Tutorial 4: Power System Operation and Controls & Transmission Lines

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Note: More than one options can be correct.

Problem 1 Power transfer capability over a long line can be increased by installing
(a) a series inductor (b) a series capacitor (c) a shunt inductor (d) a series resistor.

Problem 2 Bundled conductor configuration is used in extra high voltage (EHV) lines to
(a) reduce corona (b) decrease line resistance (c) increase current flow (d) increase line reactance.

Problem 3 A loaded power transformer experiences 'over-fluxing' when
(a) the input voltage decreases
(b) the supply frequency decreases
(c) the supply frequency increases
(d) the load on the transformer increases.

Problem 4 For a long parallel two wire system, where the diameter of the conductor is very small compared to the spacing between the conductors, if the spacing is doubled, the inductance of the system:
(a) doubles (b) marginally decreases (c) marginally increases (d) halves.

Problem 5 A loss-less transmission line is terminated by a resistance whose magnitude equals the characteristic impedance. Which of the following statements is **TRUE** (50 Hz ac transmission)?

(a) The phase and magnitude of sinusoidal voltage is the same all along the line

(b) The phase angle difference between sending and receiving end voltages is not dependent on the length of the line

(c) The phase angle difference between sending and receiving end voltages is dependent on the length of the line

(d) None of these.

Problem 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.

Problem 7 The surge impedance loading (SIL) of a 50 km line is 450 MW. What will be the SIL if the line length is doubled?

(a) 225 MW (b) 675 MW (c) 450 MW (d) 900 MW.

Problem 8 A long lossless transmission line has length l. If both ends are maintained at a voltage V as shown in Figure 1, find the expression for the mid-point voltage as function of δ.

Note: Characteristic impedance $Z_c = \sqrt{\dfrac{\mathcal{L}'}{\mathcal{C}'}}$ where, $\mathcal{L}'$: inductance per unit length and $\mathcal{C}'$: capacitance per unit length. Also $\beta = 2\,\pi\, f\,.\sqrt{\mathcal{L}'.\mathcal{C}'}$, where f is the frequency of the system.

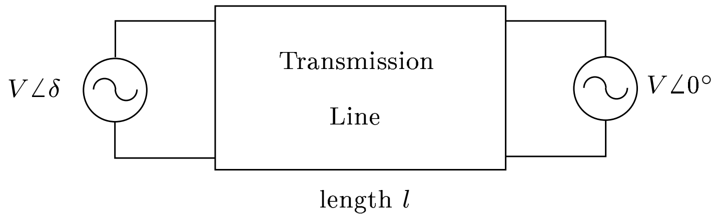

Figure 1: Figure for Problem 8.

Problem 9 Two generators A and B are connected in parallel to supply a common load of 100 MW. The speed governor on generator A is equipped with proportional controller and that on generator B is with an integral controller. If the common load increases by 1 MW, then

(Assume loads to be frequency independent)

(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.

Problem 10 Power transmission using ac over 1000 km distance is feasible if:

(a) Variable (inductive and capacitive range), shunt compensation of high rating at several points on the line is provided

(b) Only capacitive shunt and/or capacitive series compensation is provided

(c) Fixed shunt inductive and fixed series capacitive compensation is provided in a well distributed fashion throughout the line

(d) No compensation is necessary at all.

Problem 11 The power-angle curve for a Single Machine connected to Infinite Bus (SMIB) system is shown in Figure 2. With regard to stability, which of the following statement is **TRUE**?
(a) The point A is stable for all small and all large disturbances
(b) The point B is unstable for all small and all 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 all small disturbances but unstable for all large disturbances.

