UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	POWER SYSTEMS/ ELECTRICAL POWER SYSTEM
COURSE CODE	:	BEF 25503/ BEE 3243/ BEX 32103
PROGRAMME	:	2 BEV/ BEE
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) List four (4) categories of frequency standards for power systems. Give an example application for each category stated.

(4 marks)

(b) HVDC and FACTS are two (2) widespreadly used technologies in modern power system. Describe in brief the main function of these technologies.

(6 marks)

(c) Construct the impedance diagram of the power system as depicted in Figure **Q1(c)** in per-unit basis. The three-phase load connected in parallel at Bus 4 absorbs 33 MVA, 0.85 power factor lagging at 10.8 kV. The Line 1 has line inductance of 208 mH, while Line 2 with 80 km long has an impedance of 0.5 + j1.2 Ω/km. Use 100 MVA and 22 kV on the generator G1 as a common base. The technical data of the components are given as follows:

G1 : 50 MVA, 22 kV, 50 Hz, Xs = 0.5 p.u.
G2 : 30 MVA, 21 kV, 50 Hz, R = 0.02 p.u., Xs = 0.18
T1 : 30 MVA, 22/110 kV, X = 6%
T2 : 25 MVA, 110/11 kV, X = 4%
T3 : Three single-phase of transformers, each rated at 10 MVA, 22/ 63.51 kV, X = 6%

(15 marks)

Q2 (a) Explain the main function of active and reactive powers in an electric motor.

(3 marks)

(b) An 11 kV RMS three-phase supply is applied to a balanced Y-connected three-phase load consisting of three identical impedances of 123 Ω with 0.80 lagging power factor. Taking the phase-to-neutral voltage V_{an} as reference, calculate,

(i) The phasor currents in each line

(7 marks)

(ii) The total active and reactive power supplied to the load

(3 marks)

(c) Three parallel three-phase loads are supplied from a 415 V RMS, 50-Hz three-phase supply. The loads are as follows:

- **Load 1**: A 10 HP motor, 92% efficiency, and 0.60 lagging power factor
- **Load 2**: A balanced resistive load that draws a total of 6 kW
- **Load 3**: A Y-connected capacitor bank with a total rating of 16 kVAr

(i) Analyse the total system active power (in kW), reactive power (in kVAr), power factor, and the supply current per phase

(7 marks)

(ii) Predict the system power factor and the supply current per phase when the capacitor bank is being switched off

(5 marks)

Q3 (a) Explain briefly the generation system, transmission system, and distribution system present in an electric power system using one-line diagram representation. Label the diagram clearly.

(6 marks)

(b) A 350 MW thermal power station consumes 160 tons of coal per hour when the station is delivering its full rated output. Assume the thermal efficiency of the station is 35% and electrical efficiency is 94%. Determine the coal calorific value in kcal/kg.

(4 marks)

(c) A 275 kV, 50 Hz three-phase transmission line has a per phase series impedance of $z = 0.03 + j\ 0.25\ \Omega$ per km and a per phase shunt admittance of $y = j\ 1.6 \times 10^{-6}$ Siemens per km. The line is 120 km long.

(i) Using the nominal *T* model, determine the transmission line *ABCD* constants

(7 marks)

(ii) Analyse the sending end voltage and current, voltage regulation, the sending end power and the transmission line losses when the line delivers 500 MW at 0.8 lagging power factor and at 95% of rated voltage

(8 marks)

Q4 (a) Define the meaning of swing bus in power flow analysis.

(3 marks)

(b) Figure **Q4(b)** depicts the one-line diagram of a simple three-bus power system with generation at bus 1. The scheduled load at bus 3 and the line impedances as marked on the diagram are given in per unit on a 200 MVA base. The line charging susceptances are neglected. Perform the Gauss-Seidal power flow analysis to find the followings:

(i) The new voltage angles and magnitudes of bus 2 and bus 3 after two (2) iterations [k=2]. Use the initial values, $V_2^{(0)} = 1.01\angle 0°$ pu and $V_3^{(0)} = 1.0\angle 0°$

(9 marks)

(ii) The total real and reactive power generated at slack bus

(2 marks)

(iii) The line flows for this system

(6 marks)

(c) Consider the radial system shown in Figure **Q4(c)**.

(i) Analyse the fault currents for faults at F_A, F_B, and F_C

(3 marks)

(ii) Propose relay settings for *R1* and *R2* on the basis of current grading, assuming a 15% relay error margin

(2 marks)

– END OF QUESTION –

FINAL EXAMINATION

SEMESTER/SESSION : I/ 2013/ 2014
COURSE NAME : POWER SYSTEMS/ ELECTRICAL POWER SYSTEM
PROGRAMME : 2 BEV/ BEE
COURSE CODE : BEF 25503/ BEE 3243/ BEX 32103

