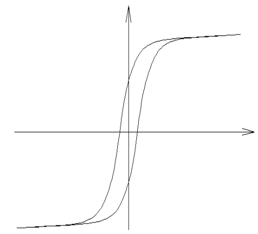
ECE 3600 Final, given: Fall 2017

Closed Book, Closed notes except for those given in class for Exam 1, 2, and final, Calculators OK, Show all work to receive credit.Circle answers, show units, and round off reasonably

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

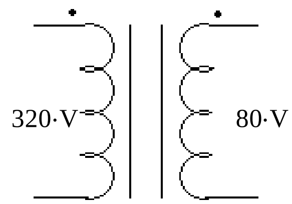
(31 pts) Questions



1. 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.



2. You have a 320/80-V, 640-VA transformer.

   a) Can you use this transformer to transform 320 V to 240 V? If yes, show the connections and compute the new VA rating.

   b) Can you use this transformer to transform 160 V to 120 V? If yes, what is the maximum real power that could be transformed?

   c) Is there a requirement for the load to actually transform this much real power? if yes, say what.

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

4. An induction motor with just one winding connected to an AC source has what interesting behavior?

5. Is there a readily available device (perhaps made for a different use, which could regulate the speed of a synchronous motor? If yes, name the device,

6. 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 start winding.

   b) Reverse the leads to the main winding.

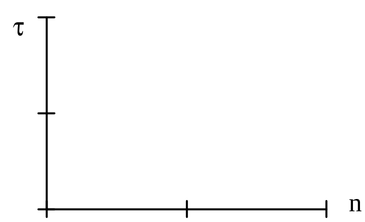
   c) Reverse the leads to both windings.

   d) Change which winding has the capacitor.

   e) Reverse the leads to the capacitor.

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

7. a) In the space at right, sketch the torque-speed curve of a series-wound DC motor (field in series with rotor).



   b) If this type of motor is used with an AC source, what is it called?

   c) Name at least 2 common uses of this type of motor.

8. 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.

9. 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.

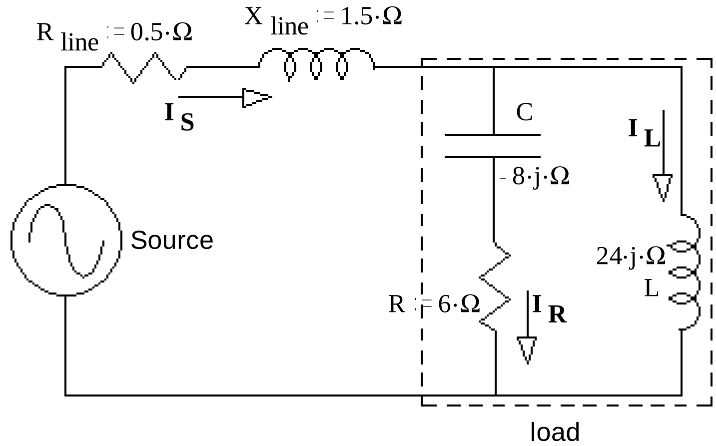
10. What insulates the wires from one another in an overhead transmission line?

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

    b) It is typically used for transmission lines with line voltages ≥ ______________ fill in blank

    c) Name the 3 most important reasons for doing this. (advantages)

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



1. (34 pts) R, L, & C together are the load (in dotted box). The power used by the load is $P_{Load} := 726 \cdot W$ Find:

   a) The magnitude of the resistor current. $|\mathbf{I_R}| = ?$

   b) The voltage at the load (magnitude). $V_{Load} = ?$

   c) The reactive power used by the load. $Q = ?$

   d) The apparent power of the load. $|\mathbf{S}| = S = ?$

   e) The power factor of the load. $pf = ?$

   f) This power factor is: i) leading ii) lagging (circle one)

   g) The magnitudes of the other currents. $|\mathbf{I_L}| = ?$ $|\mathbf{I_S}| = ?$

   h) The source voltage (magnitude). $V_S = ?$

   i) Is there something weird about this voltage? If so, what?

   j) Why?

