Power system Dynamics and Control

Power System Operation and Control

1. The power transfer capability of short lines is limited due to:
(a) thermal limit of conductors (b) stability limits
(c) voltage consideration (d) None of these.

2. Power transfer capability over a long line can be increased by installing
(a) series inductor (b) series capacitor (c) shunt inductor (d) series resistor

3. In a power system, it is necessary to maintain the voltage phase-angle difference across a line well below 90^o during normal operation, so as to:
(a) have adequate stability margin
(b) improve transmission efficiency
(c) prevent over-voltage
(d) coordinate protection systems

4. Shunt reactors are connected to long EHV lines to:
(a) increase the power flow through the line
(b) prevent over-voltages
(c) control the system frequency
(d) improve the power factor of loads.

5. Cables are not used for AC transmission of more than 30-40 km because:
(a) Cables absorb substantial amounts of reactive power under typical loading conditions
(b) Cables generally face under-voltage problems
(c) Cables generate substantial amounts of reactive power under typical loading conditions
(d) Cables have very high characteristic impedance.

6. Operation of power system with large frequency deviation is not desirable. If frequency deviations, say greater than 2 Hz, occur, which of the following statement is false:
(a) Turbine blades may get damaged.
(b) Power output of many loads deviate from their rated value.
(c) Transformers may get saturated (at lower frequencies)
(d) Skin effect becomes significant

7. A lossless power system is shown in Fig. 1, with $\phi_A - \phi_B$=30^o. In order to reduce this phase angle difference without changing the system frequency :

Figure 1:

(a) Machine A should increase generation and machine B should reduce generation
(b) Machine B should increase generation and no action be taken by machine A
(c) Machine A should reduce generation and machine B should increase generation
(d) none of these.

8. Two alternators A and B are connected in parallel to supply a common load of 1.0 p.u. The speed governor on generator A is equipped with 5% droop controller and that on generator B is with zero droop controller. The speed reference for both machines is the same.If the common load (which is not frequency dependent) increases by 0.01 p.u, then
(a) generator A and B share the new load change equally
(b) generator A alone takes-up the new load change
(c) generator B alone takes-up the new load change
(d) generator A and B share the new load change proportional to their ratings

9. An isolated 100 MVA generator operates at 100 MW output at a frequency of 50 Hz. The load is suddenly reduced to 50 MW. Due to the dead-time associated with the speed governor system, the steam valve

begins to close after 0.4 s. Determine the change in the system frequency, before the governor comes into action. The generator has a inertia constant, H = 5 MJ/MVA. Assume that the load is not voltage or frequency dependent:
a) 1 Hz
b) 0.1 Hz
c) 2 Hz
d) 10 Hz

10. A lossless power system consists of 4 generators having inertia constant (H in MJ/MVA) of 5.0, 5.4, 6.0 and 6.4 respectively. Their constant mechanical input powers are 0.7 p.u. , 0.7 p.u., 0.8 p.u. and 0.9 p.u. The base frequency of the system is 50 Hz. The real power loads which are independent of voltage and frequency are 0.65 p.u., 0.55 p.u, 0.40 p.u., 0.95 p.u. and 0.80 p.u. For this condition, the rate of variation of Center of Inertia speed (which is defined as $\frac{\sum H_i \omega_i}{\sum H_i}$) in rad/$s^2$ is:
(a) -1.722 (b) 0.25 (c) 3 (d) -1.5

11. A certain power system has completely blacked out. In the context of power system restoration, indicate whether the following statements are true or false.
    (a) Avail black start power assistance from a neighboring (normally asynchronous) area by utilizing an existing thyristor based back to back HVDC link, in order to start thermal stations.
    (b) Avail black start power assistance from a neighboring (normally asynchronous) area by utilizing an AC line if available, in order to start thermal stations.
    (c) Energize long extra high voltage lines in order to extend power to loads.
    (d) Smaller Hydro and Gas stations are started up first, and power is extended to nearby loads and generating stations
    (e) Large thermal stations are started up first using in-house diesel generators for auxiliaries, and power is extended to nearby loads and generating stations

12. An initially open circuited steam turbine driven generator (terminal voltage = 1.0 pu) is loaded gradually by connecting it to an infinite bus (1.0 pu) and increasing the prime mover input *without changing the field voltage*:
(a) It is likely to lose synchronism much before it is loaded to its rated capacity
(b) It is likely to lose synchronism when loaded at around its rated capacity
(c) It does not lose synchronism at all
(d) None of these

13. The power-angle curve for a Single Machine connected to Infinite Bus (SMIB) system is shown in Fig. 2. With regard to stability, which of the following statement is True

