MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

MODEL ANSWER

SUMMER - 2017 EXAMINATION

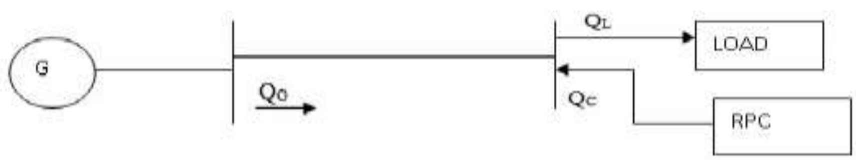
Subject: Power System Operation & Control **Subject Code: 17643**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q.N.	Answer	Marking Scheme
1.	**(A)**	**Attempt any THREE:**	**12**
	(a)	**State the difference between 'Generator bus' and 'slack bus'.**	**4M**
	Ans.		***Any 4 point 1M for each***

Sr. No	**Generator Bus**	**Slack Bus**
1.	At this bus power generated is injected into the system	Oneof the generator bus is made to take additional real and reactive power to supply transmission losses. This bus is known as slack or swing bus.
2.	Specified quantities in this bus is P & V.	Specified quantities in this bus is V &δ.
3.	Unknown quantities in this bus- Q &δ.	Unknown quantities in this bus- P & Q.
4.	It is not a reference bus.	It is a reference bus.
5.	This bus does not provides additional real & reactive power losses	This bus provides additional real & reactive power losses

	(b)	**State the concept of reactive power compensation. Name any two reactive power compensating equipments.**	**4M**
	Ans.	**concept of reactive power compensation**: The main objective of the utilities is to satisfy the consumers with its power demand. To meet the consumer's reactive power demands, if the same power is generated at generating stations & feed to the consumer, it will cause voltage drop in line. This will result into reduction of transmission efficiency and the cost of power transmission increases. Instead of this is we generate power locally near the load centers& feed it to consumers to his satisfaction the performance of power system will not affect & cost of power transmission also will not increase.  Reactive power generating equipments are located near the load centers which will help to meet the reactive power demand of consumers to his satisfaction. These also help to control the voltage levels in the system. The methods used for this is also called as "Reactive Power Compensation ". And the equipment used is called as "reactive power compensating equipment". Reactive power compensating equipment can be employed either at load level, substation level, or at transmission level. **<u>Reactive power compensating equipments:-</u>** 1. Shunt compensation equipment's - Shunt reactor, shunt capacitor 2. static VAR system 3. Series compensation equipments - Series reactors 4. Synchronous compensation equipments - Synchronous condenser	***2M for concept*** ***2M for equipments (any 2)***
	(c)	**Define the following terms.** **- Power system stability.** **- Power system instability.** **- Power system stability limit.**	**4M**
	Ans.	**Power System Stability:** It is the ability of power system to return to normal or stable operation after having been subjected to some form of disturbance.	***Power system stability 1M***

		Power System instability: It is status of system when it loses its normal stable operating condition because of sudden increase/ decrease in power demand or due to occurrence of major fault. **Power system stability limit:** The maximum feasible power flow through some point in the power system. When the entire system or port thereof under investigation is operating with stability.	***Power system instability & Stability limi 1½ M each***
	(d) Ans.	**State the adverse effects of instability on power system.** Due to instability of power system following effects can be observed: 1) As the Pd>>Pg, frequency of system varies over a wider range/ beyond the limits. Hence protective scheme of generators, transformersmaytrip them. 2) Due to fluctuation of V, F, P, Q performance of grid network reduces and power transmission capacity reduces and so consumers receive poor quality of supply. 3) If the system parameters are not controlled, than one by one generator will trip off and it leads major failure sometimes leads to collapsing of whole system. 4) As consumer receives poor quality supply the performance of their machines reduces, production rate decreases, quality of product reduces and overall there is financial loss.	**4M** ***Each effect 1M***
1.	**(B)** **(a)** Ans.	**Attempt any ONE:** **State the importance of load flow analysis in operation of power system.** **Following are the reasons that shows importance of load flow analysis in operation of power system:** 1) The total amount of real power flow thro' the network generates at generating stations whose size and location are fixed. 2) At each moment power generation must be equal to power demand as electrical power cannot be stored. 3) Hence the load on the system has to be divided between no. of generators in a unique ratio in order to achieve optimum economic power generation. 4) Hence the generator output must be closely maintained at	**06** **6M** ***1M each point***

		predetermined set closely maintained at predetermined set points. 5) It is important to remember that the power demand under goes slow but wide variation throughout the 24 hrs. of the day. 6) Therefore we must change these set points slowly or continuously or in discrete step as the hours wear on. This means that load flow configuration that fits the demand of a certain hr. of the day may look quite different next hour.	
	(b) Ans.	**List out the significant features of Y_{bus} matrix.** **Features of Y_{bus}:** 1) $Y_{bus}$is a symmetrical matrix "n x n" matrix. 2) All diagonal elements Y_{ii} represent "self-admittances" of bus "I". 3) All off diagonal elements Y_{ij} represents mutual admittance between bus "I" bus "j". 4) With reference to mutual admittance $Y_{ij}= Y_{ji}$i.e. $Y_{12} = Y_{21}, Y_{13} = Y_{31}$ Hence it is a symmetricalmatrix. 5) Any element in the matrix "zero" indicates that there is not to line between those buses. $Y_{21} = Y_{12} = 0$ ………… No tr. line between bus I bus II or outage of tr. Line $Y_{ik} = Y_{ki} = 0$ if i k between but I bus II i k are not connected. 6) $Y_{bus} = (Z_{bus})^{-1}$ whereZ_{bus}– bus impedance matrix. 7) All elements are complex numbers. 8) Self admittances are defined as $Y_{11} = \boldsymbol{y}_{11} + \boldsymbol{y}_{12} + \boldsymbol{y}_{13}$ Where $\boldsymbol{y}_{11}$ – line changing admittance $\boldsymbol{y}_{12}, \boldsymbol{y}_{13}$ – line admittances $\boldsymbol{Y}_{11}$ = sum of line changing admittance and total line admittances connected to a bus. 9) Mutual admittances are defined as $Y_{12} = -\boldsymbol{y}_{12} = -\boldsymbol{y}_{21} = Y_{21}$ and $Y_{13} = -\boldsymbol{y}_{13} = Y_{31}$ i.e. mutualadmittance is negative of line admittance between two buses. 10) All mutual admittances are negative complex numbers.	**6M** ***Any 6 1M each***
2.	 **(a)** Ans.	**Attempt any FOUR:** **Why power utilities maintain the fluctuation in frequency within the tolerance limit?** **Power utilities maintain the fluctuation in frequency within the tolerance limit because:** 1. In thermal power station steam turbines are especially designed to operate	**16** **4M**

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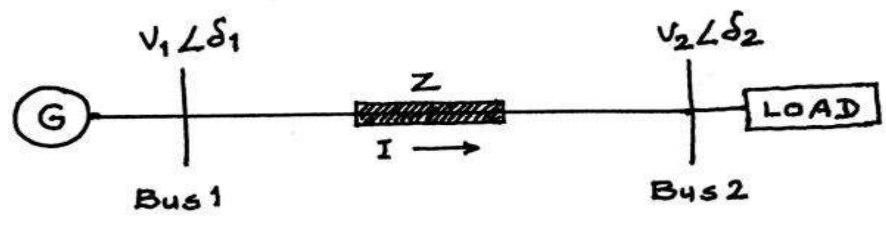
		at a very precise speed for required efficiency. The velocity of the expanding steam is beyond our control. Hence variation in frequency results in reduction in life of the turbine and generator. 2. In hydro power stations a turbo rotor with its many large turbine blades consists a mechanical system of many natural frequencies. These frequencies are quite un-damped and at various speeds they are subjected to resonance. Hence it is very important that under load condition rotor should never drift into such a speed range where dangerous amplitudes of blades are build up. Hydro turbines are not supposed to subject to this dangerous condition. 3. The overall operation of power system can be much better controlled if the frequency error is kept within strict limits. By reducing normal frequency fluctuations to a faint ripple, fault can be detected at early stage. Hence in modern power system the frequency variation is normally kept within $\pm$ 0.05 Hz 4. Power systems are interconnected through H.V. line to meet increase in demand. Hence to regulate the power flow through these lines, need accurate constant frequency. 5. The operation of a transformer below the rated frequency is not desirable. When frequency goes below rated frequency at constant system voltage then the flux in the core increases and then the transformer core goes into the saturation region. 6. With reduced frequency the blast by ID fans and FD fans decrease, and so the generation decreases and thus it becomes a multiplying effect and may result in shut down of the plant.	***Any 4 point 1M each***
	(b) Ans.	**Derive the relation between real power and frequency considering a simple two bus system.**  Consider a simple two bus system in which power is transmitted from bus 1 to bus 2 through a short transmission line. Let $V_1\angle\delta_1$ be the voltage at bus 1, $V_2\angle\delta_2$ be the voltage at bus 2 Z be the total series impedance of the transmission line per phase = R+jX	**4M** ***Diagram 1M*** ***Explanation 3M***