2. (38 pts) A separately excited dc motor is rated at 2-hp, 1200rpm, armature: 150 V 14A, field: 150 V 0.8A.

a) The field is connected to the rated voltage and then you spin this motor with another motor at 900rpm.
Nothing but a voltmeter is hooked to the armature terminals and it measures 88 V .
Find R_A from this information and the ratings. $1 \cdot hp = 745.7 \cdot W$

If you can't find R_A , mark an X here ______ and use 2.5Ω for the rest of the problem.

Unless stated otherwise, assume rated voltages below.

b) Find the rotational losses when operated at full load. $P_{rot} = ?$

c) Find the overall efficiency (includes power needed for the field) when operated at full load.

d) Find the no-load armature current. Show the algebra needed to find I_A from the basic equations.
The rotational losses are proportional to the motor speed.
Hint 1: This also means that the rotational losses are proportional to E_A, like this: $P_{rot2} = P_{rot1} \cdot \frac{E_{A2}}{E_{A1}}$
Hint 2: This turns out to be amazingly easy to calculate, no quadratic required.

If you can't find I_{Anl} , mark an X here ______ and use 1.5A for the rest of the problem.

e) Find the no-load shaft speed.

f) The mechanical load on the shaft is increased and the motor slows down to: $n_{new} := 1300 \cdot rpm$
Find the load power at this speed.

g) The field voltage is reduced to 120V and the armature is left at the rated voltage.
The load is then adjusted so that the speed is again 1300rpm.
Find the armature current at this field voltage.

h) Would it be OK to operate this way for a long time?

3. (34 pts) A 230 kV (nominal) transmission line has the following length and line parameters. $S := \text{siemens}$

$len := 180 \cdot km$ $\quad r := 0.2 \cdot \frac{\Omega}{km}$ $\quad x := 0.70 \cdot \frac{\Omega}{km}$ $\quad g := 0 \cdot \frac{S}{km}$ $\quad y := 3.9 \cdot 10^{-6} \cdot \frac{S}{km}$

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.

The line current to the **load**, $\mathbf{I_R}$ (not $\mathbf{I_{Line}}$) is 240+80j A.

The magnitude of one phase of the Y-connected load impedance is 520Ω.

b) Find the load phase voltage, $\mathbf{V_R}$, magnitude. Assume its phase is 0º (relative to the current given above).
$\mathbf{V_R}$ = ?

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

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

e) What is the "power angle" (δ)?

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

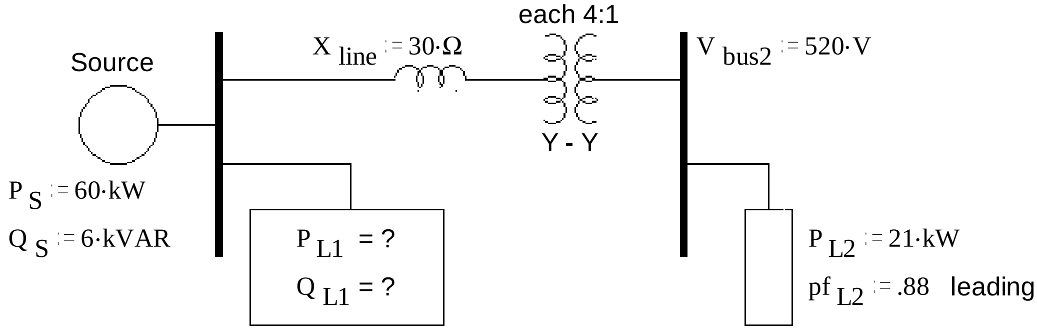
g) Find the power consumed by the entire load.

h) Find the power factor of the load.

i) Consider the source voltage and the load voltage of this transmission line. Is there anything weird about them? If yes, say what and tell me the cause of the of this weirdness.

