

**ENGINEERING SERVICES
EXAMINATION-2016**

0063443

Sl. No.

A-HUF-P-VEA

**ELECTRONICS AND
TELECOMMUNICATION ENGINEERING**

**Paper I
(Conventional)**

Time Allowed : Three Hours

Maximum Marks : 200

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions.

There are SEVEN questions in the paper.

Candidates are required to attempt FIVE questions in all.

Question No. 1 is compulsory.

Out of the remaining SIX questions, attempt any FOUR questions.

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

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches are to be drawn to illustrate answers, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

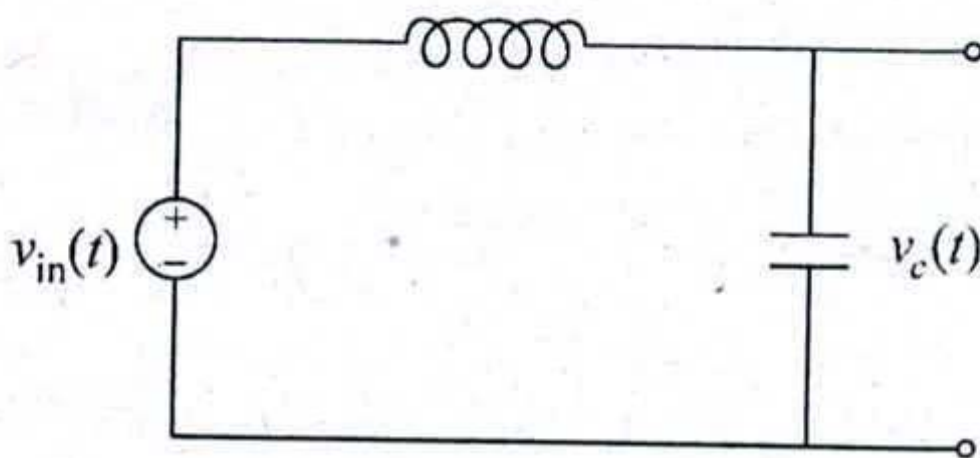
Answers must be written in ENGLISH only.

Any page or portion of the page left blank in the answer book must be clearly struck off.

Values of constants which may be required :

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

1. (a) Distinguish between zener and Avalanche breakdown phenomenon. Determine the temperature co-efficient of a 5 V zener (Rated 25°C value), if the nominal voltage drops to 4.8 V at temperature of 100°C. 5
- (b) An *n*-type semiconductor Si containing 10^{16} phosphorous atoms per cm^3 is doped with 10^{17} Boron atoms/ cm^3 . Calculate the electrons and hole concentration. Assume $n_i = 10^{10}/\text{cm}^3$. 5
- (c) Consider the circuit shown below in which $C = 0.5 F$ and $L = 0.5 H$.
Suppose $v_{in}(t) = 20 e^{-2t}$ and all initial conditions are zero. Calculate $v_c(t)$.



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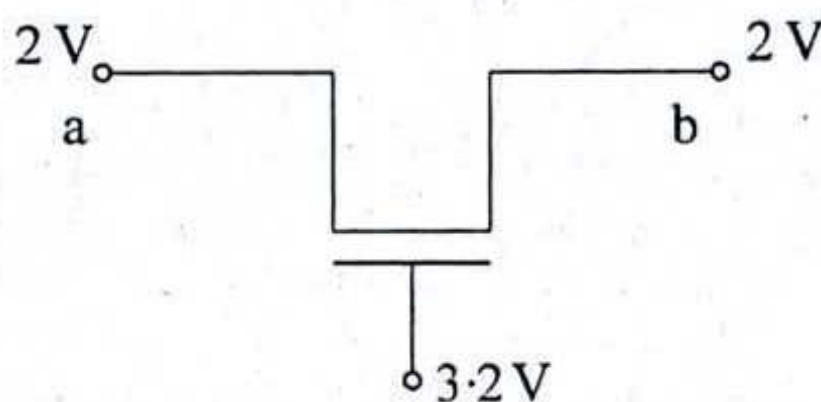
- (d) Clearly distinguish between
- (i) ionic and covalent bonding
 - (ii) Reach through and punch through phenomenon 5

