CBCS SCHEME

USN [| | | | | | | | |]

15EE71

Seventh Semester B.E. Degree Examination, Dec.2019/Jan.2020
Power System Analysis – II

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Define the following with simple examples:
(i) Tree
(ii) Element bus incidence matrix **(04 Marks)**

b. Explain how buses are classified for load flow study. **(06 Marks)**

c. Obtain Y_{bus} by singular transformation method for the system having following data. Take bus 4 as ref bus

Element No.	1	2	3	4	5
Bus code (p-q)	1-2	2-3	3-4	1-4	2-4
Admittance (pu)	2	1.5	3	2.5	4

(06 Marks)

OR

2 a. What is primitive network? Obtain admittance form of primitive network. **(04 Marks)**

b. Explain the method of Y_{bus} by singular transformation. **(06 Marks)**

c. For the system shown in Fig.Q2(c) obtain solution of voltage and angles of bus 2 and 3 at the end of one iteration. Using Gauss-Seidel load flow method. Use flat start. Line data is in impedance form.

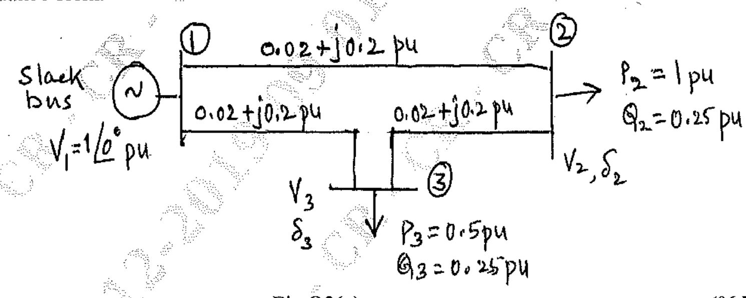


Fig.Q2(c) **(06 Marks)**

Module-2

3 a. What are Jacobian elements? Obtain Jacobian elements for basic equations for J_1 and J_3 only. **(04 Marks)**

b. Give the algorithm for Newton-Raphson (NRLF) load flow. **(06 Marks)**

c. Explain any two methods of control of voltage profile. **(06 Marks)**

OR

4 a. Explain the control of voltage by Tap changing transformer. **(04 Marks)**

b. Draw a flow chart for Fast Decoupled Load Flow (FDLF) method. **(06 Marks)**

c. Compare load flow methods with standard features. **(06 Marks)**

Module-3

5 a. Explain the followings:
(i) Input-output curve
(ii) Heat rate curve
related to thermal plants **(04 Marks)**

b. Define Unit Commitment. Explain Dynamic programming method of Unit Commitment solution. **(06 Marks)**

c. With the help of two state model of generator derive probability of availability and unavailability in terms of failure rate and repair rate. **(06 Marks)**

OR

6 a. The fuel input per hour of plant 1 and plant 2 are given by,
$F_1 = 0.2P_1^2 + 40P_1 + 120$ RS/Hr $\quad F_2 = 0.25P_2^2 + 30P_2 + 150$ RS/Hr
Determine the economic scheduling neglecting the losses for a load of 180 MW. Also calculate cost of production of 180 MW for the obtained schedule. **(04 Marks)**

b. Obtain transmission line loss coefficients interms of plant generation capacities for two units delivering a load. **(06 Marks)**

c. Obtain economic scheduling for a system having transmission line losses and no limits on generators. **(06 Marks)**

Module-4

7 a. Explain the followings:
(i) Loss of Load Probability (LOLP)
(ii) Frequency and duration of state (FAD) **(04 Marks)**

b. Explain hydro-thermal scheduling in brief with the mathematical formula. **(06 Marks)**

c. With the help of Bath tub curve, explain different failures in a system and initiatives to reduce the failures. **(06 Marks)**

OR

8 a. List and explain advantages of maintenance scheduling. **(04 Marks)**

b. Explain system security states with a block diagram. **(06 Marks)**

c. Explain the followings:
(i) Generation shift distribution factor
(ii) Line outage distribution factor **(06 Marks)**

Module-5

9 a. Explain the Z_{build} algorithm for a link addition to the partial network with no mutual coupling. **(08 Marks)**

b. Explain solution of swing equation by Runge-Kutta order 4 method. **(08 Marks)**

OR

10 a. Obtain Z_{bus} by Z_{build} technique for the system shown in Fig.Q10(a). All values are in pu (impedance). Take bus '0' as reference bus. Add the elements in the order ref bus to bus 1, ref bus to bus 2 and lastly bus 1 to bus 2.

