SUMMER – 2019 EXAMINATION
MODEL ANSWER

Subject: Power System Operation and 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 try to 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)** **(a)** **Ans.**	**Attempt any THREE:** **State the importance of 'bus' in power system.** **Importance of 'bus' in power system:** • In a power system Bus is a node or junction where two or more than two transmission lines are connected. • Each bus or node is associated with four quantities -magnitude of voltage V, P, Q, and load angle „δ", • Bus data is required to study the performance & operation of power system network • There are three types of buses classified in load flow analysis as - **Slack bus or swing bus**: In this bus voltage magnitude |Vi| and load angle δi are specified. This bus is the first to respond to changing load condition and is called as slack bus because it takes up slack in losses. - **Generator/ voltage control bus**: In this type of bus real power output Pgi and voltage magnitude |Vi| are specified. It means we specify the bus power Pi. The voltage of this types of bus can be controlled. - **Load bus:** for this type of bus we will have a prior knowledge of load power PLi and QLi. As these buses do not have any generator so PGi	**12** **4M** ***1M for each***

		and QGi (generated power) are equal to zero and therefore is known as load bus.	
	(b) **Ans.**	**List the data required for load flow studies with reference to transformers, transmission lines, buses and generator.** Following Data are required for load flow analysis: **1. Transformer data:** Type of transformer such as distribution transformer / power transformer, auto-transformer, tap-changing transformer (on-line or ff-line). Also ratings, % impedance and tap setting points, tap setting on HV /LV /both sides are required. (Quite often it may be necessary to adjust voltages on one or both sides of the transformers to maintain the potential levels at the neighboring buses within specified limits. For achieving this, auto and double winding transformers with provision for tap changing on H. V. side or used so as to facilitate smoother control. For every transformer connected between buses *i* and *k* the data to be given includes: the starting bus number *i*, ending bus number *k*, resistance of the transformer, reactance of the transformer, and the off nominal turns-ratio. **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. - Identification of each line and its „Π" equivalent circuit. **3. Bus data:** Depending upon no. of buses in the system, bus data should be made available.	**4M** ***Each data 1M***

Type of bus	**Bus data**	**No of buses**	**For each Bus**
Generator bus	P, (V)		PGi, V_i, , minimum and maximum reactive power limit (Qi,min, Qi,max).
Load bus	P, Q		active power demand PDi, and the reactive power demand QDi.
Slack bus	V, δ		Generator ratings which is

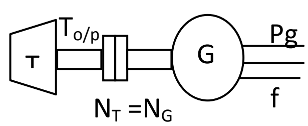
			assume to be connected to slack bus
Voltage control bus	P Q V		Voltage control equipment used and its rating, max. & min. limits

4. Generator data: No. of generating stations connected in the system ready 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

(c) Explain briefly the relation between real power and frequency of the system. **4M**

Ans. Real power is generated at generating station by generators to meet the real power demand. During transmission of power from generating station to load centers some of the power in lost in the apparatus such as transmission line, transformers & generators which is also accounted as real power loss.

We know that electrical energy cannot be stored .Whatever amount of energy is generated has to be utilized at the same moment .That means rate of energy generation must be equal to rate of power consumption. We also know that electricity is transmitted at almost velocity of light.



Considering entire power system when real power flows from generating end to load end, it can be represented in equation form as…

Real power generated = Real power demanded by load + Real power lost in the system

$P_g = P_d + P_L$ i.e power balance equation.

Under normal operating condition the system generator run synchronously and generate together the power that at each moment is being drawn by all load plus the real transmission losses.

The losses in the system are negligible compared to P_g and P_d. Hence $Pg \approx Pd$

Sins power system is a not an ideal system, hence $Pg \neq Pd$. Then Pg

		>Pd or Pg < Pd. If Pg >Pd, then excess amount of power is at input side of generator that means at output of turbine .This shows that more KE is available in turbine so it's speed increases. Since generator is coupled to turbine, generator speed also increases. Now we know that, f= PN/120 i.e. frequency of generated e.m.f. also increases. If Pg **>**Pd $\longrightarrow$ Pg $\uparrow \longrightarrow$ (Gen. i/p =Turbine o/p)$\uparrow \longrightarrow$ more KE in turbine $\longrightarrow$ $N_T\uparrow\uparrow \longrightarrow$ $N_G\uparrow\uparrow \longrightarrow$ f= PN/120 hence - f$\uparrow$ Vice-Versa ,if Pg **<**Pd, If Pg **<**Pd $\longrightarrow$ Pg $\downarrow \longrightarrow$ (Gen. i/p =Turbine o/p) $\downarrow \longrightarrow$ more KE in turbine $\longrightarrow$ $N_T\downarrow\downarrow \longrightarrow$ $N_G\downarrow\downarrow \longrightarrow$ f= PN/120 hence- f$\downarrow$ This shows that, difference between Pg and Pd will enter into or exit from kinetic energy storage in prime mover. This kinetic energy varies the speed of the generator .Hence imbalance in real power is reflected in variation in speed i.e. variation of frequency of generated voltage. Imbalance of real power arises due to sudden drop or rise in load demand or fault occurred or failure of generator. Say suddenly all the loads connected to the system are put off or failure of transformer / tr. Line then, Pg >>> Pd, Hence speed of the generator i.e frequency of the supply increases ,But due to over speed protective system will operate and generators are trip off. If generators are trip off, we cannot restore the supply immediately or instantly .Generator units in hydro power station require half an hour in restart generation .Thermal power station requires more, once the generator started they have to be connected in parallel. Load on the system has to be increased in discrete steps.	***2M*** ***2M***
	(d) **Ans.**	**State the need of load forecasting in 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.	**4M** ***Any four needs 1M each***

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 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.