- (e) Show that if R_H is the Hall co-efficient and σ is the conductivity of a metal then the drift mobility of the conduction electron is given by

$$\mu_d = |\sigma R_H| \quad 5$$

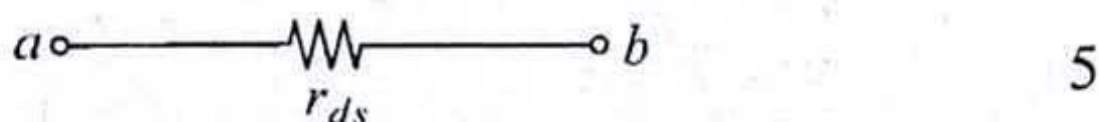
- (f) A 0–1 mA meter with internal resistance of 5Ω is given. How would the range of the meter is extended to measure up to 10 mA ? 5

- (g) Consider the following figure :



Given $\frac{\mu_n C_{ox} \cdot W}{L} = \frac{1 \text{ mA}}{V^2}$ and $V_{th} = 1 \text{ V}$.

Calculate the resistance (r_{ds}) between a and b ,



- (h) Estimate the energy of a blue photon which has a wavelength of 450 nm. 5

2. (a) Let G represent a causal system that is described by the following differential equation;

$$\frac{dy(t)}{dt} + y(t) = \frac{dx(t)}{dt} - x(t)$$

where $x(t)$ and $y(t)$ are input and output of the system respectively. Determine the output $y_1(t)$ of G when the input $x_1(t)$ is defined as

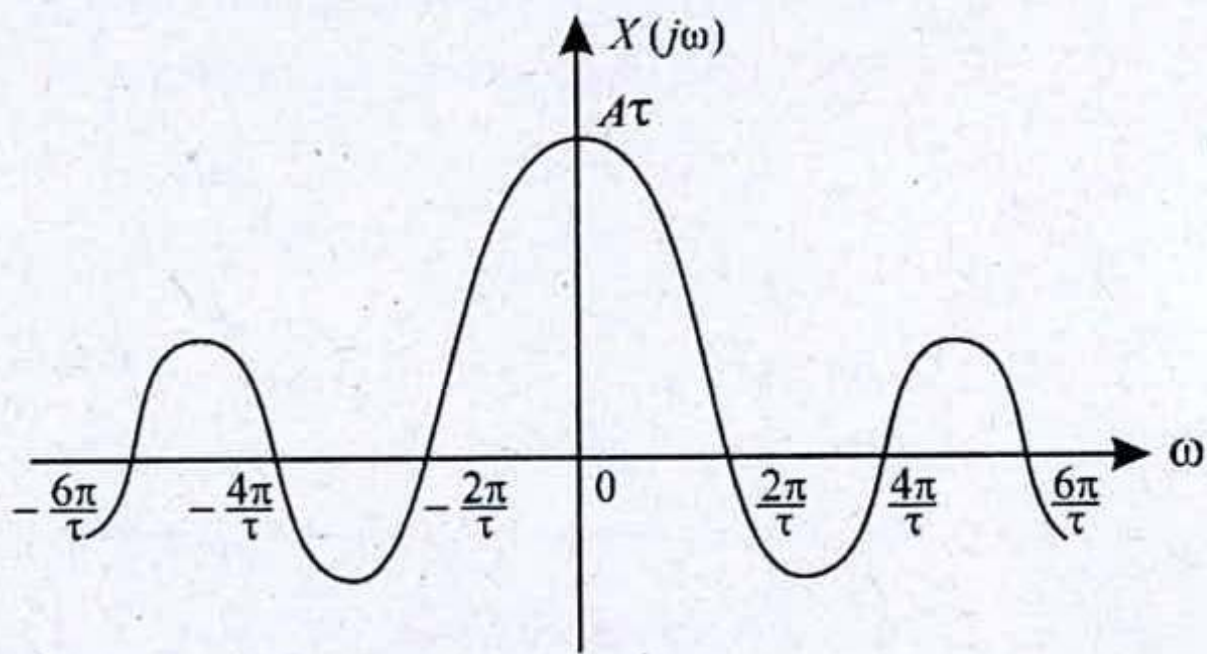
$$x_1(t) = \left\{ \begin{array}{ll} e^{-2t}; & t \geq 0 \\ 0; & \text{otherwise} \end{array} \right\} \quad 5$$