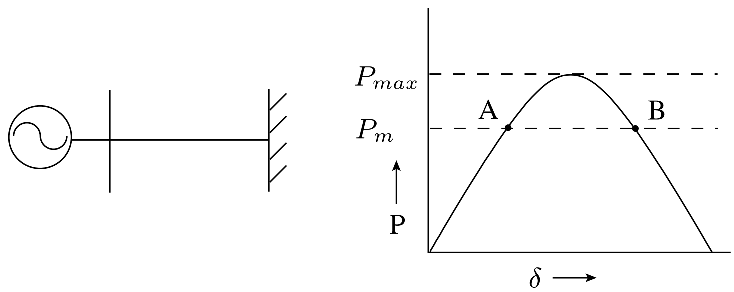


Figure 2:

(a) The point A is stable for all small and all large disturbances.
(b) The point B is unstable for all small and large disturbances.
(c) The point A is unstable for all small disturbances but stable for all large disturbances.
(d) The point B is stable for small disturbances but unstable for all large disturbances

14. In a single machine infinite bus system, if the effective line reactance decreases, then:
(a) Frequency of swing mode decreases
(b) Frequency of swing mode increases
(c) Transient Stability margin increases
(d) Transient Stability margin decreases

15. It is required to supply power using under-sea cables to remote islands (distance >100 km) which have no generation of their own. In this situation which of the following technologies should/should not be considered and why ?
(a) dc transmission using line commutated converters
(b) dc transmission using line commutated rectifier but voltage source inverter
(c) ac transmission
(d) dc transmission using voltage source converters

16. Consider a power system consisting of two areas connected with only HVDC link. Which of the following statements are true/false - Give a brief comment as well:
(a) Power Modulation in the HVDC link may be used to improve inter-area power swing damping between the two regions.
(b) HVDC Power Flow Control can be used to avoid transient instability (loss of synchronism) between the 2 areas.
(c) HVDC Power Flow Control can be used to control the frequency in both areas *independently.*
(d) HVDC Power Flow control can control the power flow between the 2 areas.

17. Which of the above statements would be true if the system had a AC line in parallel with the DC link.

18. Two large systems are to be synchronized by connecting them with AC lines. The large systems are initially connected with a large capacity DC link (the AC lines are to be connected in parallel). To synchronize them, the systems have to be first brought to the same frequency, and the voltage phasors (at the buses at the two ends of the lines which are to be connected) are to be made almost equal. Which of the following ways can it be done ?
(a) The loads of one/both systems are adjusted
(b) The power generation of one/both systems are adjusted
(c) The DC link power is adjusted

19. If a large load in Maharashtra which is a part of the 'New' grid, is suddenly thrown off *but the system is still in synchronism after this incident*, what are the possible consequences:
(a) Frequency in Maharashtra alone will rise while the frequency in Eastern and Northern India will remain unaffected.
(b) If governors are enabled throughout the system but tie line flow is not regulated, drawl of power by Maharashtra is likely to increase.
(c) Frequency throughout the grid will rise
(d) The value to which frequency will settle will depend on the governor characteristics *of all generators in the synchronous grid* and load-frequency characteristics *of all loads in the synchronous grid*
(e) The system transmission losses will be marginally affected.

20. Two large multi-generator and multi- load systems, initially not interconnected, desire to exchange a **fixed amount of power**. They decide to connect the two systems through a single line to achieve this. By which of the following methods can we control power flow through the tie line?
(a) Speed controller (governor) on the generators of one system alone using local generator speed as the control signal.
(b) Speed controller (governor) on the generators of both systems using local generator speed as the control signal.
(c) Generation Control using signals from the tie line
(d) Connecting the two AC systems by an HVDC link instead of an AC line.
(e) Connecting a controllable series reactance in series with the AC line

21. For a thyristor rectifier based static excitation system where AC side is connected to the generator terminal, which of the following is true:
(a) Slip rings are required
(b) Maximum applicable field voltage is independent of field current
(c) Field voltage can be negative
(d) Maximum applicable field voltage is dependent on terminal voltage
(e) Time constants associated with this type of exciter are large
(f) Voltage buildup in a generator fed by this exciter can be done by *self excitation* (aided by station batteries)

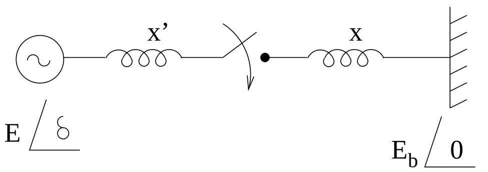
22. The equations of motion of the rotor *for small disturbances* around an equilibrium is represented by the following differential equations:

$$\frac{d\Delta\delta}{dt} = \Delta\omega$$
$$\frac{2H}{\omega_B}\frac{d\Delta\omega}{dt} = -\Delta P_e$$

