ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper – I

Time Allowed : *Three* Hours

Maximum Marks : 300

Question Paper Specific Instructions

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

*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 notations have their usual standard meanings.

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 or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

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

Values of constants which may be required :

|		
Electron charge	=	$-1 \cdot 6 \times 10^{-19}$ 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/s
Boltzmann constant	=	$1 \cdot 38 \times 10^{-23}$ J/K
Planck's constant	=	$6 \cdot 626 \times 10^{-34}$ J-s

SECTION A

Q1. **(a)** Consider an ideal pMOS capacitor of area $100 \ \mu m \times 100 \ \mu m$ operated at $T = 300 \ K$. ϕ_M (work function for the metal) $= 5 \cdot 2 \ eV$, x_o (oxide thickness) $= 3 \ nm$ and $N_D = 10^{17}/cm^3$. Calculate the flat band voltage V_{FB} and the threshold voltage V_{TP}. Assume $E_{ox} = 3 \cdot 43 \times 10^{-13} \ F/cm$, V_T (thermal voltage) $= 0 \cdot 026 \ V$, $n_i = 10^{10}/cm^3$, χ_{Si} (electron affinity of Si) $= 4 \cdot 05 \ eV$, $E_G = 1 \cdot 12 \ eV$ and $E_{Si} = 10^{-12} \ F/cm$. **12**
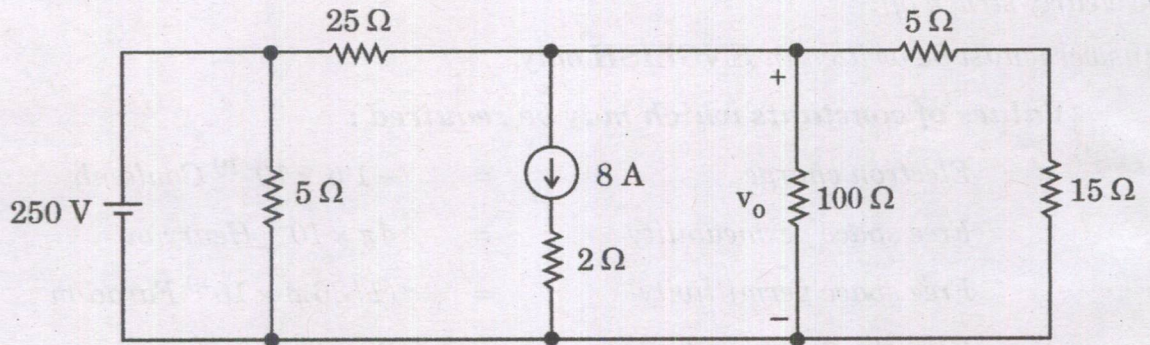
(b) In the circuit shown in the figure below, M_1 serves as an electronic switch. If v_{in} is very small, determine W/L such that circuit attenuates the signal by 5%.

Assume $V_G = 1 \cdot 8 \ V$ and $R_L = 100 \ \Omega$.

$\mu_n \ C_{ox} = 200 \ \dfrac{\mu A}{V^2}$ and $V_{TN} = 0 \cdot 4 \ V$. **12**
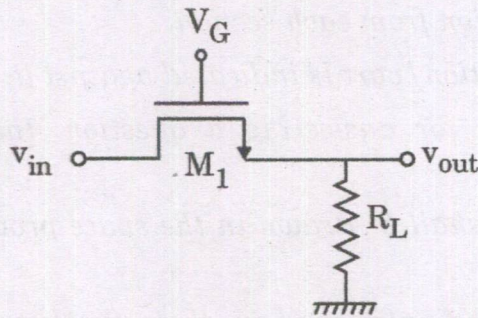
(c) Find the voltage v_o in the circuit shown in the figure using source transformation. Also, find the power developed by the 250 V voltage source. **12**

(d) An electrical load absorbs an average power of 85 kW at lagging power factor of 0·85. If the load operates at 240 V rms, calculate the complex power and impedance of the load. **12**

(e) (i) Draw neat sketches of the edge and screw dislocations. Illustrate the Burger's vector on the sketches of dislocations. 6

(ii) Calculate the line energy of dislocation in BCC iron if the shear modulus and lattice parameter of BCC iron are 80.2 GN/m^2 and 2.87 Å, respectively. 6

