3 Power System Control

3.1 - Voltage Control

Multiple Choice Questions

Q.1 For a given power delivered, if the working voltage of a distributor line is increased to n times, the cross-sectional area A of the distributor line, would be reduced to

(a) $\frac{1}{n}A$ (b) $\frac{1}{n^2}A$

(c) $\frac{1}{2n^2}A$ (d) $\frac{1}{2n}A$

[IAS-1998]

Q.2 If a fixed amount of power is to be transmitted over certain length with fixed power loss, it can be said that volume of conductor is

(a) Inversely proportional to magnitude of the voltage and that of power factor of the load
(b) Inversely proportional to square of the voltage and square of power factor of the load
(c) Proportional to square of voltage and that of power factor of the load
(d) Proportional to magnitude of the voltage only

[ESE-2010]

Q.3 For a fixed value of complex power in a transmission line having a sending end voltage V, the real power loss will be proportional to

(a) V (b) V^2
(c) $1/V^2$ (d) $1/V$

[GATE-2009]

Q.4 Match the items in **List-I (To)** with the items in **List-II (Use)** and select the correct answer using the codes given below the lists.

List-I
A. improve power factor
B. reduce the current ripples
C. increase the power flow in line
D. reduce ferranti effect

List-II
1. shunt reactor
2. shunt capacitor
3. series capacitor
4. series reactor

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	2	4	3	1
(c)	4	3	1	2
(d)	4	1	3	2

[GATE-2009]

Q.5 For enhancing the power transmission in a long EHV transmission line, the most preferred method is to connect a

(a) series inductive compensator in the line
(b) shunt inductive compensator at the receiving end
(c) series capacitive compensator in the line
(d) shunt capacitive compensator at the sending end

[GATE-2011]

Q.6 The rated voltage of a 3-phase power system is

(a) rms phase voltage
(b) peak phase voltage
(c) rms line to line voltage
(d) peak line to line voltage [GATE-2004]

Q.7 A 3-phase 11-kV generator feeds power to a constant power unity power factor load of 100 MW through a 3-phase transmission line. The line-to-line voltage at the terminals of the machine is maintained constant at 11 kV. The per unit positive sequence impedance of the line based on 100 MVA and 11 kV is $j0.2$. The line to line voltage at the load terminals is measured to be less than 11 kV. The total reactive power to be injected at the terminals of the load to increase the line-to-line voltage at the load terminals to 11 kV is

(a) 100 MVAR (b) 10.1 MVAR
(c) –100 MVAR (d) –10.1 MVAR

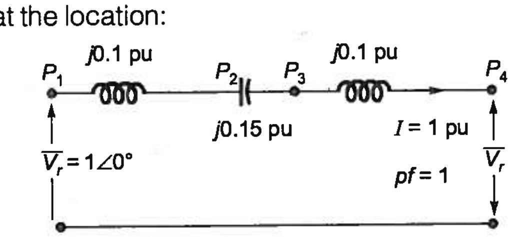
[GATE-2003]

Q.8 The ABCD parameters of a 3-phase overhead transmission line are $A = D = 0.9\angle 0$, $B = 200\angle 90°\ \Omega$ and $C = 0.95 \times 10^{-3}\angle 90°$ S. At no-load condition a shunt inductive reactor is connected at the receiving end of the line to limit the receiving-end voltage to be equal to the sending-end voltage. The ohmic value of the reactor is

(a) $\infty\ \Omega$ (b) 2000 Ω
(c) 105.26 Ω (d) 1052.6 Ω

[GATE-2003]

Q.9 Consider the model shown in figure, of a transmission line with a series capacitor at its mid-point. The maximum voltage on the line is at the location:



(a) P_1 (b) P_2
(c) P_3 (d) P_4

[GATE-2001]

Q.10 Consider two buses connected by an impedance of $(0 + j5)\ \Omega$. The bus 1 voltage is $100\angle 30°$ V, and bus 2 voltage is $100\angle 0°$ V. The real and reactive power supplied by bus 1, respectively are

(a) 1000 W, 268 Var
(b) –1000 W, –134 Var
(c) 276.9 W, –56.7 Var
(d) –276.9 W, 56.7 Var [GATE-2010]

Q.11 Shunt reactors are sometimes used in high voltage transmission systems to

(a) limit the short circuit current through the line.
(b) compensate for the series reactance of the line under heavily loaded condition.
(c) limit over voltages at the load side under lightly loaded condition.
(d) compensate for the voltage drop in the line under heavily loaded condition.

