Data Provided: List of Useful Equations (attached at the end of the paper)

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2013-14 (2.0 hours)

EEE218 Electric Circuits 2

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1.

a. An electrical load consisting of a resistance, $R = 10\Omega$, in parallel with a capacitance, $C = 400\mu F$ is connected across a $200V_{rms}$, 50Hz sinusoidal supply, V_S, as shown in Figure 1.1.

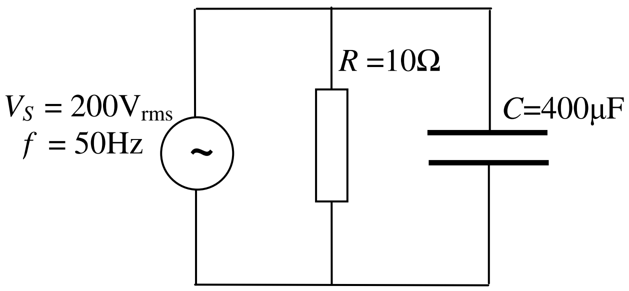

Figure 1.1

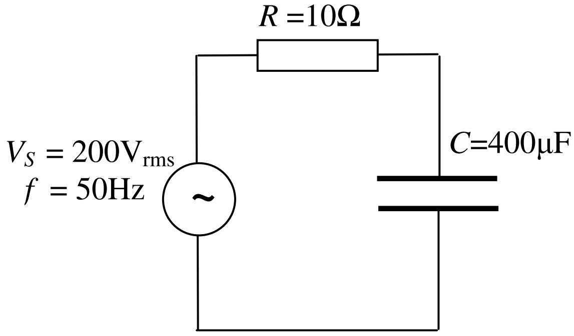

Figure 1.2

(i) Calculate the magnitude and phase angle of the current drawn from the supply **(3)**

(ii) What is the real power drawn from the supply and the power-factor of the circuit? **(2)**

b. The resistance and capacitance are now reconnected in series with each other and connected across the same $200V_{rms}$, 50Hz sinusoidal supply as shown in Figure 1.2.

(i) Calculate the magnitude and phase angle of the impedance of the load. **(2)**

(ii) Hence calculate the magnitude and phase of the current drawn from the supply. **(1)**

(iii) What is the new power drawn from the supply? **(1)**

c. An inductance, L, is then placed in series with the R and C of Figure 1.2 to form a series resonant circuit.

(i) Write down an expression for the total impedance, Z, of the series resonant circuit in terms of R, L, and C. **(1)**

(ii) State the condition for resonance and hence derive an expression for the resonant frequency, $f_{resonant}$ (in Hz) of the circuit in terms of its components. **(2)**

(iii) Sketch the variation of the magnitude of the total impedance, Z, with frequency, f, over the frequency range $f << f_{resonant}$ to $f >> f_{resonant}$. **(2)**

(iv) Sketch a phasor diagram for the circuit at resonance showing the relative direction of the voltages across each component. Take the current phasor as reference. **(2)**

(v) Calculate the value of inductance which results in the maximum current being drawn from the 50Hz supply. What is the magnitude and phase angle of this current? **(2)**

(vi) Calculate the voltage across the capacitor and inductor and hence find a value for the Q factor. **(2)**

2.

a. A battery with an electromotive force of 40V and no internal resistance is connected to a particular load which may be represented by a network of resistors, R_1, R_2 and R_3, as shown in Figure 2.1 below. Calculate:

- **(i)** the overall resistance of the load. **(2)**
- **(ii)** the current flowing through the series pair R_2 and R_3. **(1)**
- **(iii)** the power dissipated in each of the resistors R_1, R_2 and R_3. **(2)**
- **(iv)** the total power dissipated in the load. **(1)**

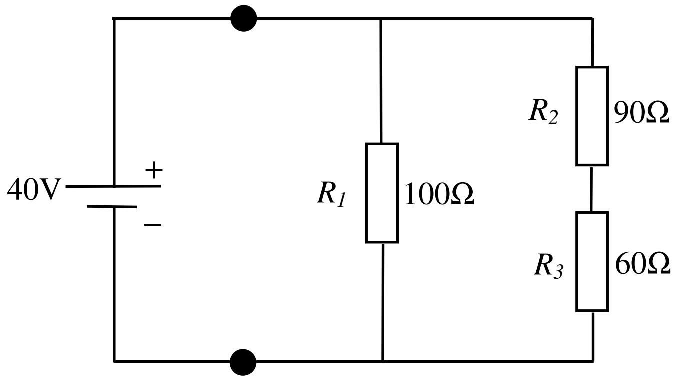

Figure 2.1

b. The battery now develops an internal resistance of 3Ω. Calculate:

- **(i)** the new voltage across the resistor R_1. **(3)**
- **(ii)** the new value of the power dissipated in resistor R_3 and the power dissipated within the battery itself. **(3)**
- **(iii)** the efficiency of the system. **(2)**
- **(iv)** If the resistor R_1 is now replaced by a 50mH inductor, calculate the power dissipated in resistor R_3 and the energy stored in the inductor after steady-state has been reached. **(3)**

c. A 2.0μF and a 5.0μF capacitor are connected in series across a 2100V d.c. supply. Each capacitor has a maximum voltage rating of 1200V. Calculate by how much the value of the 5.0μF capacitor is required to change to ensure the 2.0μF capacitor does not exceed the maximum voltage rating? **(3)**

3.

a. An ideal transformer has a turns ratio of 8:1 (primary:secondary) and an input voltage of $400V_{rms}$ at 50Hz.

(i) Calculate the secondary voltage, the current in **both** the primary and secondary windings and the power dissipated if a resistive load of 25Ω is connected across the secondary. **(3)**

(ii) Calculate the secondary voltage, the current in **both** the primary and secondary windings and the power dissipated if the load across the secondary now comprises a resistance of 30Ω in series with a capacitance of 100µF. **(4)**

(iii) For the case described in part **(ii)** above, what would be the input power factor and the required VA rating of the transformer? **(2)**

(iv) If the maximum core flux of the transformer is 4mWb calculate the actual number of turns on each winding. **(2)**

(v) If the transformer were to be operated in a country where the supply frequency is 60Hz, what is the maximum permissible supply voltage without the maximum core flux of 4mWb being exceeded? **(1)**

b. An ideal transformer with 1000 turns on its primary and 20 turns on its secondary has its primary winding connected to a $200V_{rms}$, 50Hz supply. Connected across the secondary is a steel rod, 0.8m long and having a diameter of 10mm. You may assume the following information:

Resistivity of steel at 0 °C = $\rho = 8.33 \times 10^{-8}$ Ωm

Temperature coefficient of resistance of steel = $\alpha_0 = 6 \times 10^{-3}$ /°C

$R_T = R_0\,(1+\alpha_0 T)$

R_T = Resistance at temperature T °C

R_0 = Resistance at temperature 0 °C

(i) Find the power dissipated in the rod at 30°C and when it is at a temperature of 700°C. **(6)**

(ii) Calculate the transformer primary current for both cases in **b (i)**. **(1)**

(iii) If the transformer was now assumed to have an efficiency of 95% calculate the input power required if the rod is at 30°C. **(1)**

4.

a. Figure 4.1 shows a network which is to be used as a source for a load resistor which is to be connected between *A* and *B* (Load not shown).

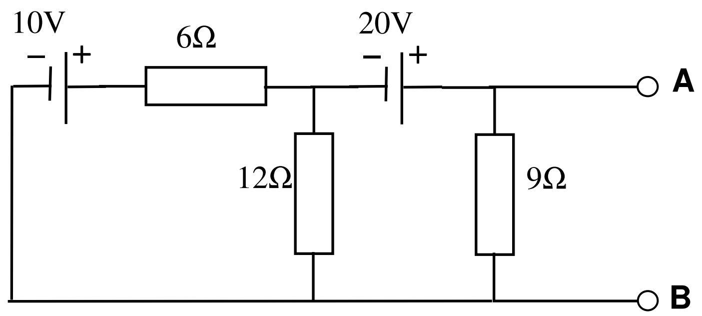

Figure 4.1

(i) Derive the Thevenin equivalent circuit for the source network using Kirchoff's laws. **(6)**

(ii) Derive the Norton equivalent circuit for the source network **(2)**

b. A factory is connected to an $11kV_{rms}$, 50Hz supply and consumes 800kW of power at a 0.8 power-factor lagging.

(i) Calculate the kVA rating of the site. **(1)**

(ii) Calculate the reactive power in kVAr. **(1)**

(iii) Calculate the rms current drawn from the supply. **(1)**

c. The factor is enlarged and the following loads are added:

- Process heaters rated at 100kW (operating at unity power-factor)
- A motor load of 300kVA at 0.75 power-factor lagging

(i) Calculate the new kVA rating of the factory. **(4)**

(ii) Calculate the new overall power-factor and state whether it is lagging or leading. **(2)**

(iii) It is decided to connect a capacitor in parallel with the other loads to correct the power-factor to unity. (i.e. power-factor = 1) Find the kVAr rating of the capacitor, the magnitude of the current drawn by the capacitor, and the value of the capacitor in Farads. **(3)**

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