

# ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING

## PAPER-I

Time Allowed: **Three Hours**

Maximum Marks: **300**

### **Question Paper Specific Instructions**

**Please reach each of the following instruction carefully before attempting questions:**

Answers must be written in **ENGLISH** only.

There are **EIGHT** questions divided in **TWO** sections.

Candidate has to attempt **FIVE** questions in all

Questions **No.1** and **5** are **compulsory** and out of the remaining, any **THREE** are to be attempted choosing at least **ONE** question from each section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/figures, wherever required, shall be drawn in the space provided for answering the question itself.

Unless otherwise mentioned, symbols and rotations carry their usual standard meanings.

Candidate should attempt all questions in the space prescribed under each question in the Question-cum-Answer (QCA) Booklet. Any answer written outside the space allotted may not be given credit.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page of portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

### **Values of constants which may be required:**

Electron charge	$= -1.6 \times 10^{-19}$ Coulomb
Free space permeability	$= 4\pi \times 10^{-7}$ Henry/m
Free space permittivity	$= \left( \frac{1}{36\pi} \right) \times 10^{-9}$ Farad/m
Velocity of light in free space	$= 3 \times 10^8$ m/sec
Boltzmann constant	$= 1.38 \times 10^{-23}$ J/K
Planck's constant	$= 6.626 \times 10^{-34}$ J-s

**SECTION-A**

1. (a) Plot the output voltage of the circuit, as shown in figure (a) below, which has as its input a sawtooth waveform depicted in Figure (b).

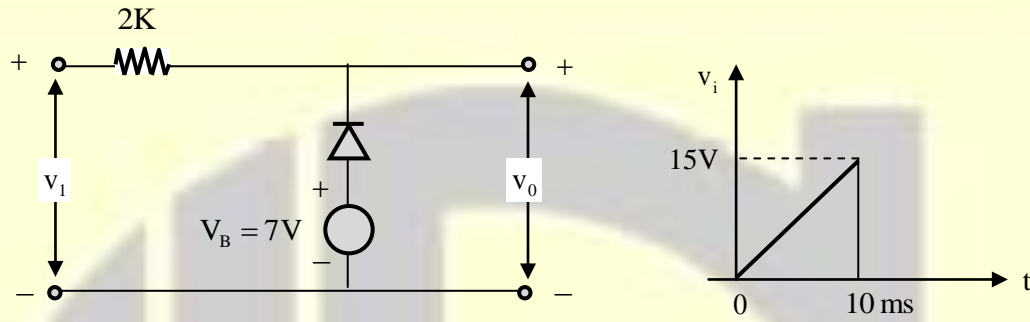


Figure (a)

Figure (b)

The diode parameters are  $R_f = 10\Omega$ ,  $V_f = 0.65V$  and  $I_s = 0$

[12 Marks]

- (b) The electric field in a region of space is given by

$$\vec{E} = (yz \hat{x} + xz \hat{y} + xy \hat{z}) \text{Vm}^{-1}$$

Calculate the charge density at the point  $(x, y, z) = (1, 2, 3)$  m and the magnitude flux density at the point  $(1, 2, 3)$ m. Given that  $\vec{B}(5, 6, 7) = 3T$ .

[12 Marks]

- (c) (i) Compare accuracy and precision with an example of archery target shooting.

- (ii) How can time and frequency standard be disseminated?

[12 Marks]

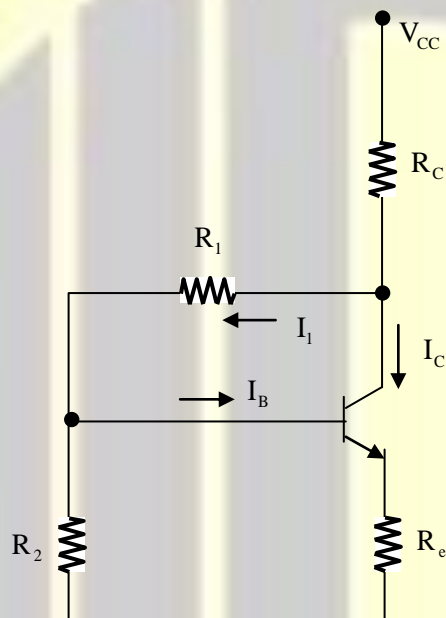
- (d) What are Bottom-up and Top-down methods of synthesis of nano materials?