Q2. (a) A p-n junction solar cell is fabricated using silicon and has the following important parameters :

$$N_A = 3 \times 10^{18} /cm^3, \, N_D = 2 \times 10^{16}/cm^3$$

$$D_n = 25 \, cm^2/s, \, D_p = 10 \, cm^2/s$$

$$\tau_{n0} = 4 \times 10^{-7} \, s, \, \tau_{p0} = 10^{-7} \, s$$

The photocurrent density $J_L = 20$ mA/cm^2. Calculate the open circuit voltage of the solar cell at T = 300 K. Assume $n_i = 1.5 \times 10^{10}/cm^3$. 20

(b) (i) What are the two functions of commutator in DC machines ? 5

(ii) Explain how the commutator keeps the armature mmf stationary in space, along the interpolar axis, even though the armature rotates. 15

(c) (i) Explain why end-centred tetragonal geometry does not exist in Bravais crystal structures. 10

(ii) Differentiate between different types of magnetic materials on the basis of magnetic dipoles and hysteresis loops. 10

Q3. (a) (i) Design a Widlar current source shown in the figure below to give $I_o = 5$ μA and $I_R = 1$ mA. The parameters are $V_{CC} = 30$ V, $V_{BE1} = 0.7$ V, $V_T = 26$ mV and $\beta_F = 100$. 10
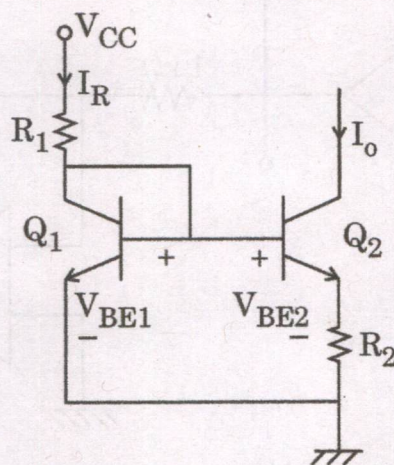
(ii) Design an amplifier that has a voltage gain of 2 if $V_{IN} < 0$ and 1, if $V_{IN} > 0$. Assume ideal diodes and ideal op amps are available. 10
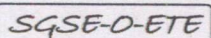
(b) (i) Discuss the points of similarities between a transformer and induction machine. Explain, why an induction machine is called a generalized transformer.   10

(ii) A 10 kVA/2500/250 V, single-phase transformer has the following parameters :

Primary winding (h.v. side) : Resistance r_1 = 2·4 Ω

Leakage Reactance, x_1 = 6·00 Ω

Secondary winding (l.v. side) : Resistance r_2 = 0·03 Ω

Leakage Reactance, x_2 = 0·07 Ω

With primary supply voltage held constant at 2500 V, calculate the secondary terminal voltage, when the low voltage winding is connected to a load impedance of 5 + j 3·5 Ω and the transformer delivers its rated current at 0·8 p.f. lagging on the low voltage side.   10

(c) (i) Discuss photoelectric effect and find out the number of photoelectrons emitted per unit time from a transmitter operated at a frequency of 800 kHz and 10 kW power.   10

(ii) Define dielectric strength. Discuss different types of dielectric breakdowns in solids.   10

Q4. (a) For the circuit shown in the figure below, determine the frequency of oscillation f_o and overall voltage gain A_v. Also identify the type of oscillator. (Assume op amps are ideal)   20

(b)   (i)   Determine the impedance Z_L that results in maximum average power transferred to Z_L for the circuit shown in the figure. Calculate the maximum average power transferred to the load impedance determined.   *10*
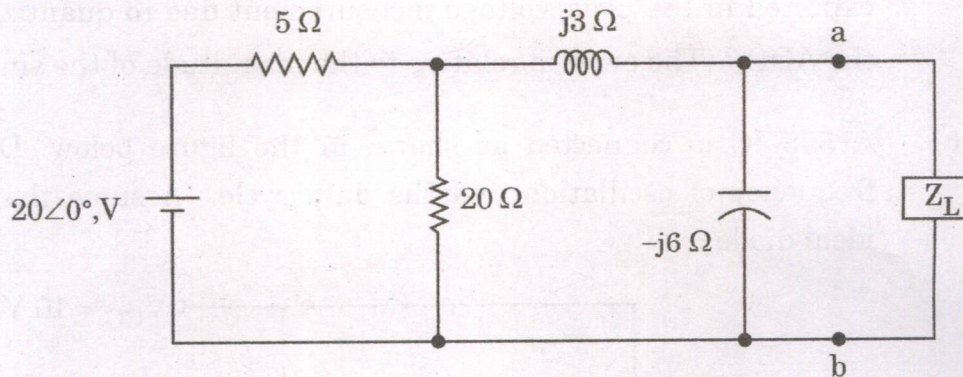
(ii)   What are the major factors that have led to the acceleration and development of solar and wind power ?   *10*

