

# ECE370 MACHINES & POWER

## Review problems for Test 2

1.

A 1 $\phi$  transformer is rated: 200 kVA, 2400 V : 120 V, and has the following approximate equivalent circuit parameters referred to the high voltage side:

$$R = 0.72 \, \Omega, \quad X = 2.0 \, \Omega, \quad R_c = 1 \, \text{k}\Omega, \quad X_m = 300 \, \Omega$$

Determine the Voltage Regulation and Efficiency when rated load is supplied at 0.85 lag.

$$(5.88\% \quad 93.7\%)$$

2.

A single-phase transformer is rated, 3 MVA, 7.2 kV/240 V, and has the following data from tests conducted on the high voltage side:

$$\text{Short-circuit test: } V = 635 \, \text{V}, \quad I = 420 \, \text{A}, \quad P = 80 \, \text{kW}$$

$$\text{Open-circuit test: } V = 7.2 \, \text{kV}, \quad I = 32 \, \text{A}, \quad P = 70 \, \text{kW}$$

- a) Determine the approximate equivalent circuit.
- b) Estimate the efficiency if rated load is supplied at 0.7 lag pf.
- c) Determine the voltage regulation for the conditions in (b).

$$(Z = 0.4535 + j1.4423 \, \Omega, \quad R_c = 740 \, \Omega, \quad X_m = 236.2 \, \Omega \quad 93\frac{1}{3}\% \quad 7.88\%)$$

3.

The following information is taken from the nameplate of a separately-excited DC generator.

$$\text{Armature: } 60 \, \text{kW}, 600 \, \text{V}, 0.15 \, \Omega.$$

$$\text{Field: } 120 \, \text{V}, 2.5 \, \text{A}$$

At its rated speed of 2000 rpm the no-load torque is measured at 19.1 Nm.

Ignore armature reaction and magnetic saturation.

- a) For rated load conditions determine:
  - i) Rated Driving Torque
  - ii) Rated Efficiency
  - iii) Load Impedance
- b) Determine the terminal voltage, kW output and the efficiency if the field current is reduced to 2 A, and the speed is increased to 2500 rpm, causing the rotational losses to become 6 kW. The load impedance is unchanged.

$$(312.7 \, \text{Nm} \quad 91.2\% \quad 6 \, \Omega \quad 600 \, \text{V} \quad 60 \, \text{kW} \quad 88.6\%)$$

4.

A 1200 V dc shunt motor is rated at 500 hp, 3000 rpm. It has an armature resistance of  $0.17 \Omega$  and a total field circuit resistance of  $120 \Omega$ . It draws a current of 350 A from the supply when delivering rated load. Ignore magnetic saturation and determine:

- Rated output torque.
  - Rated developed torque.
  - Rated efficiency.
  - Rotational losses at rated speed.
  - Speed when the load is changed, causing the line current to drop to 200 A. (Field resistance is unaltered.)
  - Developed torque for the conditions in part (e).
  - Horsepower output for the conditions in part (e), if  $P_{\text{ROT}} \propto \text{speed}^2$
- (1187 Nm    1236 Nm    88.8%    15.3 kW    3067 rpm    690.8 Nm    276 hp)

5.

A 240 V dc series motor is rated at 15 hp, 2000 rpm. It has an armature resistance of  $0.3 \Omega$  and field resistance of  $0.2 \Omega$ . It draws a current of 57 A from the supply when delivering rated load. Ignore magnetic saturation and determine:

- Rated output torque.
  - Rated developed torque.
  - Rated efficiency.
  - Rotational losses at rated speed.
  - Speed when the load is changed, causing the line current to drop to 20 A.
  - Developed torque for the conditions in part (e).
- (53.4 Nm    57.6 Nm    81.8%    865.5 W    6199 rpm    7.09 Nm)

6.

A 295 hp, 600 V, dc shunt motor has a rated speed of 2500 rpm and draws 420 A when supplying rated load. Armature resistance is  $0.1 \Omega$ , and total field circuit resistance is  $30 \Omega$ . Determine:

- Rated output torque and rated developed torque.
  - Rated efficiency and rotational losses at rated speed.
  - Line (supply) current if the field resistance is changed to  $40 \Omega$ . (Developed torque remains constant)
  - Shaft speed for the conditions in part (c).
  - Horsepower output for the conditions in part (c), if  $P_{\text{ROT}} \propto \text{speed}^2$
- (840.6 Nm    855.6 Nm    87.3%    3930 W    548.3 A    3254 rpm)

7.

A 750 MVA, 25 kV, 4 pole, synchronous generator has a synchronous reactance of  $1.25 \Omega$ . The per-phase excitation voltage is determined by  $|E_f| = 65.I_f$ . Determine:

- The load angle ( $\delta$ ) when rated load is supplied at rated voltage and 0.85 lagging.
  - The field current required.
  - The phasor diagram.
  - Shaft torque if the overall efficiency is 90%
  - If you neglect saturation, what is the %VR?
- ( $\delta = 35.5^\circ$     VR = 119.8%)