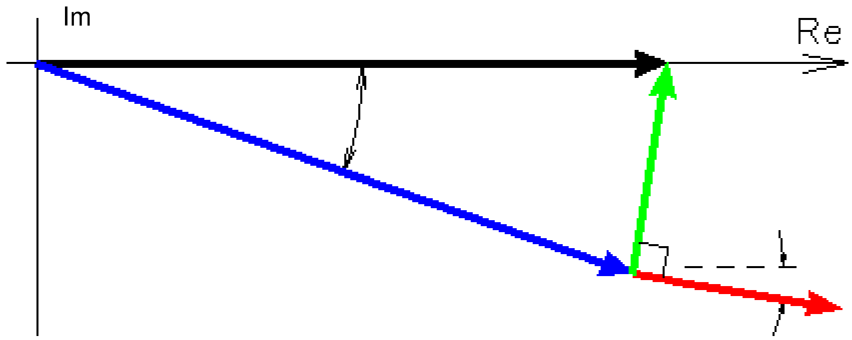
ECE 3600 Exam 3 given: Fall 24

DO NOT use erasable ink

Write Legibly! Closed book, Closed notes, Calculator OK. 11/20/24

(28 pts) Questions If I can't read what you've written or your answer is ambiguous, I'll assume you don't know.

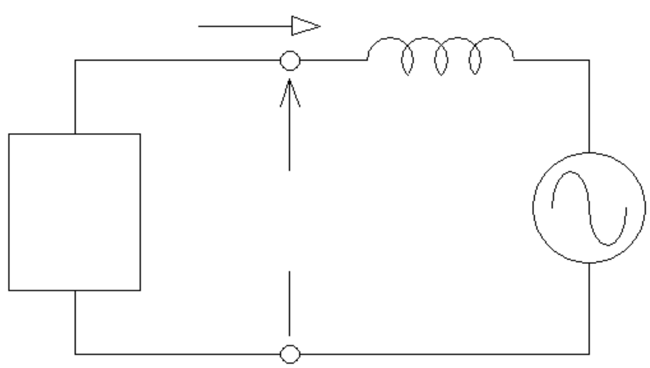
1. The following questions pertain to a 3-phase synchronous machine.
   a) Label all the phasors and angles shown.



   b) Is this phasor diagram for a motor or a generator?

   c) Judging by the phasor diagram, is the machine using + or - reactive power?

   d) Label the diagram with the voltage and current labels used in a). Also label anything else of importance.



   e) Express the relationship between the 3 voltage phasors above (they can be complex numbers).

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2. What is the purpose of the capacitor often used with a single-phase induction motor?

3. List at least 3 common long-distance high-voltage transmission line voltages given in class.

4. What insulates the wires from one another in an overhead transmission line?

5. a) What does the term "bundling" mean for high-voltage transmission lines?

   b) Name at least 2 important reasons for doing this. (advantages)

   c) Are there disadvantages? Answer no or name one or more.

6. You have the stator of a 3-phase motor which you suspect may be bad. It has 3 connections (3 wires connected to the stator in an unknown way). Let's call these connections or wires X, Y, & Z. X, Y, & Z are not connected to anything else at this time. This stator may be from a synchronous motor, an induction motor, or even from a so-called brushless DC motor.
   Describe a simple test, using one or more measurements made with a simple multimeter which would very-likely show whether the windings were OK or not. Be sure to say how you would interpret the results of the measurement(s).

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1. (25 pts) A 1/4-hp, 120-V, 60-Hz, single-phase, capacitor-run, induction motor has two identical windings set 90º apart in the motor housing. Each winding draws 3 A at 30° lag when the rotor is locked and 1 A at 10° lag when the motor is running at its rated speed.
   a) Find the ideal capacitor to place in series with one of the windings at startup.
      Note: the ideal capacitor would create the ideal phase difference between the winding currents.

   b) Find the input power at **rated speed** with this capacitor in place.

   c) Instead of the capacitor found in part a), choose a different capacitor to make the current magnitude in the two windings exactly the same at rated speed. (Don't worry about the phase angles.)

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1. continued d) Find the input power at rated speed with this different capacitor in place.

2. (25 pts) A 2-hp, shunt excited dc motor has the following nameplate information: 150 V, 1000 rpm, 14 A. The 14 A <u>includes</u> 1 A of field current. Assume rotational losses are 200 W and are constant.

