ECE 3600 Exam 1 given: Fall 10

(The space between problems has been removed.)

Write Legibly! This part of the exam is Closed book, Closed notes, No Calculator.

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

1. List the three largest sources of energy used to produce electricity in the US.

   a) largest source: b) 2nd largest source: c) 3rd largest source:

2. Give the approximate efficiencies of each type of power plant:

   a) Hydroelectric

   b) Rankin-cycle steam turbine plants, regardless of the source of heat. (coal, oil, gas-steam, nuclear, solar-steam, geothermal)

   c) Single-cycle gas turbine

   d) Combined-cycle gas turbine

3. a) At the Gadsby power plant (the subject of the first field trip) we saw which type of power plant? Choose from a, b, c, or d given above.

   b) The Gadsby power plant uses what source of energy?

   c) Is the Gadsby power plant is used to supply base load or peak load?

4. What four things happen to the water in a Rankin-cycle power plant.
   List them in the order that they occur, starting where the energy is added to the water.
   1.
   2.
   3.
   4.

5. Explain the basics of a natural gas combined-cycle power plant.

6. Express the power factor (pf) in terms of P and Q.

7. Express efficiency (η) in three different ways using the following: P_{in} P_{out} P_{losses}

   a) η = b) η = c) η =

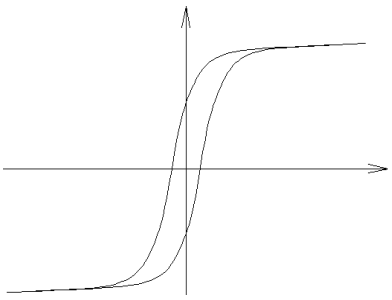
8. A B-H curve is shown at right.

   a) Label the axes.

   b) This curve shows the characteristics of a _____

   c) Which axis is directly related to the current in the coil? B or H

   d) Which axis is most closely related to the voltage across the coil? B or H



9. The voltage regulation of a transformer is often specified as %VR. Of the four values given below, circle the best %VR that could be a specification for a transformer.

   a) 2% b) 50% c) 98% d) 120%

10. The secondary of a current sensing transformer must always be connected in what way?

The following problems were handed out to the student after finishing the closed-book part.

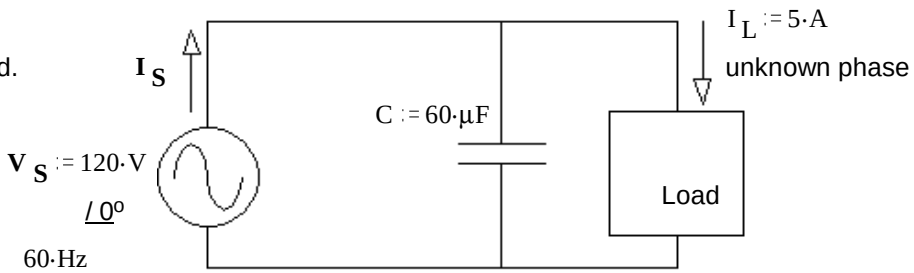
This part of the exam is open book, open notes. You MUST show work to get credit. Show the correct units for each value. Assume voltage and current values are RMS and $f := 60 \cdot Hz$. Assume normal abc sequence and balanced systems for all 3ϕ.

1. (20 pts) An capacitor is used to completely correct the power factor of a load.

   Find the following:

   a) The power consumed by the load.

   P_L = ?



   If you can't find this power, mark an x here _____ and assume $P_L = 500W$ for the rest of the problem.

   b) The power supplied by the source.

   P_S = ?

   c) The source current (magnitude and phase).

   $\mathbf{I_S}$ = ?

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

   e) The capacitor, C, is replaced with a 30 μF capacitor.

   circle one

   i) The **new** source current $|\mathbf{I_S}|$ is **greater** than that calculated in part c).

   ii) The **new** source current $|\mathbf{I_S}|$ is **the same** as that calculated in part c).

   iii) The **new** source current $|\mathbf{I_S}|$ is **less** than that calculated in part c).