Mechanical power, E, E_b, ω_o are assumed to be a constant.
If effective line reactance is *variable* ($x = x' + x_{line} - x_{TCSC}$), and x_{TCSC} is varied in proportion with $\Delta\omega$, with a small gain K, ($K > 0$), then:
(a) Oscillations will decay as $e^{\sigma t}$, where $\sigma = -\frac{K\omega_B}{4H}\frac{P_{eo}}{x_o}$
(b) Oscillations will decay as $e^{\sigma t}$, where $\sigma = -\frac{4H}{K\omega_B}\frac{P_{eo}}{x_o}$
(c) Oscillations will grow as $e^{\sigma t}$, where $\sigma = \frac{K\omega_B}{4H}\frac{P_{eo}}{x_o}$
(d) Oscillations will grow as $e^{\sigma t}$, where $\sigma = \frac{K\omega_B}{4H}\frac{x_o}{P_{eo}}$
where P_{eo}, x_o are equilibrium values of electrical power and x.

23. In a *balanced* star connected three phase circuit with phase to neutral voltages v_a, v_b and v_c, the average value of (v_b-v_c)i_a over a cycle is :
(You may assume that rms value of phase-neutral voltage is V and rms value of current i_a is I, and the phase angle between v_a and i_a is 30^0).

24. A synchronous generator is to be synchronized to a power system represented by a single machine infinite bus. Initially, the synchronous generator is open circuited and is running at a speed ($\omega = \omega_{init}$) which is slightly higher than the frequency of the infinite bus (ω_o). The mechanical power input to the generator $T_m = 0$.
The synchronous machine is connected at the instant when $\delta = 0$. What is the maximum value of ω_{init} so that the generator does not slip poles ?
Assume that the equation for motion of the rotor in per-unit after connection is given by:



$$\frac{2H}{\omega_B}\frac{d(\omega - \omega_o)}{dt} = -\frac{EE_b}{X}\sin\delta$$
$$\frac{d\delta}{dt} = \omega - \omega_o$$

where $X = x + x' = 0.4$ pu, $\omega_B = \omega_o = 2 \times \pi \times 50$ rad/s. $E = E_b = 1.0$ pu, $H = 5$ MJ/MVA.(Use the classical model of the generator for your analysis)

25. A certain protective relay requires the computation of the "instantaneous" voltage phasor components, V_i and V_r, corresponding to a certain sinusoidal voltage $v(t)$. This is obtained by computing the "moving window" integral:

$$V_i(t) = \frac{2}{T}\int_{t-T}^{t} v(t)\sin(\omega_o t)dt$$
$$V_r(t) = \frac{2}{T}\int_{t-T}^{t} v(t)\cos(\omega_o t)dt \qquad \text{where } T = \frac{2\pi}{\omega_o}.$$

The instantaneous phasor is then defined by: $\overline{V(t)} = V_r(t) + jV_i(t)$.

(a) If $v(t) = V_m \sin(\omega_o + \Delta\omega_o)t$, where $\Delta\omega_o$ is very small, then derive an expression for $\overline{V}(t)$ and comment on the same ?

(b) An R-L circuit has equations
$$\frac{di}{dt} = -\frac{R}{L}i + \frac{1}{L}v$$
Show that the dynamical equations can be written in terms of these phasors as follows:
$$\frac{d\overline{I}}{dt} = \alpha\overline{I} + \frac{1}{L}\overline{V}$$
What is α ?

26. Consider the two power systems shown in figure A below, which are initially not interconnected, and are operating in steady state at the same frequency. Separate loadflow solutions are computed individually

