ECE 476 – Power System Analysis Fall 2017
Homework 4

Reading: Chapter 5 from textbook.
In-class quiz: Thursday, September 28, 2017

Problem 1. A 500-km, 500-kV, 60-Hz uncompensated three-phase line has a positive-sequence series impedance $\overline{z} = 0.03 + j0.35$ Ω/km and a positive-sequence shunt admittance $\overline{y} = j4.4x10^{-6}$ S/km. Calculate:
(a) $\overline{Z}_c$
(b) (γd)
(c) The exact ABCD parameters for this line.

Problem 2. A 320-km 500-kV, 60-Hz three-phase uncompensated line has a positive-sequence series reactance x=0.34 Ω/km and a positive-sequence shunt admittance y=4.5 x 10^{-6} S/km. Neglecting losses, calculate:
(a) Its characteristic impedance $\overline{Z}_c$.
(b) The value of γd.
(c) The exact ABCD parameters for this line.
(d) The surge impedance loading in MW.

Problem 3. The per-phase impedance of a short three-phase transmission line is $0.5\angle 53.15°$ Ω. The three-phase load at the receiving end is 900 kW at 0.8 p.f. lagging. If the line-to-line sending-end voltage is 3.3 kV, determine:
(a) The receiving-end line-to-line voltage in kV.
(b) The line current.
(c) The phasor diagram with the line current I, as reference.

Problem 4. To maintain a safe "margin" of stability, system designers have decided that the power angle $\theta_{12} := \theta_1 - \theta_2$, where θ_1 is the phase angle of the sending-end voltage and θ_2 is the phase angle of the receiving-end voltage, cannot be greater that 45°. We wish to transmit 500 MW though a 300-mile line and need to pick a transmission-line voltage level. Consider 138−, 345−, and 765−kV lines. Which voltage level(s) would be suitable? As a first approximation, assume that the voltage magnitudes on sending and receiving ends are equal, i.e., $V_1 = V_2$ and the lines are loseless, i.e., $\gamma = j\beta$, with $\beta = 0.002$ rad/mi.

Problem 5. Given a transmission line described by a total series impedance $\overline{Z} = \overline{z}d = 20 + j80$ Ω and a total shunt admittance $\overline{Y} = \overline{y}d = j5 \times 10^{-4}$ Ω.
(a) Find its characteristic impedance $\overline{Z}_c$, γd, $e^{\gamma d}$, $\sinh \gamma d$, and $\cosh \gamma d$.
(b) Suppose that the line is terminated in its characteristic impedance $\overline{Z}_c$. Find the efficiency of the transmission line in this case, i.e., find $\eta = -P_{21}/P_{12}$, where P_{21} is the active power flowing from the receiving end to the sending end of the line, and P_{12} is the active power flowing from the sending end to the receiving end of the line.