- (b) A causal and stable LTI system S has the property that when we apply the input;

$$\left(\frac{4}{5}\right)^n u(n), \text{ it gives the output } n \left[\frac{4}{5}\right]^n u(n).$$

- (i) Determine the transfer function $H(e^{j\omega})$ for the system. 5
- (ii) Determine the difference equation relating any input $x[n]$ and the corresponding output $y[n]$. 5

- (c) The amplitude spectrum of a signal $x(t)$ is given in the following figure. Determine the signal $x(t)$ and plot it.



10

- (d) What is z -transform? Find the z -transform of

$$F(s) = \frac{1}{s^2}$$

5

- (e) A discrete time system, with input $u(k)$, has a transfer function given by

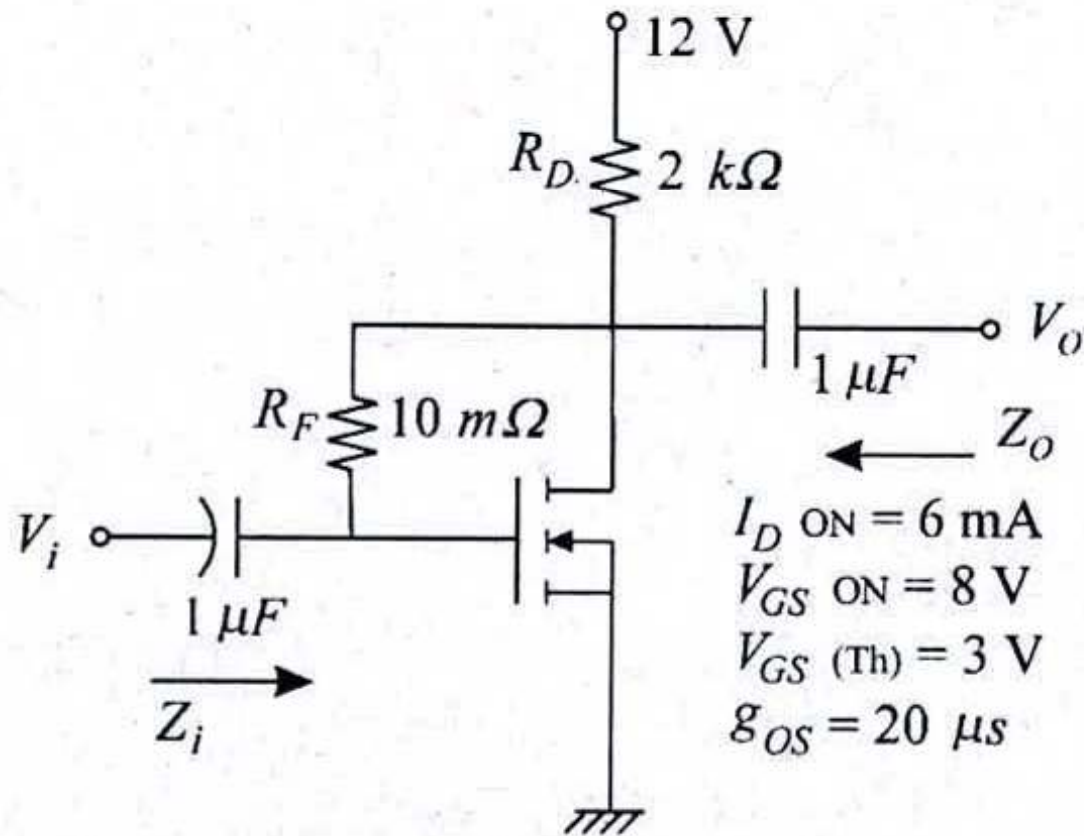
$$G(z) = \frac{z - 0.8}{z^2 - 1.3z + 0.42}$$

Compute the unit-step response of the system assuming all initial conditions to be zero. 10

3. (a) A sample of germanium is doped to the extent of 10^{14} atoms/cm³ and 7×10^{13} acceptor atoms/cm³. At the temperature the resistivity of pure (intrinsic) germanium is 60Ω cm. If the applied electric field is 2 V/cm, find the total conduction current density. 10

