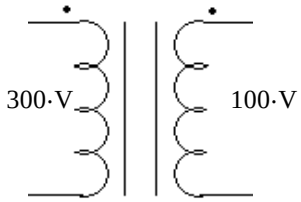
ECE 3600 Exam 2 given: Fall 24

DO NOT use erasable ink

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

1. a) You have a 300/100-V, 600-VA transformer.
   Can you use this transformer to transform
   400 V to 300 V? If yes, show the connections and
   compute the new VA rating.



   b) Show the 400-V source and the load.

   c) Could this transformer also be used to transform 160 V to 120 V ? If yes, what is the maximum real power that could be transformed at these voltages?

2. Why do transformers have a maximum voltage rating?
   That is, what bad thing (that could cause excess current and overheting) are you trying to limit by limiting the voltage?

3. Why do transformers have a maximum current rating? That is, what limits the safe current?

4. a) List at least 3 different synchronous motor speeds in the US, in rpm.

1. (30 pts) A 3-phase, synchronous generator is not electrically connected to anything. The prime mover is spinning the generator at $3600\ \text{rpm}$. The input torque is $20\ \text{Nm}$.
The generator E_A perfectly matched to the grid voltage and is then Y-connected to a $4.8\ \text{kV}$, $60\ \text{Hz}$, bus.

   a) The prime mover torque in increased to $\tau_{in} := 600 \cdot \text{N} \cdot \text{m}$ Find the generated electrical power P = ?

The prime mover torque is held at this value for the rest of the problem.

   b) The line current is measured at: $I_L := 28 \cdot \text{A}$ Find the total reactive power generated.

   c) Find the power angle. δ = ? Hint: Remember the special conditions when $|\mathbf{E_A}| = |\mathbf{V_\phi}|$.
   I suggest you draw a phasor diagram with $|\mathbf{E_A}| = |\mathbf{V_\phi}|$, such as in SG2, problem 2.

If you can't find X_S, or doubt your value, mark here ____ and use $X_S = 70\ \Omega$ for the rest of the problem.

e) The generator operator is told to produce $60\ \text{kVAR}$, no change in power. Find the new E_A

g) Find the power angle. δ = ?

h) Did the power angle change with the the previous change?
If yes, say whether it increased or decreased. No calculation is required.

i) Did the generated power change with the the previous change?
If yes, say whether it increased or decreased. No calculation is required.

2. (30 pts) A 3-phase induction motor is Y-connected to a 480-V bus. It draws 12kW of real power and has a power factor of 0.9 . Some more knowns: **Exam 2 F 24 p4**

$X_M := 100\cdot\Omega$	$R_C := \infty$	Input power:	$P_{in} := 12\cdot kW$ at $pf := 0.9$
	$n := 1720\cdot rpm$	Rotor copper loss:	$P_{RCL} := 505\cdot W$
The output shaft torque:	$\tau_{load} := 58\cdot N\cdot m$	Stator copper loss:	$P_{SCL} := 640\cdot W$

$\mathbf{E_1} := (250 - j\cdot 25.5)\cdot V$ relative to terminal (input) voltage with 0^o phase angle.

a) Draw the model for this motor. This will be your working drawing, so you may want to add information from above. Leave room on your drawing for current, voltage, and component values to be added later.

b) Find the line current. $\mathbf{I_L}$ = ?

c) Find R_1

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2. continued d) Find $|\mathbf{I}_2|$

e) Find P_{AG}

f) Find s

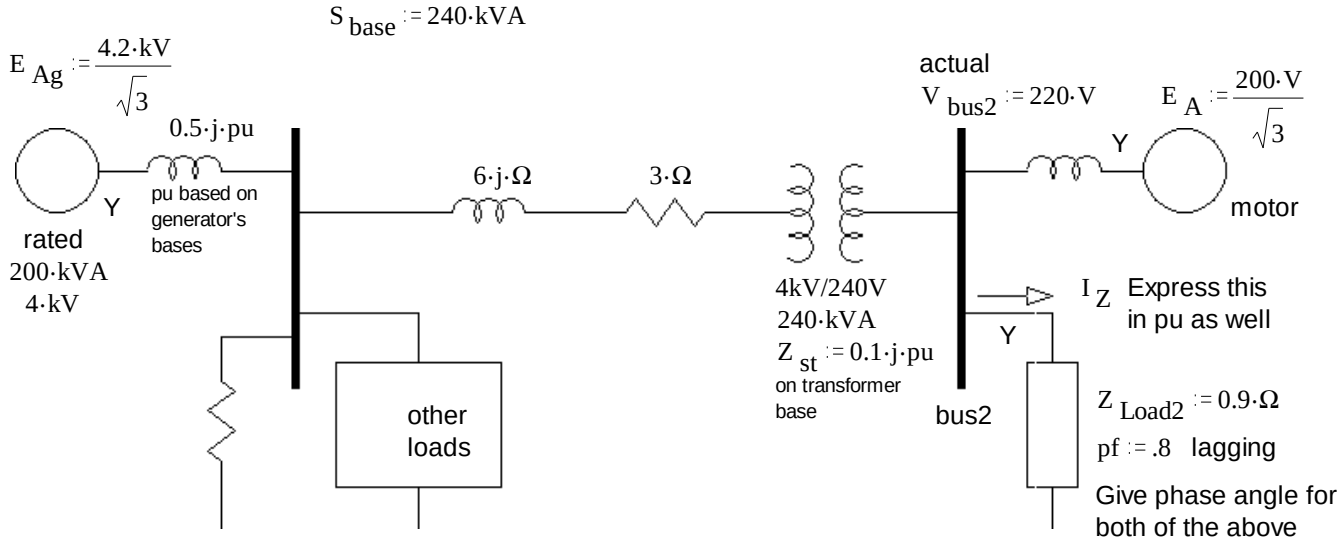
g) Find R_2

h) Find the shaft output power

i) Find the mechanical power losses (all lumped together).

