Ref.: EX/EE/T/414E/2019

B. ELE. ENGG. 4TH YEAR 1ST SEMESTER EXAMINATION 2019

ADVANCED POWER SYSTEM ANALYSIS

Time: Three hours | Full Marks: 100

(50 marks for each part)
Use separate answer script for each part.

PART I

Answer **any two** questions.
Figures in the margin indicate full marks
All the symbols used have their usual significance

1.(a) Mentioning the proper reasons discuss how the synchronous machines and loads are modeled in classical transient stability. Write down the load flow equations in the form suitable for such study. Give proper explanation why this form is required. (10)

(b) What are the limitations of second order machine models for longer duration transient stability study? With proper reasons mention what model of synchronous machine you suggest to overcome those limitations? With the help of a vector diagram show the relation between the internal and terminal voltages and currents for that model. (10)

(c) Show the transfer function model of IEEE type-I excitation system. From the transfer function model develop a differential equation model of the excitation system in a form suitable for incorporating it in transient stability study. (5)

2.(a) From the following pre-fault operating data (p.u.) for a synchronous machine of a 50 Hz power system, calculate the initial values for all the variables necessary for transient stability study when the machine is i) not equipped with excitation control ii) equipped with static excitation controller iii) equipped with rotating excitation system. (12)

$V = 1.025\angle 9.3°$, $P = 1.63$, $Q = 0.62$

Machine parameters (p.u.): $x_d = 0.8958$, $x_d' = 0.1198$, $x_q = 0.8645$

Static Excitation System parameters: $K_A = 20$, $T_A = 0.2$ sec.

Rotating Excitation System parameters:

$K_A = 20$, $T_A = 0.2$ sec., $K_E = 1.0$, $T_E = 0.314$ sec., $K_F = 0.063$, $T_F = 0.35$ sec.

$SE = 0.0039e^{1.55E_{fd}}$

(b) Derive the generalised expression for fault current (in sequence quantities) in a 3-phase power system with the fault taking place at the k-th bus when (13)

(i) fault impedance matrix is to be used
(ii) fault admittance matrix is to be used

and hence, deduce the expression for the fault current for a 3-phase fault at the k-th bus.

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3 (a) Develop the fault impedance or admittance (as applicable) matrix in phase quantities for a double line to ground fault in a power system. (5)

(b) The partial Z_{bus} of a power system is as follows: (20)

$$Z_{bus} = j\begin{bmatrix} 0.25 & 0 \\ 0 & 0.25 \end{bmatrix}$$

With necessary derivation obtain the new Z_{bus} when the network is augmented first by connecting bus 2 to a new bus 3 by a branch having impedance of j0.10 and then by connecting bus 3 to bus 1 by a branch of impedance j0.20. All the impedances are in p.u.

Ref.: EX/EE/T/414E/2019

B. E. ELECTRICAL ENGG. 4TH YEAR 1st SEMESTER EXAMINATION 2019

ADVANCED POWER SYSTEM ANALYSIS

Time: Three hours Full Marks: 100

(50 marks for each part)
Use separate answer script for each part.
PART II
Figures in the margin indicate full marks

Answer part (a) or part (b)

(a).
(i) Discuss the necessity of load flow analysis in Power System. (3)

(ii) Discuss the basis of classification of Power System buses for load flow analysis. (4)

(iii) Why P-V buses are to be treated specially in the solution algorithm of the load flow problem? Also, discuss the steps to be performed for a P-V bus. (3+4)

(iv) In the single line diagram of a part of a Power system, buses connected to bus **i** are shown in Fig. 1. Voltage of bus **j and m** are regulated through excitation control of the generators. A load is connected at bus **i**. Write expressions for the diagonal elements of the Jacobian matrix of the Newton-Raphson load flow for bus **i** in terms of the load flow variables and system admittance matrix. Use conventional notations wherever necessary. (6)

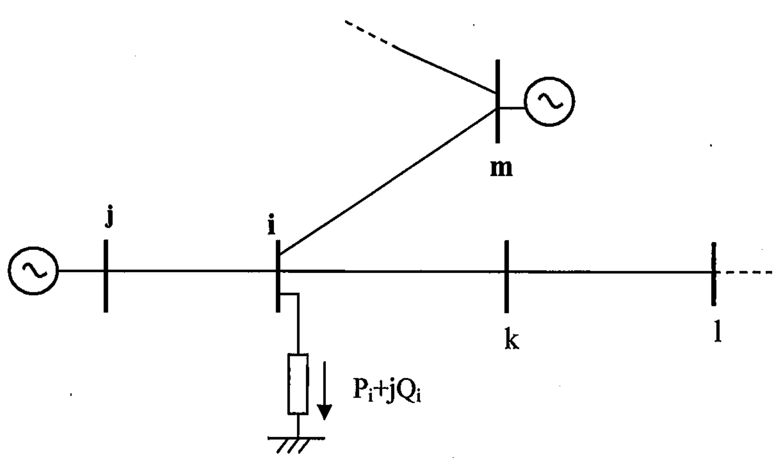

Fig. 1.

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(b).

(i) Between the Newton-Raphson and Fast decoupled load flow which algorithm, you think, should have better convergence? Why? (1+4=5)

(ii) Discuss the solution algorithm of the Fast Decoupled load flow. (7)

(iii) In the single line diagram of a part of a Power system, buses connected to bus **i** are shown in Fig. 1. Voltage of bus **j** and **m** are regulated through excitation control of the generators. A load is connected at bus **i**. Write expressions for the non-zero elements of the Jacobian matrix of the Fast Decoupled load flow for bus **i** in terms of the load flow variables and system admittance matrix. Use conventional notations wherever necessary. (8)

2. Answer **any two** questions from the following parts.

(i) Discuss the importance of the Economic dispatch problem in Power system operation. (4+6)
Explain the computational steps needed for solving the Economic dispatch problem.

(ii) Derive expressions for the transmission loss coefficients in terms of the active power outputs of the generators. Comment on the assumptions made in the process of derivation. (6+4)

(iii) Why the Unit commitment problem has to be solved well ahead of actual operation of the units? How various constraints are satisfied when priority order approach is used for solving the Unit commitment problem? Differentiate between the start up costs when the units are kept in banking and the units are allowed to cool down. (3+3+4)

3. Answer part (a) or part (b)

a. (i) Why frequency control of two area Power system needs the control of tie line power flow as well? (3)

(ii) How tie line is modeled for frequency control analysis? (7)

b. (i) From the view point of frequency control, what is the advantage of interconnecting two power system areas? (3)

(ii) Two Power system areas A and B are interconnected through a tie line. Governor droop and Load damping for both the areas are 4 Hz/p.u MW and 0.01 p.u. MW/Hz respectively based on the respective capacities of the areas. A load increase of 50 MW takes place in area A. Find the changes in tie line power flow and steady state frequency. Nominal frequency of operation is 50 Hz. Capacities of areas A and B are 5 GW and 10 GW respectively. (7)