NATIONAL UNIVERSITY OF SINGAPORE

EXAMINATION FOR

(Semester II : 2012/2013)

EE2022 – ELECTRICAL ENERGY SYSTEMS

April/May 2013 - Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This paper contains **SEVEN (7)** questions and comprises **SIX (6)** printed pages.
2. Answer **ALL** questions in **Section A** and **ANY TWO (2)** questions in **Section B**.
3. This is a **CLOSED BOOK** examination.
4. Programmable calculators are **NOT** allowed.
5. The total marks for the examination paper is 100.

SECTION A : Answer ALL questions in this section

Q.1

Answer the following TRUE/FALSE questions. The correct answer (TRUE or FALSE) to each question should be written neatly on a separate line in your answer book. Each correct answer carries 1 mark.

(10 marks)

(a) As the ambient temperature increases, the voltage across a solar PV cell increases slightly.
(b) Solar energy falling on the Earth's surface in one hour is enough to meet world energy needs for an entire year.
(c) The solar tower system is the best choice among all concentrated solar power technologies for installation in locations with very little water.
(d) The main limitation of algae as a possible source of biodiesel is the large amount of space required for its cultivation.
(e) An inverter is an important part of a wind power system to convert the generated DC power into AC.
(f) Pumped hydro systems can store large amounts of energy which can be used during periods of high load demand.
(g) As wind speed doubles, power generation capability increases eightfold.
(h) When used in vehicles, biodiesel produces less greenhouse gases than the fossil fuel based diesel it replaces.
(i) The main role of Energy Market Authority (EMA) in Singapore is to ensure secure and reliable electricity supply to all consumers.
(j) China is the world leader in wind power, adding almost 40% of the global wind power capacity since 2010.

Q.2

Three loads, L1, L2 and L3, are connected in parallel to a single-phase 6kV, 50 Hz AC voltage source, where

L1: $10\angle 0^0$ kVA
L2: $40\angle 60^0$ kVA
L3: $25\angle 53.13^0$ kVA

(i) Find the total active and reactive power, and overall power factor of the three parallel connected loads L1, L2, and L3.

(12 marks)

(ii) A fourth load L4 is now added in parallel to this arrangement such that the overall power factor of the circuit becomes 0.8 while the total real power consumed by the circuit remains the same as before. Find the active and reactive power of Load L4, and change in current drawn by the circuit after L4 is added.

(8 marks)

Q.3

Consider a balanced three-phase system shown in Fig. Q.3., the three-phase voltage source has line-to-line voltage of 230V. Both three-phase loads are Y-connected. Assuming positive sequence system, find the current supplied by the source in phase B, I_B. Answer both magnitude and phase when the line-to-neutral source voltage of phase A is the reference angle of zero degree.

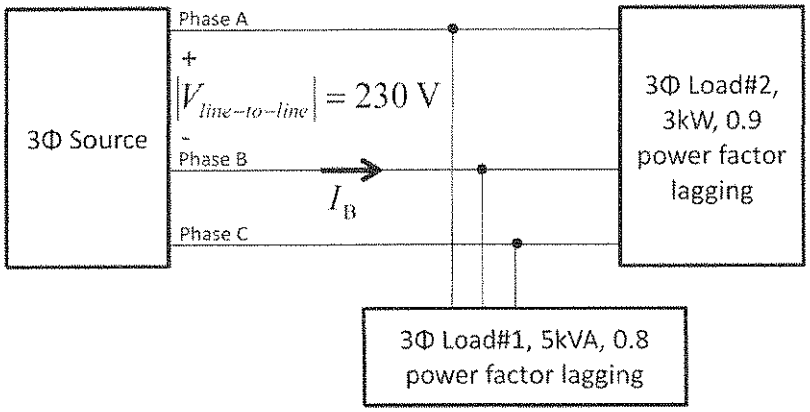

Fig. Q.3

(10 marks)

Q.4

A 50MVA 23kV three-phase wye-connected synchronous generator supplies power to 150kVA load 0.8 power factor lagging at the rated terminal voltage of 23kV. Assume that armature resistance is negligible, find the followings.