Since R<<<X, Z=jX
I be the current through the line per phase

$$I=\frac{V_1\angle\delta 1-V_2\angle\delta 2}{z} = \frac{v1L\delta 1-v2L\delta 2}{jX}$$

S_{12} - complex power transferred from bus-1 to bus-2 = $V_1 I_1^*$

$$=\frac{V_1^2 - V_1 V_2\angle(\delta_1-\delta_2)}{-jX} \times \frac{jX}{jX} = \frac{jXV_1^2 - jXV_1V_2\angle(\delta_1-\delta_2)}{X^2}$$

$$= \frac{jV_1^2 - jV_1V_2\angle(\delta_1-\delta_2)}{X}$$

$$= \frac{jV_1^2 - jV_1V_2(\cos\delta - j\sin\delta)}{X} \quad \text{where } \delta_1-\delta_2=\delta$$

$$= \frac{V_1V_2\sin\delta}{X} + \frac{j(V_1^2 - V_1V_2\cos\delta)}{X} = P_1 + jQ_1$$

So now, $P_1 = \frac{V_1V_2\sin\delta}{X}$ ---------------------------------1

$Q_1 = \frac{(V_1^2 - V_1V_2\cos\delta)}{X}$ ------------------------2

Similarly, we can also calculate complex power S_{21} that flows from bus-2 to bus-1.

We have,

$$S_{21} = V_2 I_2^* = V_2\angle\delta_2 \left(\frac{V_2\angle-\delta_2 -- V_1\angle-\delta_1}{jX}\right)$$

$$= \frac{V_1V_2\sin\delta}{X} + \frac{j(V_1V_2\cos\delta - V_2^2)}{X} = P_2 + jQ_2$$

Therefore,

$P_2 = \frac{V_1V_2\sin\delta}{X}$ -------------------------------3

$Q_2 = \frac{(V_1V_2\cos\delta - V_1^2)}{X}$ ----------------------4

From equations 1 & 3, we get……

$$P_1 = P_2 = \frac{V_1V_2\sin\delta}{X}$$

Therefore, net power flow through the line is…..

$$P = \frac{V_1V_2\sin\delta}{X}$$

		For given system X is constant. If voltages at both ends of the line are maintained constant i.e. V_1& V_2 remains same. Then, $P \propto Sine\delta$ ……………Where δ = ωt=2∏ft $\delta \propto t$ This shows that variation in real power flow results in variation of supply frequency. P is maximum when Sin δ = 1 $P = P_{max}$ when $\delta = 90^0$ But to operate the power system under stability condition the value δ is maintained between 35^0 to 45^0.	
	(c) Ans.	**State the data required for load flow, analysis about-Transformer, Triline, Generator and Bus.** **1. Transformer data:** Type of transformer such as distribution transformer / power transformer, auto-transformer, tap-changing transformer (on-line or off-line). Also ratings, % impedance and tap setting points, tap setting on HV /LV /both sides are required. Resistance of the transformer, reactance of the transformer, and the off nominal turns-ratio. provision for tapping's For every transformer connected between buses *i*and*k* the data to be given includes: the starting bus number *i*, ending bus number *k*, **2. Transmission line data:** For every transmission line connected between buses I and k the data includes the starting bus number i, ending bus number *k*, - Line parameters – .*r*esistance of the line, reactance of the line and the half line charging admittance. Series impedance (z) in per unit, shunt admittance (Y) in per units, - Thermal limits of the line. - Length of the line. $S_{G1}=P_{G1} + j\ Q_{G1}$ - Identification of each line and its '∏' equivalent circuit. **3. Generator data:** No. of generating stations connected in the systemready to generate the required amount of power and their time duration should be available. Each generators rating, maximum& minimum limits of generation, their characteristics, and excitation control details are made available. **4.Bus data:** Depending upon no. of buses in the system, bus data	4M ***1M for each point***

should be made available.

Type of bus	**Bus data**	**No. of buses**	**For each Bus**
Generator bus	P, (V)		P, V_i, , minimum and maximum reactive power limit ($Q_{i,min}$, $Q_{i,max}$).
Load bus	P, Q		Active power demand P_{Di}, and the reactive power demand Q_{Di}.
Slack bus	V, δ		Generator ratings which is assume to be connected to slack bus
Voltage control bus	P Q V		Voltage control equipment used and its rating, max. & min. limits

(d) Ans.

Write general form of SLFE considering two-bus system.

For a two bus power system , Load flow equations can be written as……

$V_1\angle\delta_1$ be the voltage at bus 1, $V_2\angle\delta_2$ be the voltage at bus 2

$\mathbf{Y_{11}}$– self admittance of bus-1 $\mathbf{Y_{22}}$– self admittance of bus-2

$\mathbf{Y_{12} = Y_{21}}$– mutual admittance between bus-1&bus-2

Then real power at bus -1…

$P_1 = P_{G1} - P_{D1} = V_1^{\,2} Y_{11} \cos\alpha_{11} + Y_{12} V_2 V_1 \cos(\delta_2 - \delta_1 + \alpha_{12})$

Reactive power at bus -1…

$Q_1 = Q_{G1} - Q_{D1} = -[V_1^{\,2} Y_{11} \sin\alpha_{11} + Y_{12} V_2 V_1 \sin(\delta_2 - \delta_1 + \alpha_{12})]$

Real power at bus -2…

$P_2 = P_{G2} - P_{D2} = Y_{21} V_2 V_1 \cos(\delta_1 - \delta_2 + \alpha_{21}) + V_2^{\,2} Y_{22} \cos\alpha_{22}$

Reactive power at bus -2….

$Q_2 = Q_{G2} - Q_{D2} = -[Y_{21} V_2 V_1 \sin(\delta_1 - \delta_2 + \alpha_{21}) + V_2^{\,2} Y_{22} \sin\alpha_{22}]$