$V_T := 150 \cdot V$ $\quad n_{FL} := 1000 \cdot rpm$ $\quad I_{FL} := 14 \cdot A$ $\quad I_F := 1 \cdot A$ $\quad P_{rot} := 200 \cdot W$

$1 \cdot hp = 745.7 \cdot W$

a) Find R_A

b) Find the no-load armature current. Show the algebra needed to find I_A from the basic equations.

More on next page ===>

2. continued

c) Find the no-load shaft speed.

d) Is this speed likely to damage the motor?

f) A mechanical load on the motor and the motor slows down to: $n_{new} := 1100 \cdot rpm$

Find the load power at this speed.

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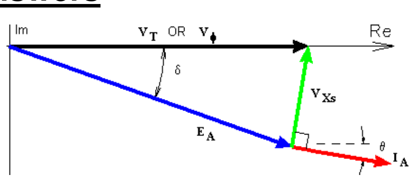
Answers

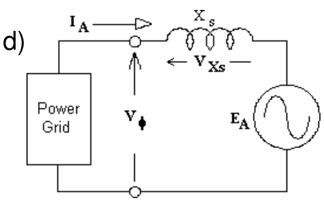
1. a)



b) motor

c) positive, +

d)



e) $\mathbf{E_A} = \mathbf{V_\phi} - \mathbf{V_{Xs}} = \mathbf{V_\phi} - \mathbf{I_A} \cdot j \cdot X_s$

OR

$\mathbf{V_\phi} = \mathbf{E_A} + \mathbf{V_{Xs}} = \mathbf{E_A} + \mathbf{I_A} \cdot j \cdot X_s$

2. Make the current in one of the windings lead the other, so as to get a spinning magnetic field and start the motor.

3. 3 of these: $115 \cdot kV$ $230 \cdot kV$ $345 \cdot kV$ $500 \cdot kV$ $765 \cdot kV$

4. Air (and distance)

5. a) Using more than one conductor per phase. b) 2 of these: Reduce corona discharge, Decrease line inductance, Increase line capacitance
c) Costs more

6. Use the multimeter to measure the resistance between X and Y (R_{XY}), between X and Z (R_{XZ}), and between Y and Z (R_{YZ}). They should all be small and equal, if not, the winding is probably bad.
$R_{XY} = R_{XZ} = R_{YZ}$ Must be true, if not, there is problem.

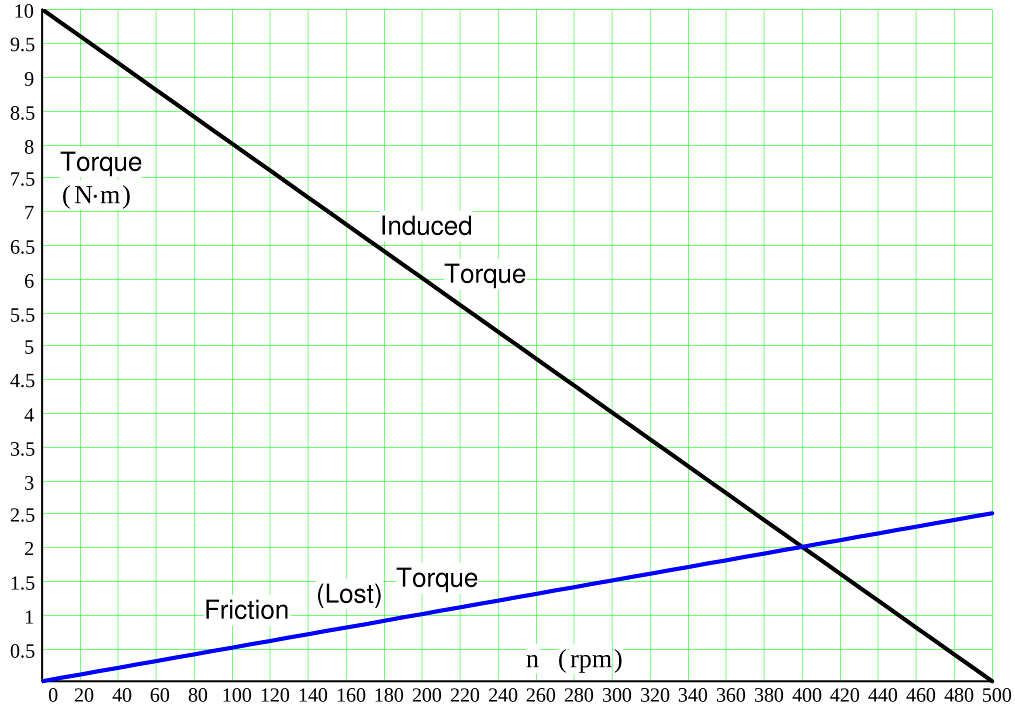
1. a) $33.2 \cdot \mu F$ b) $215.6 \cdot W$ c) $63.6 \cdot \mu F$ d) $236.4 \cdot W$ 2. a) $1.530 \cdot \Omega$ b) $1.35 \cdot A$ c) $1137 \cdot rpm$ d) NO f) $443.6 \cdot W$