1. (B) Attempt any ONE: **06**

(a) Develop a Y matrix for the following 3 bus system: **6M**

Bus Code	Line Impedance (P.u.)	Bus Code	Line charging admittance (P.u.)
1 - 2	0.08 + j0.32	1	j0.02
2 - 3	0.06 + j0.082	2	j0.01
1 - 3	0.05 + j0.06	3	j0.03

Ans. **Y bus matrix for given system**

Bus code	Impedance Z (pu)	Admittance pu(Y) = Z^{-1}	Line charging admittance(pu)
1-2	0.08 +j 0.32	0.73 – j2.94	j 0.02
2-3	0.06 +j 0.082	5.871–j7.94	j 0.01
1-3	0.05 +j 0.06	8.197-j9.84	j 0.03

½M

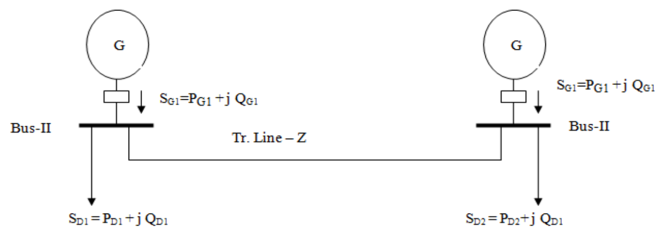
Line charging admittance of	in(pu)
Bus-1 -	y_{11} = j0.02 /2 + j0.03/2 = j0.025
Bus-2 -	y_{22} = j0.02/2 +j0.01 /2= j0.015
Bus-3 -	y_{33} = j0.01/2 +j0.03/2 = j0,02

1M

		Calculation of diagonal elements: $Y_{11} = y_{11} + y_{12} + y_{13}$ $=(j0.025) + (0.73 – j2.94) + (8.197 – j9.84)$ $= 8.927 – j12.755$ pu $Y_{22} = y_{21} + y_{22} + y_{23}$ $=(0.73 – j2.94) + (j0.015) + (j5.811 – j7.94)$ $= 6.541 – j10.865$ pu $Y_{33} = y_{31} + y_{32} + y_{33}$ $=(8.197 – j9.84) + (5.811 - j7.94) + (j0.02)$ $= 14.00 – j17.76$ pu	***2M***
		Calculation of off-diagonal elements: $Y_{12} = y_{21} = -y_{12} = -y_{21} = -(0.73-j2.94)$ pu $Y_{13} = y_{31} = -y_{13} = -y_{31} = -(8.197-j9.84)$ pu $Y_{23} = y_{32} = -y_{23} = -y_{32} = -(5.871-j7.94)$ pu	***2M***
		$\therefore Y_{bus}$ matrix $\begin{vmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{vmatrix} =$ $\begin{vmatrix} 8.927 - j12.755 & -(0.73 - j2.94) & -(8.197 - j9.84) \\ -(0.73 - j2.94) & (6.541 - j10.865) & -(5.871 - j7.94) \\ -(8.197 - j9.54) & -(5.871 - j7.94) & -(14.00 - j17.76) \end{vmatrix}$	***½ M***
	(b)	**For a simple two bus power system, derive the equation**	**6M**

$I_{bus} = Y_{bus} \cdot V_{bus}$

Ans. Consider a simple two bus power system as shown in the fig.



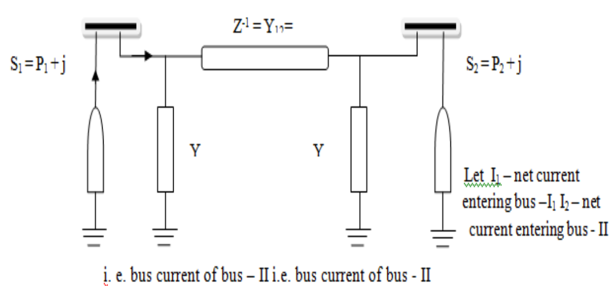
Let S_{G1}&S_{G2} be the power injected by the generators in bus – I and bus – II resply which was measured on the h. v. side of the transformers. Let S_{D1}&S_{D2} be the load demands on bus I & bus II resply. Two buses are interconnected by a transmission line having ∏ equivalent ckt. Let $V_1$and V_2be the voltage at two buses I & IIresply. *1M*

Let S_1&S_2 be the bus power which is defined as difference between generated power and load demand.

Hence,

$$S_1 = S_{G1} - S_{D1}$$
$$= (P_{G1} - P_{D1}) + j\,(Q_{G1} - Q_{D1})$$
$$= P_1 + j\,Q_1$$

This bus power can be considered as the power injected into the bus by a bus power source. Hence equivalent ckt. For the given system can be drawn as follow *1M*



1M

Bus power S_1 can also be written as,

$S_1 = V_{1\,/}\, I^*_1$ $\quad I_1^* = S_1/V_1$ $\quad I_1 = S_1^*/V_1^*$

Where I_1 enters tr. Line from bus – I.

<table>
<tr><td></td><td></td><td>By applying KCL at bus – I , we get
$I_1 = V_1 Y + (V_1 - V_2) Y'$
We get
$I_1 = S_1^*/V_1^* = V_1 Y + (V_1-V_2) Y'$ ----------------- (1)
$I_2 = S_2^*/V_2^* = V_2 Y + (V_2-V_1) Y'$ ----------------- (2)
The above two = o.s. can be simplified as
$I_1 = V_1 (Y + Y') - Y' V_2$------------------ (3)
$I_2 = -Y_1Y' + (Y+Y') V_2$ ------------------- (3)
Let $Y+Y' = Y_{11} = Y_{22}$
$-Y = Y_{12} = Y_{21}$
Substituting in above equn, we get
$I_1 = Y_{11} V_1 + Y_{12} V_2$ ------------------ (4)
$I_2 = Y_2 V_1 + Y_{22} V_2$ ------------------ (4)
Above eq. 7 o.s. can be written in matrix form as,
$$\begin{vmatrix} I_1 \\ I_2 \end{vmatrix} = \begin{vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{vmatrix} + \begin{vmatrix} V_1 \\ V_2 \end{vmatrix}$$ ---------- **(5)**
i.e. $I_{bus} = Y_{bus} V_{bus}$ ---------------- (6)
I_{bus} = bus current vector
V_{bus} = bus voltage vector
Y_{bus} – bus admittance matrix = $\begin{vmatrix} Y_{11} \\ Y_{12} \\ Y_{21} \\ Y_{22} \end{vmatrix}$</td><td>1M

1M

1M</td></tr>
<tr><td>2.</td><td>(a)
Ans.</td><td>Attempt any FOUR:
State the need for load flow analysis.
Need for load flow analysis:
Load flow studies give magnitude & phase angle of the voltage at each bus, Real and reactive power flow through tr. Lines, current flow through tr. Lines.
Hence load flow Studies are essential for- - - -
• For designing the power system.
• For operation of the system.
• For future expansion of the system to meet increase in the demand.
• For inter connecting the two systems to meet the load demand.
• For analyzing both normal and abnormal (means outage of tr. Lines or transformer or gen. units) operating conditions.</td><td>16
4M

Any four needs 1M each</td></tr>
</table>

- For analyzing the initial conditions of the system when the transient behavior of the system is to be studied.
- Transmission lines can carry only certain amount of current and we must make sure that we do not operate these links too close to their stability or thermal limits so LFA helps to know the amount current flowing through various lines in the network.
- LFA also helps in maintaining the stability of the system by giving the information about real, reactive power flow in the system.

