Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2013-14 (3.0 hours)

EEE117 Electrical Circuits & Networks 1

Answer **FOUR** questions. **No marks will be awarded for solutions to a fifth 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. For the circuit of figure 1a, find the effective resistance between the terminals X and Y

If a 20 V d.c. source is connected between X and Y, calculate;

i) the current through the 15 Ω resistor and

ii) the power dissipated in the 5 Ω resistor

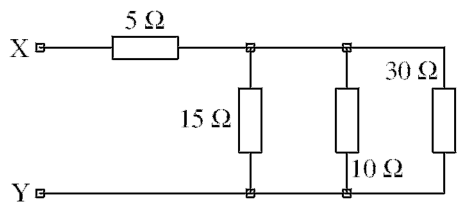
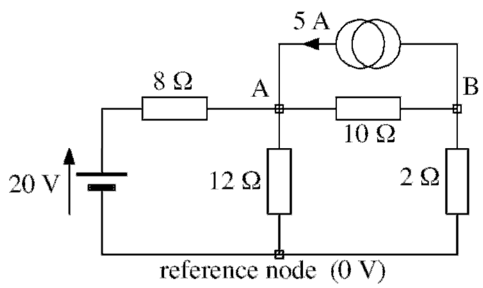


Figure 1a

(6)

b. For the circuit of figure 1b, use nodal analysis to find the node voltages V_A and V_B measured with respect to the reference node.

For each source determine whether the source is delivering energy to the circuit or absorbing (sinking) energy from it.

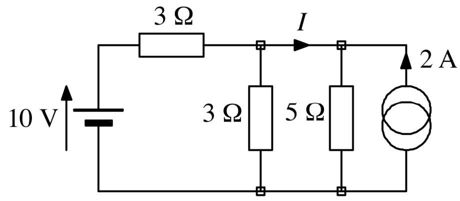


(8)

Figure 1b

c. Simplify the circuit of figure 1c to a series loop by using a Thevenin transformation and a Norton to Thevenin transformation. Hence find the current, I.

Check your value of I by applying the principle of superposition to the circuit of figure 1c.



(6)

Figure 1c

2. **a.** In the resonant circuit of figure 2a it is known that C and R are ideal but that L has a series resistance R_L as shown. In an experiment to assess the circuit it is observed that the resonant frequency f_r is 10 kHz and that at resonance $V_I = 1$ V and $V_R = 0.8$ V. Use these observations to calculate values for L and R_L.

What value of Q would you expect to measure for this circuit?

The value of R_L is a function of frequency. Explain briefly why this is so. **(7)**

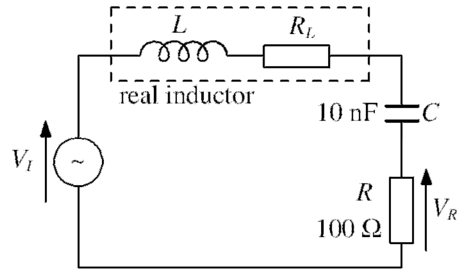


Figure 2a

b. Use nodal analysis to find V_A. Express your answer in both polar and Cartesian forms.

What is the power dissipated in the 10 Ω resistor?

(Assume that the source magnitudes are rms quantities.) **(6)**

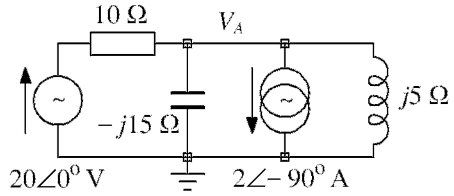


Figure 2b

c. For the circuit of figure 2c, express the two source voltages in the form $a + jb$.

Find the value of the current, I, and express it in polar form.

Calculate the peak energy stored in L assuming that the source magnitudes given are rms quantities. The energy stored in an inductor is $LI^2/2$. **(7)**

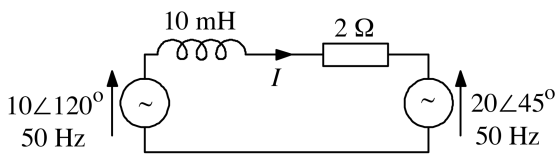


Figure 2c

3. **a.** The circuit of figure 3a is driven by a step waveform that is −3 V for all $t < 0$ and 6 V for all $t > 0$. Evaluate I_C, I_R, I_L and V_O at $t = 0^-$ and $t = 0^+$.

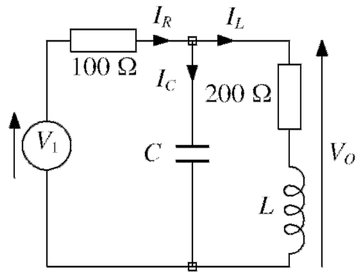


Figure 3a

(8)

b. Write down the relationship between admittance and impedance.

For each of the two circuits of figure 3b work out the circuit admittance looking into terminals AA'. Give your answer in the form $a + jb$ in both cases.

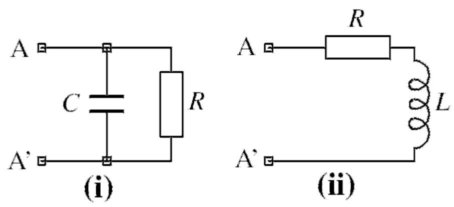


Figure 3b

(6)

c. Show that the circuit of figure 3c has a transfer function given by

$$\frac{v_o}{v_i} = \frac{1}{1 + j\dfrac{f}{f_0}} \quad \text{where } f_0 = \frac{R}{2\pi L}$$

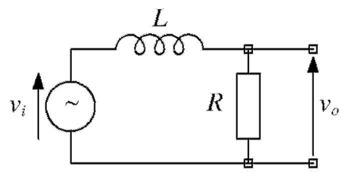


Figure 3c

Sketch the magnitude of this response as a function of frequency using a dB scale for gain magnitude and a logarithmic scale for frequency. Label the key features of your sketch.