1M for each equation

		OR Consider a power system having 'n' no. of buses, and $V_1\angle\delta_1$, $V_2\angle\delta_2$, $V_3\angle\delta_3$,……………….$V_K\angle\delta_K$……….$V_n\angle\delta_n$ are the bus voltages. Let $Y_{11}\angle\alpha_{11}$, $Y_{22}\angle\alpha_{22}$, $Y_{33}\angle\alpha_{33}$,……….$Y_{kk}\angle\alpha_{kk}$……….$Y_{nn}\angle\alpha_{nn}$ are self-admittances of bus1,2,3….k….n resply. Let $Y_{12}\angle\alpha_{12}$, $Y_{13}\angle\alpha_{13}$, $Y_{14}\angle\alpha_{14}$,……….$Y_{1k}\angle\alpha_{1k}$……….$Y_{1n}\angle\alpha_{1n}$ are mutual admittances of bus-1 with bus,2,3….k….n resply. Similarly… $Y_{21}\angle\alpha_{21}$, $Y_{23}\angle\alpha_{23}$, $Y_{24}\angle\alpha_{24}$,……….$Y_{2k}\angle\alpha_{2k}$……….$Y_{2n}\angle\alpha_{2n}$ are mutual admittances of bus-2 with bus,1 ,3….k….n resply. And similarly for all buses. Now SLFE can be written as……. Power at **1st bus** can be written as…. $P_1 = V_1^2 Y_{11} \cos \alpha_{11} + Y_{12} V_2 V_1 \cos(\delta_2 - \delta_1 + \alpha_{12}) + Y_{13} V_3 V_1 \cos(\delta_3 - \alpha_{13}) + \ldots\ldots \ldots\ldots + Y_{1n} V_n V_1 \cos(\delta_n - \delta_1 + \alpha_{1n})$ $Q_1 = -- [(V_1^2 Y_{11} \sin \alpha_{11} + Y_{12} V_2 V_1 \sin(\delta_2 - \delta_1 + \alpha_{12}) + Y_{13} V_3 V_1 \sin(\delta_3 - \delta_1 + \alpha_{13}) + \ldots\ldots$ $\ldots\ldots + Y_{1n} V_n V_1 \sin(\delta_n - \delta_1 + \alpha_{1n})]$ Power at **k th bus** can be written as…. $P_k = Y_{k1} V_1 V_k \cos(\delta_1 - \delta_k + \alpha_{k1}) + Y_{k2} V_2 V_k \cos(\delta_2 - \delta_k + \alpha_{k2}) + Y_{k3} V_3 V_k \cos(\delta_3 - \delta_k + \alpha_{k3}) + \ldots\ldots + V_k^2 Y_{kk} \cos\alpha_{kk} + \ldots\ldots \ldots\ldots + Y_{kn} V_n V_k \cos(\delta_n - \delta_k + \alpha_{kn})$ $Q_k = -- \{ Y_{k1} V_1 V_k \sin(\delta_1 - \delta_k + \alpha_{k1}) + Y_{k2} V_2 V_k \sin(\delta_2 - \delta_k + \alpha_{k2}) + Y_{k3} V_3 V_k \sin(\delta_3 - \delta_k + \alpha_{k3}) + \ldots\ldots + V_k^2 Y_{kk} \sin\alpha_{kk} + \ldots\ldots$ $\ldots\ldots + Y_{kn} V_n V_k \sin(\delta_n - \delta_k + \alpha_{kn}) \}$	
	(e) Ans.	**State and explain Bus-loading and Line-flow equations refer to power system.** **Bus Loading:** The real of reactive power at any kthbus can be written as $S_k = P_k - jQ_k = I_k$	**4M**

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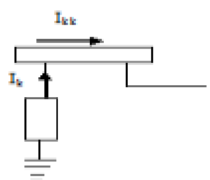
Current at bus i $I_K = \frac{P_k - jQ_K}{V_k^*}$

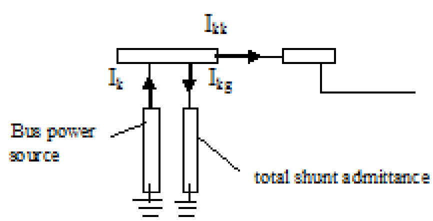
Bus current Ik is positive when if flows into the system.

Explanation of bus loading 2M



If the shunt elements are neglected or considered in Ybus matrix then above equation represents bus current i.e. bus loading Ik = Ikk If the shunt elements is considered then equivalent ckt. For bus can be drawn as.

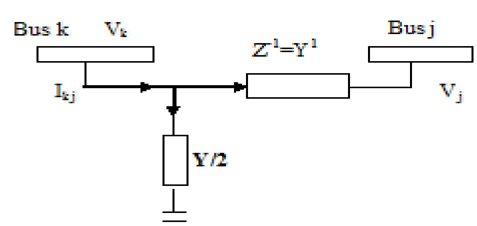
Now



Now the net current through bus - $I_{kk} = I_k - I_{kg} = - V_k Y_{kk}$ When Y_{kk} – total shunt admittance

Tr. Line Flow equation:

Line flow equation 2M



Assume that current is flowing throl tr. Line from bus k to bus j.

$I_{kj} = \frac{V_k - V_j}{Y} Y^1 + V_k\, Y/2$

Where Y_1– line admittance Y – line changing admittance Now power

		flow from bus k to bus j is P_{kj}-jQ_{kj} = Similarly power flow from bus j to bus k is P_{jk} – jQ_{jk} = The above two equations are called as "Line flow equation". The algebraic sum of power expressed by above equations gives power loss in the transmission line k – j	
	(f)	**Develop a Y_{bus} matrix for the following 3-bus system.**	**4M**

Bus code	Line Impedance Pu	Bus code	Line-charging admittance Pu
2–3	0.04 + j 0.08	1	j 0.01
3–1	0.055+j 0.6	2	j 0.00
1–2	0.09+j 0.35	3	j 0.00

Ans.

Each step 1M

Given Data -

$Z_{12} = 0.09 + j0.35$

$Z_{23} = 0.04 + j0.08$

$Z_{31} = 0.055 + j0.6$

step - I - calculate line admittance. (1M)

$y_{12} = \frac{1}{Z_{12}} = \frac{1}{0.09 + j0.35} = \frac{1}{0.36\angle 75.58^\circ}$

$= 2.77\angle -75.58^\circ$

$\boxed{y_{12} = 0.69 - j2.68}$

$y_{23} = \frac{1}{Z_{23}} = \frac{1}{0.04 + j0.08} = \frac{1}{0.09\angle 63.43^\circ}$

$= 11.11\angle -63.43^\circ$

$\boxed{y_{23} = 4.97 - j9.94}$

$y_{31} = \frac{1}{Z_{31}} = \frac{1}{0.055 + j0.6} = \frac{1}{0.60\angle 84.76^\circ}$

$= 1.66\angle -84.76^\circ$

$\boxed{y_{31} = 0.15 - j1.65}$

step-II
$y_{10} = j0.00$
$y_{20} = j0.01 + j0.00 = j0.01$
$y_{30} = j0.01 + j0.00 = j0.01$
} 1M

		$y_{12} = y_{21} = 0.69 - j2.68$ $y_{23} = y_{32} = 4.97 - j9.94$ $y_{13} = y_{31} = 0.15 - j1.65$ step - III - calculate self admittances (1M) $Y_{11} = y_{10} + y_{12} + y_{13}$ $= j0.00 + 0.69 - j2.68 + 0.15 - j1.65$ $= 0.84 - j4.33$ $Y_{22} = y_{20} + y_{12} + y_{23}$ $= j0.01 + 0.69 - j2.68 + 4.97 - j9.94$ $= 5.66 - j12.61$ $Y_{33} = y_{30} + y_{31} + y_{32}$ $= j0.01 + 0.15 - j1.65 + 4.97 - j9.94$ $= 5.12 - j11.58$ step - IV - calculate off. diagonal elements (1M) $Y_{12} = Y_{21} = -y_{12} = -(0.69 - j2.68)$ $Y_{23} = Y_{32} = -y_{23} = -(4.97 - j9.94)$ $Y_{31} = Y_{13} = -y_{13} = -(0.15 - j1.65)$ $Y_{Bus} = \begin{bmatrix} 0.84 - j4.33 & -0.69 + j2.68 & -0.15 + j1.65 \\ -0.69 + j2.68 & 5.66 - j12.61 & -4.97 + j9.94 \\ -0.15 + j1.65 & -4.97 + j9.94 & 5.12 - j11.58 \end{bmatrix}$	

3. **Attempt any FOUR:** **16**

(a) State the comparison between shunt and series compensating equipments. (any four factors). **4M**

Ans.

Sr. No	Shunt Compensating Equipment	Series Compensating Equipment
1.	A device that is connected in parallel with a transmission line is called a shunt compensation equipment	A device that is connected in series with the transmission line is called a series compensation equipment
2.	the shunt compensator is always connected at the midpoint of transmission system	he series compensator can be connected at any point in the line.
3.	Shunt Reactive Power compensation equipment - Shunt reactor , shunt capacitor	Series Reactive Power compensation equipment - Series reactors, Series capacitors
4.	shunt compensation is to improve voltage profile.	series compensation is for system stability.