OR

(1) The total amount of real power flow thro' the network generates at generating stations whose size and location are fixed. At each moment power generation must be equal to power demand as electrical power cannot be stored. 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. Hence the generator output must be closely maintained at predetermined set closely maintained at predetermined set points. It is important to remember that the power demand under goes slow but wide variation throughout the 24 hrs. Of the day. 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.

(2) Transmission lines can carry only certain amount of current and we must make sure that we do not operate these links too close to their stability or thermal limits. Load flow analysis help to know the amount current flowing thro' various lines in the network.

(3) Due to flow of reactive power voltage profile of certain buses changes. It is necessary to keep the voltage levels of these buses within close tolerances. This can be achieved by proper scheduling of reactive power flow and that can be studied by load flow analysis.

(4) To meet power demand it is necessary to inter connects the networks through tie lines. Then both networks must fulfill certain contractual power scheduling commitments via its tie lines to neighboring system. Hence power flow through tie lines can be monitored with the help of load flow solution.

(5) The disturbances in network leads to a massive network fault and sometime it can cause system outages. The effect of system outage can be minimized by proper pre-fault power flow strategies. These strategies can be decided based off on load flow analysis.

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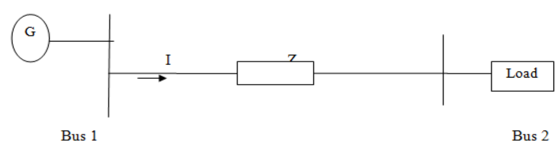
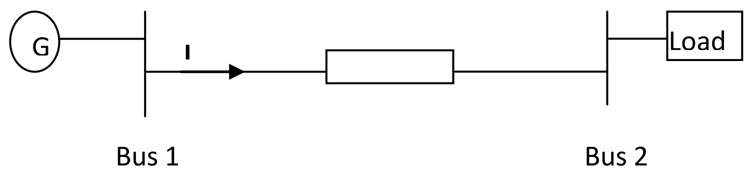
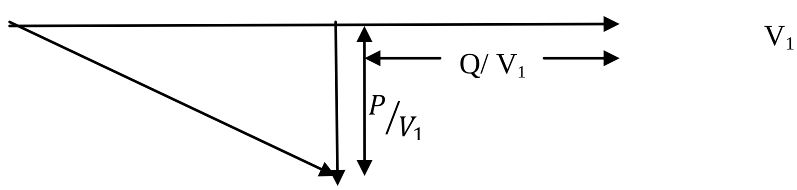
		(6) Load flow analysis is very important in the planning stages of new system networks or additions to existing ones.	
	(b)	**Derive the equation to prove that the voltage drop across the transmission line is mainly due to reactive power flow.**	**4M**
	Ans.	Consider a simple two bus system represented by a single line diagram as :  	***1M***
		Let $V_1 < \delta_1$ - be the voltage at bus-1 and $V_2 < \delta_2$ - be the voltage at bus-2 $S_1 = V_1 I_1$ $S_2 = V_2 I_2$ S_1= complex power that flows from bus 1 to bus 2 $= V_1 I_1 * = \left[\frac{V_1 < -\delta 1 - V_2 < -\delta 2}{-JX}\right]$ $= \frac{V_1 V_2 sin\delta}{X} + j\left(\frac{{V_1}^2 - V_1 V_2 COS\delta}{X}\right) = P_1 + jQ_1$ $\therefore Q_1 = \frac{{V_1}^2 - V_2 I_2 cos\delta}{X}$.............(1)	***1/2M***
		S_2 = Complex power that flows from by bus 2 to bus 1 $= (V_2 I_2) * = V_2 < \delta_2 \left[\frac{[V_2 < -\delta_2 - V_1 < -\delta_1]}{-jX}\right] =$ $\frac{V_2 V_1 sin\,\delta}{X} + \left(\frac{(V_2 V_1 Cos\delta - {V_2}^2)}{X}\right)$ $= P_2 + Q_2$	***1/2M***
		$\therefore Q_2 = \frac{V_2 V_1 \cos\,\delta - {V_2}^2}{X}$..................(2) To maintain the stability of system the angle δ is maintained at lower value. For small value of δ, the value of cos $\delta \approx 1$ Rewriting the equations (1) & (2)	***1/2M***
		$Q_1 = \frac{{V_1}^2 - V_2 V_1}{X} = \frac{V_1 (V_1 - V_2)}{X} Q2 = \frac{V_2 V_1 - V2^2}{X} = \frac{(V_2 - V_2) V_2}{X}$ This shows that the reactive power depends on voltage drop.i.e. Q$\propto V_1 - V_2$	***1/2M***

		∴ As reactive power flow increases the voltage drop across the line also increases. Reactive power flow through the system depends on voltage level at buses but independent of δ i.e. frequency. **OR** Consider a simple power system represented by a single diagram  Let V_1 be Bus voltage at bus 1 Let V_2 be Bus voltage at bus 2 Two buses are interconnected by a short transmission line with zero line losses (i.e R=0) ∴ Z= j X Maintain the voltage at bus 1 by regulating output voltage of generator Now V_2=V_1-I Z = V_1- jI X Complex power at bus 1 is S= $V_1 I_1$* = P+ j Q ………… assuming inductive $I = \frac{P+jQ}{V_1}$ ∴$I_1 * = \frac{P-jQ}{V_1}$ $V_2 = V_1 - \left(\frac{P-jQ}{V_1}\right) jX = (V_1 - \frac{Q}{V_1}X) - j\frac{P}{V_1}X$ The above equation can be represented in vector form as  From this vector diagram it is clear that the load voltage V_2 is not affected much due to real component of the power P as it is normal to the vector V_1, whereas the drop due to reactive component of power is directly subtracted from the voltage V_1. Assuming the voltage drop due to real power negligible, the voltage drop is directly proportional to the reactive power Q. $$V_2 = V_1 - \frac{Q}{V_1}X$$ $$V_1 - V_2 = +\frac{Q}{V_1}X$$	*1M* *1M* *1M* *1M* *1M*

