Name: ____Answers___________

ECEN 460

Exam #1

Thursday, October 5, 2017

Closed book, closed notes
One 8.5 by 11 inch handwritten note sheet allowed (front and back)
Calculators allowed

1. _________ / 20

2. _________ / 24

3. _________ / 24

4. _________ / 32

Total _________ / 100

1. (20 points total)

A load operates at 1.0 per unit voltage, and 1.0 per unit complex power with a power factor of 0.80 lagging.

(10 pts) a. What is the per unit rating need for a Y-connected bank of capacitors to be installed in parallel with the load to bring the net power factor up to 0.95 leading?

(5 pts) b. With the capacitors from part a and assuming the load voltage stays at 1.0 per unit, what is the net real and reactive per unit power consumed at the load bus?

(5 pts) c. Assume the load is being supplied by a line with per unit impedance of 0.02 + j 0.1. **Without the additional capacitors from part a**, what are the real and reactive per unit losses in this line?

Part A

$$S_{org} = 0.8 + j0.6$$

With power factor correction P stays constant; for a power factor of 0.95 leading, Qnew = $-\frac{0.8}{0.95}\sqrt{1-0.95^2} = -0.263$

$$S_{new} = 0.8 - j0.263$$

$$Q_{cap} = 0.6 - (-0.263) = 0.863$$

Part B

S_{new} = 0.8 – j0.263

Part C

The magnitude of the current is one per unit. So the real power losses are 0.02 per unit and the reactive power losses are 0.1 per unit.

2. (24 points total)

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

<u>**T**</u>	F	1.	High Voltage DC (HVDC) is sometimes used for long distance, overhead power transmission.
<u>**T**</u>	F	2.	When a three-phase load is wye-connected its phase currents equal its line currents.
T	<u>**F**</u>	3.	The Electric Reliability Council of Texas (ERCOT) supplies electricity to the entire state of Texas.
T	<u>**F**</u>	4.	A well designed, balanced three-phase power system can transmit three times the power of an equivalent single-phase system that uses the same amount of wire.
T	<u>**F**</u>	5.	A bundled two conductor 345 kV transmission line will have twice the resistance of an unbundled line using the same conductor type.
<u>**T**</u>	F	6.	Per unit values are always dimensionless.
T	<u>**F**</u>	7.	As discussed in class, the "duck-curve" is a device commonly used on transmission lines to preventing birds from getting shocked.
T	<u>**F**</u>	8.	Phasing shiftting transformers are commonly used for controlling bus voltage magnitudes.
T	<u>**F**</u>	9.	A nice characteristic of nonlinear systems of the form f(x)=0 is that there is always at least one solution.
T	<u>**F**</u>	10.	The area control error (ACE) for an electric balancing authority can never be negative because transmission lines always have real power losses.
T	<u>**F**</u>	11.	The ballpark figure given in class for the real power losses on a high voltage transformer (e.g. 500 MVA) was about 8%.
T	<u>**F**</u>	12.	A load that consumes 200 kW and 30 kvar has a leading power factor.

3. (24 points total)

Short Answer, eight points each

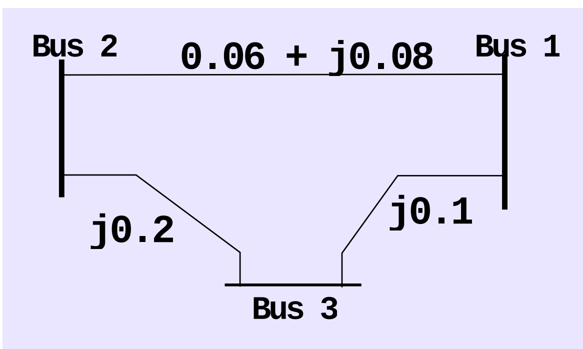
a) For a three-phase system using a 100 MVA power base and a 230 kV (line-to-line) voltage base, what is the per unit impedance of Z = 2 + j20 Ω?

Zbase = 529 Ω, Z_{pu} = 0.0038 + j 0.0378

b) As discussed in class, a common power flow load model is to assume the load is constant power. That is, with no voltage dependence. Why might this be an appropriate model for a resistive heater in which the instantaneous power consumed varies with the square of the voltage?

While the instantaneous power does vary with the square of the voltage, because ultimately the load needs a set amount of energy (e.g., controlled by a thermostat), a drop in the supply voltage just means is cycles on for longer. When a number of such loads are aggregated over time their behavior looks to be independent of voltage and hence constant power.

c) Give the 3 by 3 Bus Admittance Matrix (**Y_{bus}**) for the three bus power system shown below with the indicated short line model per unit line impedances



$$\frac{1}{0.06 + j0.08} = 6 - 8j$$

$$Y = \begin{bmatrix} 6 - j18 & -6 + j8 & j10 \\ -6 + j8 & 6 - j13 & j5 \\ j10 & j5 & -j15 \end{bmatrix}$$

4. (32 points total)

Short Answer, eight points each

a) For the equation 0.5x – cos(x) -2 = 0 with an initial guess $x^{(0)} = 1$, do two Gauss iterations to determine $x^{(2)}$. Be sure to use x in radians!

$$x^{v+1} = 2\cos x^{v} + 4 \rightarrow x^{0} = 1, x^{1} = 5.081, x^{2} = 4.72$$

b) Calculate the per phase reactance for a balanced three-phase, 60 Hz transmission line with a conductor geometry of an equilateral triangle with D = 6 m using conductors with a GMR of 0.012 m and a total line length of 5 miles.

$$L = 2\times 10^{-7}\ln\left(\frac{6}{0.012}\right) = 1.243\times 10^{-6} \text{ H/m} \rightarrow X = 3.77\ \Omega$$

c) A single-phase, 12-kVA, 2400/240-volt, 60 Hz distribution transformer has a loaded connected on the secondary (240 volt) winding that consumes 10 kVA at a power factor of 0.9 lagging; assume the load is operating at 260 V. Assuming an ideal transformer, what is the primary voltage, the total real and reactive power supplied to the primary winding, and the load impedance referred to the primary.

$$V_{primary} = 2600, S = 9 + j4.36 \text{ kVA (since an ideal transformer is lossless)}$$

$$S^{*} = \frac{|V|^{2}_{primary}}{Z_{primary}} \rightarrow Z_{primary} = 608.3 + j294.7\ \Omega$$

d) For the below equations use Newton-Raphson method do determine the values of x_1 and x_2 after the first iteration with an initial guess of $x_1 = 1$ and $x_2 = 2$.

$$3x_1 - 2x_1x_2 - 4 = 0$$
$$2x_1x_2 + 6x_2^2 - 6 = 0$$

$$\mathbf{x}^{1} = \begin{bmatrix} 1 \\ 2 \end{bmatrix} - \begin{bmatrix} -1 & -2 \\ 4 & 26 \end{bmatrix}^{-1} \begin{bmatrix} -5 \\ 22 \end{bmatrix} = \begin{bmatrix} -3.78 \\ 1.89 \end{bmatrix}$$