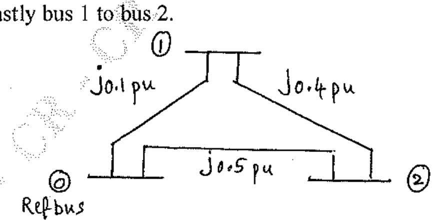


Fig.Q10(a) **(08 Marks)**

b. Explain solution of swing equation by point by point method. **(08 Marks)**

* * * * *

Solutions

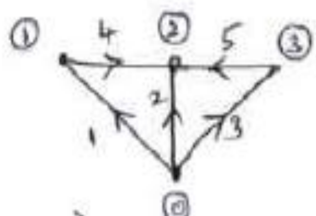
1 a) i) Tree : Tree is a subgraph containing all the nodes of the original graph without any closed path.

Ex:

Elements of Tree are branches. Such example is expected. —2—

ii) Element -bus incidence matrix: It is also known as Augmented A matrix i.e, $\hat{A}$. It is the matrix representing incidence of elements with all the nodes including ref node.

Ex:



Use the Rule

$a_{ij} = +1$ i^{th} element incident to j^{th} node and orient away —2—

$= -1$ i^{th} element incident and oriented towards the j^{th} node

$= 0$ Not Incident.

$\therefore \hat{A} =$

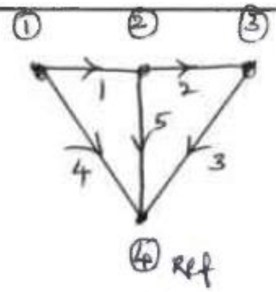
$\downarrow e$ $\vec{n}$	0	1	2	3
1	1	-1	0	0
2	1	0	-1	0
3	1	0	0	-1
4	0	1	-1	0
5	0	0	-1	1

b) Buses are classified as,

i) Swing or slack bus
ii) Load bus or PQ bus
iii) Generator or PV bus. (Voltage Controlled bus)

—3x2—

1 c)



$$A = \begin{array}{c|ccc} e \downarrow \; n \rightarrow & 1 & 2 & 3 \\ \hline 1 & 1 & -1 & 0 \\ 2 & 0 & 1 & -1 \\ 3 & 0 & 0 & 1 \\ 4 & 1 & 0 & 0 \\ 5 & 0 & 1 & 0 \end{array}$$ -2-

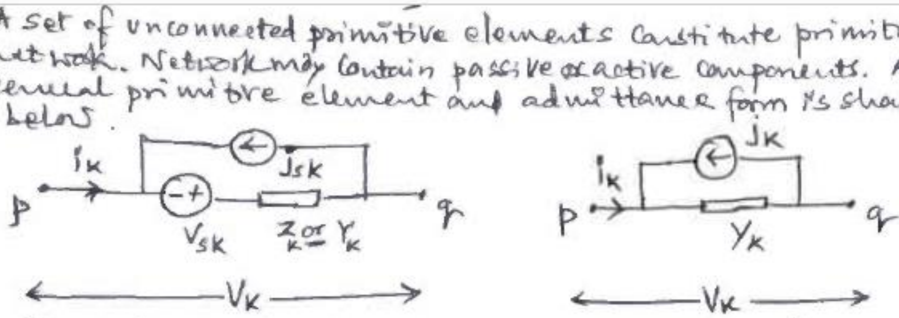
$$Y_{pri} = \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{bmatrix} 2 & 0 & 0 & 0 & 0 \\ 0 & 1.5 & 0 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 2.5 & 0 \\ 0 & 0 & 0 & 0 & 4 \end{bmatrix}$$ -2-

Using, We get

$Y_{bus} = A^{t} \times Y_{pri} \times A$

$$Y_{bus} = \begin{bmatrix} 4.5 & -2 & 0 \\ -2 & 7.5 & -1.5 \\ 0 & -1.5 & 4.5 \end{bmatrix}$$ -2-

2 a) A set of unconnected primitive elements constitute primitive network. Network may contain passive or active components. A general primitive element and admittance form is shown below. -1-