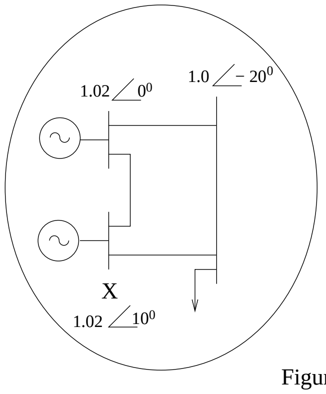


Figure A

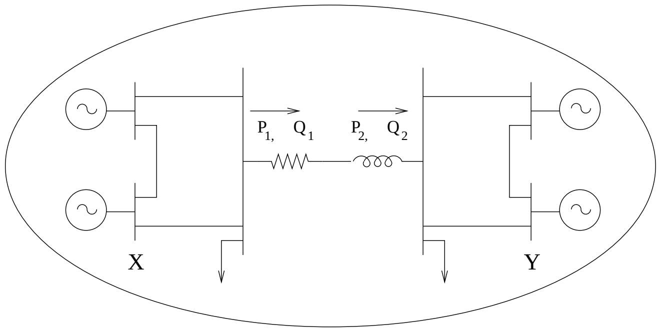


Figure B

for the two systems, corresponding to this scenario. The bus voltage phasors so obtained are indicated on figure A. These two isolated systems are now interconnected by a short transmission line as shown in figure B, and it is found that $P_1 = P_2 = Q_1 = Q_2 = 0$.
The bus voltage phase angular difference between generator bus X and generator bus Y after the interconnection is:

27. An isolated 50 Hz synchronous generator is rated 15 MW, which is also the *maximum continuous power limit of its prime mover.* It is equipped with a speed governor with a proportional gain of $\frac{15}{50}.\frac{1}{0.05}$ MW/Hz Initially, the generator is feeding three loads of 4 MW each at 50 Hz. One of these loads is programmed to trip permanently if frequency falls below 48 Hz. If an additional load of 3.5 MW is connected, then the frequency will settle down to:
Assume that the loads are frequency independent

28. Two systems are connected to each other by an HVDC link. There is no other interconnection between them. The DC power is normally at its scheduled value, but if the frequency in either systems deviates from the nominal (50 Hz) by more than 0.5 Hz, then the link attempts to adjust the power exchange so that this deviation is reduced (See Fig. 3).

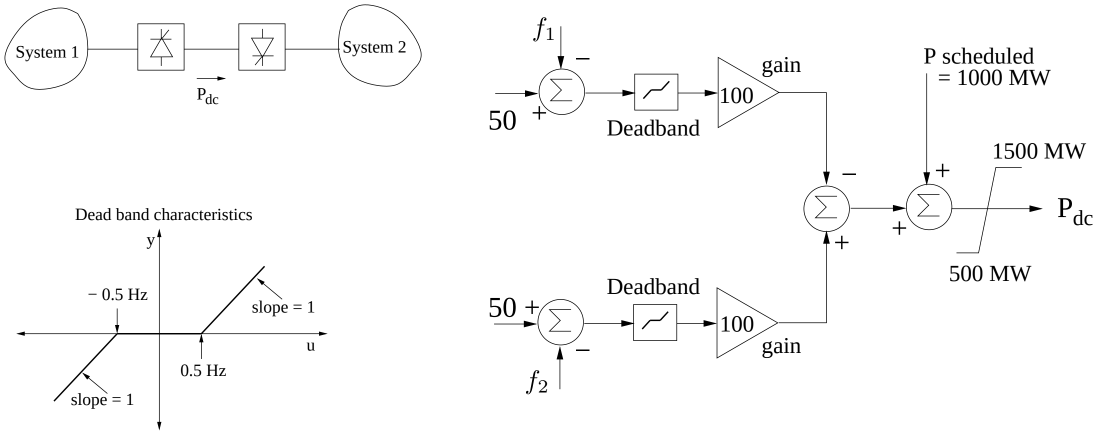


Figure 3:

In all that follows, the subscript '1' refers to the first system and subscript '2' refers to the second system. Suppose the load frequency characteristics of both systems is given by :

$$P = P_{oi}(1 + 2\frac{\Delta f_i}{50}) \text{ MW, where } \Delta f_i = f_i - 50 \text{ Hz}$$

Initially, $P_{o1} = P_{o2} = 10000$ MW. Total generation in system 1 is 11000 MW and in system 2 is 9000 MW. $f_1 = f_2 = 50$ Hz. The DC link power is 1000 MW.

Suppose load in system 1 increases such that P_{o1} changes to 10250 MW. What will be the final settling frequency in both the systems ?

Assume that the governors are disabled and all losses are negligible.

29. Consider a synchronous generator connected to an infinite bus by two identical parallel transmission lines as shown in Fig.4. The transient reactance x' of the generator is 0.1 pu and the mechanical power input to it is constant at 1.0 pu. Due to some previous disturbance, the rotor angle (δ) is undergoing an undamped oscillation, with the maximum value of δ equal to 130^0.
Now one of the parallel line trips due to relay maloperation, at an instant when $\delta = 130^0$, as shown in figure. The maximum value of reactance, x such that the generator does not lose synchronism subsequent to this tripping is :