(6)

4.

A load of $(6 + j8)\ \Omega$ is supplied from a $400V_{rms}$, 50Hz line through a single phase transformer having a 5:1 primary to secondary turns ratio.

a. Assuming the transformer to be ideal:

(i) Calculate the magnitude and phase angle of the load current and the load voltage taking the supply voltage as reference. **(3)**

(ii) Calculate the required VA rating of the transformer and the real power supplied to the load. **(2)**

b. In practice the transformer is not ideal. The primary winding has a resistance of 3Ω and a leakage reactance of 8Ω and the secondary winding has a resistance of 0.2Ω and a leakage reactance of 0.4Ω. (*Note: the secondary values given are non-referred values*). In addition, when no load is connected, the transformer draws an input current of 0.3A at a power-factor of 0.1 lagging.

(i) Calculate the magnitude and phase angle of both the actual load current and the load voltage. **(5)**

(ii) Calculate the total input current to the transformer and the overall power-factor. **(4)**

(iii) Calculate the real power supplied to the load and the transformer efficiency. **(4)**

c. The transformer above is constructed with a laminated iron core. What would be the effect of using a solid iron core for the magnetic circuit in order to lower the manufacturing costs for the device? **(2)**

5.

A small industrial factory is connected to a $11kV_{rms}$, 50Hz three-phase supply and consists of the following loads:

- a star-connected induction motor, with an effective input impedance of $(80+j100)\Omega$ per phase
- a total resistive, unity power-factor, load of 150kW
- other general loads equivalent to 300kVA at a power-factor of 0.75 lagging

a. For the induction motor calculate:

(i) the motor line current, input power and power-factor and state whether this is leading or lagging. **(4)**

(ii) the mechanical output torque of the motor if it is operating at 1440 rpm and with an efficiency of 93%. **(4)**

b. For the total factory load calculate:

(i) the total active and reactive power in kW and kVAr respectively. **(4)**

(ii) hence calculate the total KVA and overall power-factor. **(2)**

c. Calculate the value of capacitance per phase, connected in a delta configuration across the supply input to the factory, required to correct the overall power-factor to 0.9 lagging. **(6)**

6.

a. A rectangular iron core, shown in figure 6.1 below, has a coil of 600 turns wound on it. The mean length of each side of the core is 15cm and it has a cross-section of 4cm × 4cm. The relative permeability of the iron is 900. Assume the permeability of air, $\mu_0 = 4 \times \pi \times 10^{-7}$H/m.

(i) Calculate the reluctance of the magnetic circuit. **(2)**

(ii) What value of current flowing through the coil is required to establish a flux density of 1.2T in the iron core? **(2)**

(iii) Calculate the self inductance of the coil. **(1)**

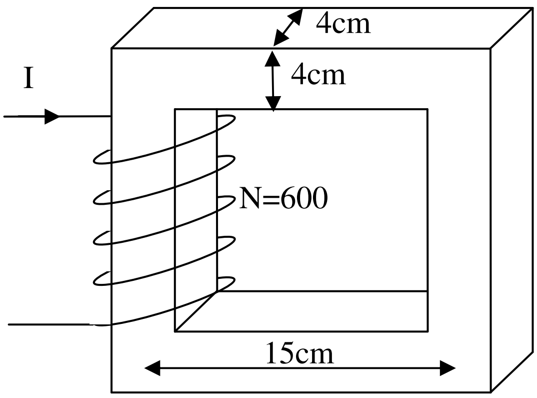


Figure 6.1

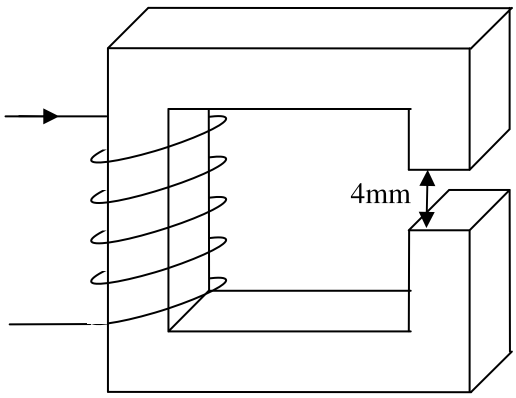


Figure 6.2

b. In practice, such cores are usually designed to include an airgap in the magnetic circuit. If a 4mm long gap is cut through one of the sides as shown in figure 6.2, find:

(i) how many turns would now be required to produce an inductance of 0.2H? **(3)**

(ii) the new flux density in the core with this new number of turns for a coil current of 1 A **(2)**

(iii) From your knowledge of the characteristics of typical core materials, explain why an airgap is normally included in the design of such devices. **(2)**

c. If the coil of the inductor from section **(b)** part **(i)** had a resistance 70Ω and it was connected across a $25V_{rms}$, 100Hz sinusoidal supply:

(i) calculate the peak flux density in the core. **(4)**

(ii) the power dissipated in the coil and the peak energy stored in the inductor. **(2)**

d. The sinusoidal supply is now replaced by a 40V d.c. source and connected to the coil through a switch which is initially closed. The switch is then opened and the current falls from its initial steady-state value to zero within 1.5ms. Calculate the peak voltage which appears across the coil when the switch is opened. **(2)**

RCT / JKM