General primitive element   Admittance form -1-

From above diagrams - $i_k + j_{sk} = (V_{sk} + V_k) Y_k$

on further substitution & simplification -2-

$$i_k + j_k = V_k Y_k \Rightarrow \bar{i} + \bar{j} = [Y]\bar{V}$$

b) We know from admittance form of primitive element

$$\bar{i} + \bar{j} = [Y]\bar{V} \text{ ——}$$ -1-

Take

$$A^{t}\bar{i} + A^{t}\bar{j} = A^{t}[Y]\bar{V}$$

$A^{t}\bar{i} = 0$ as per KCL at bus. $A^{t}\bar{j} = I_{Bus}$ at a bus -1-

$\therefore 0 + I_{Bus} = A^{t}[Y]\bar{V}$ -1-

We have $\bar{V} = A\,E_{Bus}$ from incidence matrix study -1-

$\therefore \quad I_{Bus} = A^{t}[Y]A\,E_{Bus}$ -1-

$$\frac{I_{Bus}}{E_{Bus}} = A^{1}[Y]A \Rightarrow \therefore Y_{Bus} = A^{1}[Y]A$$ -1-

2 c) Line data in impedance form $Z = 0.02 + j0.2$ pu
Admittance of each element $Y = 0.495 - j4.95$ pu

$$Y_{bus} = \begin{bmatrix} 0.99-j9.9 & -0.495+j4.95 & -0.495+j4.95 \\ -0.495+j4.95 & 0.99-j9.9 & -0.495+j4.95 \\ -0.495+j4.95 & -0.495+j4.95 & 0.99-j9.9 \end{bmatrix}$$ -2-

Using flat start, $V_2^0 = 1\angle 0$ $V_3^0 = 1\angle 0$

$$\therefore V_2^1 = \frac{1}{0.99-j9.9}\left[\frac{-1+j0.25}{(1\angle 0)^*} - (-0.495+j4.95)(1\angle 0) - (-0.495+j4.95)(1\angle 0)\right]$$ -1-

$$= 0.9650 - j0.0975 \text{ pu} \cong 0.9699\angle -5.77^{\circ} \text{ pu}$$

$$V_3^1 = \frac{1}{0.99-j9.9}\left[\frac{-0.5+j0.25}{(1\angle 0)^*} - (-0.495+j4.95)(1\angle 0) - (-0.495+j4.95)(0.9699\angle -5.77)\right]$$ -1-

$$= 0.9525 - j0.0963 \text{ pu} \cong 0.9574\angle -5.77^{\circ} \text{ pu}$$

$\therefore V_2^1 = 0.9650 - j0.0975$ pu or 0.9699 pu
$\delta_2^1 = -5.77^{\circ}$. -1-

$V_3^1 = 0.9525 - j0.0963$ pu $\cong 0.9574$ pu
$\delta_3^1 = -5.77^{\circ}$. -1-

3 a) Jacobians are the negated partial derivatives of Active and reactive power mismatches derived with respect to angle δ and voltage V. This Jacobian matrix is very useful & mandate for NRLF. -1-
We have P_i & Q_i basic equations like,

$$P_i = \sum_{K=1}^{n} |V_i||V_K|[G_{iK}\cos\delta_{iK} + B_{iK}\sin\delta_{iK}]$$
$$Q_i = \sum_{K=1}^{n} |V_i||V_K|[G_{iK}\sin\delta_{iK} - B_{iK}\cos\delta_{iK}]$$ -1-

Elements of J_1: diagonals & off diagonals are

$$\therefore \frac{\partial P_i}{\partial \delta_i} = \sum_{\substack{K=1 \\ \neq i}}^{n} |V_i||V_K|[G_{iK}(-\sin\delta_{iK}) + B_{iK}\cos\delta_{iK}]$$ -1-

$$\frac{\partial P_i}{\partial \delta_K} = |V_i||V_K|[G_{iK}\sin\delta_{iK} - B_{iK}\cos\delta_{iK}]$$

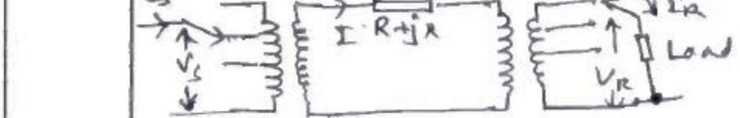
Elements of J_3: diagonal & off diagonals

$$\therefore \frac{\partial Q_i}{\partial \delta_i} = \sum_{\substack{K=1 \\ \neq}}^{n} |V_i||V_K|[G_{iK}\cos\delta_{iK} + B_{iK}\sin\delta_{iK}]$$ -1-

$$\frac{\partial Q_i}{\partial \delta_K} = -|V_i||V_K|[G_{iK}\cos\delta_{iK} + B_{iK}\sin\delta_{iK}]$$

3 b)	Step wise presentation of NRLF procedure covering complete mechanism.	-6-
c)	Any Two methods of Control voltage with suitable content & diagrams as required. i) Voltage Control by adjusting generator excitation ii) Voltage Control by VAR generator iii) Voltage Control using Transformer iv) Voltage Control by Booster concept etc.	-2×3-

4 a) Control of voltage by Tapchanging transformer.