2. (32 pts) a) A 3-phase system consists of a generator, 3 lines and a load. At the generator the line voltage is 300-V, the total power is 12 kW, and the power factor is 0.80. The overall efficiency of the system is 85%. Each line has the same resistance (R_{line}) and no reactance.

   a) Find the line resistance. R_{line} = ?

   b) What is the line voltage at the load (magnitude)?
   Do not ignore the phase difference between the voltage and the current.

   c) Assume that the load is Y-connected and each branch is a resistor (R_{load}) in parallel with a reactance (X_{load}).
   Find the value of load resistance. R_{load} = ?

   d) The power factor is corrected to 1 at the load. The generator line voltage remains 300-V.
   What is the new efficiency?

   Hint: You may interpret the power factor correction as though X_{load} has been eliminated.

   Beware! The power given above is no longer valid.

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3. (20 pts) The parameters of a 5:1 step-down transformer are shown below.
The transformer is loaded with $\mathbf{Z_L} := (2.5 + 0.8\cdot j)\cdot\Omega$ and the secondary voltage is $V_2 := 36\cdot V$

$R_m := 2\cdot k\Omega$ $R_s := 2\cdot\Omega$ $X_m := 800\cdot\Omega$ $X_s := 5\cdot\Omega$

a) draw the model with the load connected. Label parts, voltages and currents as needed for the rest of the problem.

b) Find the primary, source voltage. Magnitude only. $|\mathbf{V_S}|$ = ?

c) Find the efficiency of the transformer.

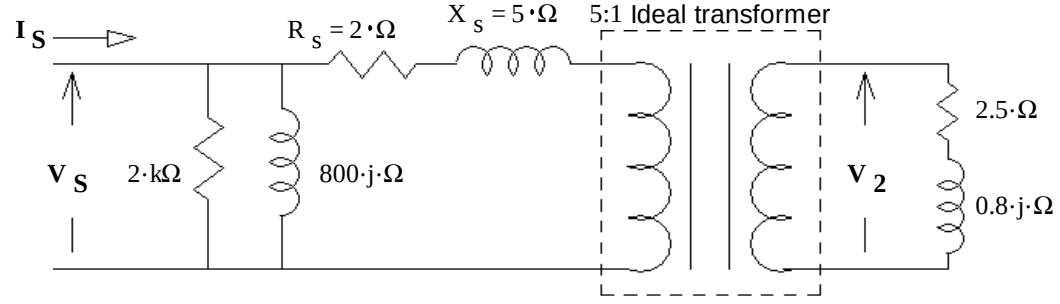
Answers

Closed-book part

1. a) Coal b) Natural Gas c) Nuclear (Natural gas is now #2, not nuclear)
2. a) ≥ 90% b) 35 - 40% c) ~ 38% d) 55 - 60%
3. a) b b) Natural Gas c) peak
4. 1. The water is boiled in the boiler.
   2. The high-pressure steam turns the steam turbine.
   3. The low-pressure steam is cooled in the cooling tower and condenses back to water.
   4. The water is pumped back into the boiler.
5. Natural gas is burned in a gas turbine which spins a generator for electricity. The exhaust or "waste" heat from this gas turbine is used to boil water for a Rankin-cycle. the steam turbine generates more electricity.
6. $pf = \frac{P}{\sqrt{P^2 + Q^2}}$ OR $pf = \cos\left(\operatorname{atan}\left(\frac{Q}{P}\right)\right)$
7. a) $\eta = \frac{P_{out}}{P_{in}}$ b) $\eta = \frac{P_{out}}{P_{out} + P_{losses}}$ c) $\eta = \frac{P_{in} - P_{losses}}{P_{in}}$
8. a) vertical (y) is B, horizontal (x) is H b) magnetic core c) H d) B
9. a) 2% 10. The secondary of current sensing transformer must always shorted.

Open-book part

1. a) $504\cdot W$ b) $504\cdot W$ c) $4.2\cdot A \angle 0^o$ d) $20.2\cdot\Omega$ resistor & $34.6\cdot mH$ inductor e) i)
2. a) $0.72\cdot\Omega$ b) $272\cdot V$ c) $7.26\cdot\Omega$ d) $90.97\cdot\%$
3. a)



b) $189.7\cdot V$ c) $93.4\cdot\%$