- (b) What are SCRs? Draw the symbol and its V-I characteristics. Explain its operation. 5
- (c) Draw and explain the Energy Band diagram of a $p-n$ junction semiconductor under Forward, Reverse and Zero bias conditions. 10

(d)



For the E-MOSFET of above figure, Determine;

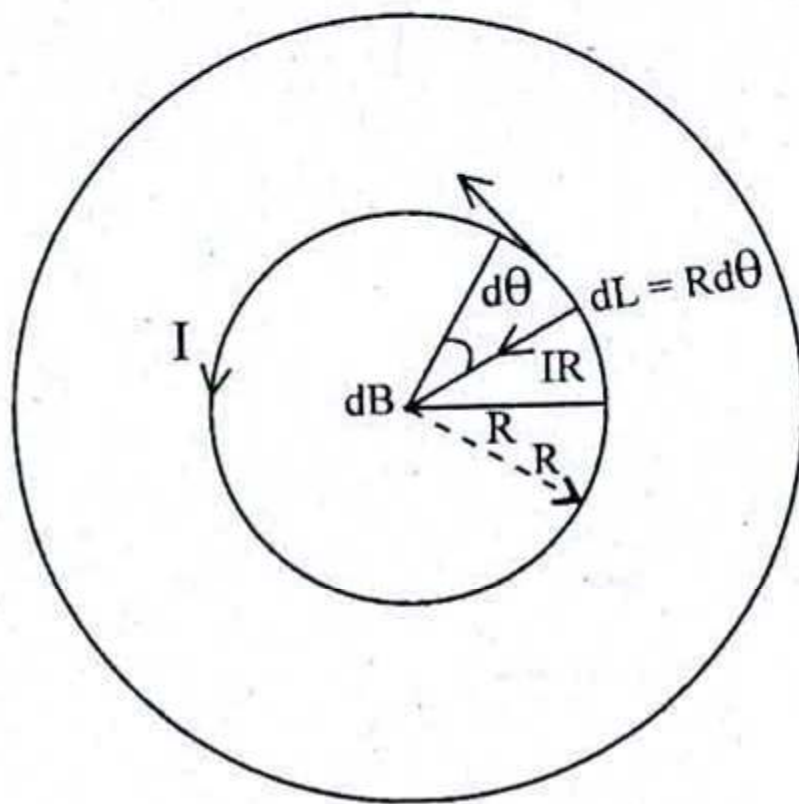
- g_m
- find r_d
- calculate z_i with and without r_d and compare result
- find z_o with and without r_d and compare result
- find A_v with and without r_d and compare result