[12 Marks]

- (e) An amplifier with an open-loop gain  $A_v = 1000 \pm 100$  is available. It is necessary to have an amplifier whose voltage gain varies by no more than  $\pm 0.1\%$ .
- (i) Find the reverse transmission factor,  $\beta$ , of the feedback network used.
- (ii) Find the gain with feedback.

[12 Marks]

2. (a) Determine the stability factor,  $S''$ , that is related to the variation of collector current  $I_C$  with respect to  $\beta$ , for the circuit shown below.



Assume silicon transistor and also  $\beta$  to be much larger than unity.

[20 Marks]

- (b) An output power of 10 W is to be delivered from a class-B push-pull amplifier. What will be the collector dissipation power of each of the transistors used?

Instead, if another configuration of two paralleled transistors, operating in class A mode are used, what will be the collector dissipation power of each transistor? Derive the equations used.

[20 Marks]

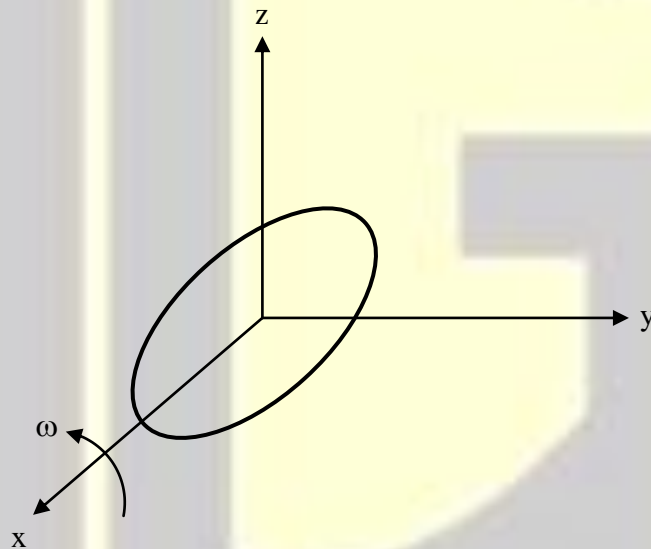
- (c) Hall measurements are conducted on a p-type semiconductor bar  $500\mu\text{m}$  wide and  $20\mu\text{m}$  thick. The Hall contacts 'A' and 'B' are displaced  $2\mu\text{m}$  with respect to each other in the direction of current flow of  $3\text{ mA}$ . The voltage between A and B with a magnetic field of  $10^{-5}\text{ Wb/cm}^2$  pointing out of the plane of the sample is  $3.2\text{ mV}$ . When the magnetic field direction is reversed the voltage changes to  $-2.8\text{ mV}$ . Find the value of mobility of holes.

[20 Marks]

3. (a) Draw a schematic diagram of a solar photovoltaic cell and explain its principal of operation.

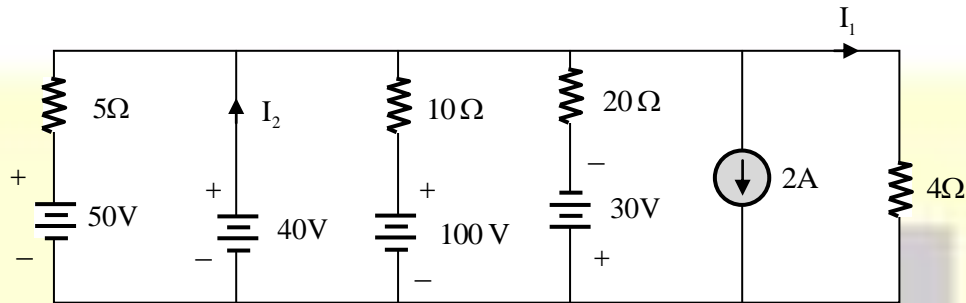
[12 Marks]

- (b) A rotating circular loop of radius  $0.1\text{ m}$  and resistance of  $10\Omega$  is placed in a constant magnetic field of  $0.2\hat{z}\text{ T}$  as shown in the figure. If the frequency of rotation is  $100\text{ Hz}$ , determine the current through the loop.