1M each point

(b) Why consumers demand constant voltage supply? **4M**

Ans. **Consumer demand constant voltage supply because:**

1. Due to variation in the supply voltage the current drawn by the equipment varies.
2. When supply voltage decreases beyond the limit the current drawn by equipment increases & efficiency decreases. As a result performance of the equipment also reduces its life.
3. The induction motor which is commonly used as industrial drive develops the torque which depends on supply voltage $\therefore T \propto V^2$.
Hence large variation in supply voltage leads to more variation in torque developed .So far small variation in supply voltage the performance of motor gets affected and as a result the quality of product& the process gets affected.
4. In the lighting system the luminous output of lamp sources depends on supply voltage. Light flux of a lamp depends on voltage, with the voltage fluctuation light flux varies strongly As supply voltage decreases the luminous output of lamp decreases with more fluctuation in supply voltage reduces life of lamp also reduces.

Any 4 point 1M each

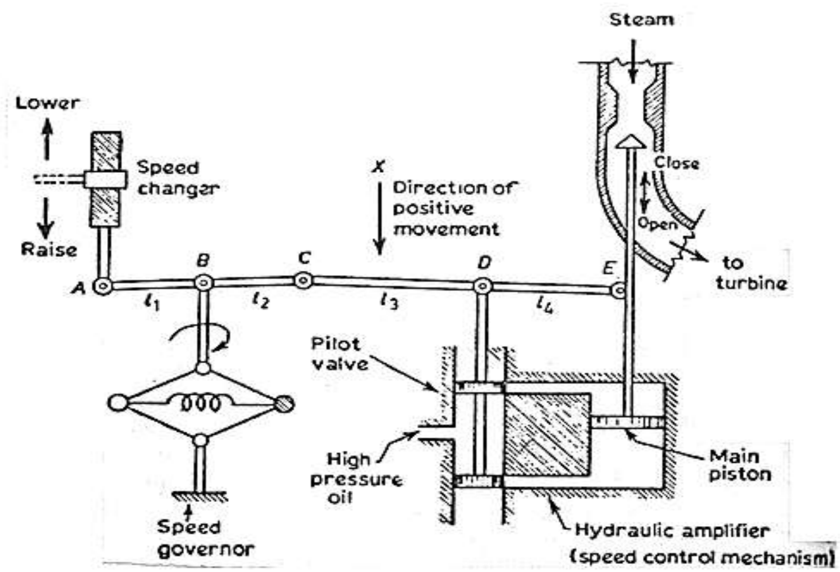
		5.Nowadays the more sophisticated equipment are used e.g computers which are very much sensitive towards supply parameters. Fluctuation in supply voltages damages these instruments permanently. Because of above reason consumer demand constant supply.	
	(c) Ans.	**List out the informations that can be collected from load flow studies.** (1) We get MW and MVAR flow in the various parts of the system network. (2) We get information about voltages at various buses in the system. (3) We get information about optional load distribution. (4) Impact of any change in generation (increase or decrease) on the system. (5) Influence of any modification or extension of the existing circuits on the system loading. (6) It also gives information for choice of appropriate rating and tap-setting of the power transformer in the system. (7) Influence of any change in conductor size and system voltage level on power flow.	**4M** ***Any four points 1M each***
	(d) Ans.	**State the significance of Y_{bus} matrix in loud flow studies.** **Significance of Y_{bus} matrix in load flow studies:** 1. Y bus is a nodal matrix , is called as a n×n matrix which describes power system network which having n number of buses . 2. Admittance matrix is use to analyze data which is use in power flow study. 3. Y bus matrix explain admittance & topology of network. 4. Outage of line or outage of generator can be easily indicated through Y bus matrix in load flow analysis. 5. The off diagonal elements of matrix indicate mutual admittance i.e the transmission line admittance between 2 bus. 6. All diagonal element indicate the sum of line charging admittance & transmission line admittance. It is also called as self admittance of bus.	**4M** ***Any 4 Points 1M for each***
	(e) Ans.	**When we can say that the power system is in 'transient stability condition' or in steady state stability condition?** **Transient state stability condition:** 1.Transient state stability is the ability of the system to return to its normal operating condition of same equilibrium or new equilibrium position after experience sudden and large disturbance in the network.	**4M**

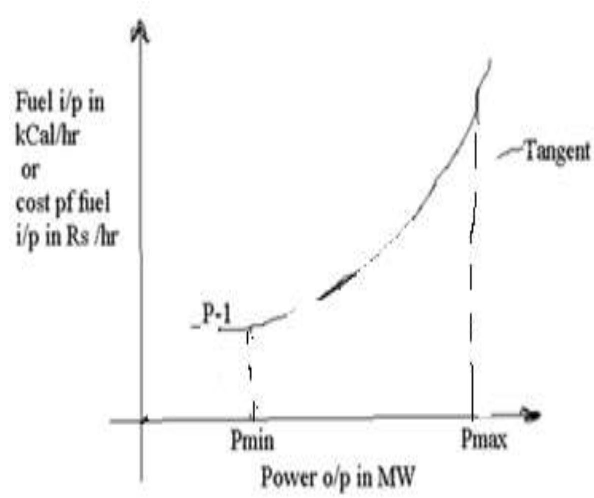
		2. Large disturbance is the cause of Transient state stability. Large disturbance means occurrence of fault, sudden increase in large amount of load, switching operation etc. **Steady state stability condition:** 1. A power system is in steady state operating condition if all the measured or calculated physical quantities describing the operating condition of the system can be considered as constant for purpose of analysis. 2. Small disturbance is the cause of Steady state stability . Small disturbance is nothing but change in setting of automatic voltage regulator of excitation system. Stable operation of system is obtained when $\delta>0$ &$\delta<90^o$. But practically it is maintained between 35^o-45^o. If load angle delta falls below 10^o then system drawn into transient stability condition	***2M for each point***
	(f) Ans.	**List out the factors that affects the transient stability condition of a power system.** **Following are the factors that affects the transient stability condition of a power system:** i) Generators play a vital role in any power system. Their characteristics have a significant impact on the stability characteristics of the system. ii) Under transient conditions, the transient reactance, rotor inertia (inertia constant), excitation response and the electrical damping provided by the generator rotor and the mechanical damping by the prime mover determine the generator performance. iii)From swing equation the acceleration of the rotor $d^2\delta/dt^2$ is inversely proportional to the moment of inertia of the machine, when accelerating power is constant, which means higher the moment of inertia, the slower will be the change in rotor angle, hence longer time for breaker operation. iv)By reducing the switching time and also the transient reactance, power limit can be substantially improved. v)Voltage regulators improve stability limits subsequent to the first swing oscillation, after the clearing of the faulty section. vi) Excitation response	**4M** ***Any four points 1M each***

MODEL ANSWER

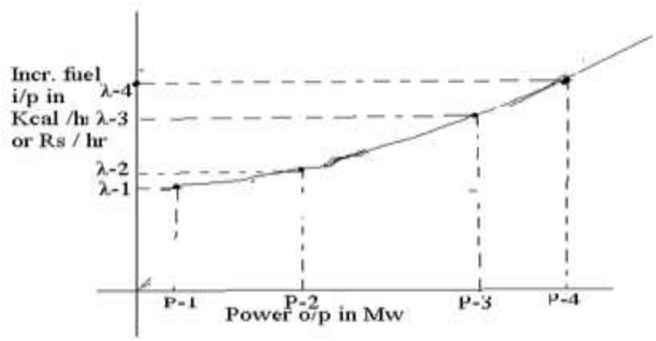
SUMMER - 2017 EXAMINATION

Subject: Power System Operation & Control **Subject Code: 17643**

4.	**(A)** **(a)** Ans.	**Attempt any THREE:** **Draw neat labeled schematic diagram of a 'turbine speed governing system'.**  Turbine-Speed Governing System	**12** **4M** ***Correct diagram with labeled 4M***
	(b) Ans.	**Explain the functioning of each component of 'turbine speed governing system'.** The**Turbine speed Governing** system consists of the following components: **i) Speed Changer:** It provides a steady state power output setting for the turbine. Their downward movements open the upper pilot valve so that more steam is admitted to the **ii) Fly ball speed governor:** This is the heart of the system which senses the change in speed. As the speed increases the fly balls move outwards and the point B on linkage mechanism moves downwards. The reverse happens when the speed decreases. **iii) Linkage mechanism:** ABC is a rigid link pivoted at B and CDE is another rigid link pivoted	**4M** ***Each component 1M***

