THE HONG KONG POLYTECHNIC UNIVERSITY

FACULTY OF ENGINEERING

Programmes : BEng(Hons)/MEng in Mechanical Engineering
BEng(Hons)/MEng in Industrial and Systems Engineering

Programme Codes : 43078, 45085

Subject Title : Basic Electricity & Electronics **Subject Code** : ENG233

Session : Semester 1, 2003/2004

Date : 17 December 2003 **Time** : 09:30-12:30

Time Allowed : 3 hours **Subject Examiner(s)** : Prof. D. Sutanto(EE)
Dr David Cheng(EIE)

This question paper has a total of ____11____ pages (attachments included).

Instructions to Candidates :

This is an open-book examination. Candidates are allowed to bring in the following text book: "G. Rizzoni, Principles and Applications of Electrical Engineering, McGraw-Hill Higher Education."

Answer ALL multiple choice questions in Section A (40 marks) by circling the correct answer in the exam paper AND answer ALL Questions in Section B (60 marks).

Physical Constants :

Other Attachments :

Available from Invigilator : Graph Paper

DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.

SECTION B: Answer ALL FOUR Questions. It is advisable to show all your working for section B as marks will be awarded for partial answers.

QUESTION 1

Consider the circuit shown in Figure Q1.
Resistors R1 and R2 = 1 kΩ, while R3, R4, R5, R6 and R7 are 2 kΩ:
Batteries, V1 and V2= 10V while V3 = 12V

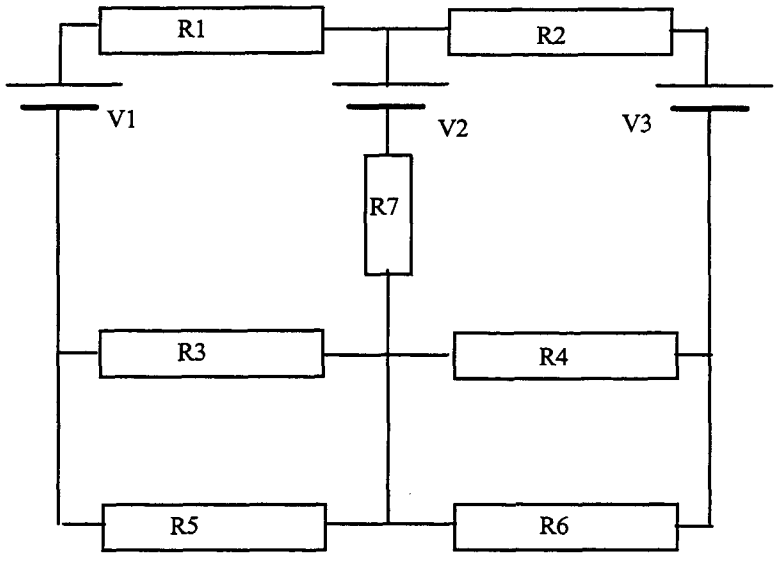


Figure Q1

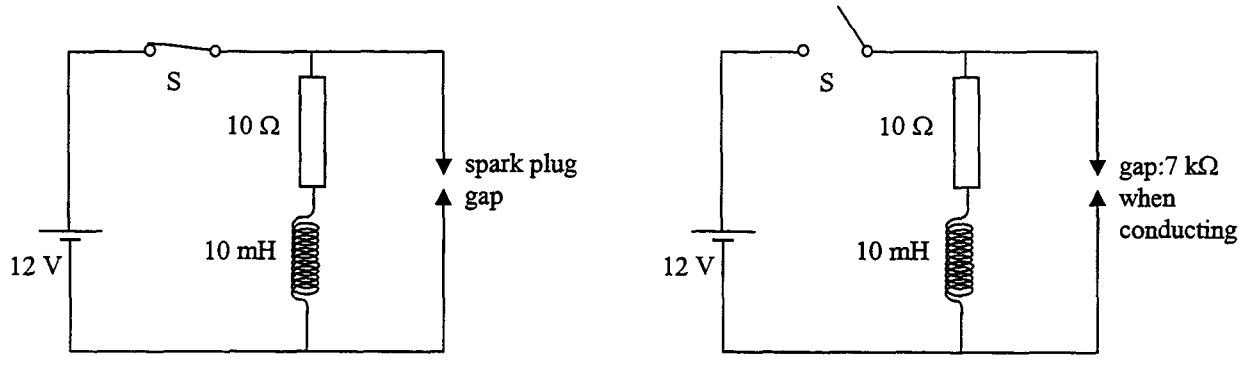
(a) Redraw and simplify the circuit as much as possible into your exam booklet showing appropriate current loops and the current that flows in each resistor. (4 marks)

(b) Write down sufficient equations which will enable you to calculate the currents through all the batteries. (7 marks)

(c) Calculate the currents through all 3 of the batteries. (4 marks)

QUESTION 2

The circuits in Figure Q2 show simplified diagrams of an automobile spark-coil circuit. The spark gap is a break in the circuit that allows a spark to jump (i.e. a current to conduct) when the voltage gets high enough.