3. a) $400 \cdot rpm$ b) $222.5 \cdot rpm$ c) $200 \cdot rpm$ d) $120 \cdot rpm$

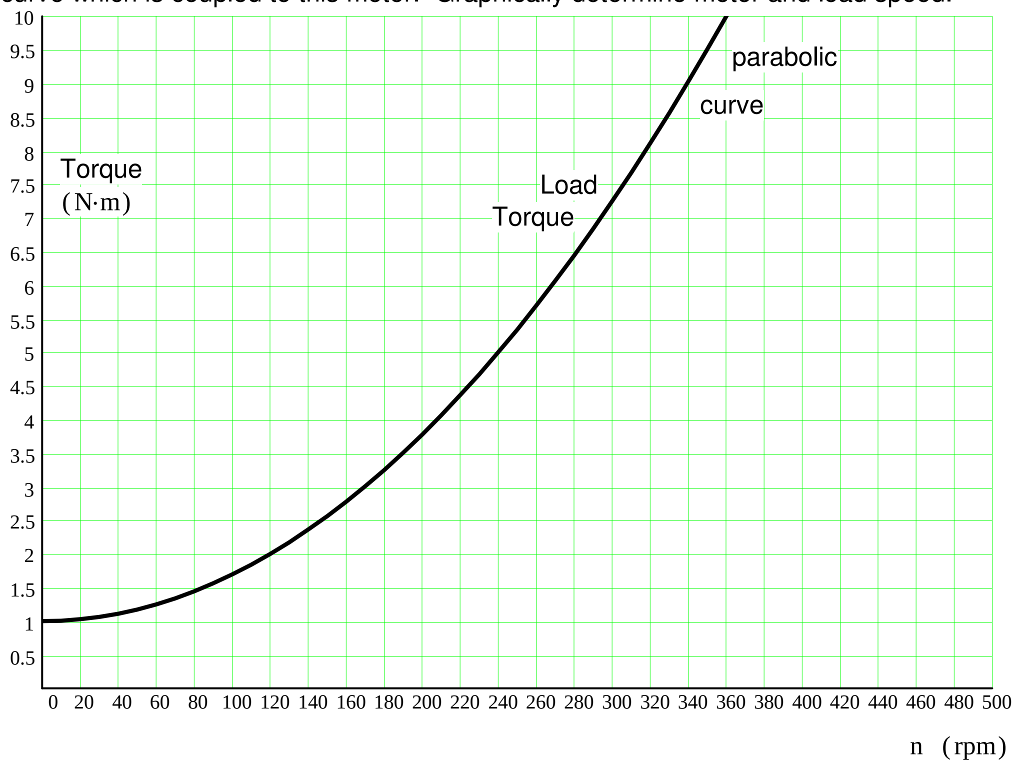
3. (22 pts) The torque-speed characteristics of a permanent-magnet DC motor are shown below. The top line is the induced torque. The lower line is torque lost to friction inside the motor.

Notes: I intend for you to solve this graphically, so answers won't be perfect. Rulers are available from Arn. Add extra lines and show operating points. You may solve this algebraically, if you wish.

a) Find the no-load speed.



b) The curve below shows a load curve which is coupled to this motor. Graphically determine motor and load speed.



For parts c) and d) The terminal voltage of the motor is reduced by half.

c) Find the new no-load speed,

d) Graphically determine the new motor speed when coupled to the load of part b).
Also show the operating points for parts b) and d) on the curve above.

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 Answers are on page 5 CB ________ / 28 Total _________ / 100