Brief explanation and obtain equations — -2-

$1 : t_s n_1$ $\qquad t_R n_2 : 1$

$t_s n_1 V_s = t_R n_2 V_R + I Z$

as, $|\Delta V| = \dfrac{R P_R + X Q_R}{t_R n_2 |V_R|} \Rightarrow |\Delta V| = t_s n_1 |V_s| - t_R n_2 |V_R|$ — -1-

and, $t_R t_s = 1$, on further substitution & simplification

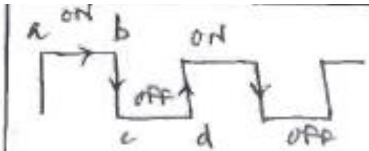
$$\frac{n_2 |V_R|}{n_1 |V_s|} = t_s^2 \left[1 - \frac{R P_R + X Q_R}{n_1 n_2 |V_s| |V_R|} \right] \quad //$$ — -1-

b) Neat flowchart covering important steps related to FDLF method is expected. — -6-

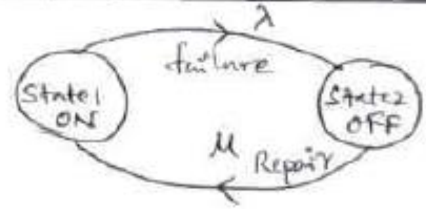
c) Comparison of GSLF, NRLF and FDLF methods with standard features like, Time for data preparation, Time per iteration, Total time, memory usage, complexity of programming, modification as required etc need to be considered. — -6×1-

5 a)	Explanation of both the characteristics with graphs.	-2×2-
b)	Definition of Unit Commitment	-2-
	Step by step presentation of Dynamic programming method for the solution of UC - problems	-4-

5 c)



Working states of units



2 state diagram -1-

Probability of Up, $P_{up} = \frac{m}{m+r}$,

Probability of down $P_{down} = \frac{r}{r+m}$

Where
m = mean up time -1-
r = mean down time
λ = Mean failure rate -1-
μ = Mean repair rate

Reliability $= R = P_{up} = \frac{m}{m+r}$ as $m = \frac{1}{\lambda}$ and $r = \frac{1}{\mu}$

$$R = \frac{\mu}{\mu+\lambda}$$ and

Probability of down $Q = P_{down} = \frac{r}{m+r} = \frac{\lambda}{\lambda+\mu}$ -1-

From probability study, $R + Q = 1$

In general, $P_{down}(t) = \frac{\lambda}{\lambda+\mu}\left(1 - e^{-(\lambda+\mu)t}\right)$ -1-

for the analysis of Reliability of a unit at time 't'

$$R(t) = \frac{\mu}{\mu+\lambda} + \frac{\lambda}{\mu+\lambda} e^{-(\lambda+\mu)t}$$ -1-

$\mu+\lambda \quad \mu+\lambda \; e$ -1-

6 a) $F_1 = 0.2P_1^2 + 40P_1 + 120$ Rs/Hr, $F_2 = 0.25P_2^2 + 30P_2 + 150$ Rs/Hr

$\frac{dF_1}{dP_1} = 0.4P_1 + 40$, $\frac{dF_2}{dP_2} = 0.5P_2 + 30$ and $P_D = 180$ MW -1-

as per EFC rule, $0.4P_1 + 40 = 0.5P_2 + 30$ & $P_1 + P_2 = 180$ -1-

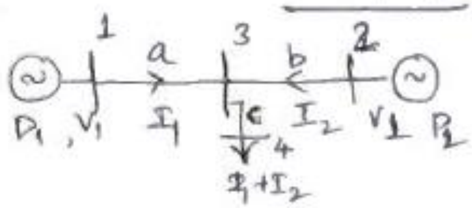
on simplifying solving $0.4P_1 - 0.5P_2 = -10$ (i) $P_1 + P_2 = 180$ (ii)

$\underline{P_1 = 88.89 \text{ MW}}$, $\underline{P_2 = 91.11 \text{ MW}}$ -1-

Cost of production for 180MW $= (0.2 \times 88.89^2 + 40 \times 88.89 + 120) + (0.25 \times 91.11^2 + 30 \times 91.11 + 120)$ -1-

$= \underline{10214.43}$ Rs/Hr

b)



$P_1 = \sqrt{3} V_1 I_1 \cos\phi_1$

$P_2 = \sqrt{3} V_2 I_2 \cos\phi_2$ -1-

R_a, R_b are resistances of sections.

