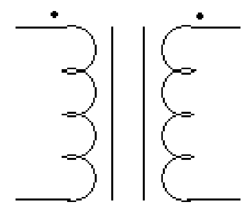
ECE 3600 Final, given: Fall 2018

Questions Closed book, Closed notes, No Calculator Write Legibly!

(20 pts) 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 320/80-V, 640-VA transformer.
   Can you use this transformer to transform 320 V to 240 V? If yes, show the connections (include source and load) and compute the new VA rating.



   b) Show the 320-V source and the load.
   c) Could this transformer also be used to transform 240 V to 180 V ? If yes, what is the maximum real power that could be transformed at these voltages?

2. A motor is rated at 15hp, 480V, 60Hz, 1140rpm. a) What type of motor is this (most likely).
   b) How many poles does it have?
   c) What is the full-load slip of this motor?
   (you may show the expression with numbers)

3. a) What DC motor is also commonly used with AC power?
   1. Separately excited 2. Series excited 3. Shunt excited 4. Permanent magnet
   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.

4. 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.

5. a) What is bundling (in transmission lines)?
   b) Name at least 2 effects of bundling.

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 or an alias that looks like a real name or u-number. The pdf spreadsheet will show the homework, lab, and exam scores of everyone who answers here.

<u>Problems Start on Next Page</u>

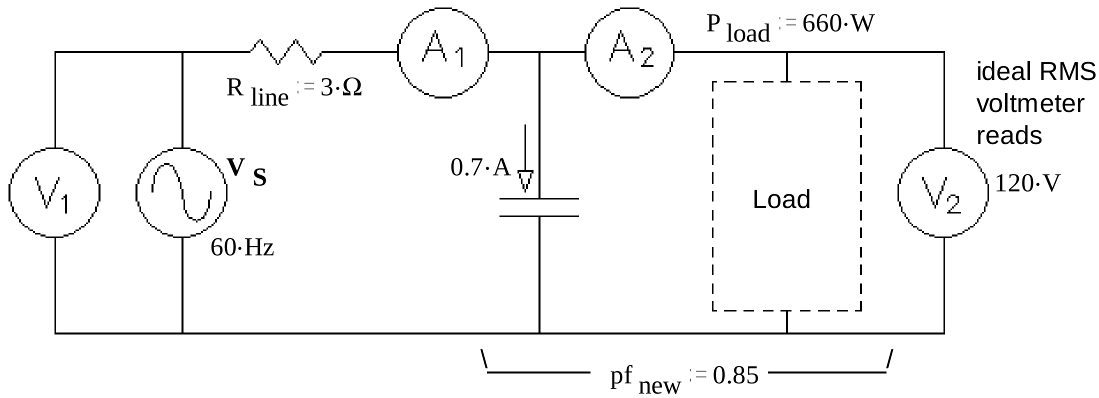
Closed Book, Closed notes except for those given in class for Exam 1, 2, and final, Calculators OK, Show all work to receive credit.Circle answers, show units, and round off reasonably

1. (40 pts) A capacitor (C, shown below) is used to partially correct the power factor of a load to 0.85. A_1 and A_2 are ideal ameters. V_1 and V_2 are ideal voltmeters. The load uses 660W. Find the following:

   a) The RMS readings of the two ideal ammeters.

   $I_{A1} = ?$

   $I_{A2} = ?$



   b) The load can be modeled as 2 parts in series. Draw the model and find the values of the parts.

   c) The voltage measured by the ideal voltmeter, labeled V_1. $V_1 = ?$

   d) The efficiency. $\eta = ?$

   e) Add (**DRAW IT**) an additional component to the drawing above in order to completely correct the power factor. Find the value of the component.

1. continued

f) Without making any additional calculations, would the efficiency be better or worse with the added component of part e)? better (higher η) ii) worse (lower η) iii) could be either iv) no difference

2. (30 pts) A 2-hp dc motor has the following nameplate information: 160 V, 1500 rpm, 11.5 A, $R_A = 0.6\ \Omega$, and $R_F = 500\ \Omega$. The field is shunt connected and the 11.5 A <u>includes</u> the field current.

a) Find the efficiency of the motor at nameplate operation. (Include the field in your calculations) $1 \cdot hp = 745.7 \cdot W$

b) Find the rotational losses at nameplate operation.

c) Find the required current (include field) for a developed (=converted) power of 1.5 hp with $V_T = 160$ V.

d) Find the shaft speed if the developed power is 1.5 hp with $V_T = 160$ V.

e) Find the output power if the developed power is 1.5 hp with $V_T = 160$ V. The rotational loss is proportional to speed.

3. (12 points, but will also include extra credit if you get parts b) and c) right) A permanent-magnet DC motor is used to pump water from lower water tank to a higher water tank. It is hooked to a 48-V source, draws 12A and spins at 1060rpm. If the power leads to the motor are reversed, it draws only 2A and spins at 1350rpm.

   a) Find R_A from this information.

