National Exams May 2003

98-BS-4 Electric Circuits and Power

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of assumptions made;
2. Candidates may use one of two calculators, a Casio FX-991 or Sharp EL-540. This is a closed-book exam.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value.

Question 1

In the DC circuit of Figure 1 assume the following: $R_1 = 2\,\Omega$, $R_2 = 5\,\Omega$, $R_3 = 4\,\Omega$, $R_4 = 1\,\Omega$, $R_5 = 3\,\Omega$, $I_2 = 4\,\text{A}$, and $V_s = 54\,\text{V}$. Using Kirchhoff's laws find:

a) Currents I_0, I_1, I_3, and I_s;

b) Voltages V_{ac} and V_{bc};

c) Resistance R_0;

d) Calculate the power dissipated in resistor R_2?

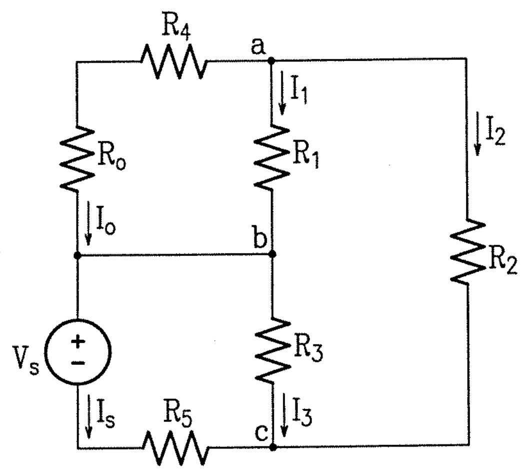

Figure 1: Circuit diagram for Question 1

Question 2

Consider the circuit of Figure 2. Known parameters are: $R_1 = 1\,\mathrm{M\Omega}$, $R_2 = 2\,\mathrm{k\Omega}$, $R_3 = 3\,\mathrm{k\Omega}$, $R_4 = 6\,\mathrm{k\Omega}$, $R_5 = 6\,\mathrm{k\Omega}$, $R_6 = 3\,\mathrm{k\Omega}$, $R_7 = 2\,\mathrm{k\Omega}$, and $V_s = 20\,\mathrm{V}$. Determine the following:

a) Thevenin equivalent resistance seen by the load;

b) Thevenin equivalent voltage seen by the load;

c) Power transferred to the load if resistance $R_L = 10\,\Omega$.

d) What is the load resistance required for the maximum power transfer? What is the power transferred to the load in that case.

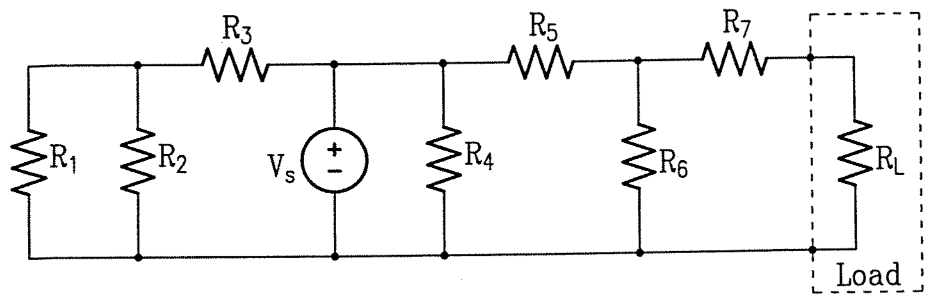

Figure 2: Circuit diagram for Question 2

Question 3

In the circuit of Figure 3, parameters are: $R_1 = 120\,\Omega$, $R_2 = 13\,\Omega$, $L_1 = 19\,\text{mH}$, $L_2 = 3\,\text{H}$, $C = 220\,\text{pF}$, $V_{s1}(t) = 24\cos(\omega t)$ V.

a) Determine the source frequency so that current $I_1(t)$ and voltage $V_2(t)$ are in phase.

b) What is this frequency called? Does any other frequency have the same property in the circuit of Figure 3?

c) For the frequency calculated under (a) calculate currents $I_1(t)$, $I_2(t)$ and $I_3(t)$.

d) Calculate active and reactive power supplied by the source.

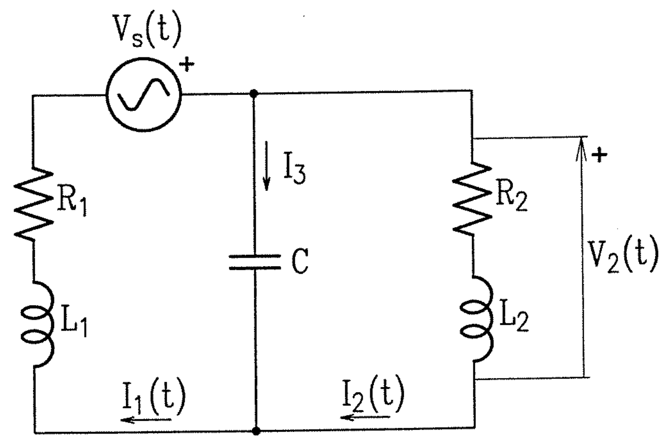

Figure 3: Circuit diagram for Question 3

Question 4

In the circuit of Figure 4 assume the following: $R_1 = 2\,\Omega$, $L_1 = 1\,\text{mH}$, $R_L = 10\,\Omega$, $C = 1\,\mu\text{F}$, $V_{s1} = 20\cos(120\,\pi\,t)\,\text{V}$, $V_{s2}(t) = 4\,\text{V}$. Two steady-state operating conditions, with switch SW open or closed, possible. Calculate the following:

