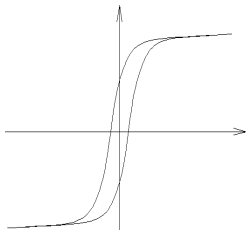
ECE3600 Final given: Fall 12

Write Legibly! If I can't read what you've written or you answer is ambiguous, I'll assume you don't know.

(53 pts) Questions This part of the exam is Closed book, Closed notes, No Calculator.

1. What is the most energy-efficient type of common power plant? Hint: It's also one of the oldest.
2. Name 3 sources of electrical power for the grid which do not produce greenhouse gasses by normal operation.
3. Express the VARs of a leading-pf load in terms of pf and P.
4. a) Name the common curve shown at right.



   b) Many of the electrical devices we studied contain a part which is characterized by this curve. What part is that?

   c) Name at least 3 issues caused by this part having this characteristic curve.

5. Why do power transformers have a maximum voltage rating?
   That is, what's the first bad thing are you trying to limit by limiting the voltage?
6. Why do transformers have a maximum current rating?
7. Most electric motors that we studied slow down if the mechanical load is increased. Are there any that do not (in normal operating range)? Either answer NO or name the exception(s) and indicate how they do respond to increased mechanical load.
8. Most electric motors that we studied draw more current if the mechanical load is increased. Are there any that do not (in normal operating range)? Either answer NO or name the exception(s) and indicate how they do respond to increased mechanical load.
9. a) A 3600-rpm, 3ϕ motor is rated for a Δ connection to a 480-V, 60-Hz bus. If this motor is to be operated from a 480-V, 50-Hz power system, what speed would you expect it to run?

   b) Is it safe to operate this motor from 480-V, 50-Hz without any other modifications? If no, say why.

   c) If the answer to b) is no, is there still a safe way to operate this motor from a 480-V, 50-Hz bus with modification(s)? If yes, tell what the modification is.

10. An induction motor with just one winding connected to an AC source has what interesting behavior?
11. How can you reverse the direction of rotation of a capacitor-start motor? That is, reverse the direction it starts. Choose from these answers.

    a) Reverse the leads to the capacitor.

    b) Reverse the leads to the main winding.

    c) Reverse the leads to the start winding.

    d) Reverse the positions of the capacitor and the start (second) winding.

    e) Reverse the leads to both the main and the start windings.

12. DC motors are usually classified by the way the field is created or wired:

    1. Separately excited 2. Series excited 3. Shunt excited 4. Permanent magnet

    a) One of these types is also commonly used with AC power, which one?

    b) What is it called when it is used with AC power?

    c) Name 2 important characteristics of this type of motor.

    d) Name 2 common uses of this type of motor.

    e) Sketch the torque-speed curve of this type of motor.

13. When we visited Terminal substation, we saw three different yards at three different line voltages. Power was also distributed locally at yet another line voltage. List as many of these voltages as you can remember.
14. Large power transformers are filled with _____ for two main reasons. Give one or both reasons.
    fill in blank
15. The breakers used in substations come in two main types, list them and indicate which type was newer technology.

16. You saw several capacitor banks at Terminal substation. We've talked in class about adding capacitors to correct power factor, but people in the power industry usually talk about the effects of adding capacitors differently. What do they say they add capacitors for?

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

    b) It is typically used for transmission lines with line voltages $\geq$ _____ fill in blank

    c) Name some of the reasons for doing this. (advantages)

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

Name _____

Do you want your grade and scores posted on the Internet?
If your answer is yes, then provide some sort of alias:

_____
otherwise, leave blank

The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here. I will not post grades under your real name. It will show the homework, lab, and exam scores of everyone who answers here.

ECE 3600 Fall 2012 Final Arn Stolp

Scores:
Questions _____ of a possible 53 pts
Prob 1 _____ of a possible 24 pts
Prob 2 _____ of a possible 21 pts
Prob 3 _____ of a possible 38 pts
Prob 4 _____ of a possible 24 pts

Total _____ of a possible 160 pts

F12 Open book

1. (24 pts) A 3-phase generator produces 280-V , 60-Hz 3-phase power. It is connected through 3 lines to a single 3-phase load which consumes 2.7 kW with a 90% lagging power factor. **Each** line has a resistance of R_{line} and a reactance of X_{line} and consumes 60 + 120j VA. .

