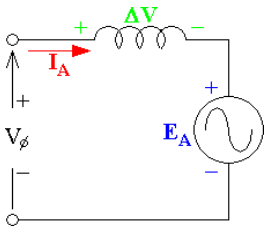
ECE 3600 Exam 2 given: Spring 24

DO NOT use erasable ink

1. (35pts) A 20-hp, 60-Hz, Δ-connected, three-phase, 8-pole synchronous motor operates from a 600-V bus. Neglect electrical and mechanical losses.



   a) The shaft of the motor is spinning freely (no mechanical load). What is the power angle? Remember, the motor is not loaded and we are neglecting all losses.

   b) The DC field current is 10 A. The armature current is 0 A. What is the value of E_A in this condition?

   c) The DC field current is increased to 11 A, assume the field is proportional to this current. The armature current is now 2 A and is leading the phase voltage by 90°. Draw the phasor diagram of this condition.

   d) Is the motor under or over excited?

   e) Find the synchronous reactance.

If you can't find X_S, or doubt your value, mark here ____ and use $X_S = 25\ \Omega$ for the rest of the problem.
If it still doesn't seem like you have enough information to answer the following parts, Ask. I will answer questions for points.

   f) Find the total reactive power "used" by the motor.

1. continued A mechanical load is now hooked to the motor so that the shaft torque is $\tau_{out} := 150 \cdot N \cdot m$

g) Find the mechanical power. $Pout = ?$

h) Find the power angle. $\delta = ?$

i) Find the total reactive power used.

j) We would like to produce $4.2\ kVAR$ (use $-4.2\ kVAR$), no change in real power. Find the required E_A.

k) What does the operator change to get this new E_A, and to what new value.

2. (40 pts) A 3-phase, Δ-connected, induction motor is rated at 50-hp, 1134-rpm, 480-V, 60-Hz. At rated conditions, it has an overall efficiency of 92.265%, a power factor of 0.80, and total rotational losses (mechanical) of 415W. **Exam 2 Sp 24 p3**

Also known are: $X_1 := 0.4\cdot\Omega$ $R_C := \infty$ $R_2 := 0.9\cdot\Omega$ $1\cdot hp = 745.7\cdot W$

a) Make a drawing the circuit model of one phase. Label **all** the parts and add known values as you work the problem.

All values below are for rated conditions. Find the following:

b) The slip. Make a reasonable assumption as necessary.

c) The power converted from electrical to mechanical form.

d) Find the magnitude of I_2 Note, you may want to find the parts e) and f) first.

e) The power transformed from the stator to the rotor (the air-gap power).

f) The rotor copper loss.

g) The stator copper loss. Hint: The input power is the sum of two or three different powers.

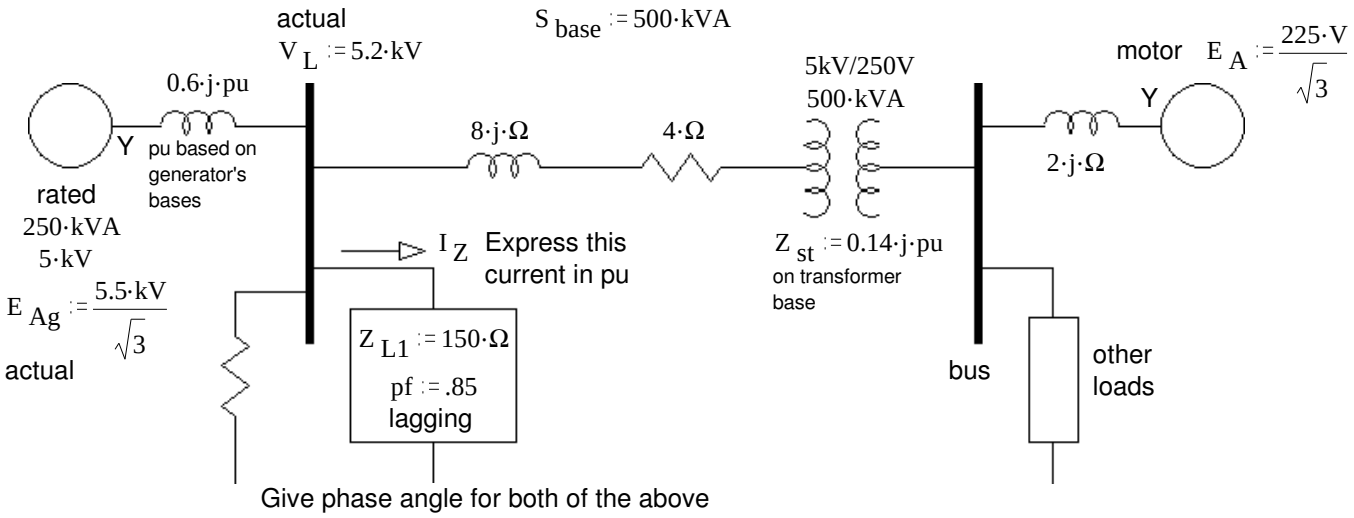
h) The magnitude of the line current. (Remember, it's Δ-connected)

i) Find R_1

j) The total reactive power used by jX_2 is: $Q_{X2} = 2.926 \cdot kVAR$ Find: X_2

k) Find: X_m Note: This will require the calculation of several numbers you probably don't have yet.
Hint: The input Q is the sum of several different Qs.