I_1, I_2 are injections

Total loss in the system is accounted as,

$P_L = 3I_1^2 R_a + 3I_2^2 R_b + 3(I_1+I_2)^2 R_c$, On simplification,

$= 3I_1^2(R_a+R_c) + 3I_2^2(R_b+R_c) + 6 I_1 I_2 R_c$ -2-

Using value of I_1 & I_2 from P_1 & P_2 equations we get

$\therefore P_L = 3\frac{P_1^2 (R_a+R_c)}{3V_1^2(\cos\phi_1)^2} + 3\frac{P_2^2 (R_b+R_c)}{3V_2^2(\cos\phi_2)^2} + 6\frac{P_1 P_2 R_c}{3V_1 V_2 \cos\phi_1 \cos\phi_2}$ -2-

above eqn can be written in standard form as

$P_L = P_1^2 B_{11} + P_2^2 B_{22} + 2 P_1 P_2 B_{12}$ where $B_{12} = B_{21}$ -1-

6 c) Let 'n' be no. of generators, P_L be system line loss. P_D be demand then for economic scheduling,

where, $\min \sum_{i=1}^{n} F_i$ such that $\sum_{i=1}^{n} P_i = P_D + P_L$ -1-

solving the above issue using Lagranges method,

$\mathcal{L} = F_T - \lambda\left[\sum_{i=1}^{n} P_i - P_D - P_L\right] = 0$ where $F_T = \sum_{i=1}^{n} F_i$ Total cost. -1-

above eqn has minima at $\frac{\partial \mathcal{L}}{\partial P_i} = 0$ & $\frac{\partial \mathcal{L}}{\partial \lambda} = 0$

$\therefore \frac{\partial \mathcal{L}}{\partial P_i} = \frac{\partial F_T}{\partial P_i} - \lambda\left[1 - \frac{\partial P_L}{\partial P_i}\right] = 0 \Rightarrow \frac{\partial F_i}{\partial P_i} - \lambda\left[1 - \frac{\partial P_L}{\partial P_i}\right] = 0$ -1-

$\therefore \frac{\partial F_i}{\partial P_i} = \frac{dF_i}{dP_i} = \lambda\left(1 - \frac{\partial P_L}{\partial P_i}\right) \Rightarrow \lambda = \frac{\frac{dF_i}{dP_i}}{\left(1 - \frac{\partial P_L}{\partial P_i}\right)}$ -1-

$\boxed{\therefore \lambda = \frac{dF_i}{dP_i}\left(\frac{1}{1 - \frac{\partial P_L}{\partial P_i}}\right) = \frac{dF_i}{dP_i} \times L_i}$ for $i = 1 \ldots n$ -1-

other one is

$\sum_{i=1}^{n} P_i = P_D + P_L$

Economic scheduling is possible if incremental fuel cost multiplied by penalty factor should be same for all the units. -1-

the units.

7 a) i) LOLP – Brief explanation with graphical representation

$$LOLP = \sum_{K=1}^{n} A_K t_K \quad \text{day/year.}$$ -2-

ii) Frequency & Duration (FAD):

Brief explanation of FAD method and equations.

