV and a power factor of 0.866 lagging. Each generator has a per phase synchronous reactance X_s = 10 Ω and a negligible armature resistance. The induced voltage (E_A) and the power angle (δ_A) of generator A are adjusted to 12.5 kV and 6.26°, respectively.

Determine for generators **A and B** the following:

a.	The magnitude of the load current $\lvert I_L \rvert$	$\lvert I_L \rvert$ = 151.51	A
b.	the real output power P_A and P_B	P_A = 1.56 P_B = 0.998	MW MW
c.	the armature current phasors I_A and I_B	I_A = 113.86 ∠-46.28 I_B = 52.92 ∠7.09	A A
d.	the power factor PF_A and PF_B and indicate lead or lag	PF_A = 0.69 PF_B = 0.99	lag lead
e.	the reactive output power Q_A and Q_B	Q_A = + 1.56 Q_B = −124.45	MVAR kVAR
f.	the induced phase voltage (E_B) and the power angle (δ_B) of generator B	$\lvert E_B \rvert$ = 6.307 ∠δ = 4.77	kV_{LN} kV_{LL}

(a) $|I_L| = \frac{2.5M/0.866}{\sqrt{3} \times 11K} = 151.51$ A θ = −30

(b) $P_A = \sqrt{3} \times 11K \times 113.86 \times 0.69 = 1496833.805 \approx 1.56$ MW

$P_B = \sqrt{3} \times 11K \times 52.92 \times 0.99 = 998178.8019 \approx 0.998$ MW

→ $P_A + P_B = 2495012.6 \approx 2.5$ MW

(c) $I_A = \frac{\frac{12.5k}{\sqrt{3}}\angle 6.26 - \frac{11k}{\sqrt{3}}}{j10} = 113.86 \angle -46.28$ $pf_A = 0.69$

(d) $I_B = 151.51\angle -30 - 113.86\angle -46.28 = 52.92\angle 7.09$ $pf_B = 0.99$

(e) $Q_A = \sqrt{3} \times 11K \times 113.86 \sin(46.28) = 1567826.98 \approx 1.56$ MVAR

$Q_B = \sqrt{3} \times 11K \times 52.92 \sin(7.09) = 124447.97 \approx 124.447$ KVAR

(f) $\bar{E}_B = \frac{11k}{\sqrt{3}} + j10(52.92\angle 7.09) = 6.807\angle 4.77$ kV

$|E_B|_{LL} = 10.924$ KV

(11

Question # 4 (11 Points)

A 480-V, 100-kW, two-pole, three-phase, 60-Hz synchronous generator's prime mover has a no-load speed of 3630 r/min and a full-load speed of 3570 r/min. It is operating in parallel with a 480-V, 75-kW, four-pole, 60-Hz synchronous generator whose prime mover has a no-load speed of 1800 r/min and a full-load speed of 1785 r/min. Determine:

a.	the no-load frequency of generator 1 and generator 2	f_{nl1} = 60.5 f_{nl2} = 60	Hz Hz
b.	the full-load frequency of generator 1 and generator 2	f_{fl1} = 59.5 f_{fl2} = 59.5	Hz Hz
c.	the speed droops (regulation) of generator 1 and generator 2	SD_1 = 1.68 SD_2 = 0.84	% %
d.	the power curve's slope for generator 1 and generator 2	S_{p1} = 0.1 S_{p2} = 0.15	MW/Hz MW/Hz
e.	the system frequency if the total load supplied by the two generators consist of 100 kW at 0.85 PF lagging	f_{sys} = 59.8	Hz
f.	the power supplied by generator 1 and generator 2	P_{G1} = 70 P_{G2} = 30	kW kW

(G1) 480 V 100 kW 2 pole 60 Hz

$f_{nL} = \frac{2 \times 3630}{120} = 60.5\ Hz$ $f_{FL} = \frac{2 \times 3570}{120} = 59.5\ Hz$

$Sp_1 = \frac{100K}{60.5 - 59.5} = 0.1\ MW/Hz$ $SD_1 = \frac{3630 - 3570}{3570} = 1.68\%$

(G2) 480 V 75 kW 4 pole 60 Hz

$f_{nL} = \frac{4 \times 1800}{120} = 60\ Hz$ $f_{FL} = \frac{4 \times 1785}{120} = 59.5\ Hz$

$Sp_2 = \frac{75K}{60 - 59.5} = 0.15\ MW/Hz$ $SD_2 = \frac{1800 - 1785}{1785} = 0.84\%$

$P = sp(f_{nL} - f_{sys})$

$100K = 0.1M(60.5 - f_{sys}) + 0.15M(60 - f_{sys})$

$\Rightarrow f_{sys} = 59.8$

$P_{G1} = 70\ KW$

$P_{G2} = 30\ KW$

$f = \frac{120 n}{...} = nP$