		In order to keep the receiving end voltage V_2 fixed the drop $\left(\frac{Q}{V}X\right)$ must remain constant. This shows that $(V_1 - V_2) \propto Q$ Any variation in Q will vary the voltage drop i.e voltage of bus 2 . Hence locally Q can be supplied to the load to maintain V_2 constant.	
	(c) Ans.	**List the various methods of voltage control and their field of applications.** Following are the method of voltage control in power system. 1. By tap changing transformers. i. Off load tap changing Location – Distribution Substations, ii. On load tap changing Location- Intermediate Distribution Substations. 2. By shunt reactors - location long Transmission line 3. By shunt capacitors Location – Distribution Substations, 4. By static shunt compensation –Distribution lines 5. By synchronous condenser location – Location LDC 6. By series capacitors – Long tr. lines 7. By flexible AC transmission (FACT) devices. Location- HV and EHV transmission lines	**4M** ***Any four - 1M each***
	(d) Ans.	**Enlist any four factors which govern the load shedding in a power system.** **Factors that governs the load shedding pattern in power system** 1) Imbalance between power demand & power generation 2) Sudden rise or fall in demand/ load 3) Major faults like 3 phase faults, L-L fault. turns into instability Condition. 4) Sharing of power so to increase run time of critical loads. 5) To reduce wastage of energy & max demand 6) To adopt energy conservation objectives 7) To reduce peak demand charges and also to reduce energy bills 8) To optimize capacity of the UPS battery can be extended.	**4M** ***Any four factors 1M each***
	(e) Ans.	**State the factors that govern load shedding.** **The factors governing load shedding duration:** 1. The imbalance between power demand and power generation due insufficient resources. To reduce effect of imbalance intentionally supply to some load are cut off. 2. The sudden rise or fall in power demand leads to wide gap	**4M**

		between demand and supply, and that results into instability in the system. To reduce effect of instability load shedding is carried out. 3. Due to major faults like three phase short circuit fault, line to ground fault, failure of switch gears or major equipments instability condition occurs in the system. To reduce effect of instability load shedding is carried out. 4. To reduce wastage of energy and to adopt energy conservation techniques supply to selective loads (mostly lighting loads) are shut off. 5. To reduce the maximum demand of any industry or commercial complex local load shedding is carried out to reduce the peak demand and also to reduce energy bills. 6. Refer to individual load; lighting control strategy is adopted for selectively reducing the output of light fixtures on a temporary basis so that it will reduce peak demand charges. 7. Load shedding is carried out to selectively shut off a set of output receptacles so that the capacity of the UPS battery can be extended. 8. To share power, the UPS switches off selected devices to increase run time of critical loads. 9. The onset of summer every year brings with it the woes of load shedding. It has hit the manufacturing sector and many times forcing them to shut down operations resulting in losses worth several crore. 10. Excessive drop in voltage profile in certain part of network then load shedding is carried out for compensation.	***Any four factors 1M each***
	(f) **Ans.**	**State & explain different types of buses in Power system.** **Types of buses:** In power system for load flow studies following types of buses are considered. i. Slack bus / Reference bus ii. Load bus / PQ bus iii. PV bus / Generator bus iv. Voltage controlled bus **i. Load Bus:** At this bus power is injected or delivered to load. Hence real & reactive component of power is specified. At this bus	**4M**

voltage is allowed to vary within the permissible limit and phase angle 'δ' is not important from consumers point of view. This is also called as PQ bus. Power ejected from bus is considered as negative.

ii. Generator bus: At this bus power generated is injected into the system. Hence the magnitude of voltage corresponding to its rating are specified from load flow solution and it is required to find out Q & S. This is also called as PV bus

Types of buses 1M each

iii. Voltage Control bus: This bus generally considered as PV bus, but there is physical difference. Voltage control bus has voltage control capabilities and uses tap-changing transformer & static VAR compensators where as generator bus has generator.
Here $P_G = 0$ & $Q_G = 0$, hence $P_i = -P_D$, $Q_i = -Q_D$.
V_i are known and δ_i is unknown.

iv. Slack Or Swing Or Reference Bus: In power system power is injected by generator bus and power is delivered or ejected at Load bus. So whatever losses takes place in the system remains unknown, until the load flow solution is complete. Hence one of 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. At this bus the magnitude of bus voltage and phase angle are specified while P & Q are obtained through the load flow solution.

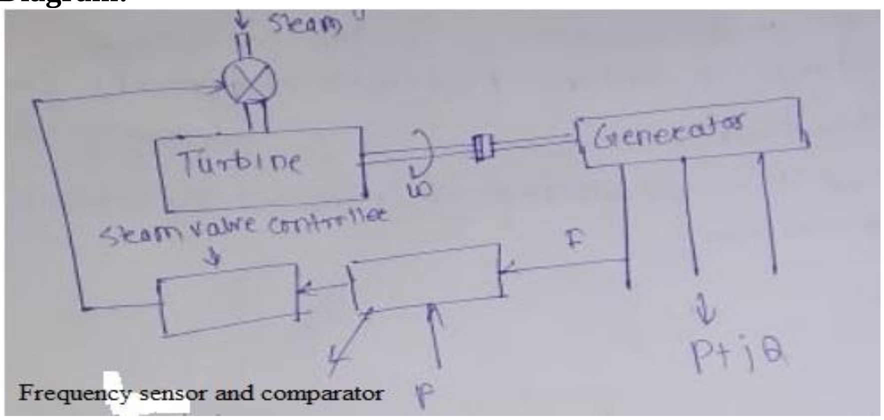
Type Of Bus	Specified quantities specification	Quantities Obtained Unknown Quantities
Load bus	P,Q	V, δ
Generator bus	P, V	Q, δ
Voltage control bus	V,P,Q	Δ

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

(a) **With the help of block diagram, explain load frequency control (single area case).** **4M**

Ans. In power system network 'single area' is defined as grid network consisting no. of generators supply power to all consumer in that area. Stability is concerned with that area only. Power demand and supply

Explanation 2M

		observed for this area only. All generators are connected in parallel in synchronism and share the load. The system can be modeled as below **Diagram:**  The above figure shows the block diagram of load frequency control.	***Diagram 2M***
	(b) **Ans.**	**List out the information that can be collected from load flow analysis.** The information collected from the load flow analysis is as, 1. Get MW and MVAR flow in the various parts of the system network. 2. Get the information about voltage at various buses in the system. 3. Get the information about optional load distribution. 4. Impact of any change in generation 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 for of appropriate rating and tap setting of the power of transformer in the system. 7. Influence of any change in conductor size of system voltage level on power flow.	**4M** ***Any four points 1M each***
	(c) **Ans.**	**Write the swing equation and define each term in it.** $\frac{md^2\delta}{dt^2} = P_a = P_m - P_e$ $where m = angular momentum,$ $P_m = mechanical power input,$ $P_e = electrical power output,$ $P_a = accelerating power,$ $\delta = angular displacement of rotor$	**4M** ***Equation 3M*** ***Meaning of each term 1M***

