B. POWER 3RD YR. 2ND SEMESTER EXAMINATION, 2017

ELECTRICAL MACHINES AND POWER CONTROL

Time: 3Hrs.

Full Marks: 100

Part I (70 marks)

Use separate answer scripts for each part / Answer any four questions

(2 marks for neatness)

1. Figure 1 shows the one line diagram of a three bus power system with generation at buses 1 and 3. The voltage at bus 1 is $V_1 = 1.025\angle 0°$ pu. The voltage magnitude at bus 3 is fixed at 1.03 pu with a real power generation of 300 MW. A load consisting of 400 MW and 200 MVAR is taken from bus 2. Line impedances are marked in per unit on a 100 MVA base. Line resistances and line charging susceptances are neglected. Use Gauss-Seidel method and initial estimates $V_2^{(0)} = 1.0 + j0.0$ and $V_3^{(0)} = 1.03 + j0.0$, calculate V_2 and V_3. 17

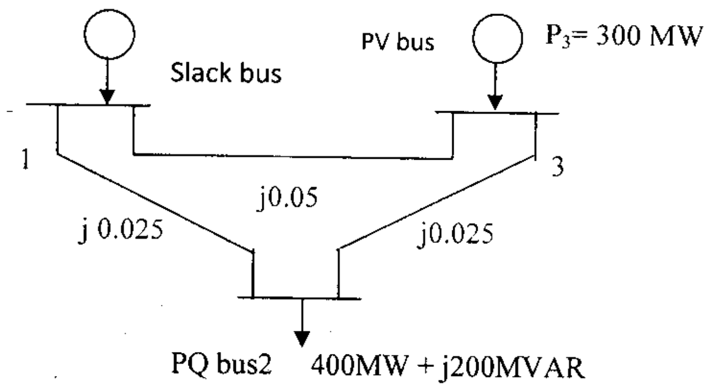

Figure 1

2. a) Derive the swing equation. Define inertia constant. 5

b) A three phase fault occurs at point 'F' in the power system shown below. Find the critical clearing angle for clearing the fault with simultaneous opening of the breakers on either side of the fault on the faulty line. The generator is delivering 1.0 pu power during pre-fault condition. 10

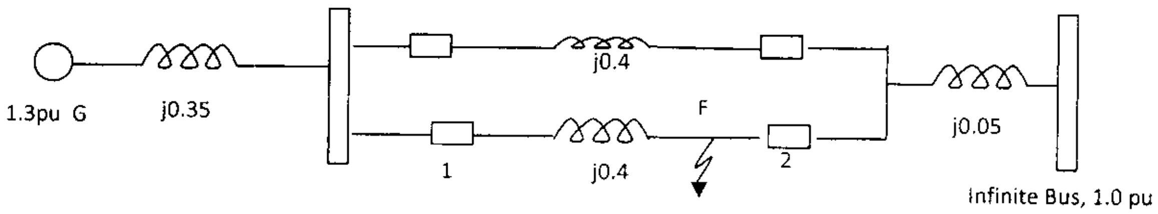

Figure 2

c) Discuss why an early fault clearing means better chances of maintaining system stability. 2

3. a) Draw the complete block diagram of load frequency control of an isolated power system and obtain the expression for steady state change in the system frequency for a sudden change in load demand. Also draw the steady state load –frequency characteristic of a speed governor system. 7

b) Two generating units rated 250MW and 400 MW have governor speed regulation of 5.0 and 5.4 percent, respectively, from no load to full. They are operating in parallel and share a load of 450 MW. Assuming free governing action, determine the load shared by each unit. 10

4. a) The incremental costs of production of three generating units are given as follows:

$IC_1 = 0.012P_1 + 8.4, \quad 100 \le P_1 \le 600$ MW; $\quad IC2 = 0.012P_2 + 8.930 \quad 60 \le P_2 \le 300$ MW; $IC_3 = 0.008P_3 + 6.78, 300 \le P_3 \le 650$ MW. Allocate a total load of 550MW optimally amongst the three units. Assume the initial value of $\lambda = 9.0$. Derive the formula used. 8+6

b) Describe the need of economic dispatch. 3

5. a) The incremental fuel costs for two units of a plant are 10

$$\lambda_1 = \frac{dC_1}{dP_{G1}} = 0.012P_{G1} + 9.0\,;\ \lambda_2 = \frac{dC_2}{dP_{G2}} = 0.008P_{G2} + 10$$

where C is in dollars per hour ($/hr) and P_G is in megawatt (MW). If both units operate at all times and maximum and minimum loads on each unit are 500 and 100 MW, respectively, plot λ of the plant in $/MWh versus plant output in MW for economic load dispatch as total load varies from 250 to 1000 MW.