DON'T WASTE TIME HERE If you don't know what to do.

   b) (Only worth 4 pts, unless all right) Assume the torques of the two cases above add and subtract like the torques in the window-lift problem of homework DC3. If you also assume that friction torque is constant, then the average torque is the torque required to overcome system friction. This also implies something about the average current.

   Power used to overcome friction is a loss. Power used to raise the water to the higher level is the output. What is the efficiency of the system when pumping the water up to the higher tank?

   c) (All extra credit) If you perform a similar calculation of efficiency for pumping the water down to the lower tank, the answer doesn't seem to make sense. You put power in, but the power out seems negative. What does that mean and where does that power come from if not from the input.

4. (36 pts) A 345 kV transmission line has the following length and parameters.

$len := 180 \cdot km$ $\quad r := 0.12 \cdot \frac{\Omega}{km}$ $\quad x := 0.6 \cdot \frac{\Omega}{km}$ $\quad g := 0 \cdot \frac{S}{km}$ $\quad y := 8 \cdot 10^{-6} \cdot \frac{S}{km}$ $\quad S := siemens$

a) Choose the most appropriate model for this transmission line and draw it, including the impedance and/or admittance value(s).

A 3ϕ load is connected at the receiving end of the transmission line. The load consumes 180MW of real power and has a power factor of 0.9, **leading**. Add it to the drawing above. The line voltage at the **load** is 346.4 kV. Assume the phase angle of the load voltage on your drawing, $\mathbf{V_R}$, is $\underline{/0^o}$.

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

c) Same load and conditions as part b). Find the source phase voltage, $\mathbf{V_S}$, magnitude and phase. $\mathbf{V_S}$ = ?

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

4. continued e) What is the "power angle" (δ)?

f) Do you see something weird about $|\mathbf{V_R}|$ and $|\mathbf{V_S}|$? If yes, what is it and what is the cause?

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

5. (22 pts) A 1/3-hp, 120-V, 60-Hz, single-phase, capacitor-run, single-phase induction motor has two identical windings set 90º apart in the motor housing. Each winding draws 5 A at 20°lag when the rotor is locked and 2 A at 40°lag when the motor is running at its rat ed speed. This is with no added capacitors, so the motor would have to be started by hand.

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 a different capacitor to replace the capacitor of part a). 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.)

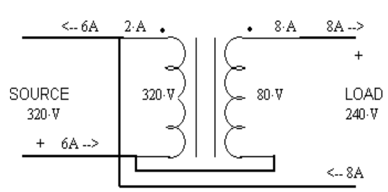
c) Find the input current (sum of both) magnitude and phase at rated speed with the capacitor of part b) in place.

Answers

Questions 1-5, Problems 1-4

Total _______ / 160

1. a)
b)



1.92·kVA c) Yes, same connections
1.44·kW

2. a) 3-phase induction motor b) 6 poles c) 5·%

3. a) 2. b) Universal motor or AC/DC motor

3. c) High torque High power-to-weight ratio High power-to-size ratio
Torque increases significantly as load is increased Noisy 2 of these

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

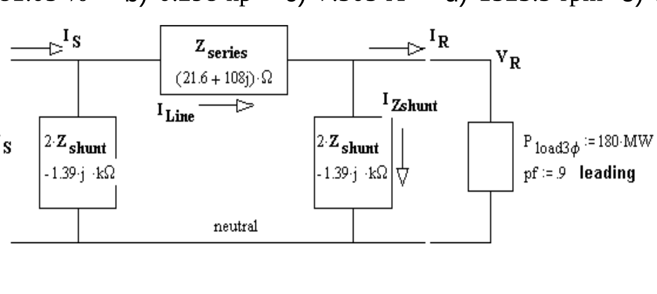
4. NO, all electric motors draw more current if the mechanical load is increased

5. a) Multiple wires per phase b) Reduce corona discharge Decrease line inductance Increase line capacitance

1. a) 6.47·A 6.875·A b) R + L 14·Ω 27.7·mH c) 136.9·V d) 84.0·% e) 75.3μF Cap in parallel w/load f) i)

2. a) 81.05·% b) 0.298·hp c) 7.505·A d) 1523.5·rpm e) 1.197·hp 3. a) 0.989·Ω b) 31.37·% c) - 180.7·W

4. a)



b) 416.8 A / 43.96º c) 179.44 V / 12.44º d) 310.8·V

e) 12.44·deg f) $|\mathbf{V_R}|$ is bigger than $|\mathbf{V_S}|$
This can happen when the load power factor is leading.

5. a) 38.7·μF b) 34.4·μF c) 3.06 A / 0º