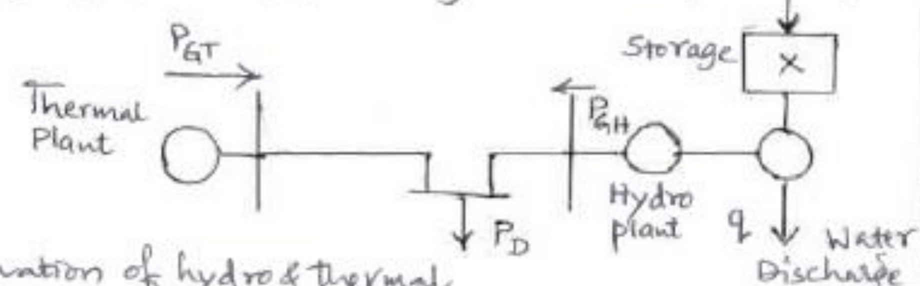
$f_1 = R\lambda$ ... where f_1 = frequency of ON state -2-

$f_2 = Q\mu$ — f_2 = frequency of OFF state

λ = Average failure rate

μ = Average repair rate

7 b) Hydro Thermal Scheduling : J (Water inflow)



-1-

operation of hydro & thermal system is also one important optimization problem. Mathematical formulation is as shown

i) Meeting the load : Power balance situation -1-

$$P_{GT}(t) + P_{GH}(t) - P_L(t) - P_D(t) = 0 \quad , \; t \in [0, T]$$

ii) Water availability : $X''(T) - X'(0) - \int_0^T J(t)\,dt + \int_0^T q(t)\,dt = 0$ -1-

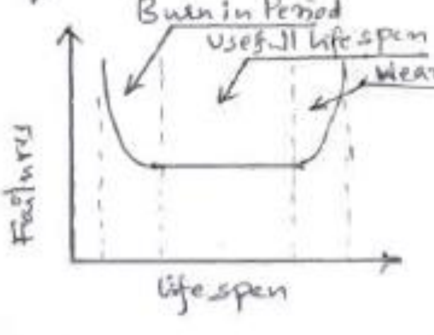
iii) $P_{GH}(t)$ in terms of discharge of water

$$P_{GH}(t) = f(X''(t), q(t))$$ -1-

In overall the optimization is,

$$\min_{q^m} \Delta T \sum_{m=1}^{M} c'(P_{GT}^m) = \min_{q^m} \sum_{m=1}^{M} c(P_{GT}^m)$$ -2-

c)



Brief explanation & possible ways to reduce the failures must be presented -3X2-

i) Burn in period

ii) Useful span

iii) Wear out period.

iii) Wear out period.

8 a)	List best minimum of 4 advantages of Maintenance Scheduling	4×1
b)	Explanation of security states with suitable block diagram covering following levels of security. Level 1 — Secure state Level 2 — Correctively secure Level 3 — Alert state Level 4 — Correctable emergency Level 5 — Non correctable emergency Level 6 — Restorative state Diagram — Brief explanation	 3 3

8 c) i) Brief explanation of generation shift distribution factor similar to,

$$\alpha_{li} = \frac{\Delta f_l}{\Delta P_{gi}}$$ where Δf_l – change in flow on l^{th} line

ΔP_{gi} – change/loss in generation at i^{th} unit

α – sensitive factor of l^{th} line for i^{th} gen outage / loss

∴ Revised flow, $\hat{f}_l = f_l^0 + \alpha_{li}\,\Delta P_{gi}$ If slack bus alone share the loss. — 3 —

If each generator respond for this loss of ΔP_{gi} then pickup of each unit is given by

$$B_{ki} = \frac{P_{gk\,max}}{\sum\limits_{\substack{m \\ \neq i}} P_{gm\,max}}$$ proportional pick up by each unit on outage of i^{th} unit

The revised flow on l^{th} line is

$$\hat{f}_l = f_l^0 + \alpha_{li}\Delta P_{gi} - \sum_{\substack{k=1 \\ \neq i}}^{n}\left[\alpha_{lk} B_{ki}\, \Delta P_{gi}\right]$$

ii) Line outage distribution factor : Brief explanation of

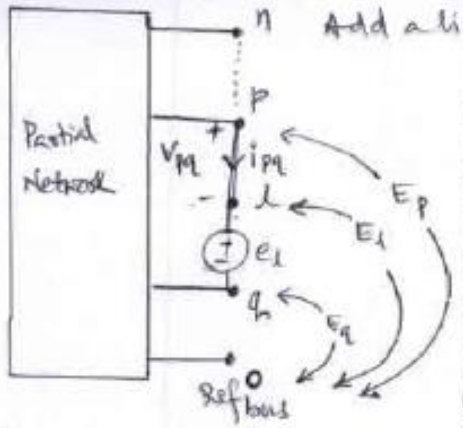
$$d_{li} = \frac{\Delta f_l}{f_i^0}$$ ∴ revised flow $\hat{f}_l = f_l^0 + d_{li} f_i^0$ — 3 —

outage of i^{th} element & impact on l^{th} element.