[GATE-2014]

Q.12 The inductance and capacitance of a 400 kV, three-phase, 50 Hz lossless transmission line are 1.6 mH/km/phase and 10 nF/km/phase respectively. The sending end voltage is maintained at 400 kV. To maintain a voltage of 400 kV at the receiving end, when the line is delivering 300 MW load, the shunt compensation required is

(a) capacitive (b) inductive
(c) resistive (d) a zero

[GATE-2016]

Numerical Data Type Questions

Q.13 The complex power consumed by a constant voltage load is given by $(P_1 + jQ_1)$, where 1 kW $\le P_1 \le$ 1.5 kW and 0.5 kVAR $\le Q_1 \le$ 1 kVAR. A compensating shunt capacitor is chosen such that $|Q| \le$ 0.25 kVAR, where Q is the net reactive power consumed by the capacitor load combination. The reactive power (in kVAR) supplied by the capacitor is _______ .

[GATE-2014]

Q.14 At an industrial sub-station with a 4 MW load, a capacitor of 2 MVAR is installed to maintain the load power factor at 0.97 lagging. If the capacitor goes out of service, the load power factor becomes_____.

[GATE-2005]

Q.15 A shunt reactor of 100 MVAr is operated at 98% of its rated voltage and at 96% of its rated frequency. The reactive power absorbed by the reactor is_____.

[GATE-1999]

Q.16 A 3-phase, 11 kV , 50 Hz , 200 kW load has a power factor of 0.8 . A delta connected 3-phase capacitor is used to improve the power factor to unity. The capacitance per phase of the capacitor in micro farads is _____ .

[GATE-1999]

Q.17 A balanced delta connected load of $(8 + j6)\ \Omega$ per phase is connected to a 400 V, 50 Hz, 3-phase supply lines. If the input power factor is to be improved to 0.9 by connecting a bank of star connected capacitors the required kVAR of the bank is_____.

[GATE-2003]

Q.18 A feeder with reactance of 0.2 p.u. has a sending end voltage of 1.2 p.u. If the reactive power supplied at receiving-end of the feeder is 0.3 p.u., the approximate voltage drop in feeder will be _____ p.u.

[IAS-1999]

Q.19 A three-phase cable is supplying 800 kW and 600 kVAr to an inductive load. It is intended to supply an additional resistive load of 100 kW through the same cable without increasing the heat dissipation in the cable, by providing a three-phase bank of capacitors connected in star across the load. Given the line voltage is 3.3 kV, 50 Hz, the capacitance per phase of the bank, expressed in microfarads, is _________.

Q.20 The power consumption of an industry is 500 kVA, at 0.8 p.f. lagging. A synchronous motor is added to raise the power factor of the industry to unity. If the power intake of the motor is 100 kW, the p.f. of the motor is _______.

[GATE-2016]

Conventional Questions

Q.21 The Thevenin's equivalent impedance of a busbar in a three-phase 400 kV system is 0.20 p.u. at a base of 500 MVA. Calculate the reactive power needed to
(a) boost the voltage by 5 kV at the busbar
(b) reduce the voltage by 4 kV at the busbar. What equipment is needed in each case?

[ESE-2002]

Q.22 A 3-phase induction motor having an impedance of (3 + j4) Ω per phase is connected across 400 V / 230 V, 3-phase 4 wire line. Find
(a) Phase and line current with respect to *R* phase.
(b) Active and Reactive power requirement of load.
(c) How much of capacitance per phase is required in parallel with load so that the line current is of U.P.F.?

Q.23 Load of 10 MW 0.6 P.F. lagging is connected to a 11 kV bus bar. Find the rating of shunt capacitor for improving the P.F. to 0.9 lag.

Q.24 Find the rating of shunt capacitor required for changing the P.F. from 0.8 lagging to 0.8 leading for a load of 5 MW.

Q.25 A transmission line sending & Receiving end voltages are maintaining at 1 p.u. The transmission line has a reactance of 1 p.u. and sending end is connected to a generator which is delivering 0.5 p.u. of active power. Find load angle of the generator
(a) without compensation of line.
(b) with 0.5 p.u. of series capacitor compensator.

Q.26 A Synchronous Phase Modifier (SPM) is used for P.F. improvement of Induction Motor of 10 MW 0.6 lagging to 0.8 lagging. Find the rating of SPM if
(a) SPM consumes 2 MW
(b) SPM under no load.