		at D. This link mechanism provides a movement to control valve in proportion to change in speed. It also provides a feedback from the steam valve movement (link 4) **iv) Hydraulic amplifier:** It comprises a pilot valve and main piston arrangement. Low power level pilot valve movement is converted into high power level piston valve movement. This is necessary in order to open or close the steam valve against high pressure steam. Speed changer moves downward to raise the speed, fly ball of speed governor moves outward, ABC link moves upward so that CDE link moves downward. Now pilot piston of Hydraulic amplifier moves downward and more oil rushes in and pushes the main piston in downward direction. As the main piston move downward the valve opens further and more steam in rushes to enter turbine. Now kinetic energy increases and speed of turbine increases which will increase the generator speed and generator output. Whenever generator output has to decrease vise versa happens.	
	(c) Ans.	**Draw a neat labelled following curves and write the expressions.** **- Input output curve** **- Incremental fuel cost curve.** **Input output curve:**  $\frac{dF}{dP} = F_{nn} P_n + f_n = \lambda_n$	**4M** ***Input output curve 2M***

Incremental fuelcost curve:



$\frac{dF}{dP} = F_{nn} P_n + f_n = \lambda_n$

Incremental fuel cost curve 2M

(d) **With reference to Indian Power system, state the types of LDCs and their locations.** **4M**

Ans.

Types of LDC:

For increasing the reliability of supply, security of the system and for increasing the stability limit of the system Load Dispatch Centers(LDC) are located. In India Government has identified different types of LDC depending on their locations.

- National Load Dispatch Centre (NLDS)
- Regional Load Dispatch Centre(RLDS)
- State level Load Dispatch Centre(SLDS)

1M

Location :

1) In India, there is one NRLDC located at Delhi.
2) In India each state has its own SLDS and in Maharashtra SLDS is located in Nagpur.
3) In India there are four RLDS – Western, Eastern, Northern and Southern. Western RLDS is located in Kalwa.

2M

RLDCs**:** There are region wise 5 RLDCS and regions are

Name of the Region	States included	Name of RLDC	Located
NORTHERN Region	Jammu and Kashmir, Uttar	NRLDC	Delhi

1M

	Pradesh, Punjab, Hariyana		
EASTERN Region	Bengal, Bihar, Orissa	ERLDC	Kolkata
SOUTHERN Region	Karnataka, Goa, Kerala,Tamilnadu	SRLDC	Banglore
WESTERN Region	Mharastra, Gujarat, Madhya Pradesh,Chattis gad	WRLDC	Mumbai
NORTH-EASTERN Region	Assam, Sikim, Nagaland	NERLDC	Shillong

Q. No.	Sub Q.	Answer	Marks
4.	**(B)**	**Attempt any ONE:**	**06**
	(a)	**State and explain any three conventional techniques used to improve transient stability condition.**	**6M**

Ans.

Conventional /Traditional Technique:

i) Effect of generator design.
ii) Increase of voltage level
iii) Reduction in transfer reactance
iv) Rapid fault clearing
v) Automatic reclosing of CB

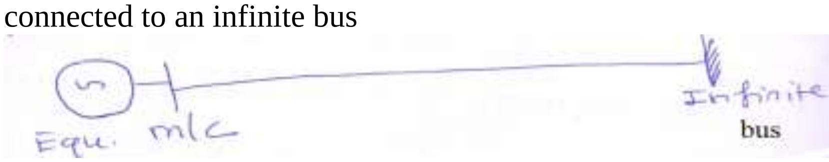
Any 3 each 2M

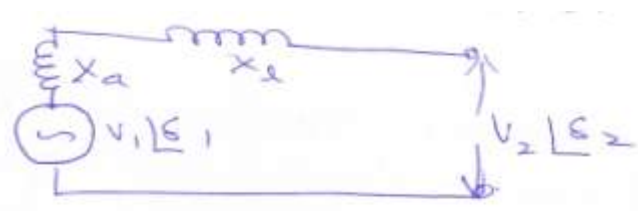
Following are conventional methods **adopted to improve transient stability condition of a power system**…..

i.) **Effects of Generator Design:**A heavy machine hasgreaterinertia and is more stable than a light machine. Modern machines are designed to get more power from smaller machines but this is undesirable from the stability point of view. In earlier days a large number of machines were employed to generate more power and this is also not desirable from stability point of view. Salient pole alternators operate at lower load angles and hence they are more preferred than cylindrical rotor generates from considerations of stability.

ii.) **Increase of voltage:** The amplitude of the power angle curve is

		directly proportional to the internal voltage of the machine.An increase in voltage increases the stability limit. iii.) **Reduction in transfer reactance:** The amplitude of the power angle curve is inversely proportional to the transfer reactance. This reactance can be reduced by connecting more line in parallel. iv.) When two lines are connected in paralleland a fault occurs in one line then some power is transferred to healthy line (except when the fault is at receiving end or sending end bus). This transmission of power helps the stability of the system. v.) Some features of the power system layout and business arrangement also help in improving stability. vi.) Use of bundled conductors helps in reducing line reactance and improving line stability. vii.) The compensation of line reactance by series capacitance is another effective method of improving stability. viii.) **Rapid fault clearing:** By decreasing the fault cleaning angle (by using high speed breakers) stability can be improved. ix.) **Automatic Reclosing:** Most of the fault's on the transmission lines are of transient nature and are self-clearing. Modern circuit breakers are mostly of reclosing type. When a fault occurs, the faulted line is de-energized to suppress the are in the fault and then the circuit breaker recloses, after a suitable time interval.	
	(b) Ans.	**State and explain any four planning tools used for load forecasting in power system operation.** **Types of planning tools:** i. Simulation Tools: Load flow models, sc models transient stability models, production costing, adequacy calculations. ii. Optimization tools: Optimum power, least cost expansion planning, generating expansion planning iii. The scenario techniques: Sequence of events recording, possible outcomes, decisions, assumptions, computerize and automatic system. **i. Stimulation Tool:** This tool help stimulate the behaviour of the system under certain load condition. This helps to calculate certain relevant indices. i .e cost of generation , transmission & distribution. Corporate models simulate the impact of various decision of financial performance of utilities. It requires voluminous data and required result from various	**6M** ***Each tool 2M***

		models to be integrated. Eg: Load flow model, short circuit model, Transient stability model, production costing, estimation of environmental impact. Results obtained are reliable as we wouldn't experience major failure. **ii. Optimization Tools:** This tool minimizes or maximizes adequate values for decision variables. Eg: Optimum power, least cost expansion planning of generation. For example, we considered the expansion of transmission circuit and planning for electrification rural areas. Though the cost involved is very high, still we can implement it, because objective behind it is on higher side (Socio economic harnessing of ground water resource food production rural employment prevention of migration). **iii. Scenario Tool:** This tool is used to known the future in quantitative fashion. In this technique narrative description is developed which includes probable, sequential or simultaneous recorded data. This can be built up into case history. A decision points are always identified and possible outcomes are investigated. The sort of decision or assumption made by utility is noted. All these narrative descriptions are computerized and used as past data. After certain period it is also used in "automatic power management" as data. Electrical utilities should prepare integrated resource plan. This long term plan must develop the best mix of demand and supply options to meet consumers need.	
5.	 **(a)** Ans.	**Attempt any FOUR:** **Derive the expression for max steady state power in a simple two bus system. Neglect the losses in the system.** This can be further simplified by considering single machine connected to an infinite bus  Let, $V_1 = V_1\angle\delta 2$ be the voltage of infinite bus. The equivalent ckt. of the above system can be written as	**16** **4M**



1M for Diagram

Let X_a * X_l are the reactance of generator & tr. Line.
Consider losses are neglible∴ R = 0.
Now the complex power injected by generator into the system is

