

# ECE370 MACHINES & POWER

## Review problems for Test 1

1. Two  $3\phi$  loads are fed from a 60 Hz supply via two parallel feeders each with impedance  $1.5 + j2 \Omega/\text{phase}$ . Load 1 is Y-connected, 3.4 MW, 0.7 pf **lag** and Load 2 is  $\Delta$ -connected, 4 MVA, 0.9 pf **lead**. The voltage at the load is 13.8 kV. Determine:
  - a) the real and reactive power of the combined loads,
  - b) the power factor of the combined loads, (0.9709 lag)
  - c) the percent voltage regulation when both feeders are in service, and
  - d) the percent voltage regulation when one feeder is out of service. (7.49%)
  
2. A factory is supplied at 69 kV from a  $3\phi$ , 60 Hz supply. It draws a continuous load of 72 MW with a pf of 0.6 lag. Determine:
  - a) The reactive power rating (kVAR) and capacitance ( $\mu\text{F}/\text{phase}$ ) of a Y-connected bank that will improve the pf to 0.96 lag. (75 MVAR)
  - b) The annual saving in demand charge, if the monthly demand charge is \$10.00/kVA. (5.4 M\$/yr)
  - c) The annual saving in energy charge, if the energy charge is 8 ¢/kWh and the feeder resistance is  $1.5 \Omega/\text{ph}$ .
  
3. Two three-phase loads are supplied at 34.5 kV via a feeder rated at 540 A with an impedance of  $0.78 + j3.9 \Omega/\text{phase}$ . The first load is 15 MW @ 0.687 lag, and the second load is 25 MVA @ 0.8 lag. The line is found to be overloaded and it is decided that some load should be transferred to another feeder. Determine:
  - a) The % of the combined load current that should be transferred, so that the feeder will satisfy the rating given. (The pf of the load remains constant.)
  - b) The % voltage regulation after the load has been transferred. (8.78%)
  - c) The value of capacitance/phase of a Y-connected capacitor bank needed to improve the new load pf to 0.98 lag.
  - d) The % voltage regulation after the pf has been improved. (3.5%)
  
4.
  - a) Determine the necessary shaft speed (rpm) and torque (Nm) of a hydro-electric turbine that drives a 50 Hz, 32 pole synchronous generator, rated 22 MW if the generator's rated efficiency is 90%. (187.5 rpm, 1.25 MNm)
  - b) The governor of a 60 Hz, 4 pole turbo-alternator is set at 1746 rpm. Determine the percent error in the developed frequency. (3%)

5. One of the powerhouses of a hydroelectric development has three penstocks, each passes  $400 \text{ m}^3/\text{s}$  of water with velocity  $30 \text{ m/s}$  when the average head behind the dam is  $54 \text{ m}$ . The generators operate at  $0.96 \text{ lag pf}$  and the electricity is transmitted at  $230 \text{ kV}$  on two parallel transmission lines.
- Calculate the penstock efficiency.
  - Assuming the coefficient of performance of the turbine is  $0.53$  and the generator efficiency is  $94\frac{1}{3}\%$ , what is the generated electrical power for the powerhouse?
  - Calculate the magnitude of the current in the individual transmission lines. ( $353 \text{ A}$ )
6. You have a requirement for a three-phase transformer to handle  $100 \text{ MVA}$  with a voltage ratio of  $69 \text{ kV} : 230 \text{ kV}$ . You are provided with three single-phase transformers each rated  $40 \text{ MVA}$  with voltage ratios of  $47.8 \text{ kV} : 276 \text{ kV}$ .
- Draw a diagram showing how each transformer should be connected. Be sure to indicate the voltage applied to each winding.
  - By what percentage is the bank underloaded or overloaded?
7.
  - Calculate the volume of  $\text{U}^{235}$  required to produce an average of  $750 \text{ MW}$  of electricity annually, if the plant is  $40\%$  efficient.
  - Compare this with a coal power plant that employs a condenser that extracts  $6 \text{ kWh}$  for each  $\text{kg}$  of burned fuel.  
Given:  $\rho_{\text{U}} = 20 \times 10^3 \text{ kg/m}^3$ ,  $\rho_{\text{coal}} = 4 \times 10^3 \text{ kg/m}^3$ ,  $\text{TEC}_{\text{coal}} = 8 \text{ kWh/kg}$