(c)   To produce a p-type semiconductor, the boron is doped in pure silicon. Doping is done through a B_2O_3 vapour phase of a surface concentration equivalent to 3.3×10^{26} boron atoms/m³. Calculate the time required to get a boron content of 10^{23} atoms/m³ at a depth of 2 μm. The doping temperature is 1000°C and D_B in Si at this temperature is 4×10^{-17} m²/s.   *20*

Given :   erf $(0.95) = 0.8209$

erf $(1.0) = 0.8427$

erf $(2.4) = 0.9993$

erf $(2.6) = 0.9998$

Q5. (a) Assume an ideal 10 bit ADC with V_{REF} = 5 V is used to sample $1V_{p-p}$ sinusoidal signal that has a 2·5 V offset. What percent of error can be expected in the peak voltage measurement due to quantization effect of the ADC ? (The error is relative to the magnitude of the sinusoid). *12*

(b) A 555 IC is connected as shown in the figure below. Determine the frequency of oscillation and the duty cycle. (Assume that diode is an ideal diode). *12*
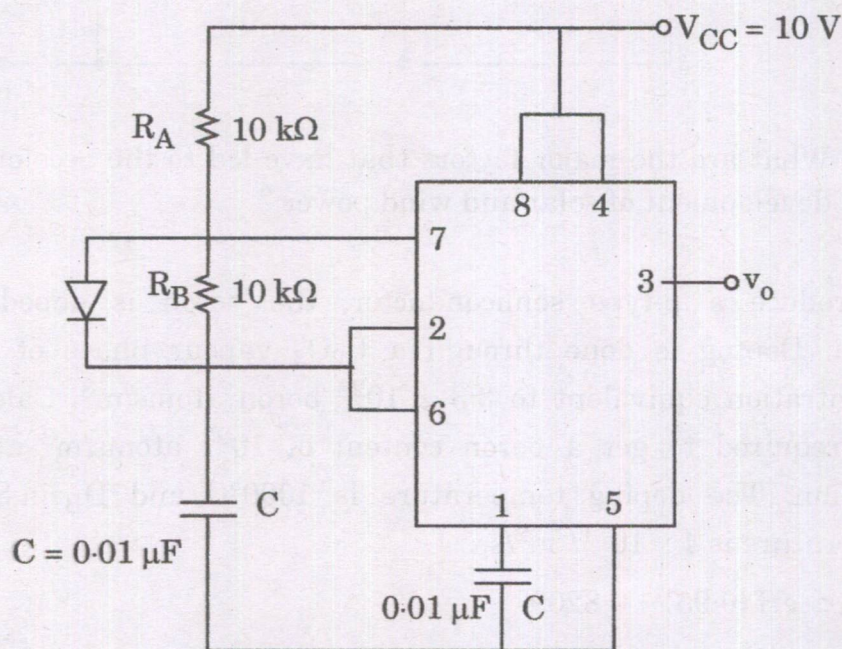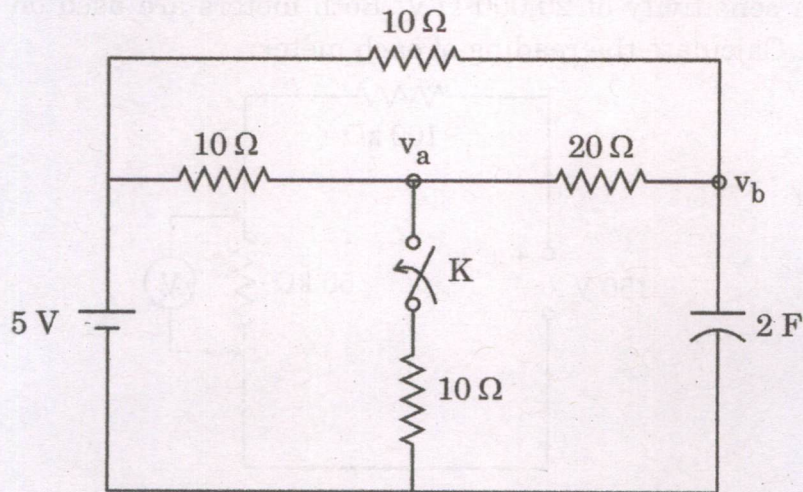