3M for Explanation

$$S = VI^* = V_1\angle\delta_1 \left\{ \frac{V_1\angle\delta_1 - V_2\angle\delta_2}{j(X_a+X_l)} \right\}^*$$

$$= V_1\angle\delta_1 \left\{ \frac{V_1\angle-\delta_1 - V_2\angle-\delta_2}{-j(X_a+X_l)} \right\}$$

$$= \frac{V_1^2 - V_1V_2\angle\delta_1-\delta_2}{-j(X_a+X_l)}$$

Let $X = X_a + X_l$ and $\delta = \delta_1 - \delta_2$
Called: transfer reactance — load angle
Now

$$S = \frac{V_1^2 - V_1V_2\angle\delta}{-jX} \times \frac{j}{j}$$

$$= \frac{jV_1^2 - jV_1V_2(\cos\delta + j\sin\delta)}{X}$$

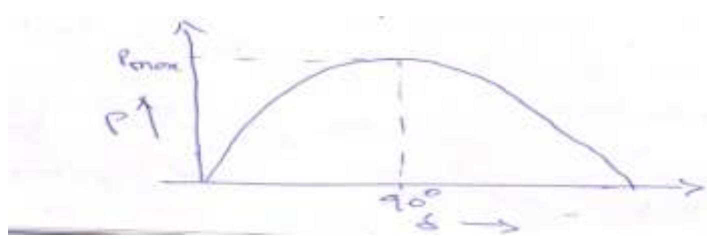
$$= \frac{V_1V_2\sin\delta}{X} + j\,\frac{(V_1^2 - V_1V_2\cos\delta)}{X}$$

$$= P + jQ$$

$$\therefore P = \frac{V_1V_2\sin\delta}{X} \qquad Q = \frac{V_1^2 - V_1V_2\cos\delta}{X}$$

$$= P_{max}\sin\delta \text{ i.e. when } \delta = 90^\circ\ P = \frac{V_1V_2}{X} = P_{max}$$

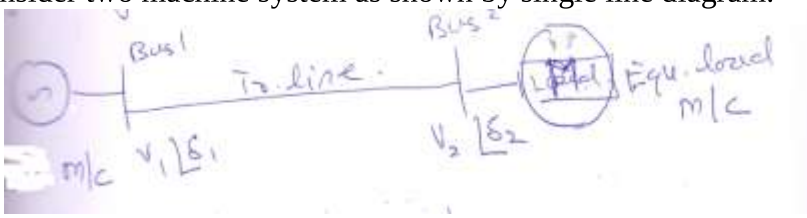
OR



The variation of P w.r.t. δ can be represented as

$P = \frac{V_1 V_2 \sin \delta}{X}$ is called "power angle equation" and curve is called "power angle curve" or "power angle diagram".

Consider two machine system as shown by single line diagram.



For two bus system Ybus is written as

$$Y_{bus} = \begin{vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{vmatrix} \quad \text{where } Y_{12} = Y_{21}$$

I_1 = current injected by equ. gen. m/c at Bus-1

$$= Y_{11} V_1 + Y_{12} V_2$$

Let $V_1 = V_1 \angle \delta_1$ $\quad V_2 = V_2 \angle \delta_2$ $\quad Y_{11} = Y_{11} \angle \alpha_{11}$

$\quad Y_{12} = Y_{12} \angle \alpha_{12}$

Subsituting in above equation.

$$\left.\begin{aligned} I_1 &= Y_{11} V_1 \angle \delta_1 + \alpha_{11} + Y_{12} V_2 \angle \delta_2 + \alpha_{12} \\ I_2 &= Y_{21} V_1 \angle \delta_1 + \alpha_{21} + Y_{22} V_2 \angle \delta_2 + \alpha_{22} \end{aligned}\right\} \text{ -- (1)}$$

Now complex power injected at Bus-1

$$S_1 = P_1 + jQ_1 = V_1 I_1^*$$

$$= V_1 \angle \delta_1 \{ Y_{11} V_1 \angle -\delta_1 - \alpha_{11} + Y_{12} V_2 \angle -\delta_2 - \alpha_{12} \}$$

$$= V_1^2 Y_{11} \angle -\alpha_{11} + Y_{12} V_2 V_1 \angle \delta_1 - \delta_2 - \alpha_{12} \text{ -- (2)}$$

For loss less line. conductance is zero

$G_{11} = 0$.

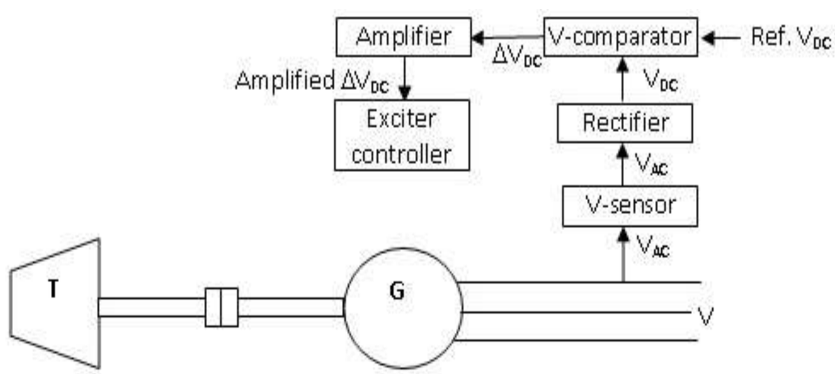
$Y_{11} = G_{11} + jB_{11}$ $\qquad Y_{12} = G_{12} + jB_{12}$

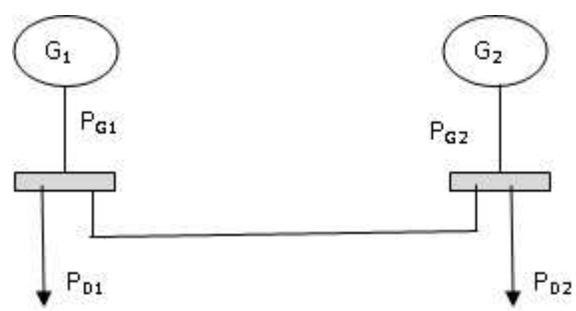
$Y_{11} = G_{11} + jB_{11}$ $\qquad = jB_{12}$

$= 0 + jB_{11}$ $\qquad = B_{12} \angle 90^\circ$

$= B_{11} \angle 90^\circ$

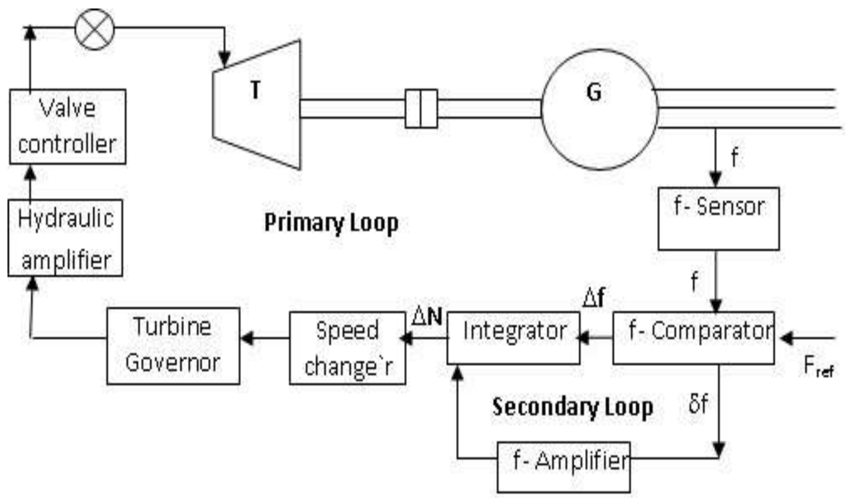
		$S_1 = P_1 + jQ_1 = V_1^2 B_{11} \angle -90^\circ + B_{12} V_1 V_2 \angle \delta - 90^\circ$ $\therefore P_1 = V_1^2 B_{11} \cos 90^\circ + B_{12} V_1 V_2 \cos(\delta - 90^\circ)$ $= 0 + B_{12} V_1 V_2 \sin\delta$ $= \frac{V_1 V_2}{X_{12}} \sin\delta$ where $B_{12} = \frac{1}{X_{12}}$ $= \frac{V_1 V_2}{X} \sin\delta$ — (3) $\therefore X_{12}$ = transfer rectance $= X$ III by complex power rejected from Bus-2 $S_2 = P_2 + jQ_2$ $= V_2^2 B_{22} \angle -90^\circ + B_{21} V_1 V_2 \angle \delta - 90^\circ$ $\therefore P_2 = \frac{V_1 V_2}{X_{21}} \sin\delta$ $X_{21} = X_{12}$ $= \frac{V_1 V_2}{X} \sin\delta$ — (4) From equation (3) & (4), we get the net Power flow through system is $P = \frac{V_1 V_2}{X} \sin\delta$ ← Power angle equation As 'δ' varies P also varies P is max. when $\delta = 90^\circ$. $\therefore P_{max} = \frac{V_1 V_2}{X}$	