(i) Explain armature reaction in the synchronous generators. How is this reaction represented in the equivalent circuit? Draw the equivalent circuit of this generator and give numerical value of this component (armature reaction) in the equivalent circuit.

(6 marks)

(ii) Calculate power angle at this operation.

(6 marks)

(iii) Find maximum power transfer under the same excitation.

(4 marks)

(iv) Is the generator operating in overexcited or underexcited mode? Why?

(4 marks)

SECTION B : Answer ANY 2 out of the 3 questions in this section

Q.5

A 50 kVA, 2400/240 V, single phase transformer was tested and the following test data were obtained.

	Voltage (V)	*Current (A)*	*Power (W)*
Short-circuit test	55	20.8	600
Open-circuit test	240	5.0	450

The transformer is used in the single-phase circuit shown in the Fig. Q5. Details of all equipment are listed below.

Voltage source, Vs: Ideal voltage source supplying 240V.
Line impedance: 0.1+j4 Ω
Load: 1+j0.1 Ω

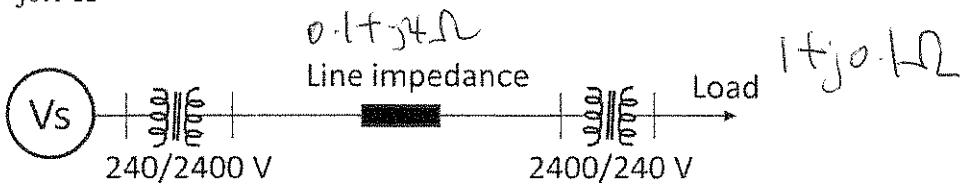

Fig. Q.5

Using 50 kVA as the base complex power and 240V at the voltage source as the base voltage, find the followings.

(i) Draw equivalent circuit of the transformer and give numerical values for the shunt admittance and series impedance of the transformer.

(8 marks)

(ii) Draw per unit circuit representation of the single-phase power system shown in Fig. Q.5. Give per unit value of transformer parameters found in (i), transmission line impedances, load impedances, and voltage source.

(12 marks)

Q.6

(a) A wind turbine with 50 m diameter produces 400kW power at a wind speed of 10 m/s. The air density is the standard 1.225 kg/m^3.

(i) Calculate the average power in the wind.

(4 marks)

(ii) What is the overall efficiency of this wind turbine under this operating condition?

(2 marks)

(iii) Calculate the annual energy delivered by this wind turbine, if the wind blows at 12 m/s for 40% of the time, and at 8 m/s for the remaining hours.

(4 marks)

(b) Briefly discuss the two main environmental impacts of second generation biofuels. Limit your answer to 50 words.

(5 marks)

(c) Briefly describe the initiatives taken by Singapore to promote Smart Grid related activities. Limit your answer to 50 words.

(5 marks)

Q.7

(a) An office building has the highest demand for power in the month of July when it reaches 130 kW, while the peak demand in every other month is less than 90 kW. The management has decided to lower the air-conditioning and lighting loads for 4 hours on all 23 weekdays in July so as to reduce the peak demand in July by 20 kW. What would be the resulting annual savings in demand and energy charges if the utility's energy charge is 15¢/kWh, and its demand charge is \$11/kW-month with an 80% ratchet on the demand charges?

(8 marks)

(b) A PV module comprises of 36 identical cells, with two parallel sets of 18 cells wired in series. With 1-sun insolation (1 kW/m^2), each cell has short-circuit current $I_{SC} = 4$ A and at 25°C its reverse saturation current is $I_0 = 6.2 \times 10^{-10}$ A.

(i) Find the voltage, current, and power delivered when the junction voltage of each cell is 0.60 V.

(6 marks)

(ii) Draw the approximate voltage-current curve for this module.

(2 marks)

(c) Why are storage systems important for efficient deployment of renewable energy systems? Limit your answer to 50 words.

(4 marks)

END OF EXAM PAPER