The Open University of Sri Lanka
Bachelor of Technology Honours in Engineering
Final Examination 2016/2017
ECX5332 – Power systems II
Duration Three Hours

Date: 09th November 2017 ***Time: 0930-1230***

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*This paper consists of six questions. Answer **ANY FIVE** questions. All questions carry equal marks.*
Graph papers and log-log papers will be available on your request
Show your work

Question 1

A synchronous generator is delivering power of 0.4 p.u. to an infinite bus through the transmission line as shown in figure Q1. Transmission line has 0.35 p.u. reactance. The generator has following parameters: X_d= 1.2 p.u. , H= 5 MJ/MVA, f=50 Hz

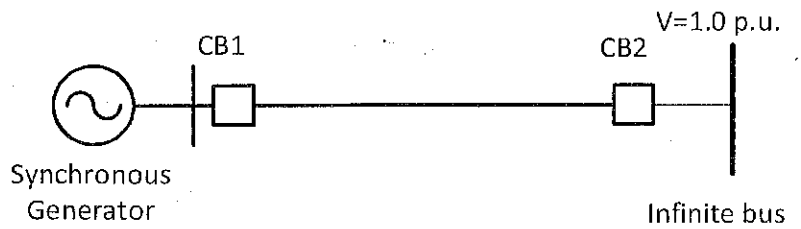


Figure Q1

At time t=0 the circuit breakers (CB1, CB2) open and reclose after t=T. Assuming that the excitation voltage of the generator is 1.8 p.u

a. Calculate critical clearing angle [7 marks]
b. Determine maximum value for T (T_{max}) [6 marks]
c. Derive analytical expression for maximum swing angle δ when T= 0.8 T_{max} [7 marks]

Question 2

A power plant is connected to a load center via three-phase 600 km, 750 kV, 50 Hz transmission line. Series impedance and shunt admittance of the line are (0.02 + j0.32) Ω/km and is j5x10^{-6} S/km respectively. The line delivers 1800 MVA at 0.8 power factor lagging. Voltage at the receiving end is 95% of the rated value.

a. Calculate ABCD constants of the line [10 marks]
b. Determine sending end voltage and current. [10 marks]

Question 3

Consider a single line diagram of a power systems shown in figure Q3. Line impedances are marked in per unit on 100 MVA base.

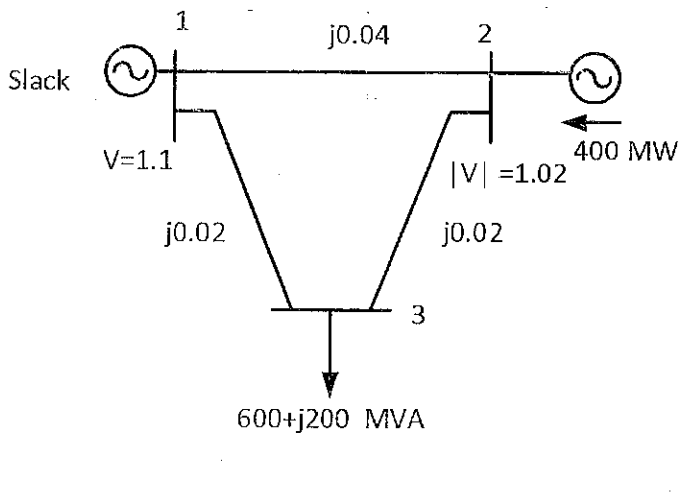


Figure Q3

a. Calculate voltage at buses using Gauss-Seidel method. Two iterations are sufficient [15 marks]

b. Determine the slack bus power and power factor. [5 marks]

Question 4

a. Consider single line diagram of a power system shown in figure Q4. Newton-Raphson method is to be used to solve the system.

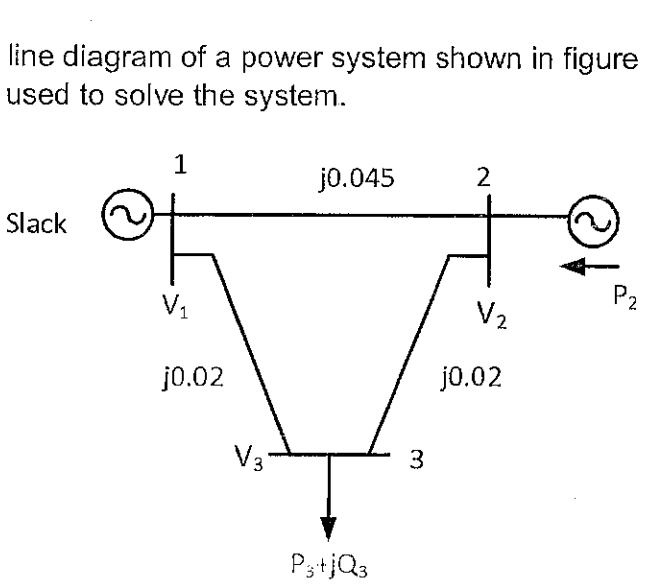


Figure Q4

(i) Write the equations for real (P3) and reactive (Q3) power at bus 3 [4 marks]

(ii) Write the elements of following matrices (full expression for the elements of J is not required)

$$[J]\begin{bmatrix}\Delta\delta\\ \Delta V\end{bmatrix}=\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix}$$

[8 marks]

(iii) Write the full expression for the first element of Jakobian matrix J_{11}

[2 marks]

b. In decoupled load flow calculation, two blocks of Jakobaian matrix are made zero.
   I. What are these two blocks? [2 marks]
   II. What is the justification of making these two blocks zero? [4 marks]

Question 5

A power station consisting two units delivers power to a load. The variation of load throughout a day is shown in figure Q5. Minimum and maximum power limits of the units are 10 MW and 60 MW each.

