**III B.Tech II Semester Supplementary Examinations,**
**November/December 2005**
**MODELLING OF POWER SYSTEM COMPONENTS**
**(Electrical & Electronic Engineering)**

**Time: 3 hours** **Max Marks: 80**

**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. (a) Define the following terms with suitable example:
   i. tree
   ii. branches
   iii. Links
   iv. co-tree
   v. loop
   (b) Write the relation among the number of nodes, number of branches, number of Links and number of elements.
   (c) For the graph given in figure 1 below, draw the tree and the corresponding co-tree. Choose a tree of your choice, and hence write the cutset schedule.

[5+2+9]

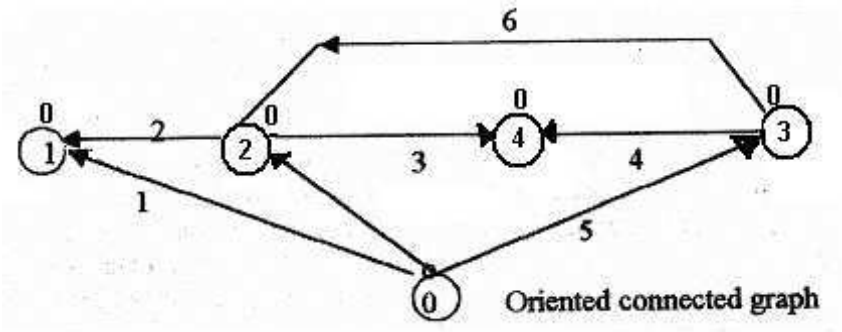


Figure 1:

2. (a) Derive the expression for the loop impedance $Z_{loop}$ using singular transformation in terms of primitive impedance matrix z and the basic loop incidence matrix C.
   (b) Derive an expression for $Z_{loop}$ for the oriented graph shown in Figure 2 below.

[8+8]

3. (a) Explain why inverse technique is not suitable for predetermination of $Z_{Bus}$ from $Y_{Bus}$ of a large power system.
   (b) The $Z_{Bus}$ matrix for the network shown Figure 3 below is found to be $Z_{Bus} = \begin{bmatrix} j0.183 & j0.078 & j0.141 \\ j0.078 & j0.148 & j0.106 \\ j0.141 & j0.106 & j0.267 \end{bmatrix}$. The line between busses 1 and 3 with

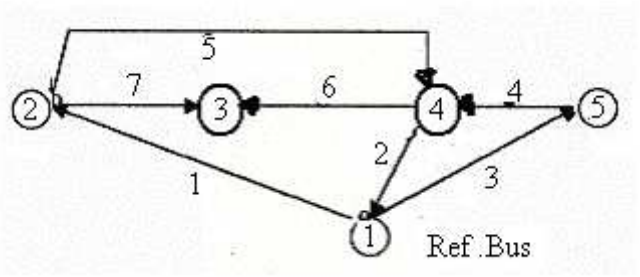


Figure 2:

$Z_{13}$=j0.56 is removed by the simultaneous opening of CBs at both ends of the line. Determine $Z_{Bus}$ new matrix. [4+12]

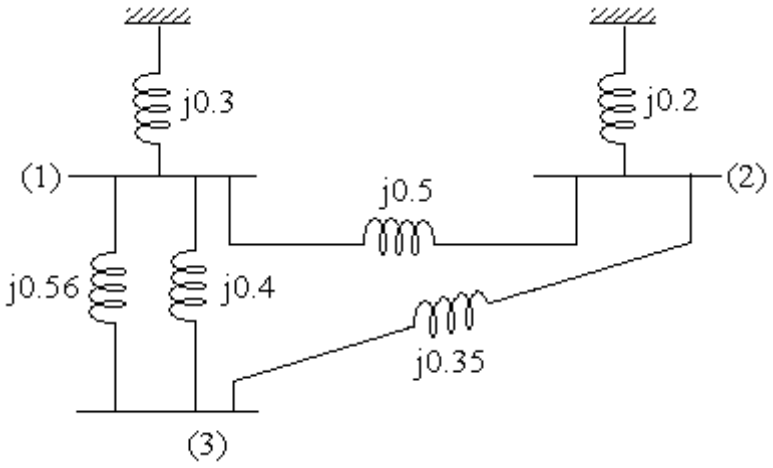


Figure 3:

