ECE 524 Exam 1 Summer 2019

EXAMINATION RULES

1. This is an open-book/open-note take-home exam.
2. I can e-mail a MathCAD file with the exam problems to you if you would like a copy.
3. Do your own work on this examination. You are on your honor. Therefore, you will neither give nor receive aid on this examination, except from the *course* instructor. If you violate this trust, you will receive the grade of zero for this examination.
4. Show all of your work! Make it neat. *No* partial credit will be given if I can not easily follow your work.
5. You have 3 days to complete the exam the exam from the time you receive it from your proctor.
6. Pease read and sign the following statement when you finish the exam:

I certify that I have neither given nor have I received any help on this examination, except from the course instructor.

SIGNED: _____

PRINTED NAME:_____

DATE:_____

1. _____/40 pts

2. _____/20 pts

3. _____/40 pts

Total: _____/100 pts

1. (40 pts) Consider the system shown below. The power ratings given are three phase ratings, and voltages listed are line to line.

A. Create a system equivalent for capacitor switching studies. Explain your reasoning in developing the model. Describe how you would validate this model to ensure accuracy.

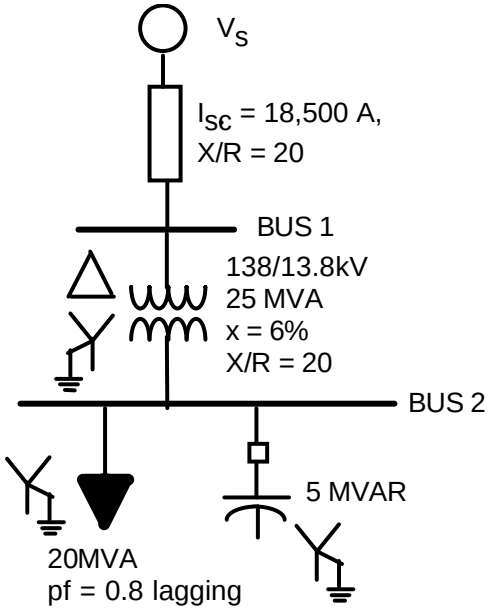
Build this model in your transient program. Perform a steady-state analysis and adjust the source voltage so the voltage at the capacitor bus is 1.0pu with the capacitor in the system. Verify this with your transient simulation program.

B. Describe (with sketches as needed) what happens when the breaker for the capacitor bank is opened. Back this up with simulation results.

C. Estimate the worst case current on energization of the capacitor bank. Does the 60Hz term need to be considered in this calculation (why or why not)? Again, confirm this with simulation results. Compare simulation results with and without the load and the resistances of the source and transformer included and comment on the impact on the response.

D. Determine the worst voltage seen by the load due to this worst case capacitor switching transient from part (**C**) through simulation.

E. Propose options to reduce this transient.



2. (20 pts). Answer the following:

A. Explain what causees overvoltage conditions in transient recovery voltage. What is the voltage we are concerned about? Describe with diagrams as needed. Explain.

B. Once you know the worst case transient recovery voltage amplitude, how will you use that information? Does natural frequency matter? Why?

C. Describe corrective actions that can be used to reduce the impact if the transient recovery voltage transient is unacceptable. Briefly describe how these corrective actions work.

D. Does the angle between the voltage and breaker current prior to transient impact the TRV transient response? In what way?

3. (40 pts) You are given a 345 kV transmission system that consists of 3 transmission line segments, with intermediate buses separating them (see figure below). Each of the transmission line segments has the following characteristics (calculated at 60Hz).

$R_0 := 0.3112\frac{ohm}{mi}$ $R_1 := 0.0381\frac{ohm}{mi}$ $R_2 := 0.0381\frac{ohm}{mi}$

$Z_{c0} := 654.86ohm$ $Z_{c1} := 256.35ohm$ $Z_{c2} := 256.35ohm$

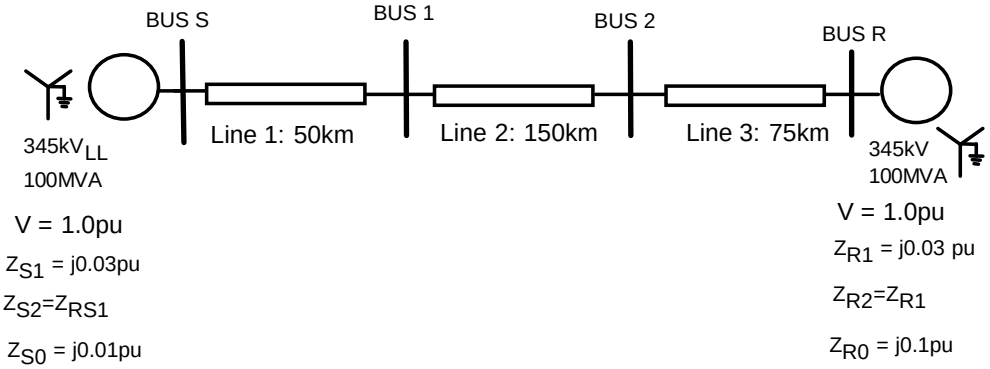
$\nu_0 := 1.2254\cdot 10^5\cdot\frac{mi}{s}$ $\nu_1 := 1.8213\cdot 10^5\cdot\frac{mi}{s}$ $\nu_2 := 1.8213\cdot 10^5\cdot\frac{mi}{s}$

A. The mode 1 and mode 2 terms are identical. Explain what this tells you about the transmission line. What underlying assumptions have been made and what limitatons should be considered for applying this model.

B. Calculate the ABC domain R', L' and C' matrices per mile.

C. What do the modes 0, 1 and 2 represent? Where do the signals they represent travel?

D. A single line diagram for the system is shown below. Implement a model of this system, each line has the characteristics above. Use the appropriate travelling wave model. Describe how you would validate your model before starting transient studies, and suggest a time step for transient simulation. Use coupled RL (sequence data input) for the source impedances.



E. Suppose a three phase fault occurs 60% of the way from Bus 1 to Bus 2 (set both sources to be at 1.0 pu at an angle of 0 degrees). Do a simple analysis for each step and then simulate.
(1) How long will it take the transient to reach Bus 1? How long will it take to reach Bus 2?
(2) What is the voltage reflection coefficent seen by the voltage when it reaches Bus 1? Based on that, what would expect the voltage to look like at that that bus?
(3) How would your answer to (2) change if the line between buses BUS S and BUS 1 were open?
(4) Calculate the initial surge current at the fault location.
(5) How long will it take the initial surge current to reach BUS 1 and BUS 2? For case (3) currents look like at BUS 1 and BUS 2 look like when those surges arrive?