Name: ______Answers____________

ECE 476

Exam #2

Tuesday, November 15, 2016
75 Minutes

Closed book, closed notes
One new note sheet allowed, one old note sheet allowed

1. _________ / 20

2. _________ / 20

3. _________ / 20

4. _________ / 20

5. _________ / 20

Total _________ / 100

1. (20 points total)

The zero, positive and negative sequence bus impedance matrixes for a three bus, three phase power system are given below. Determine the per unit fault current (sequence values only) for a single line to ground (SLG) fault involving phase "A" at bus 2. The prefault voltage at all buses is 1.0 per unit. Assume the fault impedance is zero.

$$\mathbf{Z}^0 = j\begin{bmatrix} 0.1 & 0 & 0 \\ 0 & 0.2 & 0 \\ 0 & 0 & 0.1 \end{bmatrix} \qquad \mathbf{Z}^+ = \mathbf{Z}^- = j\begin{bmatrix} 0.12 & 0.08 & 0.04 \\ 0.08 & 0.12 & 0.06 \\ 0.04 & 0.06 & 0.08 \end{bmatrix}$$

For a single line to ground fault, the fault current is determined by connecting the three sequence networks in series, along with three times the fault impedance

$$\mathrm{I}_f^+ = \mathrm{I}_f^- = \mathrm{I}_f^0 = \frac{1\angle 0}{j0.2 + j0.12 + j0.12 + 3\times 0} = -j2.273$$

2. (20 points total)

The fuel-cost curves for a two generator system are given as follows:

$$C_1(P_{G1}) = 1000 + 20 * P_{G1} + 0.01 * (P_{G1})^2$$

$$C_2(P_{G2}) = 400 + 15 * P_{G2} + 0.025 * (P_{G2})^2$$

Generator limits are: $100 \le P_{G1} \le 300$
$200 \le P_{G2} \le 600$

For a load of 600 MW, use the lambda iteration method to determine the values of λ^M, $P_{G1}(\lambda^M)$ and $P_{G2}(\lambda^M)$ after two iterations. Show the values of all variables at each iteration. Use starting values of $\lambda^L = 20$ and $\lambda^H = 60$. **Be sure to consider the generator limits; you may ignore any penalty factors.**

$$P_{G1} = \frac{\lambda - 20}{0.02},\ 100 \le \mathrm{P}_{G1} \le 300$$

$$P_{G2} = \frac{\lambda - 15}{0.05},\ 200 \le \mathrm{P}_{G2} \le 600$$

$$\text{Initially } \lambda^L = 20,\ \lambda^H = 60 \rightarrow \lambda^M = 40$$

$$P_{Tot}(\lambda^M) = 300 + 500 = 800 > 600 \rightarrow \lambda^H = 40 \rightarrow \lambda^M = 30$$

$$P_{Tot}(30) = 300 + 300 = 600 = 600,\ \text{Done!}$$

3. (20 points total)

For the system

$f_1(\mathbf{x}) = 10\ x_1 \sin x_2 + 2 = 0$

$f_2(\mathbf{x}) = 10\ (x_1)^2 - 10\ x_1 \cos x_2 + 1 = 0$

(15 pts) a. Using the Newton-Raphson method, determine the values of x_1 and x_2 after the second iteration. Use $x_1 = 1$, $x_2 = 0$ as an initial guess.

(5 pts) b. Is $x_1 = 0.5$, $x_2 = 0$ a good initial guess? Why or why not.

$$\mathbf{J}(\mathbf{x}) = \begin{bmatrix} 10\sin x_2 & 10x_1\cos x_2 \\ 20x_1 - 10\cos x_2 & 10x_1 \sin x_2 \end{bmatrix}$$

$$\mathbf{x}^{(0)} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \quad \mathbf{x}^{(1)} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} - \begin{bmatrix} 0 & 10 \\ 10 & 0 \end{bmatrix}^{-1} \begin{bmatrix} 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 0.9 \\ -0.2 \end{bmatrix}$$

$$\mathbf{x}^{(2)} = \begin{bmatrix} 0.9 \\ -0.2 \end{bmatrix} - \begin{bmatrix} -1.99 & 8.82 \\ 8.2 & -1.79 \end{bmatrix}^{-1} \begin{bmatrix} 0.212 \\ 0.279 \end{bmatrix} = \begin{bmatrix} 0.859 \\ -0.233 \end{bmatrix}$$

$x_1 = 0.5$, $x_2 = 0$ is a bad initial guess because the Jacobian is singular.

4. (Short Answer: 20 points total – five points each)

A. Give two reasons why the slack (reference) bus is needed for the power flow problem.

The slack bus 1) provides an angle reference and 2) insures that total real power generation is equal to the total load plus losses.

B. IEEE Std 1366-2012 defines SAIDI as a measure to quantify small event blackouts. Briefly tell what SAIDI is and what it measures.

SAIDI is the system average interruption duration index. It tells the average amount of time (in minutes per year) customers are interrupted.

C. What is the purpose of power system economic dispatch, and what is a necessary condition for an economic dispatch of the generation?

Purpose of economic dispatch is to schedule the generation to minimize cost. A necessary condition is equal incremental costs for the unlimited generators. Another necessary condition is that the total generation is equal to the load load plus losses (either condition is fine for an answer).

D. An ideal inductor with L = 1 H is connected in series with an ac voltage source (**v(t) = sin(t) volts**) and a switch. The switch, which is initially open, is closed at t = 0. Sketch the current through the circuit (as a function of time) for the first few cycles for $t \geq 0$.

Function is 1 – cos(t). Key point is there is a constant dc offset; there is no decay because there is no resistance.

5. (20 points total)

True/False – Two points each. Circle T if statement is true, F if statement is False.

T **F** 1. An important assumption in the dc power flow is that all the transmission line reactances are zero.

T F 2. PTDFs can be used to show the linear impact of a power transfer.

T F 3. As presented in class, the penalty factor at the slack bus is always unity.

T F 4. In the MISO LMP market the LMPs can sometimes become negative.

T **F** 5. While the power flow equations may have multiple solutions, it is quite easy to prove that the Newton-Raphson algorithm will only converge to the desired solution. That is, to the one with the highest voltage magnitudes.

T **F** 6. During economic dispatch calculations on the high voltage transmission system it is quite common for the incremental impact of the change in the generation at bus k on system losses, $\frac{\partial P_{Losses}}{\partial P_{Gk}}$, to exceed 100%

T **F** 7. In three-phase systems using symmetrical components, the positive sequence is used to represent the non-zero neutral currents.

T **F** 8. To model a line-to-line fault on an otherwise balanced system the zero sequence network is connected in series with the positive sequence network.

T **F** 9. Because of the use of directional relays, line carrier communication is never used to help in the detection of transmission line faults.

T **F** 10. During the August 14th 2003 blackout, many of the lines that tripped were due to the misoperation of differential relays.