Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2006-2007 (2 hours)

Circuits and Signals 1

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.** Sketch out the DC Thevenin equivalent circuit which models any DC network with two identifiable terminals. What are the rules used to define the Thevenin equivalent voltage and resistance? **(3)**

Repeat this for the DC Norton equivalent circuit. **(3)**

b. Find the voltage, *v*, across the 3 Ω resistor shown in figure 1(a), by replacing the remainder of the circuit with its Thevenin equivalent. What is the power dissipated in the 3 Ω resistor?

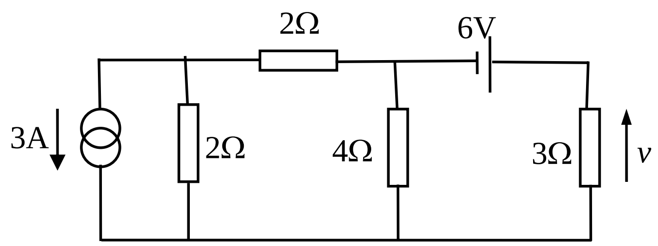

Figure 1(a) **(7)**

c. Find the Thevenin and Norton equivalent circuits across the terminals of the circuit shown in figure 1(b). Hence calculate the range of powers produced in a 5-25 kΩ variable resisitor connected between the terminals of the circuit.

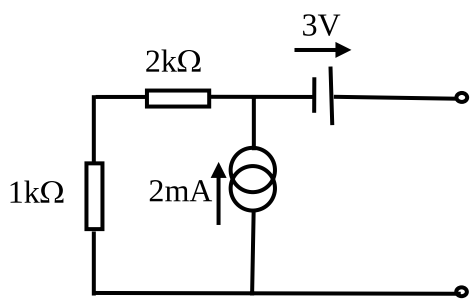

Figure 1(b)

(7)

2. **a.** Inductors and capacitors are circuit components which store electrical energy. How is the energy stored in each case and how might this energy be extracted from the component? **(4)**

Show from first principles that the energy stored in an inductor is given by

$$E = \frac{1}{2} LI^2$$

where L is the capacitance and I the dc current through the inductor. **(4)**

b. An AC voltage source, $v(t)$ = 10 sin (100t), is connected directly to an ideal inductor of value 3 H. What is the peak current flowing in the circuit and the peak stored energy in the inductor? **(4)**

Sketch the voltage, current and power waveforms, and the magnitude of the energy stored in the inductor as a function of time on the same time axis. **(8)**

3. **a.** Find the equivalent impedance, Z, of the circuit shown in Fig. 3(a). At what frequency of an applied sinusoidal voltage does the magnitude of the impedance, Z, go to infinity? Confirm this by sketching the phasor diagram of the currents in each branch of the circuit, using the applied voltage as reference.

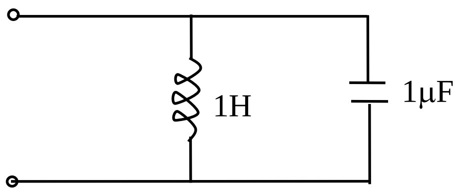

Figure 3(a) **(8)**

b. Using Kirchhoff's laws, find the magnitude and phase of the sinusoidal current through the inductor and through the capacitor in figure 3(b). Also find the magnitude and phase of the voltage across the capacitor. Verify your latter answer by comparing relative phase angles between current and voltage in the capacitor.

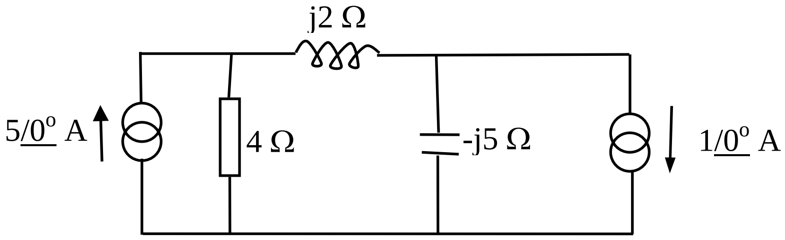

Figure 3(b) **(12)**

4. **a.** A capacitor, C, which has been charged to a voltage, V_o, is suddenly connected across a resistor, R, at time $t = 0$. Derive an expression for the resultant current in the circuit as a function of time. **(6)**

Sketch this current as a function of time, labelling the graph with the important quantities appearing in your derived equation. Sketch two more current versus time curves on the same axes, showing the effect of increasing and decreasing the resistor value. **(4)**

b. By considering the impedance presented to the voltage source in the circuit of Figure 4, calculate the sinusoidal current through the 1.5 kΩ resistor. Is the impedance presented to the voltage source inductive or capacitive in character? In what way would this aspect change if the frequency is increased?

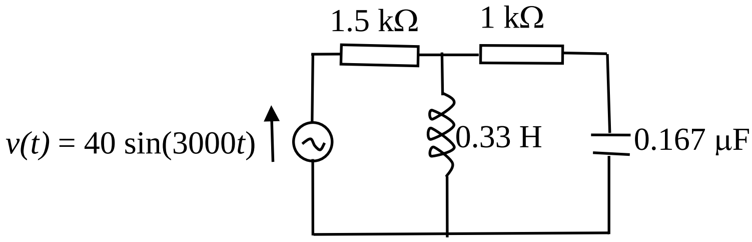

Figure 4 **(10)**

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