   Source end: 280-V Lines: $R_{line} + X_{line}$ Load end: 2.7 kW, 90% pf, lagging

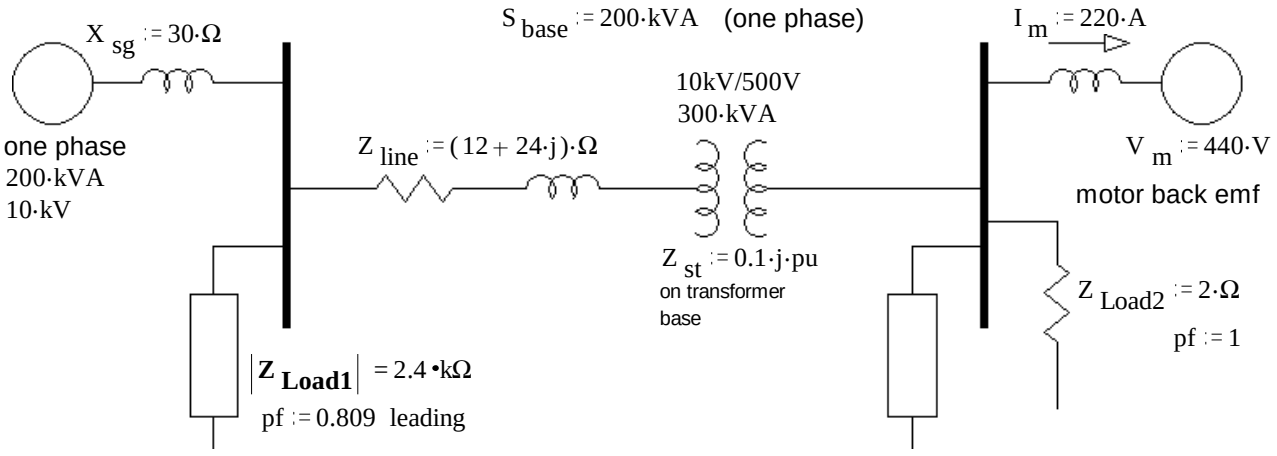
   a) Find the complex power provided by the source. $\mathbf{S_S}$ = ?

   b) Find the line current $\mathbf{I_L}$, magnitude and phase. $\mathbf{I_L}$ = ? (Line-Neutral voltage at source is 0^o reference)

   c) Find the line resistance and reactance. R_{line} = ? X_{line} = ?

   d) What is the efficiency of this system?

2. (21 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. All voltages are line-to-neutral.



   b) The Line-Neutral voltage of the left bus is 9.8 kV at 0^o. Convert the left voltage to pu and use your pu values to find the per-unit current through $\mathbf{Z_{Load1}}$. Also find it's phase angle.

3. (38 pts) A 345 kV transmission line has the following length and line parameters.

$len := 120 \cdot km$ $r := 0.12 \cdot \frac{\Omega}{km}$ $x := 0.6 \cdot \frac{\Omega}{km}$ $g := 0 \cdot \frac{S}{km}$ $y := 8 \cdot 10^{-6} \cdot \frac{S}{km}$ $S := siemens$

The line voltage at the **source** is 345kV.

The line current from the **source** ($\mathbf{I_S}$) is 231A and it leads the line-to-neutral voltage by 28^o.

a) Choose the most appropriate model for this transmission line and **draw it**, including the impedance and/or admittance value(s). Add a 3ϕ load at the receiving end of the transmission line.

b) Find the line current in your model, $\mathbf{I_{Line}}$ (not $\mathbf{I_S}$) in a complex-number form. $\mathbf{I_{Line}}$ = ?

c) Find the load phase voltage, $\mathbf{V_R}$, magnitude and phase. $\mathbf{V_R}$ = ?

d) What is the line voltage at the load (magnitude)?

e) What is the "power angle" (δ)?

f) Find the impedance of one phase of the load, assuming Y-connected.

g) Find the power consumed by the entire load.

h) Find the power factor of the load.

4. (24 pts) A 1/4-hp, 120-V, 60-Hz, single-phase, capacitor-run, induction motor has two identical windings set 90^o apart in the motor housing. Each winding draws 3 A at 30° lag when the rotor is locked and 1.5 A at 40° 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 ideal capacitor to place in series with one of the windings at rated speed.

c) Find a compromise capacitor to place in series with one of the windings. Choose this capacitor to make the current magnitude in the two windings exactly the same at rated speed. (Don't worry about the phase angles.)

d) Find the input power at rated speed with the compromise capacitor in place.

