DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
COURSE-ECSE-361
ELECTRIC POWER
MID-TERM EXAM + SOLUTIONS

Closed Book Exam — Date: October 17th 2012
Duration: 55 minutes: — Examiner: Prof. Anthony J. Rodolakis

<u>Question 1: (35 marks)</u>

In order to improve the power factor of a single-phase industrial load to a 0.9 lagging a 20 KVAR capacitor bank has been added in parallel to it. It is known that after the addition of the compensating capacitor bank the total apparent power drawn by the compensated load is 185KVA. You are asked to determine:

a) **The active reactive and apparent power of the compensated factory load. (15 marks)**
b) **The power factor of the original non-compensated factory load. Is this an inductive or a capacitive load? Explain (20marks)**

<u>Solution</u>

a) Since $S_{NEW} = 185\,\text{KVA}$ and $\cos\phi_{NEW} = 0.9$, we obtain $P_{NEW} = S_{NEW}\cos\phi_{NEW} = 185x0.9 = 166.5KW$ and since only reactive power is provided by the capacitor bank to the old load , we have that

$P_{NEW} = P_{OLD} = 166.5kW$.

Also $Q_{NEW} = S_{NEW}\sin\phi_{NEW} = 185x\sin(\cos^{-1}0.9) = 185x(0.436) = 80.64KVARS$

b) Since by definition, $Q_{NEW} = Q_{OLD} - Q_{CAP}$, we obtain that

$Q_{OLD} = Q_{NEW} + Q_{CAP} = 80.64 + 20 = 100.64KVARS$, with

$$\cos\phi_{OLD} = \cos(\tan^{-1}\frac{100.64}{166.5}) = 0.8558lag$$

Therefore, $S_{OLD} = 166.5 + j100.64$, and $S_{OLD} = \sqrt{(166.5)^2 + (100.64)^2} = 194.55KVA$

The original load was an inductive load and the addition of the capacitor bank improved its power factor.

Question 2: (35 marks)

A feasibility study has been conducted in a power plant to determine whether the existing electrical wiring can support the installation of additional lighting facilities in view of a recent expansion. The study calls for the utilization of 80 lamps rated 60-Watts @ 110 Volts. The existing wiring is supplied by a 110 Volts three-phase system and can support a maximum line current of 28.4 Amps. If the lamp-load is to be symmetrical on all three-phases and is to be connected in Delta, you are asked to determine if the wiring is sufficient to meet the scheduled lighting requirements.

Solution

Given that the system load is resistive (incandescent lamps are resistive), is connected in Delta and is balanced in all three phases, we obtain that

$$I_{LOAD} = \frac{I_{LINE}}{\sqrt{3}} = \frac{28.4}{\sqrt{3}} = 16.3967A$$

By definition the impedance of one incandescent lamp will be: $R_{LOAD} = \frac{V_{LOAD}^2}{P_{LOAD}} = \frac{V_{LL}^2}{P_{LOAD}} = \frac{110^2}{60} = 201.67 Ohms$

Since $Z_{LOAD} = R_{TOT} = \frac{V_{LL}}{I_{LOAD}} = \frac{110}{16.3967} = 6.70866 Ohms$, that will be the total resistance of the load for every one of the three legs of the delta connection.

That yields, since lamps are always connected in parallel we obtain that

$$R_{TOT} = \frac{R_{LOAD}}{N} = \frac{201.67}{N} = 6.70866 Ohms.$$

Thus $N = 30$ lamps per phase can, at maximum, be accommodated. That means that the wiring is sufficient since a total of only 80 must be commissioned.

<u>Question 3: (30 marks)</u>

Magnetic circuit #1 is composed of a good quality ferromagnetic solid rectangular toroid that has a coil with N-turns wound around its left leg. Magnetic circuit #2 is identical to the magnetic circuit #1, except that an air gap has been introduced in it by removing a very thin iron slice. If the same amount of DC current is impressed in the two identical coils of the two systems, you are asked to determine:

1. **If magnetic system #1 will experience through its core a higher or a smaller magnitude of magnetic flux that system #2. Justify your answer. (10 marks)**

2. **If magnetic system #1 has a higher or a smaller inductance than system #2. Justify your answer. (10 marks)**

3. **If magnetic system #1 is assumed to be near its saturation point with a certain level of current impressed through the coil on its left leg, will system #2 be driven more into saturation with the same current. Justify your answer. (10 marks)**

<u>Solution</u>

1. The magnetic system with the air-gap in its core will experience less flux through it due to the presence of the air-gap reluctance which is much higher than the reluctance of a good ferromagnetic material of the same cross-section.

2. The system with no air-gap will have higher inductance since its magnetic reluctance will be smaller.

3. If the magnetic system is operating near saturation point, the presence of the air-gap will have the tendency to linearize the system and the effects of any saturation will be less pronounced.