	(d) **Ans.**	**State and explain factors affecting the transient stability of a power system.** **Factors affecting the transient stability of a power system:** 1. The designing of system network and if any new addition of system, compo.(generation, transformer, sub-station, transmission line, database line protection system). 2. If the generation plays the major role in the stability condition of system. The performs characteristics of generator depend on type of prime-move, type of the flue sources and it ability and manufacturing technology hence also maximum and minimum. Power generation system and each generating unit and their characteristics have significant impact on transient stability condition. 3. Under transient condition prime-mover rotor inertia. (Inertia constant) and excitation response of excitation system response of damping system provided in the rotor of alternator the response of mechanical damping system. Prime-mover determines the performance of generator under transient stability condition. 4. The transient reactor of the network (transmission line, distribution line reactor). The transient reactor are decides transient stability limit and hence it has got significant response on a transient stability. 5. Protective scheme are adopted for system major component like generator, transformer and transmission line. The critical fault transient stability. Similarly, considering all network together total network response also has great impact on transient stability. 6. All machine connected in the network subjected to angular swing. The angular swing of machine during fault and often clearness of fault affect stability condition of the system (the excitation of rotor of machine is inversely proportional to its movement of inertia) the higher movement of inertia area variation in rotor angle will small work and there by long time is required for circuit breaker operation. 7. Switching time of reactor have which decides the transient reactor the switching type of shunt and series reactor, have sustainable reactor on transient condition. 8. The voltage regulation adopted in system affect the stability sub-sequence of first oscillation after clearance of fault.	**4M** ***Any four points 1M each***
	(e) **Ans.**	**State and explain the different planning tools used for load forecasting.**	**4M**

		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 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.	***List of Types of plannin g tools 1M*** ***Each explanat ion 1M***

	(f) Ans.	**Write down at least four major functions of load dispatch center.** ***(Note: Any other point shall be considered)*** **Following are the Major functions of Load dispatch centre:** i) LDS shall facilitate wheeling and inter-connection arrangements of local grid systems within its territorial jurisdiction, for the transmission and supply of electricity by economical and efficient ways. ii) The Load Dispatch Centre shall – be responsible for optimum scheduling and dispatch of electricity within a State/region, in accordance with the contracts entered into with the licensees or the generating companies operating in that State/region. iii) LDC should monitor grid operations within the State/region. iv) LDC has to keep the accounts of the quantity of electricity transmitted through the State/national /regional grid. v) LDC has to exercise supervision and control over the intra-state transmission system. vi) LDC are responsible for carrying out real time operations for grid control and dispatch of electricity within the State/region through secure and economic operation of the State/regional grid in accordance with the Grid Standards and the State/National Grid Code. vii) 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/region.	**4M** ***Any four functions 1M each***
4.	**(A)** **(a)** **Ans.**	**Attempt any TWO:** **State the difference between 'Shunt compensation' and 'synchronous compensation'.**	**12** **6M** ***Any six differences 1M each***

Shunt Compensation	**Synchronous Compensation**
Static system/No moving parts	Rotary system /It is a revolving machine
Control is slow and stepwise compared to synchronous compensation	Control is fast and continuous
It cannot be overloaded	It can be overloaded for short periods
Located near load	Located away from load

Less maintenance	More maintenance
Failure of one unit of static capacitor bank affects that unit only, remaining unit continue to operate	Failure of synchronous compensator means loss of complete unit
Applicable for small reactive power requirement.	Applicable for large i.e above 10 MVAr it is required.
Maintenance is easy	Maintenance is difficult
e.g Reactor, Capacitor	e.g Synchronous motor

(b) **List out the adverse effects of power system instability.** **6M**

Ans.

1) It delivers unreliable power.
2) Supply parameters fluctuate beyond the tolerance limit.
3) Delivers poor quality supply to consumers.
4) Non-economical power generation, transmission and distribution takes place.
5) The system experiences failure of system components which may lead to measure of power failure.
6) Disturbance in load scheduling and power generation and planning.
7) Operation of the system under unstable condition leads to damaging of power system components as well as loads connected to system network.

Any six 1M for each

(c) **The incremental fuel curve of 2 units of a generating station are** **6M**

$df/dp_1 = 0.6\ P_1 + 60$Rs/MWh

$df/dp_2 = 0.4\ P_1 + 40$Rs/MWh

Determine load distribution between the two units under economical load dispatch, if the total load on generating station is 600W.

Ans.

$df/dp_1 = 0.6\ P_1 + 60$Rs/MWh

$df/dp_2 = 0.4\ P_1 + 40$Rs/MWh

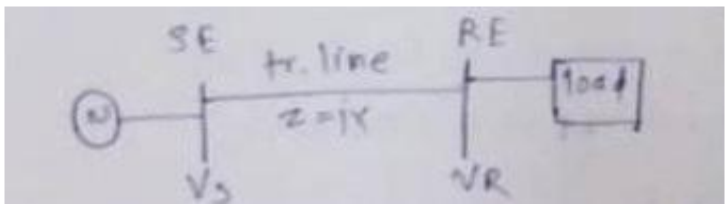
Total load = 600W

$\therefore\ P_1 + P_2 = 600W$……………………………(i) ***1M***

For economical load dispatch $df/dp_1 = df/dp_{PL}$ ***1M***

$0.6P_1 + 60 = 0.4P_2 + 40$Rs/MWh

		$0.6P_1 - 0.4P_2 = 40.60$	
		$0.6P_1 - 0.4P_2 = -20$	*1M*
		$P_1 + P_2 = 600$……………………….(ii)	
		By solving (i) and (ii)	
		$0.4(P_1 + P_2) = 0.4(600)$	
		$0.6P_1 - 0.4P_2 = -20$	*1M*
		$0.4P_1 + 0.4P_2 = 240$ $\underline{0.6P_1 - 0.4P_2 = -20}$	
		$\boxed{P_1 = 220MW}$	*1M*
		$\boxed{P_2 = 600 - 220 = 380MW}$	*1M*
4.	**(B)**	**Attempt any ONE:**	**06**
	(a)	**Write SLFE for a two bus system and define it's parameters.**	**6M**
	Ans.	For a simple two bus system Load flow equations can be written as….	
		SLFE Equation: $S_1 * = V_{12}\, Y_{11}\, L\angle\alpha_{11} + Y_{12}\, V_2\, V_1\, (\delta_2 - \delta_1) = P_1 - j\, Q_1$ $P_1 = V_{12}\, Y_{11} \,Cos\angle\, \alpha_{11} + Y_{12}\, V_2\, V_1\, Cos\, (\delta_2 - \delta_1)$ $Q_1 = (V_{12}\, Y_{11}\, Sin\angle\, \alpha_{11} + Y_{12}\, V_2\, V_1\, Sin\, (\delta_2 - \delta_1)$	*2M*
		$S_2 * = V_{22}\, Y_{22}\, L\angle\, \alpha_{22} + Y_{21}\, V_2\, V_1$ $(\delta_1 - \delta_2) = P_2 - j\, Q_2$ $P_2 = V_{22}\, Y_{21}\, Cos\angle\, \alpha_{22} + Y_{21}\, V_2\, V_1\, Cos\, (\delta_1 - \delta_2)$ $Q_2 = (V_{22}\, Y_{22}\, Sin\angle\, \alpha_{11} + Y_{12}\, V_2\, V_1\, Sin\, (\delta_1 - \delta_2)$	*2M*
		V_1, V_2….Vn are the bus voltages δ_1, δ_2…. are load angles with reference to bus-1, bus-2 and so on. Y_{11}, Y_{22}….. areself admittance with reference to bus-1, bus-2 and so on.	