3.2 - Load Frequency Control

Multiple Choice Questions

Q.27 The combined frequency regulation of machines in area of capacity 1500 MW and operating at a nominal frequency of 60 Hz is 0.1 pu on its own base capacity. The regulation in Hz/MW will be
(a) 0.1/1500 (b) 60/1500
(c) 6/1500 (d) 60/150

[ESE-1997]

Q.28 For a synchronous generator connected to an infinite bus through a transmission line, how are the change of voltage (ΔV) and the change of frequency (Δf) related to the active power (P) and the relative power (Q)?
(a) ΔV is proportional to P and Δf to Q
(b) ΔV is proportional to Q and Δf to P
(c) Both ΔV and Δf are proportional to P
(d) Both ΔV and Δf are proportional to Q

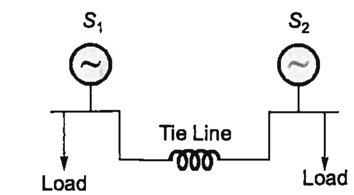
[ESE-2006]

Q.29 Consider the following statements regarding load frequency control:
1. Time constant of automatic load frequency control is about 15 seconds.
2. Integral control eliminates static frequency drop.
3. In tie-line load bias control, the control signal for each area is proportional to change in frequency as well as change in tie-line power.

Which of the statements given above are correct?
(a) 1, 2 and 3 (b) 1 and 2
(c) 1 and 3 (d) 2 and 3

[ESE-2004]

Q.30 Consider a power system with two plants S_1 and S_2 connected through a tie line as shown below:



when the load-frequency control of the system is considered, the 'flat tie-line control' system is preferred over the 'Flat frequency regulation system', because
(a) It is advantageous to control the frequency from any one particular plant without disturbing the other one during load-swings on either S_1 or S_2 areas
(b) This ensures that only the more efficient plant's input is controlled for load variation in any area
(c) Only the tie line is required to absorb the load-swing
(d) The load-change in a particular area is taken care of by the generator in that area resulting in the tie-line loading to remain constant

[ESE-2003]

Q.31 The main objective of load frequency controller is to apply control of
(a) Frequency alone
(b) Frequency and at the same time of real power exchange via the outgoing lines.
(c) Frequency and at the same time of reactive power exchange via the outgoing lines
(d) Frequency and bus voltages

[ESE-2011]

Q.32 The main objectives of load frequency control in a power system are
1. To bring the steady state error to zero after load change.
2. To maintain the net tie-line flow.
3. To maintain voltages on all buses.
4. To economize the cost of generation.

(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1, 2, 3 and 4

[ESE-2011]

Q.33 Three identical generators supply power in a system having lossless transmission lines. Generator 1 is equipped with a speed governor that maintains its speed constant at the rated value while generators 2 and 3 have governors with droops of 5% and 4% respectively. For a given increase in system load in the steady state

(a) Generators 1, 2, 3 will share the increased load in the ratio of 0 : 5 : 4
(b) Generators 1, 2, 3 will share the increased load equally
(c) Generators 1, 2, 3 will share the increased load in the ratio of 0 : 4 : 5
(d) Generators 1 will alone take the entire increased load and the output of generators 2 and 3 will remain unchanged.

[ESE-2010]

Q.34 Consider a power system with three identical generators. The transmission losses are negligible. One generator (G_1) has a speed governor which maintains its speed constant at the rated value, while the other generators (G_2 and G_3) have governors with a droop of 5%. If the load on the system is increased, then in steady state:

(a) Generation of G_2 and G_3 is increased equally while generation of G_1 is unchanged
(b) Generation of G_1 alone is increased while generation of G_2 and G_3 is unchanged
(c) Generation of G_1, G_2 and G_3 is increased equally
(d) Generation of G_1, G_2 and G_3 is increased in the ratio 0.5 : 0.25 : 0.25

[GATE-2002]

Q.35 What is the correct expression for Area Control Error (ACE) for an interconnected 2-area power system, if ΔP_t is incremental tie line power deviation, Δf is frequency deviation and b is frequency bias coefficient?

(a) $\text{ACE} = b\Delta P_t + \Delta f$
(b) $\text{ACE} = \Delta P_t + b\Delta f$
(c) $\text{ACE} = \frac{1}{b}\Delta P_t + \Delta f$
(d) $\text{ACE} = \Delta P_t + \frac{1}{b}\Delta f$

[ESE-2007]

Q.36 Three generators are feeding a load of 100MW. The details of the generators are

	Rating (MW)	Efficiency (%)	Regulation (p.u.) on 100 MVA base
Generator-1	100	20	0.02
Generator-2	100	30	0.04
Generator-3	100	40	0.03

In the event of increased load power demand, which of the following will happen?