9 a)

9 A) Z build for a addition of link to the partial network

The system condition is represented by following matrix



Add a link between bus p & q

$$\begin{bmatrix} E_1 \\ E_2 \\ E_p \\ E_q \\ \vdots \\ E_n \\ e_l \end{bmatrix} = \begin{bmatrix} Z_{11} & \cdots & Z_{1p} & Z_{1n} & Z_{1l} \\ Z_{21} & \cdots & Z_{2p} & Z_{2n} & Z_{2l} \\ Z_{p1} & \cdots & Z_{pp} & Z_{pn} & Z_{pl} \\ Z_{q1} & \cdots & Z_{qp} & Z_{qn} & Z_{ql} \\ \vdots & & \vdots & & \vdots \\ Z_{n1} & \cdots & Z_{np} & Z_{nn} & Z_{nl} \\ Z_{l1} & \cdots & Z_{lp} & Z_{ln} & Z_{ll} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_p \\ I_q \\ \vdots \\ I_n \\ I_l \end{bmatrix}$$

-2-

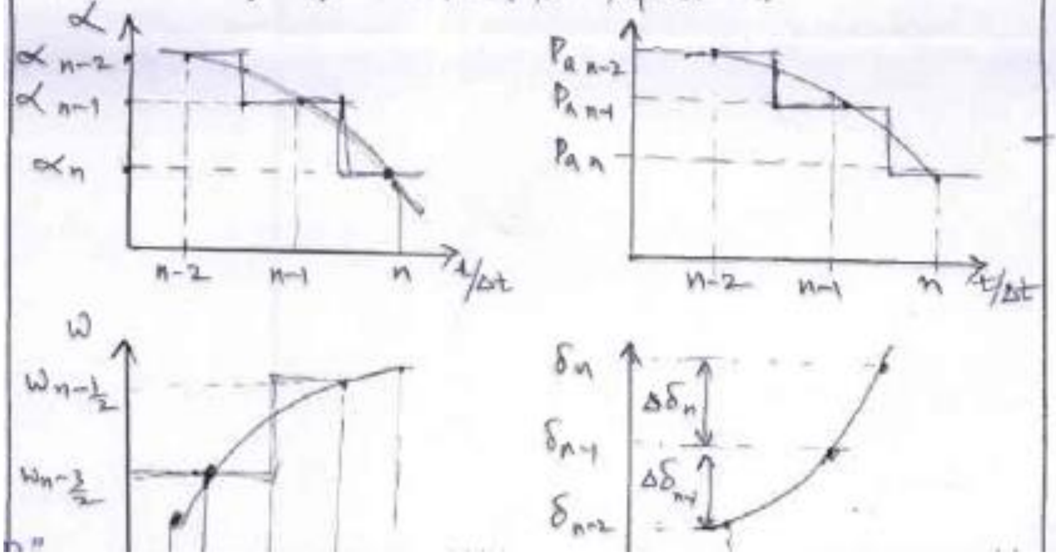
Number	Solution	Allocated
9 a)	From the study, a row & column is found extra at the early work & later it is removed.	
	$\therefore$ $e_l = E_p - E_q - V_{pl}$, $E_{ik} = Z_{ik}$ if $I_k = 1$ pu, $j = 1 \ldots n$	-1-
	$e_l = Z_{li} I_i$ & $I_j = 1$ pu, $e_l = Z_{li}$	
	$\therefore$ from fundamental equation we have,	
	$i_{pl} = V_{pl} Y_{pl\,pl} + \overline{Y_{pl\,rs}}\,\overline{V_{rs}} = 0$	-1-
	$\therefore$ $V_{pl} = \dfrac{-\overline{Y_{pl\,rs}}\,\overline{V_{rs}}}{Y_{pl\,pl}}$	
	$\therefore$ $Z_{li} = Z_{pi} - Z_{qi} + \dfrac{\overline{Y_{pl\,rs}}\,(\overline{E_{ri}} - \overline{E_{si}})}{Y_{pl\,pl}}$	-1-
	as l^{th} bus is imaginary	
	$\boxed{Z_{li} = Z_{pi} - Z_{qi} - \dfrac{\overline{Y_{pq\,rs}}\,(\overline{Z_{ri}} - \overline{Z_{si}})}{Y_{pq\,pq}}}$	-1-
	for no-coupling	
	$Z_{li} = Z_{pi} - Z_{qi}$	
	Similarly, $\boxed{Z_{ll} = Z_{pl} - Z_{ql} + Z_{pq\,pq}}$	-1-
	After these modify all the elements of Z_{bus} as.	
	$Z_{ij\,new} = Z_{ij\,old} - \dfrac{Z_{li} Z_{lj}}{Z_{ll}}$.	
	$Z_{bus} = \begin{bmatrix} Z_{11} & \cdots & Z_{1p} & \cdots & Z_{1n} \\ \vdots & & & & \\ Z_{p1} & \cdots & Z_{pp} & \cdots & Z_{pn} \\ \vdots & & & & \\ Z_{n1} & \cdots & Z_{np} & \cdots & Z_{nn} \end{bmatrix}$	-1-
b)	Runge Kutta order 4 method of solution of swing eqn in steps, $\dfrac{d\delta}{dt} = \omega$, $\dfrac{d\omega}{dt} = \dfrac{P_a}{M} = \dfrac{P_m - P_{max}\sin\delta}{M}$	
	$K_1 = \omega_0 \Delta t$, $l_1 = \left[\dfrac{P_m - P_{max}\sin\delta_0}{M}\right]\Delta t$, $K_2 = \left(\omega_0 + \dfrac{l_1}{2}\right)\Delta t$	-4×2-
	$l_2 = \left[\dfrac{P_m - P_{max}\sin\left(\delta_0 + \frac{\delta_1}{2}\right)}{M}\right]\Delta t$, $K_3 = \left(\omega_0 + \dfrac{l_2}{2}\right)\Delta t$	
	$l_3 = \left[\dfrac{P_m - P_{max}\sin\left(\delta + \frac{K_3}{2}\right)}{M}\right]\Delta t$, $K_4 = (\omega_0 + l_3)\Delta t$.	