		Y_{12}, Y_{21}…. are Mutual admittance with reference to bus-1, bus-2 and so on S_1, S_2……complex power at bus-1, bus-2. P_1, P_2……..Real power at bus-1, bus-2. Q_1, Q_2…….Reactive power at bus-1, bus-2.	***2M***
	(b) **Ans.**	**Derive the expression for maximum power flow under steady state condition.** Consider a simple power system with less transmission line as shown in figure.  Power transmitted from S.E. to R.F. is S = VsI Where 1= $\frac{V_S - V_R}{jx}$ = V_S $\therefore V_S = \left(\frac{V_S - V_R}{-jx}\right)$ Now $V_R = V_R < 0$ $V_S = \lvert V_S \rvert < \delta$ $\therefore S_S = P_S + jQ_S$ $S_S = \frac{Vs^2 - V_s V_R < \delta}{-jx}$ X $\frac{1}{J}$ $= \frac{Vs^2 - V_s V_R(\cos\delta + i\sin\delta)}{x}$ j $= \frac{V_S - V_R}{x}\sin\delta + i\frac{Vs^2}{x} - \frac{V_S V_R \cos\delta}{X}$ $\therefore P_S = \frac{V_S - V_R}{x}$ $Q_S = Vs^2 - \frac{V_S V_R \cos\delta}{X}$	**6M** ***1M*** ***1M*** ***1M*** ***1M***

<table>
<tr><td></td><td></td><td>Similarly at receiving end power will be

$S_R = V_R I_R^* = V_R \left[\frac{V_R - V_S}{jx}\right]^*$

$= V_S V_R \sin\delta + j\left(\frac{V_S V_R}{x}\cos\delta - \frac{VR^2}{X}\right)$

i.e. = $P_R = \frac{V_S V_R}{x}\sin\delta$ $Q_R = \frac{V_R (V_S \cos\delta - V_R)}{x}$

$\therefore P_S = P_R = \frac{V_S V_R}{x}\sin\delta$

$\therefore$ For constant V_S V_R . X

$P \ \alpha \ sin\delta$

When $0 < \delta < 180$ ……………P is +ve
$180 < \delta < 360$……………...P is –ve

$\therefore$ When δ is 90^0

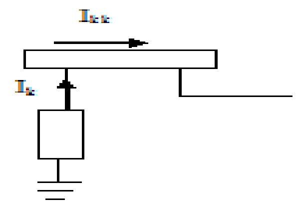
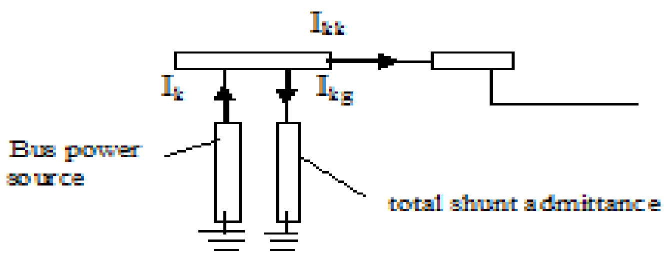
$P_{max} = \frac{V_S V_R}{x}$

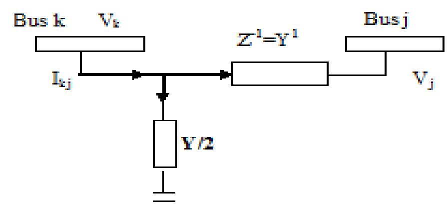
This is the maximum power flow for steady state stability.</td><td>

½M
½M

1M</td></tr>
<tr><td>5.</td><td>
(a)
Ans.</td><td>**Attempt any FOUR:**
State the advantages of reactive power compensation.
Advantage of reactive power compensation
1. Reduction in reactive component of circuit current
2. Maintenance of voltage profile within limits
3. Reduction of Copper losses in the system due to reduction of current.
4. Reduction in investment in the system per kW of load supplied
5. Decrease in KVA loading of generators and circuits. This decrease in KVA loading may relieve an overload condition or release capacity for additional load growth.
6. Improvement in p.f. of generators.
7. Reduction in KVA demand charges for large consumers
8. Overall improvement in system efficiency.</td><td>**16**
4M

Any four advantages 1M each</td></tr>
</table>

	(b)	**State and explain the terms 'Bus loading' and 'Line flow equations'.**	**4M**
	Ans.	**Bus Loading:** The real of reactive power at any kth bus can be written as $S_k = P_k - jQ_k = V_k^* I_K$ Current at bus I $I_k = \frac{P_k - Q_k}{V_k^*}$  Bus Current I_k is positive when if flows into the system. If the shunt elements are neglected or considered in Y_{bus} matrix thenabove equation represents bus current i.e. bus loading $I_k = I_{kk}$. If the shunt elements is considered then equivalent ckt. for bus can be drawn as.  Now the net current through bus -I_{kk}=$I_k - I_{kg}$= $\frac{P_k - Q_k}{V_k^*}$ -$V_k Y_{kk}$ When Y_{kk} =Total Shun Admittance **Lines Flow Equation:** Assume that current is flowing through tr. Line from bus k to bus j. $\boldsymbol{I_{kj} = \frac{V_k - V_j}{Y} Y^1 + V_k \, Y/2}$ Where Y^1- line admittance Y – line changing admittance Now power flow from bus k to bus j is $P_{kj} - jQ_{kj} = V_k^* I_{kj} = V_k^*(V_k - V_j)y^1 + V_k^* V_k Y/2$	***Bus loading 2M*** ***Lines flow equation 2M***