Given that $k = 0.24 \times 10^{-3} \text{ A/V}^2$

$$V_{GSQ} = 6.4 \text{ V}; I_{DQ} = 2.75 \text{ mA.}$$

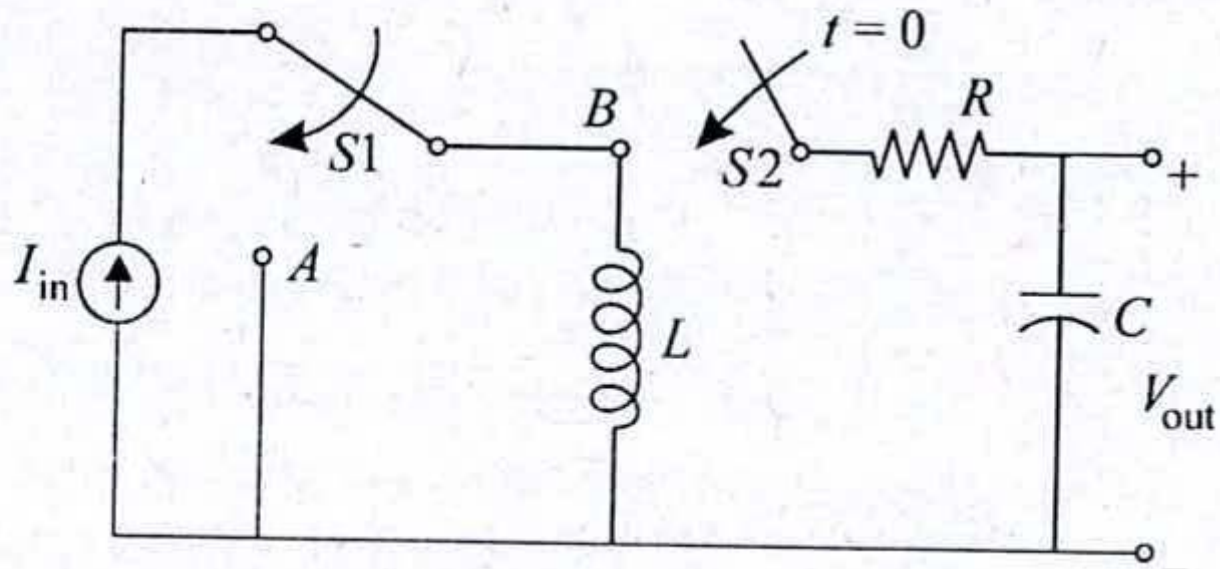
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4. (a) Write the word statements for Maxwell's equations along with the mathematical equations. 5
- (b) Show that the plasma frequency for electrons can be expressed in simple numerical form i.e. $f_p = g\sqrt{N}$ where f_p is in Hz and N is the electron density in electrons/m³.
What is f_p for the ionosphere, if $N = 10^{12}$. 10
- (c) Find the expression for the magnetic flux density in the centre of a circular current loop as shown in the following figure.



- (d) What is maximum allowed spacing d_{\max} between the parallel plate wave-guide plates? If the plate spacing is 2.1 cms and $f = 10$ GHz which TE_n and TM_n modes will propagate? 15

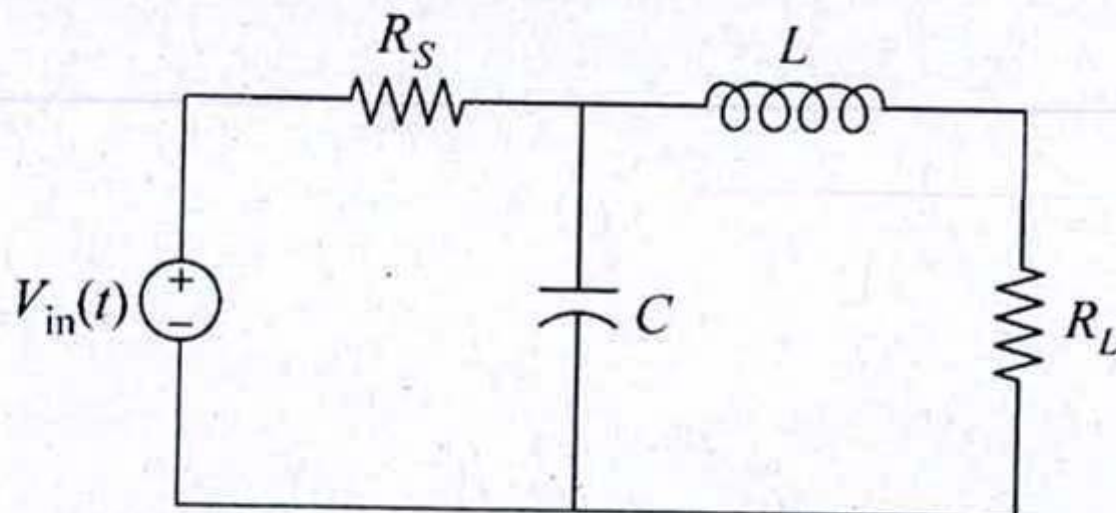
5. (a)