j) Find the overall machine efficiency, η

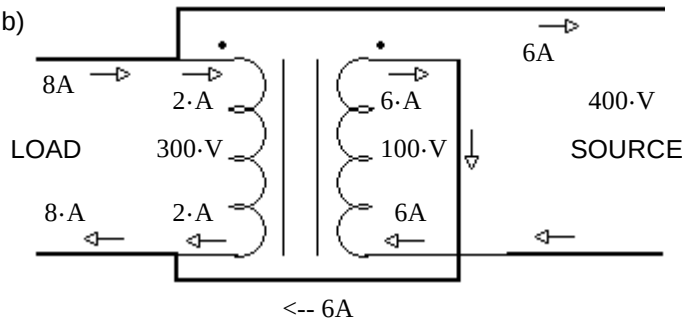
3. (20 pts) A one-line, per-phase diagram is shown below. Using the S_{base} given, draw a per-phase, per-unit diagram. Include pu values for all the values given in the drawing below. E_A voltages are line-to-neutral. **Exam 2 F 24 p6**



b) Find the actual $\mathbf{I_Z}$ in amps.

Answers

1. a) & b)



2.4·kVA

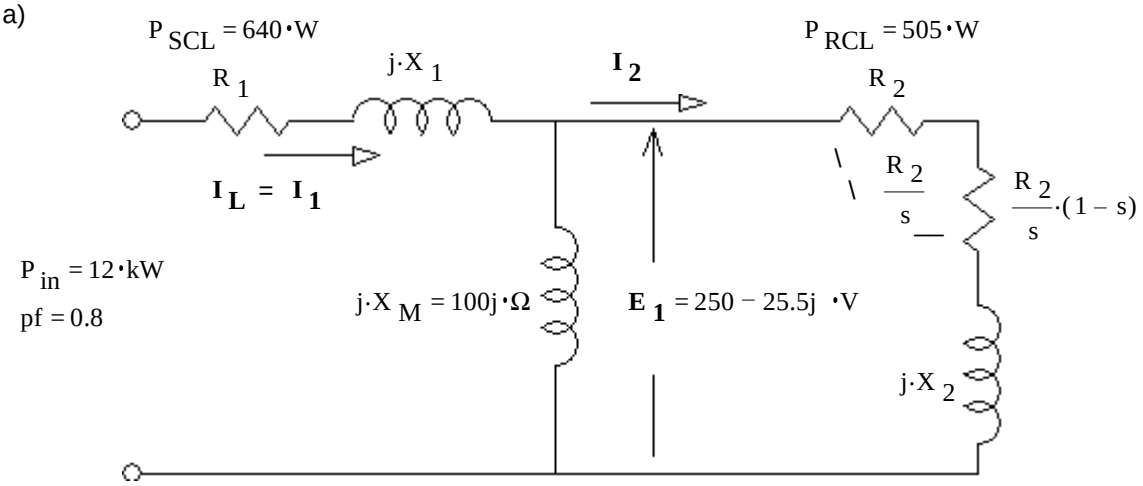
c) Same connections 960·W

2. Core saturation Insulation breakdown would happen at quite a bit higher voltage

3. Winding resistance & I^2R heating 4. $\frac{3600 \cdot rpm}{any\_integer}$

1. a) 218.7·kW b) - 79.9·kVAR c) 40.14·deg d) 67.9·Ω e) 3.72·kV g) 28.7·deg h) decreased i) NO

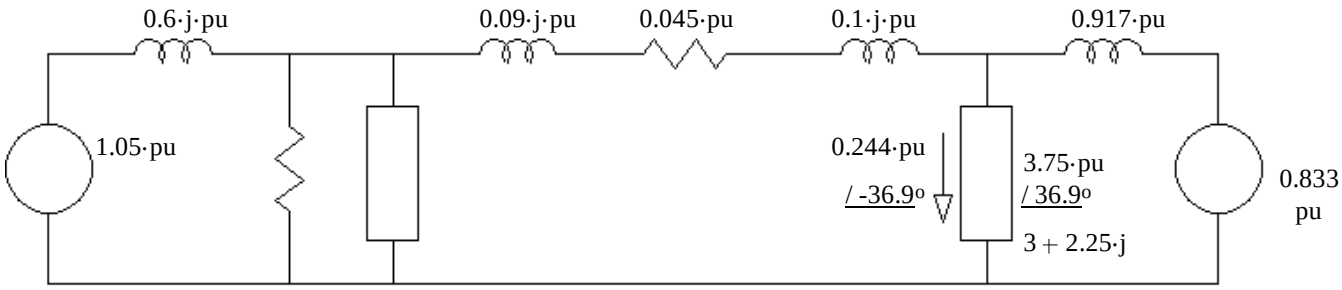
2. a)



b) (14.43 – 6.99·j)·A = 16.04A /-25.84° c) 0.829·Ω d) 15.36·A e) 11.36·kW f) 4.444·% g) 0.713·Ω

h) 10.45·kW i) 408·W j) 87.1·%

3. a)



b) 141·A /-36.9°