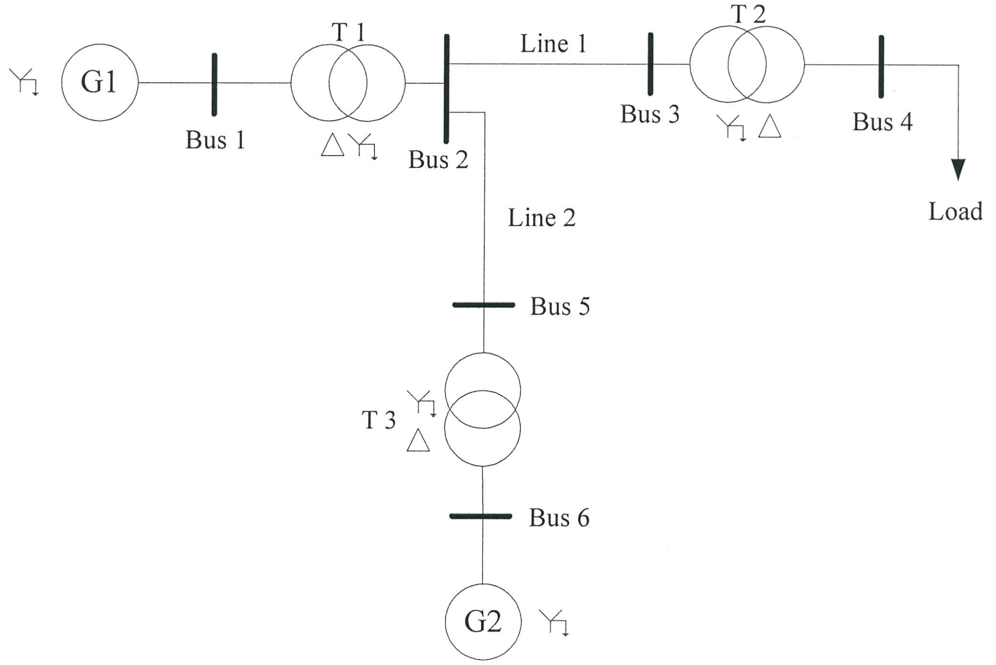

FIGURE Q1(c)

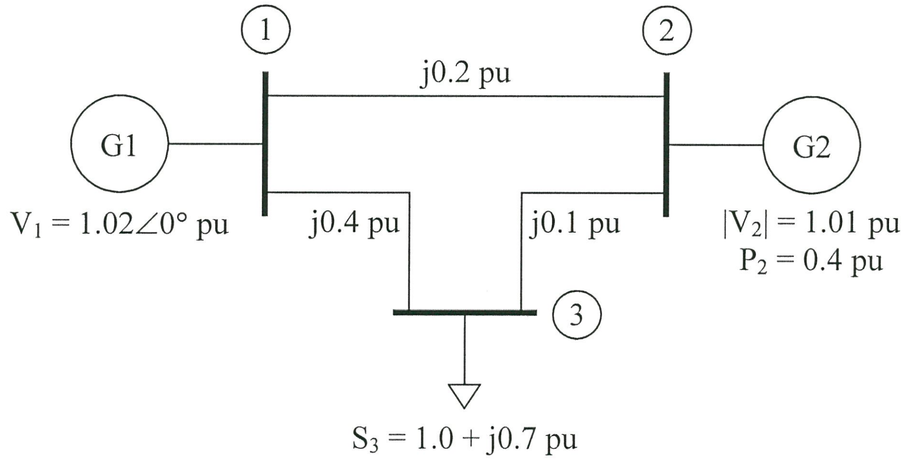

FIGURE Q4(b)

FINAL EXAMINATION

SEMESTER/SESSION : I/ 2013/ 2014
PROGRAMME : 2 BEV/ BEE
COURSE NAME : POWER SYSTEMS/ ELECTRICAL POWER SYSTEM
COURSE CODE : BEF 25503/ BEE 3243/ BEX 32103

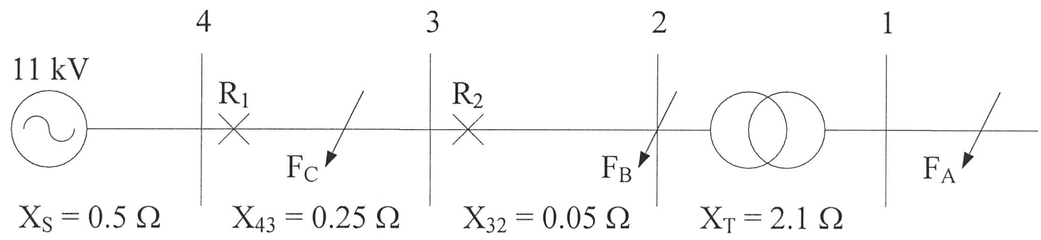

FIGURE Q4(c)

FINAL EXAMINATION

SEMESTER/SESSION : I/ 2013/ 2014 PROGRAMME : 2 BEV/ BEE
COURSE NAME : POWER SYSTEMS/ ELECTRICAL POWER SYSTEM COURSE CODE : BEF 25503/ BEE 3243/ BEX 32103

Formula:

Conversion of a given base per-unit impedance on a new base:

$$Z_{new(pu)} = Z_{old(pu)} \left(\frac{kV_{base(old)}}{kV_{base(new)}} \right)^2 \left(\frac{MVA_{base(new)}}{MVA_{base(old)}} \right)$$

Nominal T model:

$$V_S = 1 + \frac{YZ}{2} V_R + Z + \frac{Z^2 Y}{4} I_R$$

$$I_S = YV_R + 1 + \frac{ZY}{2} I_R$$

Gauss Seidal power system analysis:

$$Q_i^{(k+1)} = -\operatorname{Im} g \left\{ V_i^{*(k)} \left[V_i^{(k)} \sum_{j=0}^{n} y_{ij} - \sum_{j=1}^{n} y_{ij} V_j^{(k)} \right] \right\} \qquad j \neq i$$

$$V_i^{(k+1)} = \frac{\dfrac{P_i^{sch} - jQ_i^{sch}}{V_i^{*(k)}} + \sum_{j=1}^{n} y_{ij} V_j^{(k)}}{\sum_{j=0}^{n} y_{ij}} \qquad j \neq i$$

$I_{ij} = yi_j(V_i - V_j)$ and $I_{ji} = -I_{ij}$

$S_{ij} = V_i I_{ij}^*$ and $S_{ji} = V_j I_{ji}^*$

$S_{Lij} = S_{ij} + S_{ji}$