[12 Marks]

- (c) State the Millman's Theorem and use it to find the current ' $I_1$ ' through the  $4\Omega$  resistor. Also, find ' $I_2$ ' the current delivered by the 40 V battery.



[12 Marks]

- (d) The voltage across a  $2\mu\text{F}$  capacitor is given in the transform domain, by

$$V_c(s) = \frac{60s + 8 \times 10^4}{s^2 + 10^6}$$

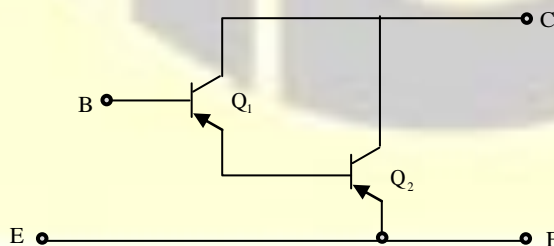
What is the current through the capacitor?

[12 Marks]

- (e) A 4-pole DC generator has 1200 armature conductors and generates 250 V on open circuit when running at a speed of 500 r.p.m. The diameter of the pole-shoe circle is 0.35 m and the ratio of pole arc to pole pitch is 0.7. The length of the shoes is 0.2 m. Find the mean flux density in the air gap. Assume lap-connected armature winding.

[12 Marks]

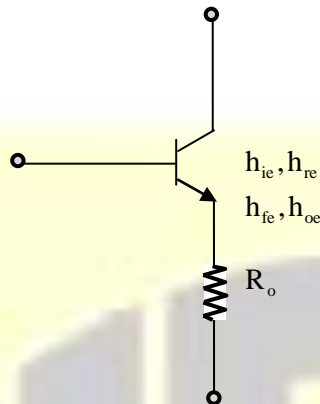
4. (a) Show that the input resistance of the transistor combination shown below is much greater than that of the individual transistors.



Why is such a combination not preferred, with three or more transistors, to further increase the input resistance?

[20 Marks]

- (b) Determine the modified h-parameter of the circuit shown below.



Reduce the expressions derived above for the case if  $h_{oe}R_e \ll 1$ .

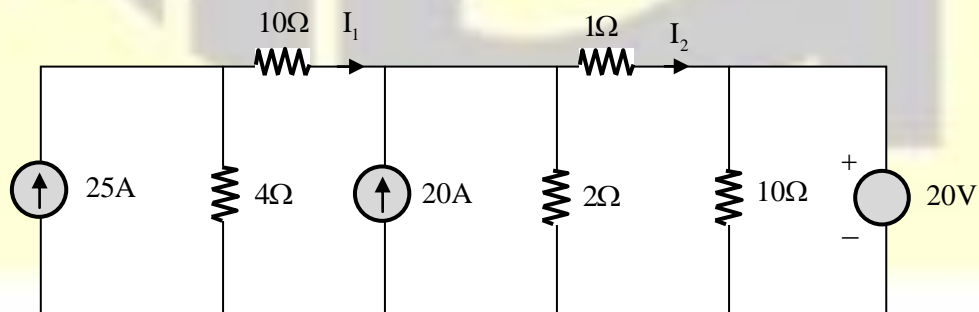
[20 Marks]

- (c) What is the internal power of an optical source emitting at a peak wavelength of 1310 nm? The radiative and non-radiative recombination times are 40 ns and 100 ns, respectively. The drive current is 30 mA.