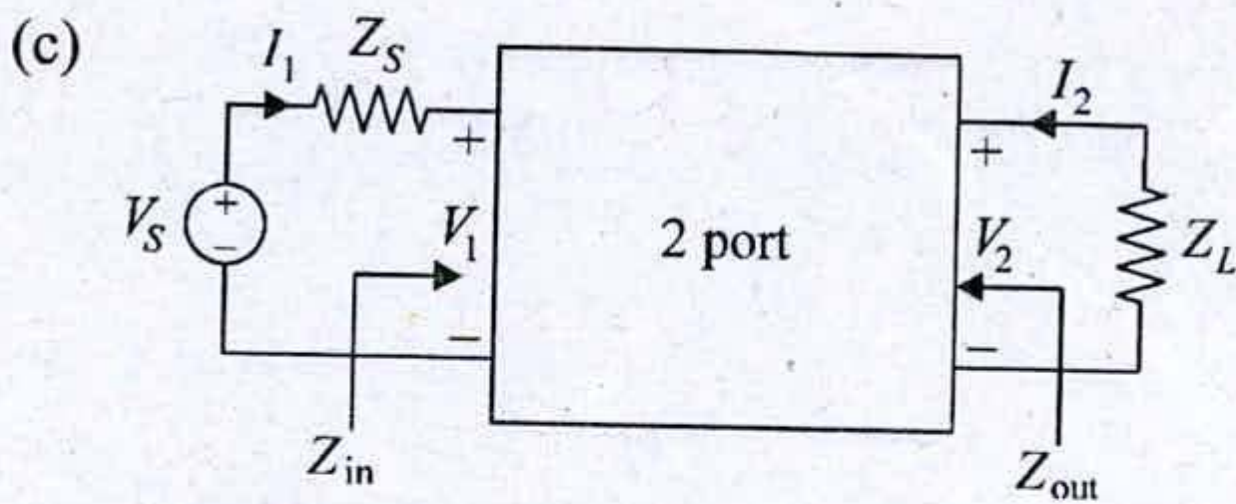
In the ckt shown above $L = 0.25 \text{ H}$, $C = 0.25 \text{ F}$, $R = 2 \Omega$ and $I_{in}(t) = 10 \text{ A(d.c)}$ for all time. Suppose that switch $S1$ has been in position B for a very long time and switch $S2$ has been open for all time. At time $t = 0$ switch $S1$ moves to position A and switch $S2$ closes on position B instantaneously. Calculate :

$V_{out}(t)$ at $t = 0.5$ seconds if $V_{out}(0^-) = 0$. 15

(b)



In the ckt given above $R_L = 5 \Omega$ and $R_S = 10 \Omega$. If $V_{in}(t) = 10 \cos(10t)u(t) \text{ V}$. Calculate the value of L and C that leads to maximum power transfer to the load at the frequency determined by the input cosine. 15



In the ckt shown above, the terminated 2 port having general h -parameters are

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

Calculate (i) the gain $GV_2 = \frac{V_2}{V_1}$

(ii) Assuming $h_{11} = 2/s$, $h_{12} = 2$, $h_{21} = 0.5$ and $h_{22} = s$. Calculate $z_{in}(s)$ in ohms. 10

6. (a) Explain the operation of a Quartz-crystal with the help of its equivalent circuit. A typical 1 MHz quartz crystal has the following properties

$$f_s = 1 \text{ MHz}$$

$$f_a = 1.0025 \text{ MHz}$$

$$C_o = 5 \text{ pF}$$

$$R = 20 \ \Omega$$

Where

f_s = Mechanical Resonant Frequency

f_a = Anti Resonant Frequency

C_o = Parallel plate capacitance between the electrodes

What are C and L in the equivalent ckt of the crystal? What is the quality factor of the crystal?

15

- (b) For a $p-n-p$ transistor show that the injection efficiency of the emitter is given by