4. In a four bus system, a generator connected to bus- 3 and a motor connected to bus-4 having reactance equal to 0.15 pu are connected through their respective transformers having$X_T$= 0.1 pu. Generated e.m.f. of generator connected to bus-3 is 1.25 $\angle 0^0$ and internal voltage of motor is 0.85 $\angle -45^0$. Line reactances connecting buses are $X_{31} = X_{23} = 0.25pu, X_{21} = 0.125pu, X_{24} = 0.2pu, X_{14} = 0.4$ pu. Develop the nodal admittance matrix for each of the network branches and then write the nodal admittance equations of the system. [16]

5. (a) Explain the primitive network three phase representation of a component in impedance form.
   (b) Show that for a stationary element, the phase impedances matrix of a component is diagonalised using symmetrical component transformation.
   (c) Define the bus incidence matrix of a Power system network whose graph is shown in figure 4. [6+6+4]

6. A synchronous generator is connected to an infinite bus through a transmission line. Neglecting the resistances draw the phasor diagram and derive the

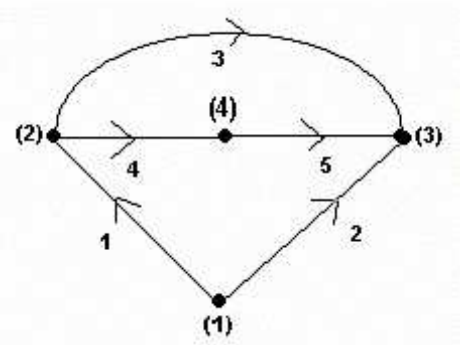


Figure 4:

(a) Relation between active power and power angle.

(b) Relation between reactive power and power angle. [8+8]

7. (a) Develop the mathematical model of hydraulic value actuator in speed governing system.

   (b) Two generators rated 200Mw and 400Mw are operating in parallel. The droop characteristics of their governors are 4% and 6% respectively from no-load to full-load. Assuming that the generator are operating at 50Hz, how a load of 500Mw be shared between them. [8+8]

8. (a) Explain about the various performance requirements of excitation system.

   (b) Explain the elements of an excitation system. [8+8]

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   (c) For the graph given in figure 1 below, draw the tree and the corresponding co-tree. Choose a tree of your choice, and hence write the cutest schedule. [5+2+9]

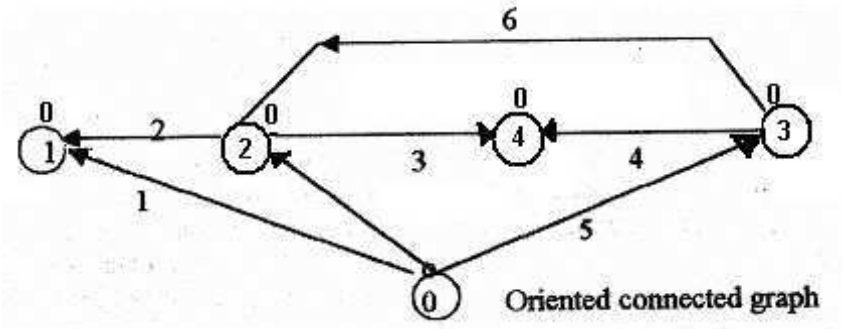


Figure 1:

2. (a) Derive the expression for the loop impedance $Z_{loop}$ using singular transformation in terms of primitive impedance matrix z and the basic loop incidence matrix C.
   (b) Derive an expression for $Z_{loop}$ for the oriented graph shown in Figure 2 below. [8+8]

3. Describe the procedure of modification of Zbus by adding mutually coupled branch from existing buses (p) and (k). [16]

4. (a) Write a detail note on tap-changing and regulating transformer.
   (b) Explain the necessity of transformer modelling for power system studies. [10+6]

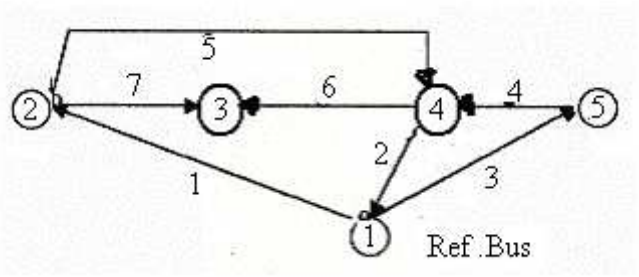


Figure 2:

5. (a) For the power system network shown Figure 3 obtain bus incidence matrix in three phase representation.