Number		Allocated
	$\lambda_4 = \left[\frac{P_m - P_{max}\sin(\delta_0 + k_3)}{M}\right]\Delta t$	
	$\therefore \delta_1 = \delta_0 + \frac{1}{6}[K_1 + 2K_2 + 2K_3 + K_4]$	
	$\omega_1 = \omega_0 + \frac{1}{6}[l_1 + 2l_2 + 2l_3 + l_4]$.	
10 a)	Step (1) Add element between $p=0$ & $q=1$	-1-
	$Z_{bus} = \begin{array}{c} \\ 1 \end{array}\begin{array}{c} 1 \\ \left[\, j0.1 \,\right] \end{array}$ Step (2) Add element between $p=0, q=2$	-1-
	$Z_{bus} = \begin{array}{c c} & \begin{array}{cc} 1 & 2 \end{array} \\ \begin{array}{c} 1 \\ 2 \end{array} & \begin{bmatrix} j0.1 & 0 \\ 0 & j0.5 \end{bmatrix} \end{array}$	
	Step (3) Add element between $p=1$ & $q=2$	
	$Z_{bus} = \begin{array}{c c} & \begin{array}{ccc} 1 & 2 & l \end{array} \\ \begin{array}{c} 1 \\ 2 \\ l \end{array} & \begin{bmatrix} j0.1 & 0 & j0.1 \\ 0 & j0.5 & -j0.5 \\ j0.1 & -j0.5 & j1.0 \end{bmatrix} \end{array}$ $Z_{li} = Z_{pi} - Z_{qi}$	-2-
	$Z_{ll} = Z_{pl} - Z_{ql} + Z_{pq,pq}$	
	Remove l^{th} row & colm $= j0.1 + j0.5 + j0.4 = j1.0$	
	New values	
	$Z_{bus} = \begin{array}{c} 1 \\ 2 \end{array}\begin{bmatrix} j0.09 & j0.05 \\ j0.05 & j0.25 \end{bmatrix}$ $Z_{11} = j0.1 - \frac{j0.1 \times j0.1}{j1.0} = j0.09$	-2-
	$Z_{12} = 0 - \frac{-j0.5 \times j0.1}{j1.0} = j0.05$	
	$Z_{22} = j0.5 - \frac{-j0.5 \times -j0.5}{j1.0} = j0.25$	-2-
b)	Explain the method of ...	

Explain the method of solution of swing equation by point by point method

$M\frac{d^2\delta}{dt^2} = P_m - P_{max}\sin\delta$ or $\frac{d^2\delta}{dt^2} = \frac{P_a}{M}$

Explanation of steps involved is expected.



-4×2-