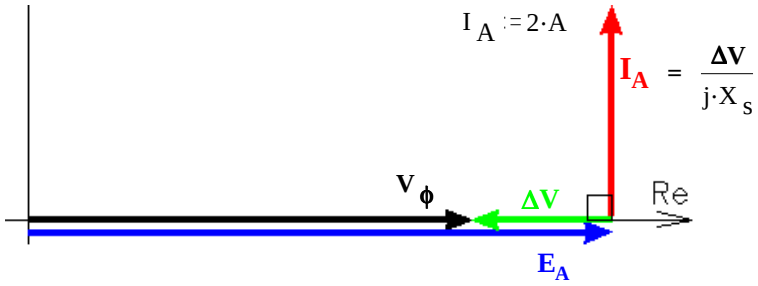
3. (25 pts) A one-line, per-phase diagram is shown below. Using the S_{base} given, draw a per-phase, per-unit diagram. Include pu values for all the values given in the drawing below. E_A voltages are line-to-neutral. **Exam 2 Sp 24 p5**



_____/ 25 Total _____/ 100

Answers

1. a) 0·deg b) 600·V c)

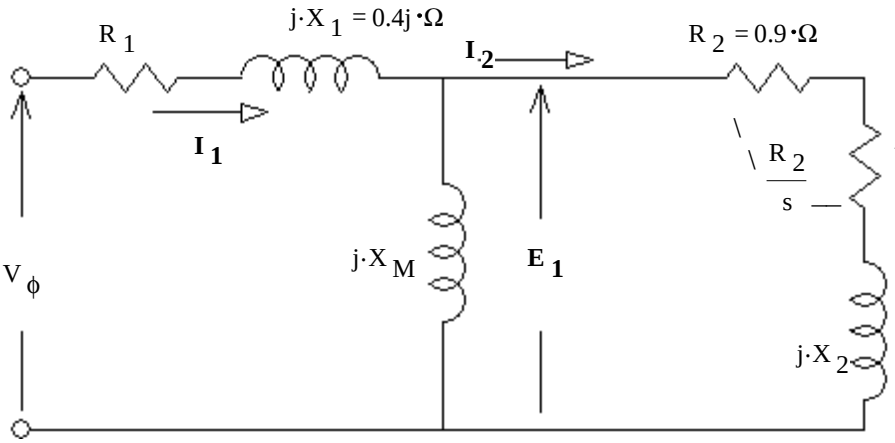


d) over excited e) 30·Ω f) - 3.6·kVAR

g) 18.96·hp h) 20.92·deg + or - acceptable

i) - 990.6·VAR j) 710.2·V k) 11.8·A

2. a)



$\frac{R_2}{s}\cdot(1-s) = R_2\cdot\left(\frac{1}{s}-1\right)$

b) 5.5·% c) 37.7·kW

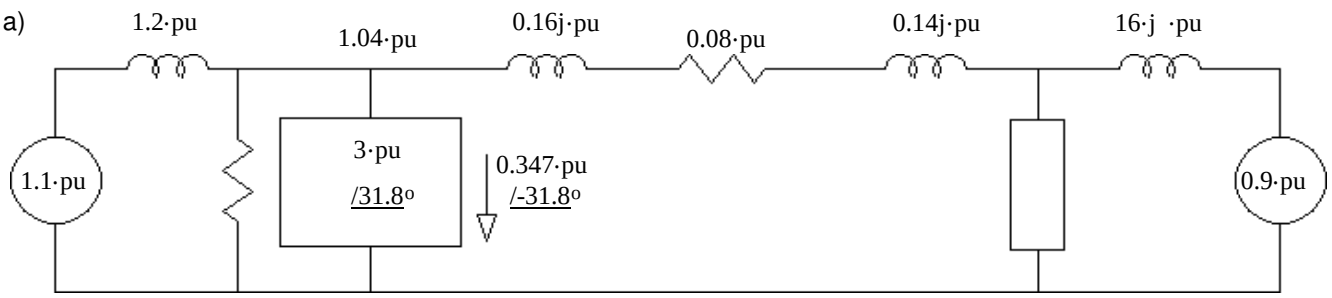
d) 28.51·A e) 39.89·kW

f) 2194·W g) 516.6·W

h) 60.76·A i) 0.14·Ω

j) 1.2·Ω k) 25.34·Ω

3. a)



b) 20.02·A