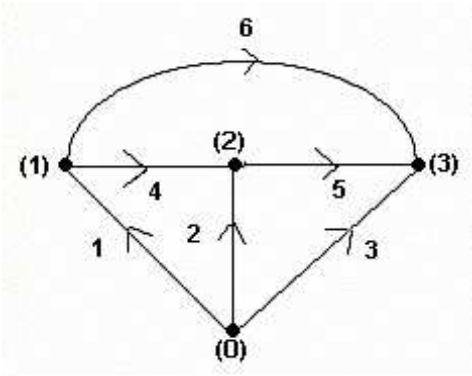


Figure 3:

(b) Find the sequence impedance matrix of an element whose phase component impedance matrix is: [8+8]

$$\left[z_{pq}^{abc}\right] = \begin{bmatrix} j0.5 & j0.2 & j0.1 \\ j0.1 & j0.7 & j0.4 \\ j0.2 & j0.3 & j0.8 \end{bmatrix}$$

Derive the formula used.

6. Clearly explain how a synchronous generator is modeled for steady state analysis. Draw the phasor diagram and obtain the power angle equation for a non salient pole synchronous generator connected to an infinite bus. Sketch the power angle curve. [16]

7. (a) Develop the mathematical model of hydraulic value actuator in speed governing system.

(b) Two generators rated 200Mw and 400Mw are operating in parallel. The droop characteristics of their governors are 4% and 6% respectively from no-load to full-load. Assuming that the generator are operating at 50Hz, how a load of 500Mw be shared between them. [8+8]

8. Describe the various blocks of IEEE Type-1 excitation system and develop the mathematical model of the system. [16]

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Code No: RR320203 **Set No. 3**

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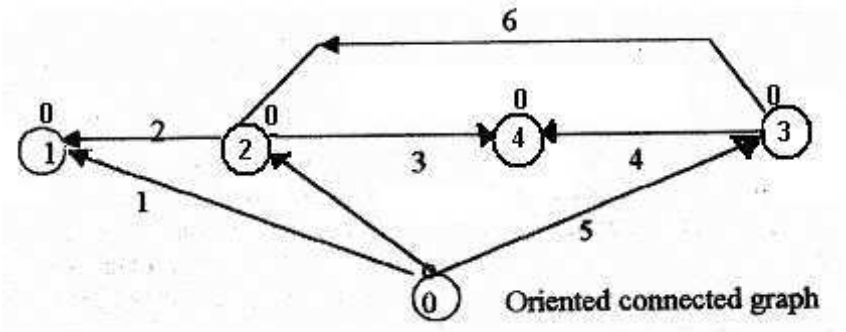


Figure 1:

2. Derive the expressions for Bus admittance and impedance matrices by singular transformation. [16]

3. Describe the procedure of modification of existing Zbus by adding branch from new bus (p) to ref node, from new bus (p) to existing bus (k) , form existing bus (k) to ref node and between existing buses (j) and (k). [16]

4. (a) Write a detail note on tap-changing and regulating transformer.
   (b) Explain the necessity of transformer modelling for power system studies. [10+6]

5. (a) Explain the primitive network three phase representation of a component in impedance form.

(b) Show that for a stationary element, the phase impedances matrix of a component is diagonalised using symmetrical component transformation.

(c) Define the bus incidence matrix of a Power system network whose graph is shown in figure 2. [6+6+4]

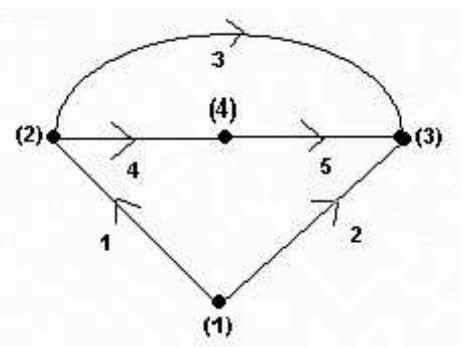


Figure 2:

6. (a) Derive the relation between, Angular momentum, kinetic energy and the inertia constant of a synchronous generator.

(b) A 50 Hz 4 pole Turbo generator rated 25 MVA, 11 KV has an inertia constant of H=9.00 KJ/KVA. Find the kinetic energy stored in the rotor at synchronous speed. Determine the acceleration if the input less the rotational losses is 25000 HP and the electrical power developed is 15 MW. If the acceleration computed for the generator is constant for a period of 10 cycles, determine the change in Torque angle in that period and the rpm at the end of 10 cycles. Assume no accelerating torque before 10 cycle period begins. [6+10]

7. (a) Develop the mathematical model of primary and secondary Control Loops and derive the transfer functions of each block.