a) When SW open: Current phasor $\underline{I}_1$ and voltage phasor $\underline{V}_1$;

b) When SW open: Power dissipated in the resistor R_L;

c) When SW closed: Currents I_1 and I_2 and voltage V_1 as a function of time;

d) When SW closed: Power power dissipated in the resistor R_L.

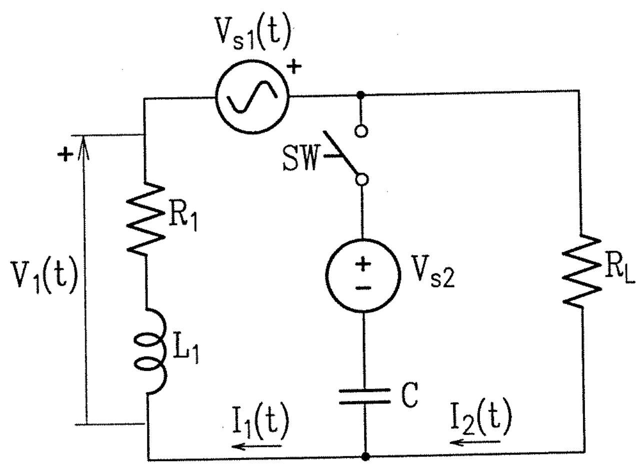

Figure 4: Circuit diagram for Question 4

Question 5

A magnetic core is shown in Figure 5. Consider that the cross section is uniform and equal to $100\,\text{mm}^2$, relative permeability $\mu_r = 2000$, number of winding turns $N = 100$ and current $I = 1A$ ($\mu_0 = 4\pi \times 10^{-7}$).

a) Compute the magnetomotive force.

b) Calculate the equivalent reluctance of each part of the magnetic circuit.

c) Draw the analog circuit representation of the magnetic circuit from Figure 5.

d) Calculate the magnetic flux, flux density and magnetic field intensity in the air gap.

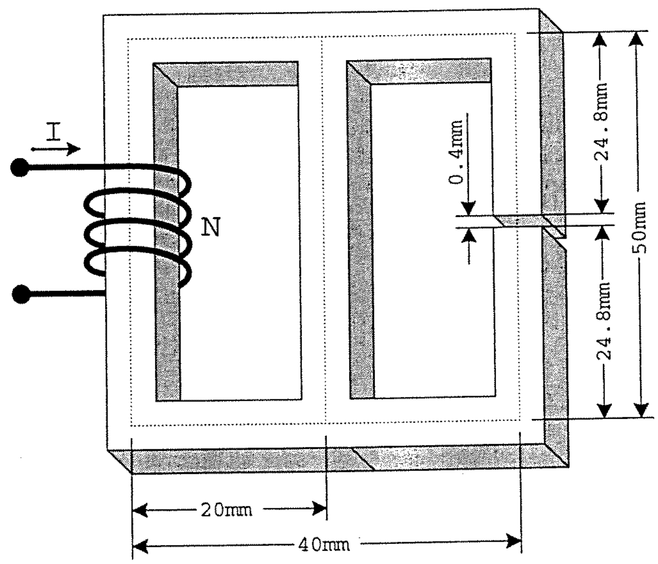

Figure 5: Magnetic core for Question 5

Problem 6

Design a full-wave bridge diode rectifier for a power supply. Rectifier will be supplied by an ideal AC voltage source (60 Hz, $12\,V_{RMS}$). Assume that each diode has an offset voltage of 0.6 V.

a) Draw the rectifier schematic diagram. Sketch the input voltage, the output voltage, and also specify which diodes conduct during each half-cycle of the AC side voltage.

b) Sketch the output voltage if the load is a $1000\,\Omega$ resistor in parallel with a $8\,\mu$F capacitor.

c) Using a $100\,\Omega$ resistance, design an RC low-pass filter (for DC side) that would attenuate a 120-Hz sinusoidal voltage by 20 dB with respect to the DC gain.

Question 7

A logic platform provides control of the logic buzzer and ignition key for cars. The following events should be considered:

A) Ignition key (1 if turned)

B) Door (1 if closed)

C) Seat belt (1 if fasten)

D) Lights (1 if on)

E) Gear (1 if in Park)

The buzzer should go on if the ignition key is turned while either the doors are open or the driver's seat belt is not fastened. The buzzer also sounds if the ignition key is not turned while the lights are on.

The engine will not start if the ignition key is not turned, if the doors are open, if the driver's seat belt is not fastened, or if the car is in park.

a) Design the logic circuit that sounds the buzzer when appropriate.

b) Design the logic circuit that starts the engine when appropriate.

Note:

All kinds of gates could be used to construct the logic circuits.