

# ECE370 MACHINES & POWER

Test # 1, Spring 2008 - 2009

Name \_\_\_\_\_

Box # \_\_\_\_\_

Attempt all four questions.

Use **Polar** notation and state magnitudes to 3 sig. figures.

**No partial credit** unless you explain your solution procedure.

Write in the space below the question, and on the page facing the question.

Calculators and an 8½ x 11 sheet (both sides) permitted.

Time Allowed - One 50 min. Period.

Question #	Possible Points	Awarded Points
1	25	
2	25	
3	25	
4	25	
Total	100	

1. Two  $3\phi$  loads are fed from a 60 Hz supply via three parallel feeders each with impedance  $0.1 + j0.25 \Omega/\text{phase}$ . Load 1 is Y-connected, 5 MW, 0.5 pf **lag** and Load 2 is  $\Delta$ -connected, 5 MVA, 0.6 pf **lead**. The voltage at the load is 4.16 kV. Determine:
- The single-phase equivalent (label the components).
  - The real and reactive power of the combined loads.
  - The power factor of the combined loads.
  - The percent voltage regulation when all three feeders are in service.
  - The percent voltage regulation when two feeders are out of service.

b)  $S_{tot} = 9.258/30.2 = \boxed{8.0 + j4.66 \text{ MVA}}$

c)  $\text{pf}_L = \boxed{0.8641 \text{ lag}}$

d) With all three feeders in service:  $Z_f = 0.0333 + j 0.0833 \Omega/\text{ph}$   
 $\text{VR} = \boxed{3.83\%}$

e) With only one feeder in service:  $Z_f = 0.1 + j0.25 \Omega/\text{ph}$   
 $\text{VR} = \boxed{11.7\%}$

2. A factory is supplied at 13.8 kV from a 3 $\phi$ , 60 Hz supply. It draws a continuous load of 8 MVA with a pf of 0.5 lag. Determine:
- The capacitance ( $\mu\text{F}/\text{phase}$ ) of a Y-connected bank that will improve the pf to 0.95 lag.
  - The annual saving in demand charge, if the monthly demand charge is \$10.00/kVA.
  - The payback time in months if capacitors cost \$100/kVAR to purchase and install.
  - The net five-year benefit in M\$.

a)  $C_Y = \frac{1}{377 \times 33.93} = \boxed{78.2 \mu\text{F}/\text{ph.}}$

b)  $\$_{\text{saved}} = \boxed{454.7 \text{ k\$/yr.}}$

c)  $\text{Payback Time} = \frac{561.3}{454.7} = 1.23 \text{ yrs} = \boxed{14.8 \text{ month.}}$

d)  $\text{Net five-year benefit} = \boxed{1.712 \text{ M\$.}}$

3.

a) Determine the necessary shaft speed (rpm) and torque (Nm) of a hydro turbine that drives a 50 Hz, 8 pole synchronous generator, rated  $66\frac{2}{3}$  MVA, 0.9 pf lag, if the generator's rated efficiency is 95.5%.

b) The governor of a 60 Hz, 2 pole turbo-alternator is set at 3654 rpm. Determine the percent error in the developed frequency and state whether it is high or low.

a) The necessary shaft speed is the synchronous speed  $n_s = 750$  rpm

$$T = 800 \times 10^3 \text{ Nm}$$

b) 
$$\text{Error} = \frac{3654 - 3600}{3600} \times 100\% = 1.5\%$$

4. One of the powerhouses of a hydroelectric development has four penstocks, each has a diameter of 4.31 m. The water velocity is 38 m/s when the average head behind the dam is 95 m. The generators operate at 0.9 lag pf and the electricity is transmitted at 345 kV. (Assume  $\rho_{\text{water}} = 1000 \text{ kg/m}^3$ .)
- Calculate the penstock efficiency.
  - Assuming the coefficient of performance of the turbine is 0.6 and the generator efficiency is 93.68%, what is the generated electrical power for the powerhouse?
  - Calculate the magnitude of the current in the individual transmission wires.

a)  $\eta_{\text{pen}} = \boxed{77.5\%}$ .

b)  $P_{\text{total}} = \boxed{900 \text{ MW}}$  for the powerhouse.

c) The Apparent Power is given by:  $S = \frac{900}{0.9} = 1000 \text{ MVA}$

The line current is:  $I = \frac{1000 \times 10^6}{\sqrt{3} \times 345 \times 10^3} = 1673 \text{ A}$