		Similarly power flows from j to k is $P_{jk} - jQ_{jk} = V_j^* I_{jk} = V_j^*(V_j - V_k)y^1 + V_j^* V_j Y/2$  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.	
	(c) **Ans.**	**State the difference between ‘power system stability’, ‘Power system instability’, ‘Stability limit’ and ‘overall stability’.** **i) Overall stability:** It is the stability of the power system when synchronism of one of working generator has been lost the normal operating condition can be re-established without disconnection of major elements. **ii) Power System Stability:** It is ability to return to normal or stable operation after having been subjected to some form of disturbance. **iii) Power System instability:** It is status of system when it loses its normal stable operating condition because of increase in power demand beyond the capacity of power generation**.** **iv) Stability Limit:** It is the maximum power flow possible though same particular point in the system when the entire system or part of the system to which the stability limit refers is operating with stability.	**4M** ***1M each***
	(d) **Ans.**	**Draw a neat labelled diagram of turbine speed governing system.**	**4M**

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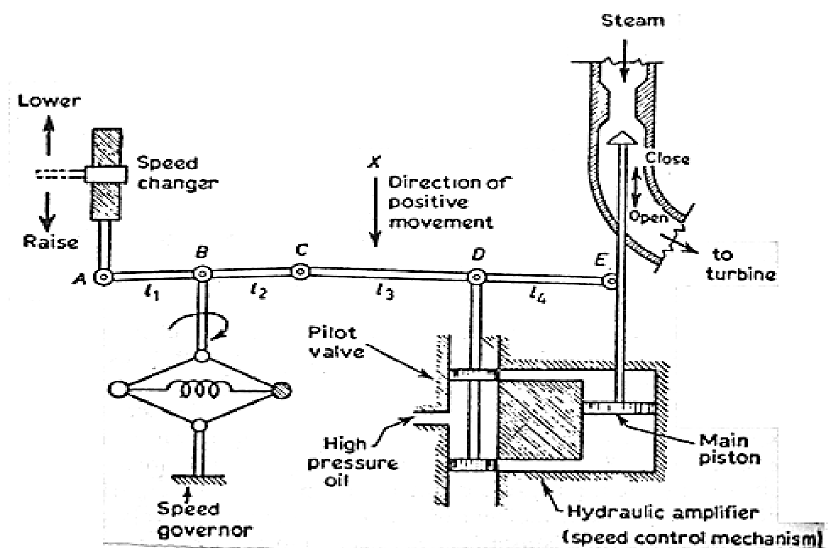
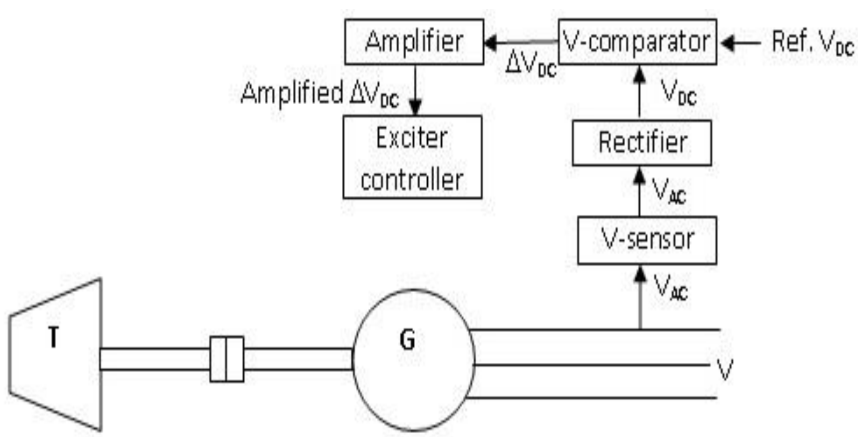
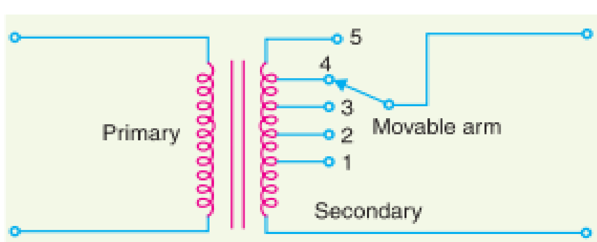
		 Turbine-Speed Governing System	*Diagram 4M*
	(e) Ans.	**Draw only a neat labelled schematic diagram for alternator voltage control system.** Voltage control system used for alternator is called as Automatic Voltage Control/Automatic Voltage regulator (AVR): 	**4M** s *Diagram 4M*

	(f)	**Explain, how voltage can be controlled in a power system with the help of transformer.** ***(Note: Diagram is not necessary)***	4M
	Ans.	Following are the different types of transformers used for voltage contr in power system. **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) Off load tap-changing transformer:** Figure shows the arrangement where a number of tapings have been provided on the secondary. As the position of the tap is varied, the effective number of secondary turns is varied and hence the output voltage of the secondary can be changed. Thus referring to figure when the movable arm makes contact with stud 1, the secondary voltage is minimum and when with stud 5, it is maximum. During the period of light load, the voltage across the primary is not much below the alternator voltage and the movable arm is placed on stud1. When the load increases, the voltage across the primary drops, but the secondary voltage can be kept at the previous value by placing the movable arm on to a higher stud. Whenever a tapping is to be changed in this type of transformer, the load is kept off and hence the name off load tap-changing transformer.  **3) Regulating transformer:** A special type of transformer designed for small adjustments of	***Any four types 1M each***

voltage is known regulating transformer. The fig. shows a typical arrangement to use a regulating transformer for voltage mag control in a 3 phase circuit. A 3 phase transformer provides on adjustable voltage to the primary of the regulating transformer. The secondary of the regulating transformer are connected in series with the lines. Thus a voltage magnitude of $|\Delta V|$ volt is added to the voltage of each phase.

Location: distribution Substation

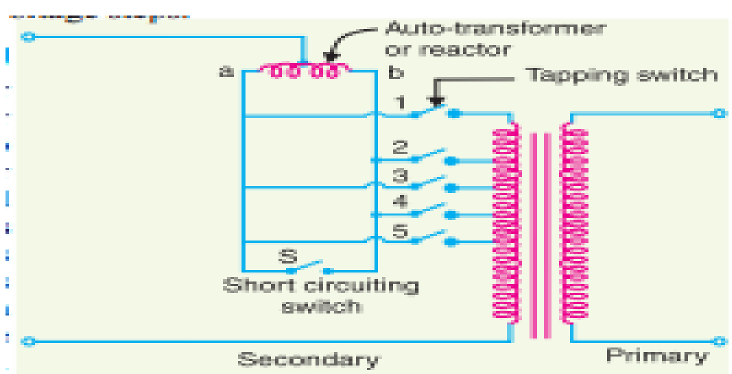
4) Booster Transformer:

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

5) Auto-Transformer Tap-changing:

It shows diagrammatically auto-transformer tap changing. Here, a mid-tapped auto-transformer or reactor is used. One of the lines is connected to its mid-tapping. One end, say a of this transformer is connected to a series of switches across the odd tapings and the other end b is connected to switches across even tapings. A short-circuiting switch S is connected across the auto-transformer and remains in the closed position under normal operation. In the normal operation, there is no inductive voltage drop across the auto-transformer.