The cost functions of units are given bellow:

$C1 = 1.7\,P_1^2 + 750\,P_1 + 1200$ Rs/hr

$C2 = 1.2\,P_2^2 + 600\,P_2 + 1500$ Rs/hr

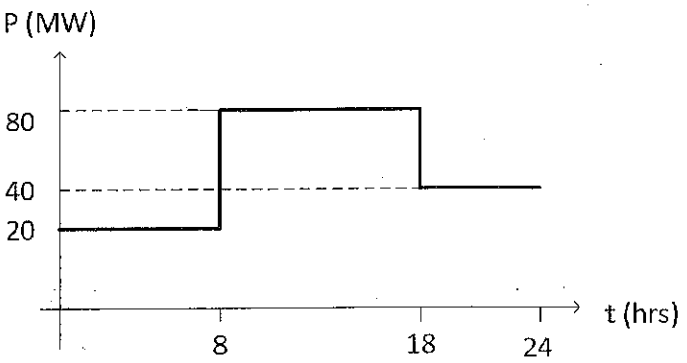


Figure Q5

Calculate

a. Incremental fuel cost of each unit [4 marks]
b. Optimum power load sharing between the units [12 marks]
c. Saving per day, if both units share the load optimally, instead of sharing them equally.

[4 marks]

Question 6

a. Briefly describe the main reasons for having a protection system in power network.

[3 marks]

b. A three-phase transformer is rated at 100 MVA, 220 kV/500 kV. Both primary and secondary windings are connected in star. The transformer is protected by a differential relay. CT ratio of the low voltage is 3000: 5 A.

I. Draw the circuit diagram [5 marks]

II. Determine the CT ratio at the high voltage side of the transformer (rated current of the secondary side of the CT should be 5A). [5 marks]

c. An induction cup type over current relay rated at 5A, 2.2 s is installed at a circuit breaker's location. Characteristic of the relay is shown in figure Q6. The pick-up value is set 125% and TMS is equal to 0.7. Calculate the operating time of the relay, when the fault current is 3.5 kA. Assume that the CT ratio is 400 : 5 [7 marks]

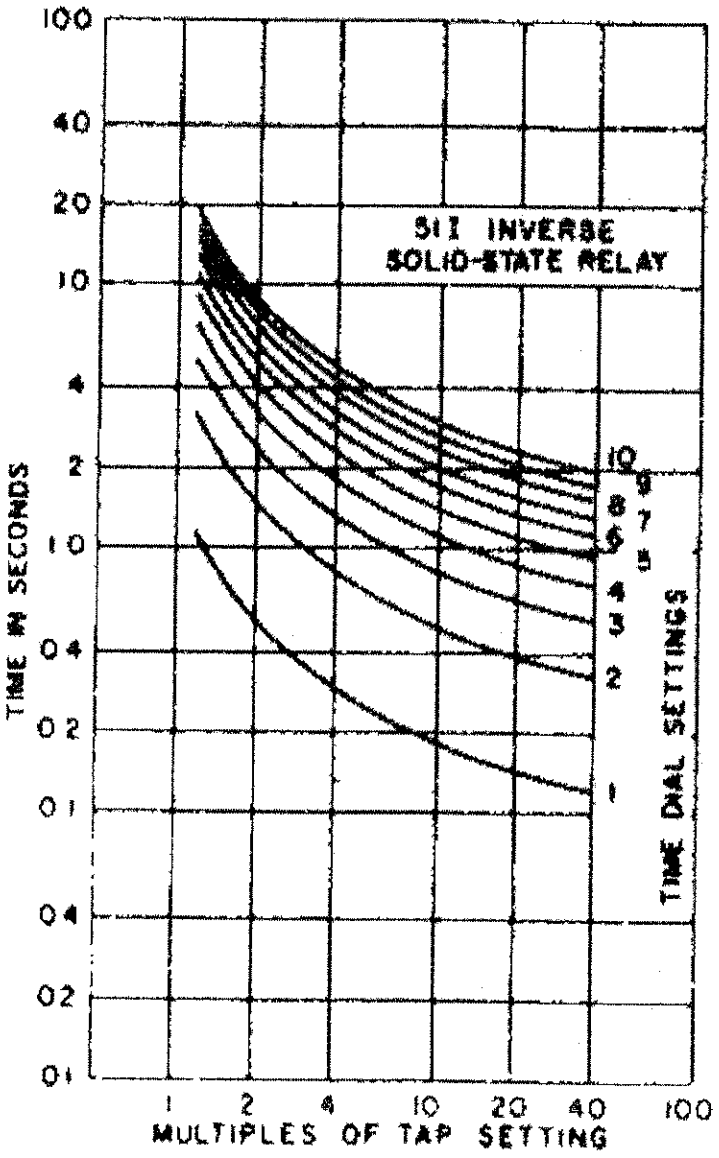


Figure Q6