(b) Determine the primary Automatic load frequency control loop parameters for the following system data:

| | | |
|---|---|---|
| Total rated area capacity | = | 2000 Mw |
| Normal operating load | = | 1000 Mw |
| Inertia constant | = | 5 sec. |
| Regulation | = | 2.4 hz/ p.u. Mw |

Assume load frequency depending is linear. [10+6]

8. Explain the functional blocks of Automatic voltage regulator. [16]

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1. (a) The rows of the bus incidence matrix A are arranged according to a particular tree and the matrix A is partitioned into sub matrices $A_b$ of dimension b × ( n-l) and $A_1$ of dimensions l × (n-l) , where the rows of $A_b$ correspond to branches and rows of $A_1$ correspond to links. Figure 1Show the above partitions for the matrix A, for the following sample network. Also form the element node incidence matrix $\hat{A}$.

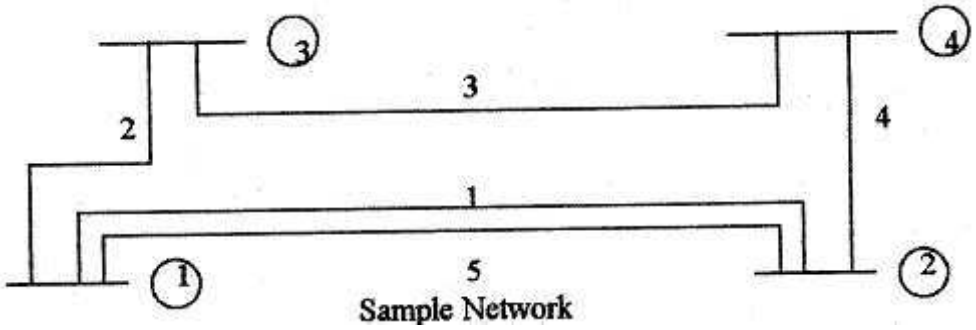


Figure 1:

(b) For the oriented connected graph obtain the Bus incidence matrix A, Branch path incidence matrix K and basic cut-set matrix B. Figure 2 [8+8]

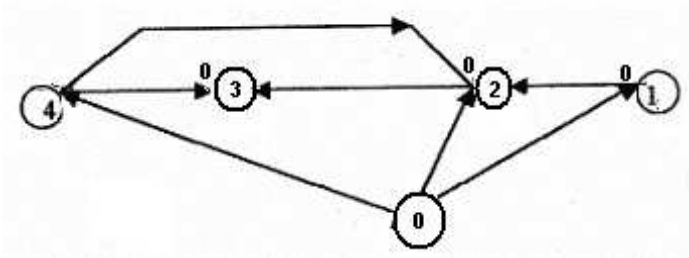


Figure 2:

2. (a) For the network shown below, draw its graph and mark also a tree. Give the total number of edges (i.e. elements), nodes, buses and branches for this graph. Write also its nodal equations and determine the elements of $Y_{Bus}$ matrix directly by inspection.

(b) For the same network, write the loop equations and hence determine the elements of $Z_{loop}$ matrix directly by inspection. Values shown are currents & admittances Figure 3 [12+4]

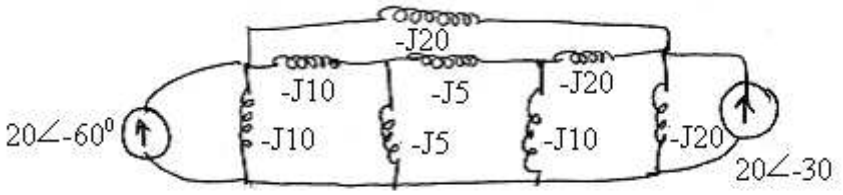


Figure 3:

3. How do you modify Zbus by adding mutually coupled Zbus between existing bus (p) to new bus (q)? Describe the algorithm by giving suitable example. [4+8+4]

4. In a four bus system, a generator connected to bus- 3 and a motor connected to bus-4 having reactance equal to 0.15 pu are connected through their respective transformers having$X_T$= 0.1 pu. Generated e.m.f. of generator connected to bus-3 is 1.25 $\angle 0^0$ and internal voltage of motor is 0.85 $\angle -45^0$. Line reactances connecting buses are $X_{31} = X_{23} = 0.25pu, X_{21} = 0.125pu, X_{24} = 0.2pu, X_{14} = 0.4$ pu. Develop the nodal admittance matrix for each of the network branches and then write the nodal admittance equations of the system. [16]

5. Develop the expressions for formation of $Z_{BUS}$ in three phase network representation for the element which is added between an existing bus and a bus being created. [16]

6. A synchronous generator is connected to an infinite bus through a transmission line. Neglecting the resistances draw the phasor diagram and derive the

   (a) Relation between active power and power angle.

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