**King Fahd University of Petroleum & Minerals**
**Electrical Engineering Department**
**EE360: Electrical Energy Engineering**

**Problem Session II** **071**

**Problem 1**
A 10-kVA 8000/230-V distribution transformer has impedance referred to the primary side of 90 + j400 ohm. The components of the excitation branch are $R_c$ = 500 k-ohm and $X_M$ = 60 k-ohm.
a) If the primary voltage is 7967 V and the load impedance $Z_L$ = 4.2 + j3.15 ohm, what is the secondary voltage of the transformer? What is the voltage regulation of the transformer?
b) If the load is disconnected and a capacitor of -j6 ohm is connected in its place, what is the secondary voltage of the transformer? What is its voltage regulation under these conditions?

**Problem 2**
A wye-delta connected bank of three identical 200-kVA 7967/480-V transformers is supplied with power directly from a large constant-voltage (infinite) bus. In the short-circuit test, the recorded values on the high-voltage side for one of these transformers are

$V_{sc}$ = 560 V $I_{sc}$ = 25.1 A $P_{sc}$ = 3400 W

a) If the bank delivers a rated load of 0.9 PF lagging and rated voltage, what is the line-to-line voltage on the primary side of the transformer bank?
b) What is the voltage regulation under these conditions?

**Problem 3**
An autotransformer is used to connect a 12.8-kV distribution line to a 14.4-kV distribution line. It must be capable of handling 500 kVA. There are three phases, connected Y-Y with their neutrals solidly grounded.
a) What must the NC/NSE turns ratio be to accomplish this connection?
b) How much apparent power must the windings of each autotransformer handle?
c) If one of the autotransformers were reconnected as an ordinary transformer, what would its ratings be?

**Problem 4**
The following data are known about a cumulatively compounded dc generator:
$N_F$ = 2000 turns $R_A$ = 0.12 ohm
$N_{SE}$ = 12 turns Rs = 0.04 ohm
$n_m$ = 1500 r/min $R_F$ = 120 ohm
$R_{adj}$ = 0 to 200 ohm, currently set to 55 ohm

The machine's magnetization curve is given in tabular form as

| $E_A$ (V) | 200 | 210 | 220 | 230 | 240 | 250 |
|---|---|---|---|---|---|---|
| $I_F$ (A) | 1.10 | 1.22 | 1.33 | 1.52 | 1.80 | 2.29 |

The armature reaction of this machine at full load can be determined from the fact that, with $R_{adj}$ = 55 ohm and $n_m$ = 1500, the generator can supply 75 A at 218 V. Assume that this armature reaction is directly proportional to the armature current,
a) Determine the full-load armature reaction of this generator in ampere-turns.
b) What would the no-load voltage of this generator be with $R_{adj}$ = 55 ohm?
c) What would the no-load voltage of this generator be with $R_{adj}$ = 30 ohm?
d) If $R_{adj}$ = 30 ohm, what would the generator's terminal voltage be with a load of 75 A?

**Problem 5**
A 20-hp 240-V series dc motor has an internal series resistance $R_A + R_s$ equal to 0.25 ohm. At full load, it draws 80 A and runs at 750 r/min.
a) What is the efficiency of the motor at full-load conditions?
b) Assuming that the flux at 30 A is 52 percent of the full-load flux, what is the speed of the motor at a line current of 30 A?

**Problem 6**
A 5-hp 120-V 41-A 1800 r/min shunt dc motor is operating at full load. Its armature resistance is 0.30 ohm, and its field resistance is 120 ohm.
a) What is the efficiency of this motor? What is its total rotational loss?
b) Assuming constant rotational losses and a linear magnetization curve, what will the machine's speed be after a 1 percent increase in field resistance?

**Problem 7**
A 13.8-kV 10-MVA 0.8-PF-lagging 60-Hz two-pole Y-connected steam-turbine generator has a synchronous reactance of 18 ohm per phase and an armature resistance of 2 ohm per phase. This generator is operating in parallel with a large power system (infinite bus).
a) What is the magnitude of $E_A$ at rated conditions?
b) What is the torque angle of the generator at rated conditions?
c) If the field current is constant, what is the maximum power possible out of this generator? How much reserve power or torque does this generator have at full load?
d) At the absolute maximum power possible, how much reactive power will this generator be supplying or consuming? Sketch the corresponding phasor diagram. (Assume $I_F$ is still unchanged.)

**Problem 8**
A three-phase Y-connected synchronous generator is rated 120 MVA, 13.2 kV, 0.8 PF lagging, and 60 Hz. Its synchronous reactance is 0.7 ohm, and its resistance may be ignored.
a) What is its voltage regulation?
b) What would the voltage and apparent power rating of this generator be if it were operated at 50 Hz with the same armature and field losses as it had at 60 Hz?
c) What would the voltage regulation of the generator be at 50 Hz?

**Problem 9**
Two identical 600-kVA 480-V synchronous generators are connected in parallel to supply a load. The prime movers of the two generators happen to have different speed droop characteristics. When the field currents of the two generators are equal, one delivers 400 A at 0.9 PF lagging, while the other delivers 300 A at 0.72 PF lagging.
a) What are the real power and the reactive power supplied by each generator to the load?
b) What is the overall power factor of the load?

**Problem 10**
A 480-V six-pole synchronous motor draws 50 A from the line at unity power factor and full load. Assuming that the motor is lossless, answer the following questions:
a) What is the output torque of this motor? Express the answer both in newton-meters and in pound-feet.
b) What must be done to change the power factor to 0.8 leading? Explain your answer, using phasor diagrams.
c) What will the magnitude of the line current be if the power factor is adjusted to 0.8 leading?