(a) All the generators will share equal power
(b) Generator-3 will share more power compared to Generator-1
(c) Generator-1 will share more power compared to Generator-2
(d) Generator-2 will share more power compared to Generator-3

[GATE-2009]

Numerical Data Type Questions

Q.37 A turbine generator set has a regulation constant of 6% on the generator rating of 120 MVA, 50 Hz. The generator frequency decreases by 0.01 Hz. The increase in turbine output for steady-state operation is _____ MW.

[ESE-2011]

Q.38 An isolated 50 Hz synchronous generator is rated at 15 MW which is also the maximum continuous power limit of its prime mover. It is equipped with a speed governor with 5% droop. Initially, the generator is feeding three loads of 4 MW each at 50 Hz. One of these loads is programmed to trip permanently if the frequency falls below 48 Hz. If an additional load of 3.5 MW is connected then the frequency will settle down to _____ Hz. **[GATE-2007]**

Q.39 A power system has two synchronous generators. The Governor-turbine characteristics corresponding to the generators are:

$P_1 = 50\,(50 - f)$
$P_2 = 100\,(51 - f)$

Where f denotes the system frequency in Hz, and P_1 and P_2 are, respectively, the power outputs (in MW) of turbines 1 and 2. Assuming the generators and transmission network to be lossless, the system frequency for a total load of 400 MW is _____ Hz.

[GATE-2001]

Conventional Questions

Q.40 Two 200 MVA alternators operate in parallel. The frequency drops in the first machine from 50 Hz at no load to 48 Hz at full load, whereas in case of the other machine, the frequency drops from 50 Hz to 47 Hz under the same conditions.

(a) How the two machines will share a total load of 300 MW?
(b) Determine the maximum load at unity power factor which can be delivered by the two machines without overloading any of them.

[ESE-2003]

Try Yourself

T1. Two alternators rated at 60 MW, 5% speed regulation and 80 MW, 4% speed regulation. For a total load of 120 MW, load sharing between these two

(a) 80 MW, 40 MW (b) 75 MW, 45 MW
(c) 45 MW, 75 MW (d) 40 MW, 80 MW

[Ans. : (b)]

T2. A power system has a total load of 1260 MW at 50 Hz. The load varies 1.5% for every 1% change in frequency. Find the steady-state frequency deviation when a 60 MW load is suddenly tripped. The speed regulation parameter $R = 0.0025$ Hz per MW.

[Ans. : (*)]

T3. Two generators rated 200 MW and 400 MW are operating in parallel. The droop characteristics of their governors are 4% and 5% respectively from no load to full load. The speed chargers are so set that the generators operate at 50 Hz sharing the full load load of 600 MW in the ratio of their ratings. If the load reduces to 400 MW, how will it be shared among the generators and what will the system frequency be? Assume free governor operation.
The speed changers of the governors are reset so that the load of 400 MW in shared among the generators are 50 Hz in the ratio of their ratings. What are the no load frequencies of the generators?

[Ans. : G_1 = 123 MW, G_2 = 277 MW, f = 50.77 Hz]

T4. You are given two system areas connected by a tie line with the following data:

Area-1	Area-2
$R_1 = 0.01$ pu	$R_2 = 0.02$ pu
$B_1 = 0.8$ pu	$B_2 = 1.0$ pu
Base MVA = 500	Base MVA = 500

A change of 100 MW occurs in area 1. What is the steady-state frequency and what is the change in tie line flow? Assume both areas were working at a nominal frequency of 60 Hz to begin.

[Ans. : f_{new} = 49.921 Hz]

T5. A transmission line has a total series reactance of 0.2 p.u. Reactive power compensation is applied at the mid-point of the line and it is controlled such that the mid-point voltage of the transmission line is always maintained at 0.98 p.u. If voltage at both ends of the linear maintained at 1.0 p.u., then the steady state power transfer limit of the transmission line is

(a) 9.8 p.u. (b) 4.9 p.u.
(c) 19.6 p.u. (d) 5 p.u.

[2002 : 2 Marks]

T6. The power factor of a 120 kW group load is 0.8 lagging. This p.f. is to be improved to 0.9 by means of shunt capacitors. The KVAR of capacitors required is _____ KVAR.

■■■■