ECE 431 Electric Machinery Name: _____

Test #2 April 8, 2020 NetID: _____

You are allowed to refer to class notes or access the internet. Any source that you use, you must mention it in your answer. Failure to mention a source is considered plagiarism. You are not allowed to chat or directly get/seek help from anyone in any way. Calculators are allowed. Please do all work on this test.

No question during the exam. Write down your assumptions.

Submission link on Compass will close at **noon (12:00 pm, April 8,2020)**. This time is strict. No late submission will be accepted.

Three options to work the midterm:

1) Type the whole answer in the same word file and save it as a pdf. For plots, you can use drawing tools like paint, powerpoint, etc, and attach them as figures with appropriate naming and referencing.
2) Write the answers on paper and use your phones/scanners to create a pdf file.
   If a phone is used, please download a proper scanning app/software, and make sure the scans are eligible. No credit will be given if the grader is not able to read your handwriting.
3) Use any other tool of your choice to create a pdf file with all the answers. You can embed the plots or attach them as figures.

Q1. (35) Induction Machine

(a) For a given induction machine

i. Which equivalent circuit parameter would you change to increase starting torque and how would you achieve this in the actual design on the machine?

ii. Draw the torque-slip curve for before and after the change descrbed above.

iii. Would the efficiency of the machine at rated conditions be impacted by this change? What additional design changes would you consider to get back to the original efficiency?

b) A student wants to add speed control to a single speed fan in his room. He uses a 'light dimmer' to adjust the input voltage of the fan. Assuming the fan is driven by an induction motor, describe what he may observe as he operates the fan at low speeds. Explain.

Q2. (35) Synchronous Machine

A three phase, 480 V(line to line), 4 pole, 60 Hz synchronous generator is supplying 20 A to the grid at 0.9 lagging power factor. The generator has a synchronous reactance of 2 ohms and is operating with a field current of 5A..

a. Calculate the internal voltage and torque angle

b. Draw the phasor diagram corresponding to this operating condition, and using dashed lines, overlay the phasor diagram when it is operating with one and a half times the excitation and supplying the appropriate amount of power to obtain unity power factor.

c. Find the new internal voltage, torque angle and armature current when the machine is operating at unity power factor with one and a half excitation as described in (b).

Q3. (30) Equal Area Criteria

a. Write 1 paragraph on the concept behind the “equal area criteria” and its use in synchronous machine analysis in your own words. Rather than providing just the equations, convey what the criteria is conceptually doing, why is it useful in modeling machines?

b. When running a synchronous motor at high power and at low field current (under-excited region), would you encounter issues you may not have at the same power level but with higher field current (over-excited region)? Explain why this is the case. What design change could help address this issue? Assume very high armature current rating.

c. A synchronous motor is connected to the grid at rated voltage, rated KVA, and non-unity power factor. It is driving a load of 0.8 pu. A fault occurs and causes the load to suddenly decrease to 0.4 pu and the terminal voltage to halve. The excitation does not change. Using the ‘equal area criterion’, sketch the power versus load angle curves associated with this scenario and mark out the areas and angles that need to be evaluated. Will the machine still revert to a stable motor mode?