$$\gamma = \frac{1}{1 + \frac{N_d W_B \mu_e}{N_a W_e \mu_h}}$$

where N_d , N_a , W_B and W_e , μ_e , μ_n have their standard meanings. 10

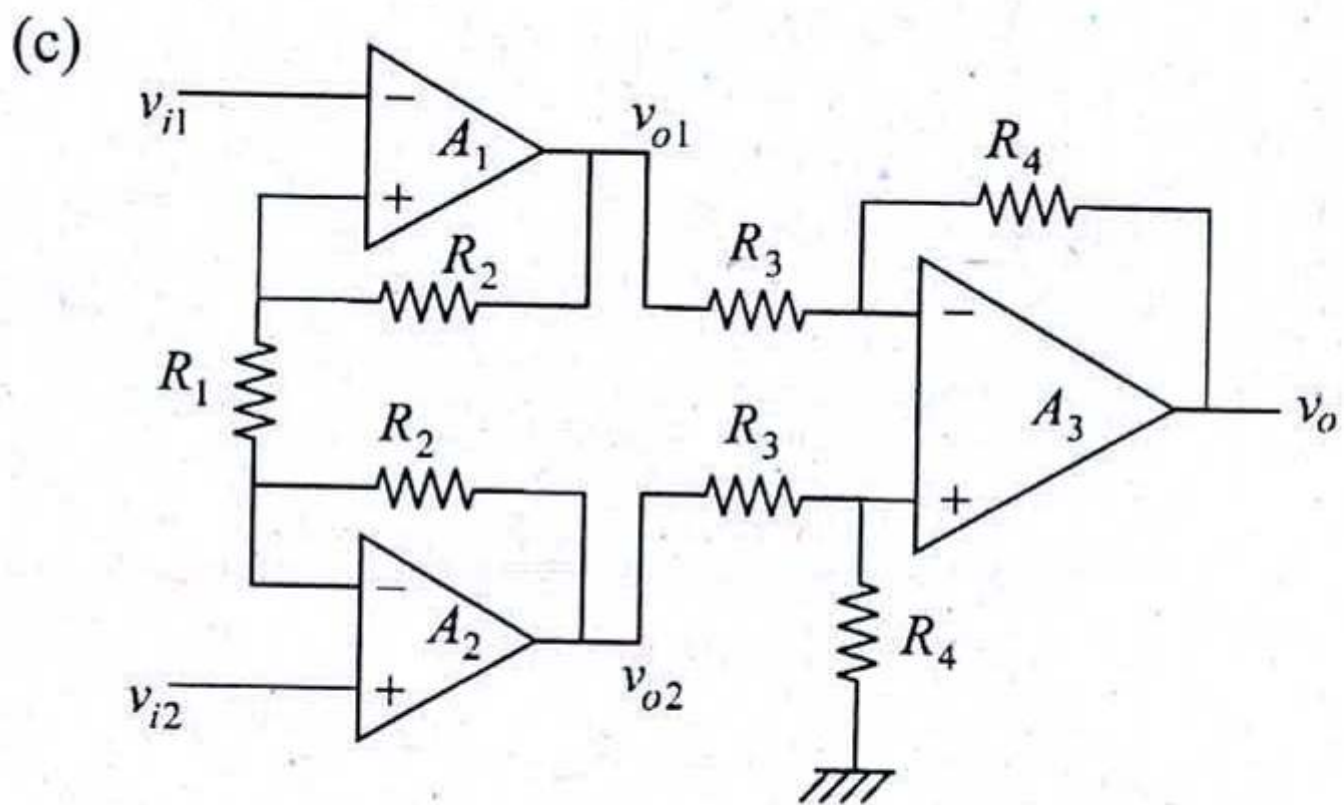
- (c) Explain the features of soft-magnetic materials with suitable examples and uses. 5

- (d) Consider a torodial coil with a ferrite core. Suppose the coil has 200 turns and is used in high frequency with small signals. The mean diameter of the toroid is 2.5 cm and the core diameter is 0.5 cm. If the core is MnZn ferrite what is the approximate inductance of the coil ?

Given Relative permeability $\mu_r = 2 \times 10^3$. 10

7. (a) A sheet of bakelite 4.5 mm thick is tested at 50 Hz between electrodes 0.12 m in diameter. The Schering bridge employs a standard air capacitor C_2 of 106 pF, a non-reactive resistance R_4 of $1000/\pi$ ohms in parallel with a variable capacitor C_4 and a non-reactive variable resistance R_3 . Balance is obtained with $C_4 = 0.5$ pF and $R_2 = 260 \Omega$. Calculate the capacitance, power factor and relative permittivity of the sheet. 15

- (b) A dual slope APC uses a 16 bit counter and a 4 MHz clock rate. The maximum input voltage is +10 V. The maximum integrator output should be -8 V, when the counter has cycled through 2^n counts. The capacitor used in the integrator is $0.1 \mu\text{F}$. Find the value of the resistor R of the integrator. 10



The instrumentation amplifier using Op-Amp is shown above. Calculate the value of R_1 , R_2 , R_3 and R_4 so as to obtain the gain of the amplifier as 2. 15