[20 Marks]

### SECTION-B

5. (a) Using mesh analysis and transformation of current sources to voltage sources, determine the currents  $I_1$  and  $I_2$  in the circuit shown below.



[12 Marks]

- (b) A series R-L-C circuit has  $R = 250 \, \Omega$ ,  $L = 10 \, \text{mH}$ , and  $C = 100 \, \mu\text{F}$ . Assume zero initial conditions and use Laplace Transforms to determine the (natural) current for a unit impulse voltage input.

[12 Marks]

- (c) (i) Distinguish between sensors and transducers, with examples.  
(ii) What are the different constants of piezo-electric crystals? How are they related?

[12 Marks]

- (d) NAND implementation of a circuit is to be designed with three data lines and a control line.

When the control line is high, the circuit is to detect when one of the data lines has 1 on it. No more than one data line will have 1 on it.

When the control line is low, the circuit will output a 0, regardless of what is on the data line.

[12 Marks]

- (e) Consider a 'Lead' material has critical temperature 7.19 K and critical magnetic flux is 0.0803 tesla. Determine the value of temperature at which 'lead' material must be cooled in a magnetic field of 15000 A/m for it to be super conductive. Assume magnetic constant value is  $4\pi \times 10^{-7} \, \text{H/m}$ .

[12 Marks]

6. (a) (i) Distinguish between thermocouple, thermistor and RTD.  
(ii) Why is cold junction of thermocouples required to be compensated and how can it be compensated?  
(iii) How can you measure flow of fluid by using ultrasonic flow meter based on change in frequency (Doppler shift)? Explain with necessary diagrams.

[25 Marks]

- (b) (i) Five measurement of the resistance of a resistor gave:

101.7  $\Omega$

101.0  $\Omega$

101.5  $\Omega$

101.2  $\Omega$

and 101.1  $\Omega$

Assume that only random errors are present.

- Calculate:**
- I.** The arithmetic
  - II.** The standard deviation of the readings.
  - III.** The probable error.

- (ii) Explain the signal conditioning requirements for measurements with strain gauges and how these can be achieved.

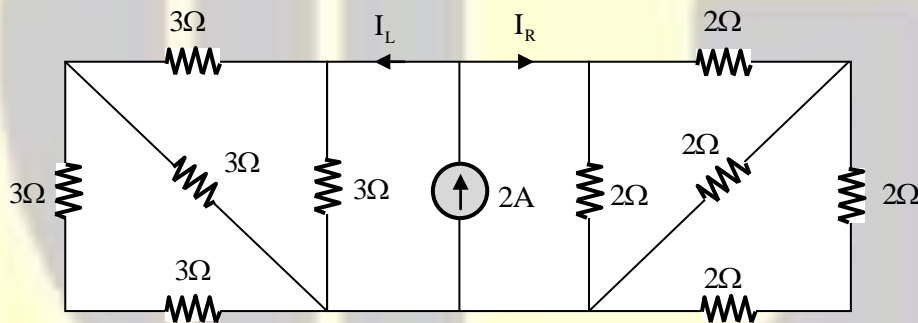
[20 Marks]

- (c) The quantum efficiency of a particular photo detector is 90% for the detection of radiation at a wavelength of  $0.8\mu\text{m}$ . When the incident optical power is  $0.8\mu\text{W}$ , the output current from the device is  $10\mu\text{A}$ .

Determine the multiplication factor of the photo detector.

[15 Marks]

7. (a) For the circuit shown below, calculate the currents  $I_L$  and  $I_R$ .



[15 Marks]

- (b) Design a counter to go through states 0, 2, 4, 5, 0 ..., using type D flip flops.

[15 Marks]

- (c) (i) What is Spintronics? Discuss two examples of spintronic devices.  
(ii) Find the relation between unit cell edge length 'a' and atomic radius 'r' for a body-centered cubic crystal.