	(b) Ans.	**Write swing equation and state significance of power angle.** "**swing equation**" which is written as $\frac{Md^2\delta}{dt} = P_a = P_m - P_e = T_a = Tm - T_e$ where, M = I ω- angular momentum and I- Inertia constant $P_a = T_a$ ω -- Accelerating Power P_m = Tm ω -- Mechanical power input to synchronous generator $P_e = T_e$ ω -- Electrical Power output of synchronous generator δ = Θ ω t in radian -- rotor angular displacement. **Significance of power angle δ** $P = \frac{V_1 V_2}{X} \sin\delta$ 1) As δ varies, power flow through the system also varies though voltage profile at each end is maintained constant. 2) when δ =90 , power flow is max . When δ =0 , power flow is zero 3) when δ> 90 , system will be unstable	**4M** ***Equation 2M*** ***Term 1M*** ***Significance 1M***
	(c) Ans.	**Draw a schematic diagram of Automatic voltage control at generators. Explain its functioning.** **Automatic Voltage Control/Automatic Voltage regulator (AVR):**  The automatic voltage, regulator (AVR) loop controls the magnitude of the terminal voltage V. The latter voltage is continuously sensed, rectified and smoothed. This D.C. signal, the resulting 'error voltage', after amplification and signal shaping serves as the input to the exciter which finally delivers the voltage Vf to the generator field	**4M** ***Diagram 2M*** ***Explanation 2M***

		winding. **What is the function of AVR?** The basic role of the AVR is to provide reliability of the generator terminal voltage during normal, small and slow changes in the load. The main objective of Automatic Voltage Controller is to control of excitation of generator with respect to change in generated voltage. **Automatic Voltage regulator** is a feedback loop system, consists of voltage sensor, Automatic voltage regulator and Excitation system. Voltage Sensor: It senses the actual generated voltage and sends the signal to rectifier. Rectifier: Now the rectifier converts into an equivalent D.C. Voltage-Vdc. Comparator: This D.C. voltage is fed to the comparator where it is compared with reference voltage Vdc ref.. The reference voltage is D.C. equivalent of the specific voltage required to maintain at generator output to maintain stability of system at that moment. The value of this is obtained by Load Flow Analysis. Amplifier &Q-V controller: The output of comparatorΔV is amplified by Power amplifier and amplified signal is given as input to Q-V controller. NowQ-V controller transfers into reactive power signal ΔQ and feeds it to excitation controller. Excitation Controller: This in turn varies the field regulator so that the generator terminal voltage varies.	
	(d) Ans.	**Explain the load frequency control refer to single area case.** 	**4M** ***Diagram 1M***

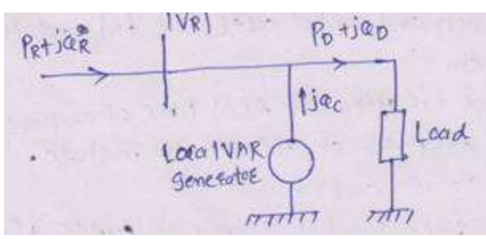
		In power system network single area is identified as single control area of the grid network, consisting number of generators supply power to all consumers in that area. All generators in this area are synchronized and they swing in unison to meet change in power demand of that area. i. e. they speed up or speed down simultaneously. Consider a control area consisting two generating plants connected through transmission line as shown in single line diagram. These generators are running in synchronism and their speed varies together by maintain their respective machine angels. At steady state condition, PG1 + PG2 = PD1 + PD2. As load on generator G2 increases, its output increases to meet the demand, while output of G_1 remains same. But speed of G_1 varies to maintain the synchronism and frequency. As load on generator G_2 go on increasing, its output increases up to its upper generation limit. Now to meet further increase in power demand, output of G_1 will increases and shares the power demand. If the demand is very large then both generators share the demand.	***Explanation 3M***
	(e) Ans.	**State the need of load forecasting for power system operation.** **Need of Load forecasting :** Load forecasting for power system operation is required 1. For proper planning, designing of new power system network or expansion of existing. 2. For varying generation of power with respect to time i.e. amount of growth expected in power demand. 3. For determining the capacity of power generation and power flow through transmission lines and distribution lines. 4. For proper planning of power flow through transmission & distribution network. 5. For proper operation of power system in instability condition. 6. For proper planning of resources for generation of power i.e. conventional or non-conventional resources. 7. For determining the cost of power generation, transmission and distribution. 8. For proper man power development or training of manpower for operation of power system. 9. To decide power tariff for different utilities and different	**4M** ***Any 4 each 1M***

		consumers. 10. For proper power transaction between neighbouring grid system. 11. For proper energy sales in electrical market. 12. For finding the requirement of fuel in future.	
	(f) Ans.	**List out the functions of LDC. (Any four)** **Functions of State Load Dispatch Centers:** In accordance with section 32 of Electricity Act, 2003 roles and functions of SLDCs are as under: 1. The State Load Dispatch Centre shall be the apex body to ensure integrated operation of the power system in a State. 2. The State Load Dispatch Centre shall - a. be responsible for optimum scheduling and dispatch of electricity within a State, in accordance with the contracts entered into with the licensees or the generating companies operating in that State; b. monitor grid operations; c. keep accounts of the quantity of electricity transmitted through the State grid; d. exercise supervision and control over the intra-state transmission system; and e. be responsible for carrying out real time operations for grid control and dispatch of electricity within the State through secure and economic operation of the State grid in accordance with the Grid Standards and the State Grid Code. 3. The State Load Dispatch Centre may collect such fee and charges from the generating companies and licensees engaged in intra-State transmission of electricity as may be specified by the State Commission. 4. Overall supervision, monitoring and control of the integrated power system in the State on real time basis for ensuring stability, security and economy operation of the power system in the State. 5. Optimum scheduling and dispatch of electricity within the State. For this SLDCs estimate the demand of the State / DISCOMS, as may be the case, availability of power in the State/DISCOMS from State generators and other sources like Central Generating stations, bilateral contracts etc, conveys the final requisition to RLDCs on the State's entitlement from the Central Generating Stations and bilateral transactions under open access, if any, and	**4M** ***Any 4 each 1M***

		issues final dispatch schedule to the State Generators and drawal schedule to the DISCOMS.	
6.		**Attempt any FOUR:**	**16**
	(a) Ans.	**State the advantages of ALFC and AVC systems.** i. **Automatic Load Frequency Control** (ALFC) or **Automatic Generation Control** (AGC) - Used to achieve real power balance (acceptable frequency values). ii. **Automatic Voltage Regulator** (AVC).--- Used to achieve reactive power balance (acceptable voltage profile).	**4M** ***Each advantages 2M***
	(b) Ans.	**Write the help of diagram, explain ALFC of synchronous generator.**  In an electric power system, Automatic Generation Control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load. Ideally it is required that at each moment in power grid power generation and power demand closely balance. To achieve this frequent adjustments are necessary to the output of generators. The imbalance can be found out by measuring the system frequency. If the system frequency is increasing, means more power is being generated than demand and all the machines in the system are accelerating. If the system frequency is decreasing, means more loads is on the system, than all the machines in the system are slowing down. The frequency is closely related to the real power balance in the	**4M** ***Diagram 2M*** ***Explanation 2M***