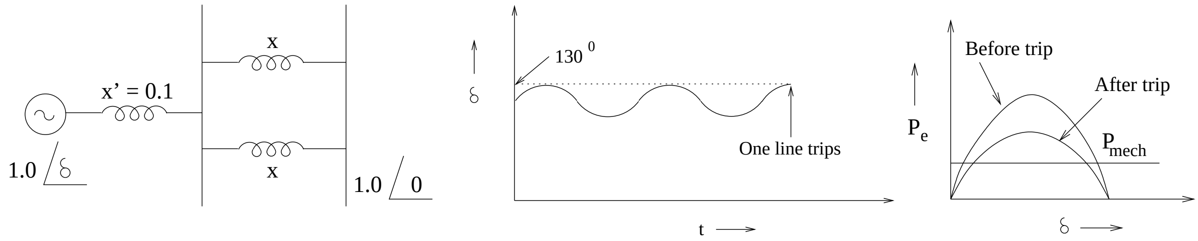
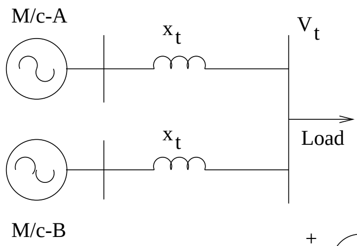


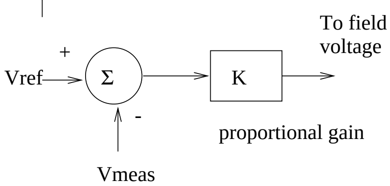
Figure 4:

(Use the classical model of the generator for your analysis)

30. Two identical alternators are connected in parallel through two identical transformers to a common bus to supply a given load as shown in Fig. (a)
Each of them has a voltage regulator of the type shown in Fig. (b).



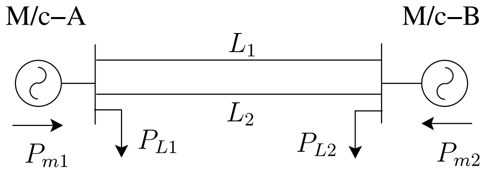
9(a)



9(b)

If the real power generated by both generators is equal, which generator will supply more reactive power Q under each of the following cases:
(a) When $V_{refA} > V_{refB}$, $K_A = K_B$, and $V_{measA} = V_{measB} = |\overline{V}_t|$.
(b)When $V_{refA} = V_{refB}$, $K_A > K_B$, and $V_{measA} = V_{measB} = |\overline{V}_t|$.

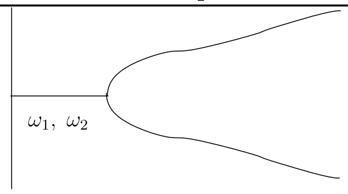
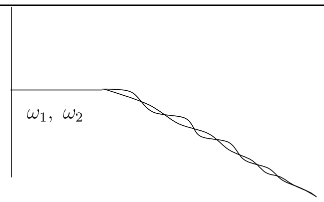
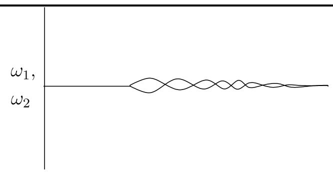
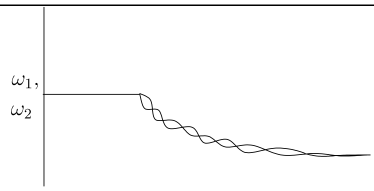
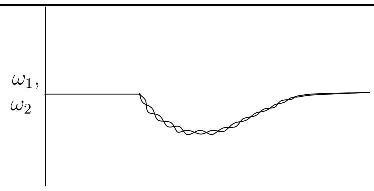
31. Consider a power system shown below, which is in steady state with mechanical input powers P_{m1} and P_{m2}, and loads P_{L1} and P_{L2} which are practically independent of voltage and frequency.



Match the speed responses of generators (ω_1 and ω_2), for the following disturbances shown in Table-1.

Table 1: Match the responses

	Case
i	P_{L1} is increased by 10% and P_{m1} and P_{m2} are constant
ii	P_{L1} is increased by 10% . Generators G1 and G2 have speed governors with 4% and 5% droop characteristics.
iii	Line L_1 is tripped to clear a fault at its midpoint. P_{m1} and P_{m2} are constant. It is assumed that the system is stable for this disturbance.
iv	P_{L2} increased by 10% and generator G1 has an integral controller speed governor and G2 has a proportional type governor with a droop of 5%. The system is assumed to be stable.
v	Line L_1 is tripped to clear a fault at its midpoint. P_{m1} and P_{m2} are constant. The system loses synchronism for this disturbance.

	Response
A	
B	
C	
D	
E	
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