4. (23 pts) A one-line drawing of a 3-phase system is shown. Some 3-phase Ps and Qs are also shown. The 3-phase transformer is made of 3 individual single-phase transformers, each with a 4:1 turns ratio. Consider them to be ideal. They are hooked up Y - Y step-down so that the voltages on the left are 4x the voltages on the right. Remember that bus and line voltages are the same. a) Find the complex power consumed by load 1.

Hints: Work from load 2 back and if you don't use Ps and Qs to solve this problem it will be VERY HARD!



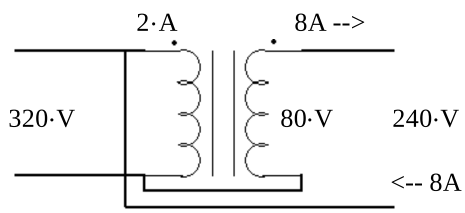
b) What is the efficiency of this system? $\eta = ?$

Answers

Questions 1. a) B-H curve or Hysteresis curve b) The core

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

2. a)



$8\cdot A\cdot 240\cdot V = 1.92\cdot kVA$

b) YES, half voltages above $6\cdot A\cdot 160\cdot V = 960\cdot W$

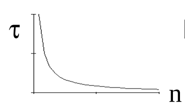
c) YES, pf = 1

3. $\frac{3600\cdot rpm}{any\_integer}$ $3600\cdot rpm$ $1800\cdot rpm$ $1200\cdot rpm$ $900\cdot rpm$ $720\cdot rpm$ etc..

4. It won't start spinning without outside help

5. Yeah, a VFD (variable Frequency Drive) made for induction motors would work.

6. a) b) d) 7. a)



b) Universal motor c) Hand drill, Food processor, Blender, Vacuum cleaner, Weed eater, Electric yard devices

8. Synchronous motors do not slow down, their speed remains constant

9. NO, all electric motors draw more current if the mechanical load is increased 10. Air (and distance)

11. a) Using more than one conductor per phase. b) $345\cdot kV$

c) Reduce corona discharge Decrease line inductance Increase line capacitance d) Costs more

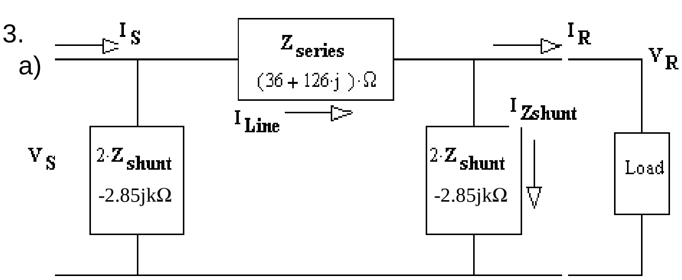
1. a) $11\cdot A$ b) $110\cdot V$ c) $-463.8\cdot VAR$ d) $861.5\cdot VA$ e) .843 f) i) g) $4.583\cdot A$ $7.832\cdot A$

h) $107.65\cdot V$ i) V_S is less than V_{Load}

j) Because the Q of the line partially cancels the Q of the load
OR Partial resonance between the inductance in the line and the capacitance of the load.

2. a) $2.333\cdot\Omega$ b) $151.3\cdot W$ c) $67.2\cdot\%$ d) $1.29\cdot A$ e) $1503\cdot rpm$ f) $1083\cdot W$ g) $20.7\cdot A$ h) NO

3. a)



b) $131.55\cdot kV$ c) 271.1 A /27.73° d) $223.6\cdot kV$ e) $15.63\cdot deg$

f) 520 Ω /-18.44° g) $94.7\cdot MW$ h) 0.949

i) The source voltage is less than the load voltage. This is because the load is capacitive and the line is inductive.

4. a) $39 + 13.89\cdot j\cdot VA$ b) $100\cdot\%$