b) Explain the automatic voltage control loop for regulation of system voltage magnitude in power system using block diagram. 7

6. Write short notes on any two of the followings: 2×8.5
   a. Different methods of voltage control in interconnected power system
   b. Unit commitment
   c. Equal area criterion

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Bachelor of Power Engineering 3rd year 2nd Semester Examination 2017

Electrical Machine and Power Control

FM: 100

Time: 3 Hours

PART II

Answer **any three** of the following:

Q1(a). Draw the block diagram of the closed loop slip control of current source inverter drive with regenerative braking? 03

Q1(b). A 440V, 50Hz, 4 pole, 1415 rpm and delta connected squirrel-cage induction motor has the following parameters:

$R_S = 0.6\Omega$, $R_R` = 0.8\Omega$, $X_S = 0.5\Omega$, $X_R` = 0.6\Omega$ and $X_M = 15\Omega$

Motor is fed from a current source inverter at a constant flux. Determine:

(i) Motor torque, speed and current when operating at 40Hz and rated slip speed.
(ii) Inverter frequency and stator current for the rated motor torque and a motor speed of 1000rpm

Assuming the speed-torque characteristics to be parallel straight lines in the region of interest, calculate

(iii) Motor speed when operating at 40Hz and 80% of rated motor torque
(iv) Motor speed when operating at 30Hz and the braking torque equal to the rated motor torque. 07

Q2(a). What are the different VSI controlled inductor motor drive? 03

Q2(b). A 3-phase, delta-connected, 6 pole, 50Hz, 400V, 925rpm, squirrel-cage induction motor has the folloing parameters:

$R_S = 0.2\Omega$, $R_R` = 0.3\Omega$, $X_S = 0.5\Omega$, $X_R` = 1\Omega$

The motor is fed from a voltage source inverter with a constant V/f ratio from 0 to 50Hz and constant voltage of 400V above 50Hz frequency.

(i) Determine the breakdown torque for a frequency of 100Hz as a ratio of its value at 50Hz.
(ii) Also obtain the torque at the rated motor current and 75Hz as the ratio of rated full-load torque of the motor.
(iii)Calculate the motor torque at 30Hz and a slip-speed of 60rpm. 07

Q3(a). How chopper control of separately excited dc motor is performed? 03

Q3(b). A 230V separately excited dc motor takes 50A at a speed of 800rpm. It has armature resistance of 0.4Ω. This motor is controlled by a chopper with an input voltage of 230V and a frequency of 500Hz. Assuming continuous conduction throughput; calculate the plot speed-torque characteristics for:

(i) Motoring operation at duty ratios of 0.3 and 0.6.
(ii) Regenerative braking operation at duty ratio of 0.7 07

Q4(a). How full single phase rectifier control of d.c separately excited motor is performed? 03

Q4(b). A 200V, 875rpm, 150A separately excited dc motor has an armature resistance of 0.06Ω. It is fed from a single phase fully controlled rectifier with an ac source voltage of 220V, 50Hz. If the armature circuit inductance of motor of the drive be 0.85mH, calculate the motor torque for

(i) $\alpha = 60^0$ and speed = 400 rpm.

Now external inductance of 2mH is added to the armature circuit to reduce the region of discontinuous conduction. Calculate the torque for

(i) $\alpha = 120^0$ and speed = - 400 rpm.
(ii) $\alpha = 120^0$ and speed = - 600 rpm. 07

Q5. Write short notes on <u>any four</u> of the following: (2.5 X 4)

(a) Classes of motor duty;
(b) Current limit control of motors
(c) Closed loop speed control of multi-motor drives
(d) Regenerative and dynamic braking of dc motors
(e) Speed control of induction motor by rotor voltage injection
(f) Controlled rectified fed DC drives