		overall network. Under normal operating conditions the system generators run synchronously and generate together the power at each moment is being drawn by all loads plus the real. Automatic load frequency control helps to regulate the MW output of the generator to maintain the frequency. It consists of two feedback loop--Primary loop & Secondary loop system. Primary loop works for a frequency variation which is a result of power imbalance in MW. In this loop the output generated voltage frequency is fed to the governor which raises a signal to control valves to regulate the steam flow so that output of the generator will match with fast load fluctuations. This loop matches the initial course of adjustment of frequency. Response time of this loop is in the order of 2-20 seconds. **Primary loop** - It is a feedback loop system, consists of frequency sensor, Frequency comparator, Integrator, speed changer, Turbine governor, Hydraulic amplifier and Valve control mechanism. Frequency Sensor: It senses the actual frequency of generated voltage and sends the signal toFrequency comparator. Frequency comparator: It compares the actual frequency with the reference frequency and rise the signal Δf to integrator. Integrator: It converts frequency signal into speed signal i.e. Δf to ΔN and feed it to speed changer. Speed Changer: According to the signal it rolls low /high side and activate Turbine governor. Turbine governor: It is a turbo-generator governor. It raises the signal to increase or decrease the speed of turbine through Link mechanisms Link mechanisms: This is a 4-link mechanism, which provides a movement to Steam valve through Hydraulic amplifier in proportion to change in speed. It also provides a feedback from the steam valve movement Hydraulic amplifier: It comprises a pilot valve and main piston arrangement. Low power level pilot valve movement is converted into high power level piston valve movement. This is necessary in order to open or close the steam valve against high pressure steam. Valve control mechanism: As per signal valve control mechanism opens or close the steam /gas valve to increase /decrease the speed i.e. power output of turbine. Accordingly generator output varies.	

		Secondary loop: It comprises Frequency amplifier which receives minor variation signal of frequency and feed the amplified signal to integrator. Secondary loop works for fine adjustment of the frequency, signal from the output of the generator is amplified by amplifier and the amplified signal is fed to integral controls which integrate the frequency error and raise a signal to control the valves which in turn regulate the steam flow. This loop is sensitive to rapid variations in load frequency. Response time of this loop is in order of one minute. This ALFC is located in power stations. It is operative only during normal changes in load and frequency. It is unable to provide adequate control during emergency conditions when large MW imbalance occurs.	
	(c) Ans.	**Explain the different methods of voltage control by using transformer.** Following are the methods of voltage control in power system. By using transformers 1. By tap changing transformers. - Off load tap changing - On load tap changing 2. By regulating transformers 3. By Booster transformers 4. Auto Transformer tap changing **1) Online tap changing transformer:** All transformers are provided with taps on the winding for adjusting the ratio of transformation. Taps are usually provided on the high voltage winding to enable a fine control of voltage. Generally the tap changing can be done any when the transformer is in de-energized state. However in some cases tap changing is also possible when the transformer is energized. These transformers make it possible to maintain a constant voltage level on important buses in the system. **Location: Intermediate distribution Substation** **2) Regulating transformer:** A special type of transformer designed for small adjustments of voltage is known regulating transformer. The fig. shows a typical arrangement to use a regulating transformer for voltage mag control in a 3 phase ckt. A 3 phase transformer provides on adjustable voltage	**4M** ***Each method 1M***

		to the primary of the regulating transformer. The secondary of the regulating transformer are connected in series with the lines. Thus a voltage magnitude 0volt to the voltage of each phase. **Location: distribution Substation** **3) Booster Transformer:** Sometimes it is designed to control the voltage of transmission line at a point for away from the main transformer. This is conveniently achieved by the use of booster transformer. The secondary of booster transformer is connected in series with the line whose voltage is to be controlled. The primary of this transformer is supplied from a regulating transformer with on load tap changing gear. **Location: HV &EHV transmission Line** **4) Auto transformer tap changing:** Here, a midtapped auto-tranformer or reactor is used. One of the line is connected its mid-tapping. One end of this transformer is connected in a series of switches across the odd tapping and the other end is connected to switches across the even tappings.	
	(d) Ans.	**How the voltage level can be controlled in power system by injecting reactive power in the tr. Line?** **Reactive power injection method for voltage control:** To keep the receiving end voltage at a specified value, a fixed amount of VARS must be drawn from the line.  QG =QD bus voltage is maintained at specific value. As VAR demand QD varies, a local VAR generator must be used as shown in fig. The VAR balance equation at the receiving end is now. QG =QD +QC Any variation QD is are absorbed / injected by the local VAR generator and $Q_G$generated by the line remains fixed. This helps to keep the receiving end voltage constant.	**4M** ***Concept 1M*** ***Each equipment 1M***

		Following are the equipments used to inject VARs in the system at different points. <table><tr><td>Generation system</td><td>Excitation control</td><td>Production of reactive power involves increasing the magnetic field to raise the generator's terminal voltage. To increase the magnetic field, increase the current in the field winding. Absorption of reactive power is limited by the magnetic-flux pattern in the stator, which results in excessive heating of the stator-end iron, the core-end heating limit.</td></tr><tr><td>Transmission system</td><td>Series reactors</td><td>Capacitors and inductors in HV and EHV trans. Line Static VAR system</td></tr><tr><td>Distribution system</td><td>Shunt reactors</td><td>Capacitor's bank Synchronous condenser Static VAR system</td></tr></table>	
	(e) Ans.	**List out the environmental factors that affects the load forecasting.** **List out the environmental factors affecting load forecasting?** Following are Environmental factors that affect load forecasting of power system. i.) Time dependent factor	**4M** ***Each factors***

MODEL ANSWER

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		ii.) Weather dependent factor (humidity, temperature) iii.) Wind --wind speed, wind direction, cloud cover, fog iv.) Random weather change (storm, sunami, heavy rain, flood)	***1M***
	(f) Ans.	**Why social activities are important for power system operation?** Electricity consumers i.e. residential consumer, commercial consumers, industrial consumers are part of society. Hence their activities, events affect the power requirement. Following are the some of the activities that affect the load forecasting of power system. 1) <u>Energy consumption pattern</u>: All 24hr,s of day load on system varies as consumer has freedom to use electricity whenever they required without any prior information. Hence daily load curves differ with the day. Also energy consumption pattern of various and type of consumer differs. To satisfy all consumers power generation must be varied with time. So during forecasting of load these factors must be considered. 2) <u>Holidays/week ends and week days:</u> During power consumption pattern is nearly same but on weekends / Sundays power consumption pattern changes. Therefore their impact on load forecasting cannot be neglected. Public holidays also have considerable impact on load forecasting. Long weekend's creates more fluctuation in load demand. 3) <u>School /college vacations</u>: Vacation period changes the daily routine of children and their stay at consumes power for their activities such as watching TV, playing video games, net surfing, watching films, etc. So in residential sector more power consumes by lighting and air-conditioning systems. 4) <u>Festivals and National days</u>: During festivals like Diwali, Dashera, Christmas, Onam etc. more lightings are used for decoration purpose. This increases power consumption of residential as well as commercial sector. Hence they have to be considered for load forecasting. National days like Independence day, republic day, Marashtra day etc. all government building are decorated with lights and more cultural programs were arranged. As power consumption is of considerable amount, their impact on load has to	**4M** ***Any 4 each 1M***

		be considered in load forecasting. 5) Emergency conditions and Major accidents: If sudden large variation power demands, failure of system components, faults (line-to-line, line-to-ground) in system, causes more imbalances in power demand and supply. It will put the system in transient stability condition. Also if major accidents takes place like sunami, wind storm, earth quack, snow storm, flood etc. may affects the infrastructure of power system. And so there may be major power failure. In such situations load forecasting becomes failure. 6) Special events:Labour strike in Industry, political events, VIP visits also creates large variation in power demand. These events cannot be neglected	