(a) switch closed (b) switch open

Figure Q2

A rotor synchronised with the engine closes the switch S, for a long enough time that a sufficiently large current builds up in the inductor.

(a) On the graph paper provided, sketch a graph of the current in the circuit (through the switch) when the switch is closed. Indicate on the graph the value of the steady state current. (4 marks)

(b) Estimate the time for which the switch must remain in contact in order for the current to build up to about 1 A. (5 marks)

When the switch opens, the interruption of the current causes a large induced emf to develop across the inductor and hence the spark gap, causing a spark (i.e. a current) to jump the gap. As the spark current decreases so does the emf and the sparking stops. When conducting, the effective resistance of the spark gap is about 7 kΩ.

(c) Estimate the duration of the spark current. (3 marks)

(d) Estimate the voltage generated across the spark gap. (3 marks)

QUESTION 3

The circuit shown in Figure Q3 is a 4-bit digital-to-analogue converter (DAC). Each switch is controlled by the corresponding bit of the digital number. If the bit is 1, the switch is connected to -5 V; if the bit is 0, the switch is connected to 0 V. Let the digital number be represented by $b_3b_2b_1b_0$.

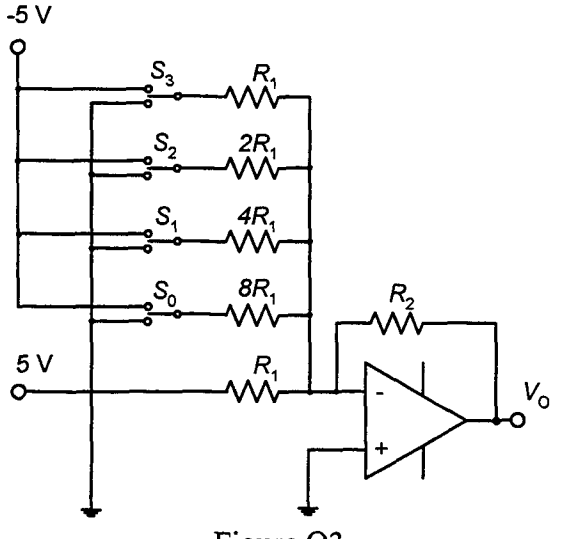


Figure Q3

(a) Determine an expression relating the output V_O to the binary input bits. (4 marks)

(b) If R_2=2 kΩ and R_1=1.25 kΩ, find the output voltage V_O if $b_3b_2b_1b_0$ = 1100. (3 marks)

(c) What is the resolution over the range of V_O from -8 V to 7 V? (4 marks)

(d) Find the number of bits required in the DAC if an improved resolution of 0.5 V is desired. (4 marks)

QUESTION 4

An RC coupled common-emitter amplifier is shown in Figure Q4 with:

- $C_S = 2.2\ \mu F$, $C_C = 0.47\ \mu F$, $C_E = 20\ \mu F$,
- $R_1 = 30\ k\Omega$, $R_2 = 5.6\ k\Omega$, $R_C = 4.7\ k\Omega$, $R_E = 1.5\ k\Omega$, $R_L = 2.2\ k\Omega$, $R_S = 200\ \Omega$,
- $V_{CC} = 20\ V$, $\beta = 100$,

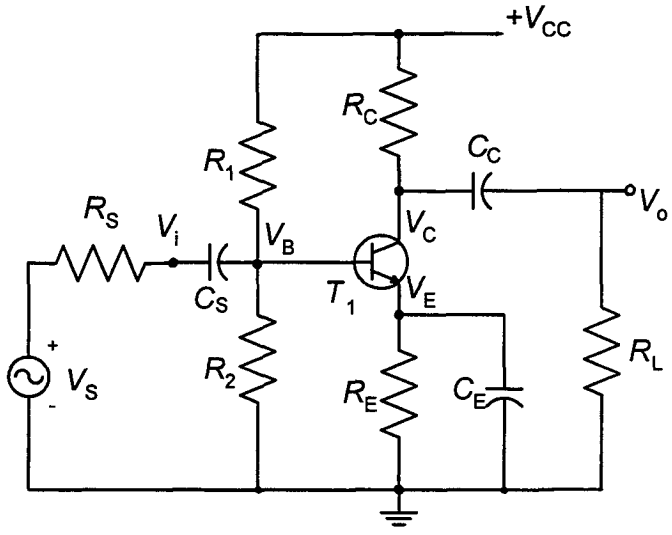


Figure Q4

(a) Calculate I_{BQ}, I_{CQ}, and V_{CEQ}. (The dc operating point for the transistor T_1.) (9 marks)

(b) Determine the region of operation of the transistor T_1. (3 marks)

(c) If the resistor R_L is short-circuited, what will happen to the voltage V_{CEQ}? (3 marks)