Answers

1. Hydroelectric 2. Hydroelectric wind solar (steam or solar-cells) nuclear geothermal 3 of these

3. $Q = -\sqrt{\left(\frac{P}{pf}\right)^2 - P^2}$ 4. a) B-H curve or Hysteresis curve b) The core

4. c) Core losses Nonlinearities, esp. in the currents 3rd harmonic currents Sets voltage limits
requires more windings so that the core flux can be less Requires larger, heavier cores 3 of these

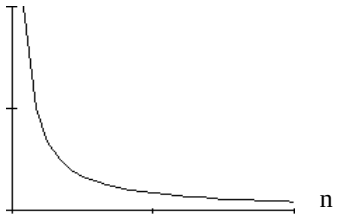
5. Core saturation Insulation breakdown would happen at quite a bit higher voltage

6. Winding resistance & I^2R heating 7. Synchronous motors do not slow down, their speed remains constant

8. NO, all electric motors draw more current if the mechanical load is increased 9. a) $3000 \cdot rpm$

9. b) NO, The core will saturate. Saturating the core would result in large currents. c) Y-connected

10. It won't start spinning without outside help 11. b) AND c) 12. a) Series excited b) Universal motor

12. c) High torque High power-to-weight ratio High power-to-size ratio e) 

Noisy Torque increases significantly as load is increased 2 of these

d) Hand drill Vacuum cleaner Blender Food processor
Weed eater Electric yard devices 2 of these

13. $12.47 \cdot kV$ $46 \cdot kV$ $138 \cdot kV$ $345 \cdot kV$

14. Oil Oil is a better insulator than air Oil is used to keep the transformers cool

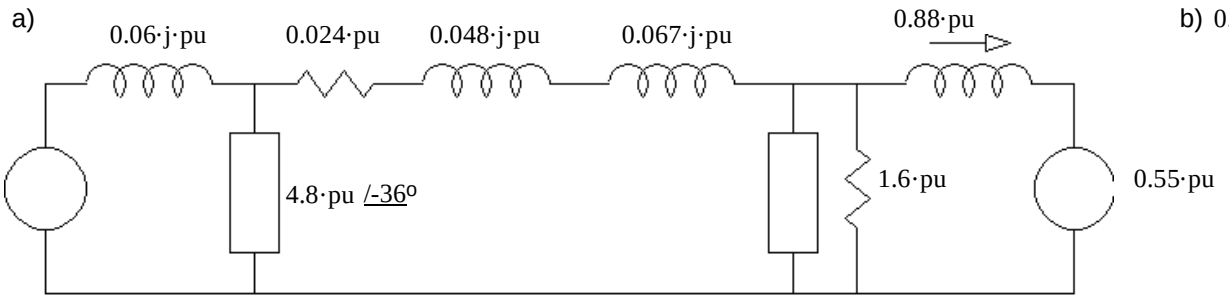
15. Oil filled (old) Gas (SF_6) filled (newer)

16. To increase the voltage 17. a) Using more than one conductor per phase. b) $345 \cdot kV$

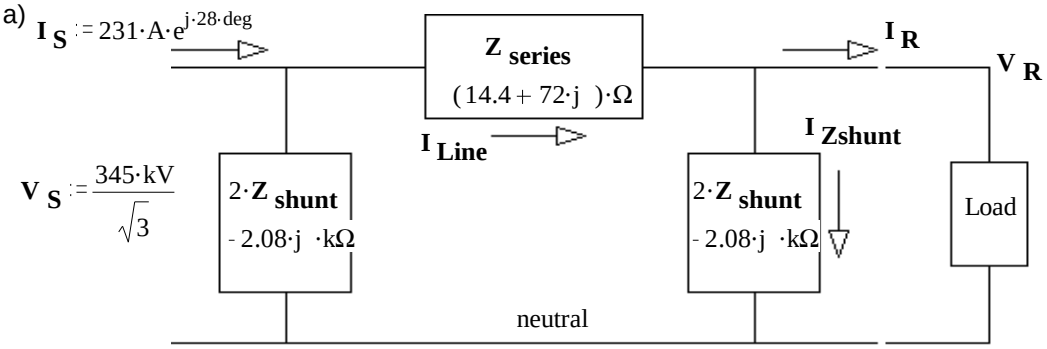
17. c) Reduce corona discharge decrease line inductance Increase line capacitance d) Costs more

Open Book

1. a) $2.88 + 1.668 \cdot j \ kVA$ b) $6.86 \cdot A \ \underline{/-30.1^o}$ c) $1.27 \cdot \Omega$ $2.55 \cdot \Omega$ d) $93.75 \cdot \%$

2. a) 

b) $0.204 \cdot pu \ \underline{/36^o}$

3. a) 

b) $204 \cdot A \ \underline{/3.6^o}$

c) $197.7 \cdot kV \ \underline{/-4.313^o}$

d) $342.5 \cdot kV$

e) 4.313^o

f) $881.0 + 290.6 \cdot j \ \Omega$

g) $120.1 \cdot MW$

h) 0.95

4. a) $33.2 \cdot \mu F$ b) $21.3 \cdot \mu F$ c) $25.8 \cdot \mu F$ d) $276 \cdot W$