

ECSE 461 Electric Machinery—Winter 2011

Midterm Examination

Answer all questions in the answer booklets provided. All questions are worth 25 points for a total of 100 points; the weightings of sub-question items are indicated in between square brackets.

1. The following two loads are connected to a 477 V single phase distribution feeder:

Load 1: 10 kVA, power factor 0.80 lagging

Load 2: 10 kW, power factor 0.80 lagging

- (a) Determine the feeder apparent power. [10]
- (b) Determine the feeder current phasor. Assume the feeder voltage is the reference phasor. [3]
- (c) Determine the reactive power that should be provided by power factor correcting capacitors to make the feeder power factor equal to 1. [4]
- (d) Determine the feeder current with the power factor correction capacitors connected. [3]
- (e) Draw and label a phasor diagram relating the feeder active, reactive and apparent powers as well as the feeder voltage and current before and after the addition of the power factor correction capacitors. [5]

2. Consider the balanced three phase circuit in Figure 1 for which the delta-connected load is rated at 600 V, 60 kVA, 0.90 lagging power factor.

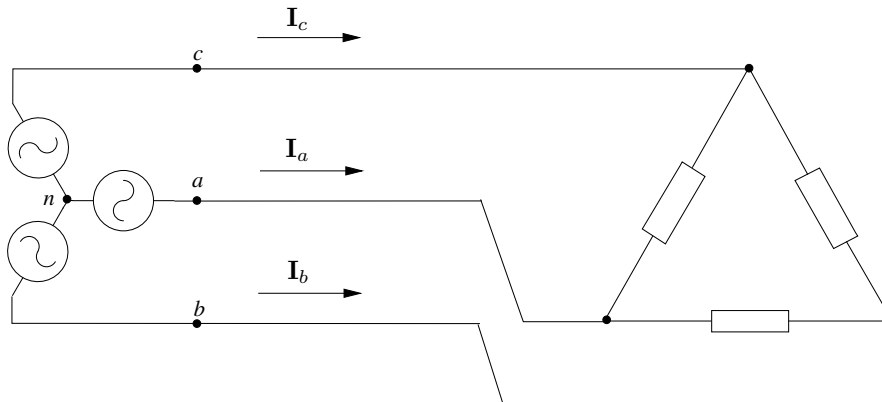


Figure 1: Three phase circuit of question 2.

- (a) Determine the impedance of each of the three phases of the load. [12]

Assume now that the three phase sources' phase voltage magnitudes are 312 V:

- (b) What are the magnitudes of the phase and line voltage of the load? [3]
- (c) What is the magnitude of the three line currents (I_a , I_b and I_c)? [5]
- (d) Calculate the active and reactive power of the three phase load. [5]

3. A single phase transformer rated 10 kVA, 2400 V / 240 V has the following parameters all in Ω referred to their respective sides:

Primary: $R_p = 5.8$, $X_p = 29.0$

Secondary: $R_s = 0.058$, $X_s = 0.29$, $X_m = 230$ and $R_c = 460$

- Draw and label the equivalent circuit of the transformer with all components referred to the primary. Provide all the component values in Ω . [5]
 - Assume the transformer is feeding a 10 kVA, power factor 0.8 lagging, load at its rated voltage on the low voltage side. Compute for this loading:
 - The voltage and current at the primary side terminals of the transformer. [10]
 - The core losses. [2]
 - The copper losses. [3]
 - For the loading in part (b), quantify (in percent) the errors that would have been introduced in the values found for the primary current and voltage in part (b) i. if you had neglected the magnetizing branch. [5]
4. Consider an electromechanical system whose cross section is shown in Figure 2. It consists of an iron core of cross sectional area $A = 0.01 \text{ m}^2$, permeability $\mu \rightarrow \infty$ with an air gap of length $\ell_g = 0.1 \text{ m}$. Wound around this core is a winding with $N = 1000$ turns which carries $I_f \text{ A}$. Within the air gap there is a single turn winding whose sides length into the page are 0.1 m and which carries a current $I = 100 \text{ A}$ with the directions shown in Figure 2.

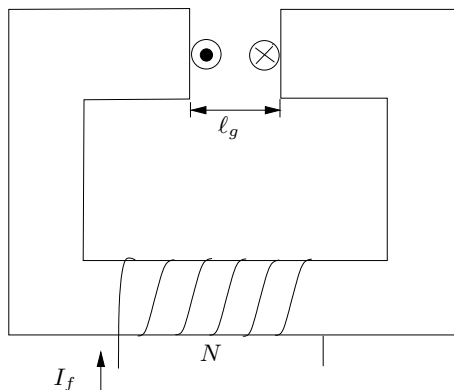


Figure 2: Electromechanical system of question 4.

- Draw and label the components of the equivalent magnetic circuit of this electromechanical system. [5]
- Determine the current I_f necessary to establish an air gap magnetic field intensity (B) of 0.5 T (assume no flux leaks off the air gap volume). [10]
- Reproduce Figure 2 in your answer booklet. Indicate the location of the North and South magnetic poles established by the core winding at the interfaces of the air gap. [2]
- Calculate the forces exerted on the air gap winding if the magnetic field intensity in the air gap is 0.5 T. [3]
- On your sketch from part (c), indicate the direction of the forces exerted on the winding. [5]