[12 Marks]



- (d) (i) The charge sensitivity of a piezo-electric transducer is  $40 \text{ pC/N}$ . A charge amplifier is connected with the piezo-electric transducer such that the combination of the transducer and amplifier is to have an overall gain of  $100 \text{ mV/N}$ .

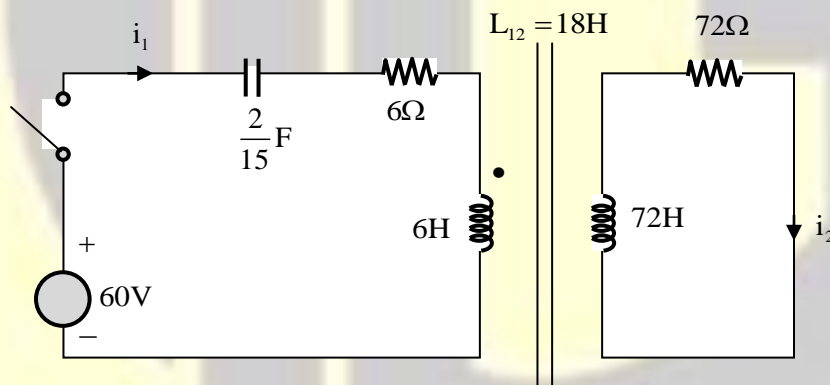
Find (I) the gain of the amplifier,  
(II) the value of the feedback capacitor required to have this gain.  
(III) What is telemetry? Classify the telemetering systems.

[15 Marks]

8. (a) (i) What are the requirements for the processing of signals using LVDT? Show a complete scheme to explain the displacement measurements with LVDT.  
(ii) A 12 A dynamometer ammeter has a full scale deflection of  $90^\circ$ . The rate of mutual inductance with deflection is constant and its value is  $0.006 \text{ } \mu\text{H}$  per degree. Find the deflection, if the current to be measured is 6A.

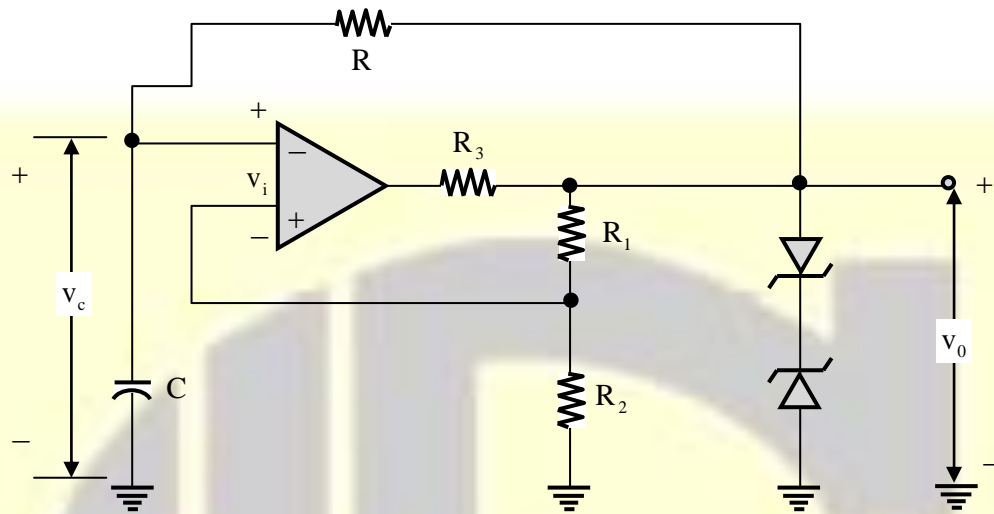
[20 Marks]

- (b) An inductively coupled circuit is shown below. The switch is closed at  $t = 0$ . Assuming zero initial conditions, determine the current  $i_2(t)$ .



[20 Marks]

- (c) How does the circuit shown below generate square wave? Calculate the time period of the generated wave and plot the voltage  $v_c$  and  $v_o$ .



How can the time period of the generated square wave be varied?

[20 Marks]