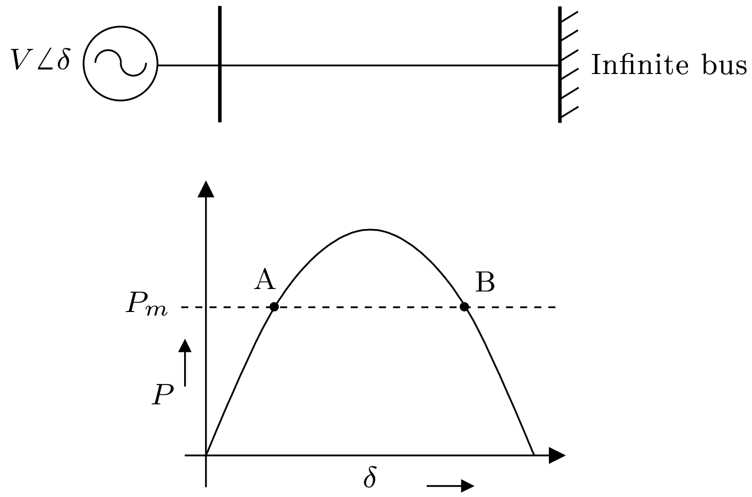

Figure 2: Figure for Problem 11.

Problem 12 Consider a 2-wire transmission system above the earth. The spacing between the wires is small compared to the height above the earth. Which of the following statements is **FALSE**?

(a) The presence of earth has no effect on the capacitance of the 2-wire system

(b) The presence of earth has a marginal effect on the capacitance of the 2-wire system

(c) Under 50 Hz and balanced conditions (no current flow in the earth), the presence of the earth has no effect on the voltage drop in the 2-wire system.

Problem 13 The surge impedance of extra high voltage (EHV) over-head lines lies in the range of
(a) 10-15 Ω (b) 230-400 Ω (c) 800-1200 Ω (d) 30-50 Ω.

Problem 14 The reactance of a 100 mile EHV over-head line is of the order of
(a) 1-10 Ω (b) 45-80 Ω (c) 400-850 Ω (d) 4500-7600 Ω.

Problem 15 The power transfer capability of short lines is effectively decided by:
(a) Thermal limit (b) Stability limit (c) Voltage limit (d) All the above.

Problem 16 For a 400 kV overhead line (characteristic impedance $Z_c \approx 300\ \Omega$) which of the following line data (resistance R, reactance x_l and total shunt susceptance b_c) is correct:

Hint: For any overhead line, speed of propagation of electromagnetic disturbance is approximately equal to a well known physical constant.

(a) 20.8 Ω, 24 Ω, 256.375 μS (b) 6.4 Ω, 73.6 Ω, 800 μS

(c) 6.4 Ω, 7.36 Ω, 800 μS (d) 20.8 Ω, 73.6 Ω, 256.375 μS.

Problem 17 For the **correct** answer to the Problem 16, the length of the line is approximately:

(a) 225 km (b) 75 km (c) 365 km (d) 400 km.

Problem 18 The low frequency model of a transmission line for sinusoidal steady-state condition is given as

$$\begin{bmatrix} \bar{V}_k \\ \bar{I}_k \end{bmatrix} = \begin{bmatrix} \cosh(\gamma\, l) & Z_c\, \sinh(\gamma\, l) \\ \dfrac{1}{Z_c}\, \sinh(\gamma\, l) & \cosh(\gamma\, l) \end{bmatrix} \cdot \begin{bmatrix} \bar{V}_m \\ \bar{I}_m \end{bmatrix}$$

where, k and m subscript refers to sending and receiving end quantities respectively.

$\gamma = \sqrt{(\mathcal{R}' + j\omega\,\mathcal{L}').(\mathcal{G}' + j\omega\,\mathcal{C}')}$ and $Z_c = \sqrt{\dfrac{(\mathcal{R}' + j\omega\,\mathcal{L}')}{(\mathcal{G}' + j\omega\,\mathcal{C}')}}$.

$\mathcal{R}', \mathcal{L}', \mathcal{G}'$ and $\mathcal{C}'$ are quantities in per unit length.

For lossless transmission line (i.e. $\mathcal{R}' = \mathcal{G}' = 0$), obtain the Thevenin equivalent when looking from the receiving end.

Problem 19 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.