EE 30372, Spring 2006
Exam 1
9 March, 2006

Show all your work and your answers clearly on the test pages. In any plots and sketches, label and include units (if possible) on anything that might be of interest. For full credit, simplify your answers as much as possible. You may use calculators for numerical evaluations but no programming capabilities. This exam is closed-book.

Problem 1 (30) ______

Problem 2 (20) ______

Problem 3 (20) ______

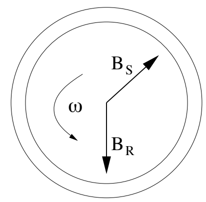
Problem 4 (30) ______

Total (100) ______

Name________________________________

1. The following short answer questions are to be answered briefly, but require some support for your answer.

   (a) (5 pts.) An AC machine has rotor and stator magnetic fields as shown below, and both are rotating in the direction indicated by the arrow. Is this machine functioning as a motor or as a generator? How do you know?

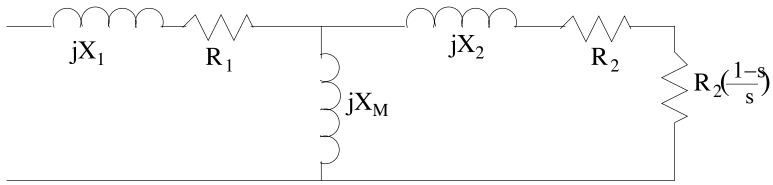


   (b) (5 pts.) What is the mechanical speed of rotation of a synchronous, 8-pole machine operating at 60 Hz?

   (c) (5 pts.) A single-phase load shows current lagging voltage by 30 degrees, with $|\mathbf{V}|/|\mathbf{I}| = 0.02$. Sketch a circuit, with resistance, inductance, and capacitance values, which could constitute this load.

(d) (5 pts.) In a generator free of any internal impedances, sketch the relationship between the stator magnetic field and the rotor magnetic field if the generator is driving a purely inductive load.

(e) (10 pts.) If an balanced three-phase AC machine outputs 3 hp with 80% efficiency and has input current $\mathbf{I}_a$ lagging terminal voltage $\mathbf{V}_{ab}$ by 60 degrees, what is the apparent power delivered to the machine at the rated load?



2. (20 pts.) Above is the *per-phase* equivalent circuit model of a 480V, 60 Hz, 6-pole, three-phase, Y-connected induction motor. Its parameters are $R_1 = 0.1\Omega$, $X_1 = 0.1\Omega$, $R_2 = 0.1\Omega$, $X_2 = 0.2\Omega$, $X_M = 10\Omega$. The mechanical, core, and miscellaneous losses total 2 kW. At a slip of 5%, find (a) the line current into the motor, (b) the air-gap power P_{AG}, (c) the rotor copper losses, (d) the induced torque, (e) the mechanical speed of rotation in rpm, and (f) the machine's efficiency.

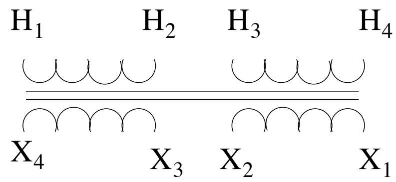
3. The following concern a 50 MVA, six-pole, three-phase, 60 Hz, Y-connected AC generator, with V_{LL} at its terminals of 12.8kV. The generator has a per-unit synchronous reactance of 0.1 and per-unit armature resistance of 0.01. It is driving a load consuming its fully rated MVA, at a power factor of 0.8 lagging.

(a) (5 pts.) Find the resistance and synchronous reactance in ohms.

(b) (5 pts.) Ignoring the losses internal to the generator, how much torque must be applied to run the machine in this state?

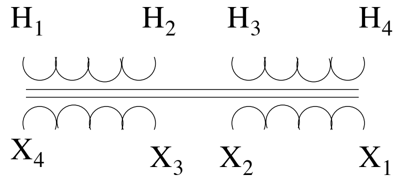
(c) (10 pts.) Find the internal generated voltage E_A and sketch an accurate phasor diagram of the current state of the generator.

4. Below is the wiring diagram of the transformers we used in class. Assume for these exercises that the "dots" of the coils are all on the ends of the coils with the larger numerical subscript, and that this general purpose transformer is rated for 240/480 volts at 60 Hz. In every case below, identify clearly the primary and secondary input/output terminals.



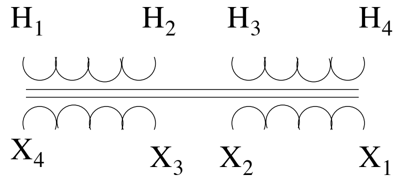
(a) (5 pts.) Using the terminal identifications above, sketch a wiring diagram to have input voltage of 120V, output of 240V with the fewest connecting wires possible.

(b) (5 pts.) Show the connections you would use for maximum current throughput and 120V input, 240V output. (Do NOT wire it as an autotransformer.)



(c) (5 pts.) Suppose we make the following connections: H_2 to H_3, H_4 to X_4. Input voltage is 200V across H_1 and X_3, that is $V_{H_1 X_3} = 200\angle 0$. Assume ideal transformer behavior, including completely mutual flux, in all respects. What voltage do we get (magnitude and phase) as V_{X_2,X_1}? Explain your reasoning.

(d) (5 pts.) We have 240 volts available as input, but would like to reduce this to approximately 200V using our transformer. Show a wiring diagram to make this possible, or explain why it's not possible.



(e) (5 pts.) Now assume this is a non-ideal transformer. We connect X_2 to X_3, H_2 to H_3. We apply a 20 volt source, phase zero degrees, at 60 Hz, across terminals X_1, X_4 and read current from the source as 0.5 amps at -60 degrees. According to the standard transformer equivalent circuit model, what parameters have we determined, and what are their values?

(f) (5 pts.) How would this transformer's ratings need to change if it is to be used in a 50 Hz system?