6.		**Attempt any FOUR:**	**16**
	(a)	**Explain the effect of change in frequency on various consumers.**	**4M**
	Ans.	Consumers need constant frequency supply because 1) In most of the industries, Induction motor is used as common drive, which runs at speed that is directly related with frequency. (N= 120f/p) variation in frequency affects the quality of the product and rate of production. 2) Induction motor used as common a.c. drives though has rigid construction but due to variation in supply frequency, life of induction motor reduces by 500 Hrs. They are not sensitive for small variation in the supply frequency. i.e. of the order of 50 $\pm$ 2 Hz. 3) In railway stations, the electric chokes are driven by single-phase synchronous motor, The speed of the synchronous motor depends on supply frequency directly. Hence it needs constant frequency supply for all 24 Hrs. of the day. If frequency falls by 1 hr , then clock falls back by 15 min. & it takes no. of hours to reduce the error to zero. 4) In some industries such as the textiles rubber, plastic & paper require frequency constant or to a tolerance of $\pm$ 0.25 per min. 5) Electric gear systems used in industries requires the frequency 49.5 Hz to 50.5 Hz range.	***Any four points 1M each***
	(b)	**Define the following terms:** **(i) Steady state stability and its limit.** **(ii) Transient state stability and its limit.**	**4M**
	Ans.	**(i) Steady state stability:** When the power system has capacity to regain and maintain equilibrium condition (synchronous speed) after a small slow disturbance such as load variation or changes in load condition occurs, then the power system is said to be in steady state stability condition. **Steady State stability limit:** It is defined as max power which can flow through point in the system without causing loss of stability, when system experiences a small disturbance. **(ii) Transient stability:** Transient stability is the ability of the power system to regain or maintain equilibrium conditions after experiencing a large sudden disturbance. **Transient state stability limit**: It refers to max possible flow of power through a point without loss of stability when system experiences a large sudden disturbance.	***1M for each***

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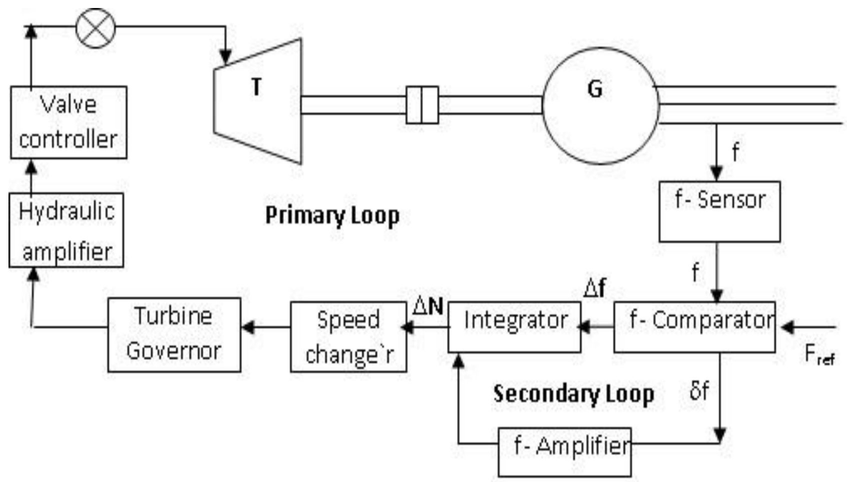
	(c) **Ans.**	**Explain with the help of block diagram working of automatic load frequency control (ALFC) of a synchronous generator.**  In an electric power system, Automatic Generation Control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response 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 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	**4M** ***Diagram 2M*** ***Explanation 2M***

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 to Frequency 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.

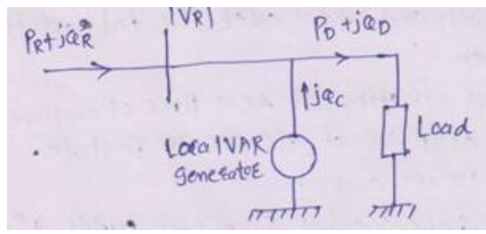
Secondary loop: It comprises Frequency amplifier which receives minor variation signal of frequency and feed the amplified signal to integrator.

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.

(d) **Explain reactive power injection method used for voltage control.** **4M**

Ans.



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. $Q_G = Q_D$ bus voltage is maintained at specific value.

As VAR demand Q_D varies, a local VAR generator must be used as shown in fig. The VAR balance equation at the receiving end is now.

$Q_G = Q_D + Q_C$

Any variation Q_D 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.

Concept 1M

Following are the equipments used to inject VARs in the system at different points.

Generation system	Excitation control	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.
Transmission system	Series reactors	Capacitors and inductors in HV and EHV trans. Line Static VAR system
Distribution system	Shunt reactors	Capacitor’s bank Synchronous condenser Static VAR system

Each equipment 1M

	(e) Ans.	**State and explain any two methods that can be adopted for the improvement of transient stability condition of a power system** Following are methods that can be adopted for the improvement of transient stability condition of a power system: These techniques are classified as Traditional Technique and New Approaches Traditional Technique: i) Effect of generator design. ii) Increase of voltage iii) Reduction in transfer reactance iv) Rapid fault clearing v) Automatic reclosing New Approaches: i) Quick valve opening action. ii) Application of braking resistors iii) Single pole switching iv) Fast acting automatic voltage regulator **i) Effects of Generator Design:** A heavy machine has greater inertia 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. A 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. When two lines are connected in parallel and 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. Some features of the power system layout and business arrangement also help in improving stability. Use of bundled conductors helps in reducing line reactance and improving line stability. The compensation of line reactance by series capacitance is another effective method of improving stability. **iv) Rapid fault clearing:** By decreasing the fault cleaning angle (by using high speed breakers) stability can be improved. **v) Automatic Reclosing:** Most of the fault's on the transmission	**4M** ***Any two methods from any techniques 2M each***

		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 fault and then the circuit breaker recloses, after a suitable time interval.	
	(f) **Ans.**	**State the significant features of Y bus.** **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 explains 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 two buses. 6. All diagonal elements indicate the sum of line charging admittance & transmission line admittance. It is also called as self admittance of a bus.	**4M** ***Any four points 1M each***