(c) (i) The network of the figure contains both a dependent voltage source and a dependent current source. Determine the y and z parameters. *6*
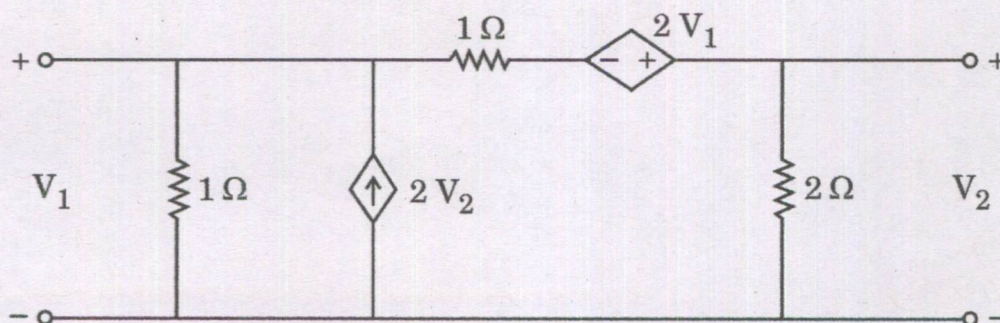
(ii) In the figure shown, a network with a steady state is reached with switch K open. At t = 0, the switch is closed. For the element values given, determine the value of v_a (0−) and v_a (0+).   6

(d) (i) For the figure shown, find i_1.   6
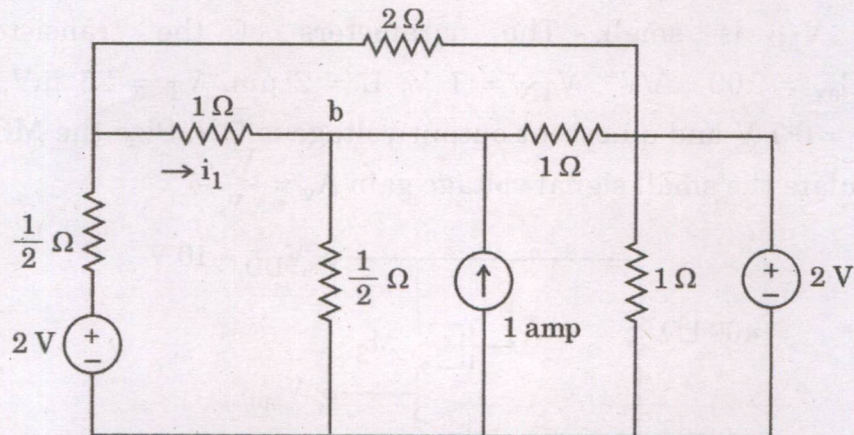
(ii) The network of inductors in the figure below is composed of a 1 H inductor on each edge of a cube with the inductors connected to the vertices of the cube as shown. Find out the $L_{equivalent}$ between the terminals A − B.   6
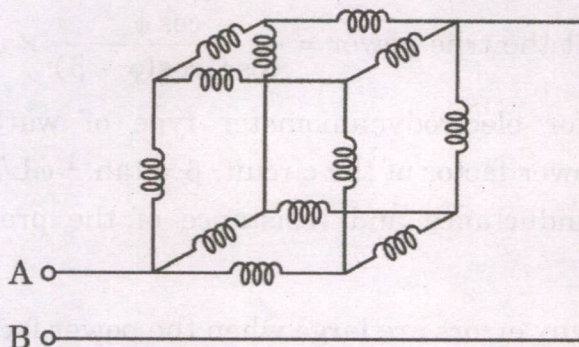
(e) It is desired to measure the voltage across the 50 kΩ resistor in the circuit shown in the figure. Two voltmeters are available for this measurement : Voltmeter 1 with sensitivity of 1000 Ω/V and Voltmeter 2 with a sensitivity of 20,000 Ω/V. Both meters are used on their 50 − V range. Calculate the reading of each meter. 12
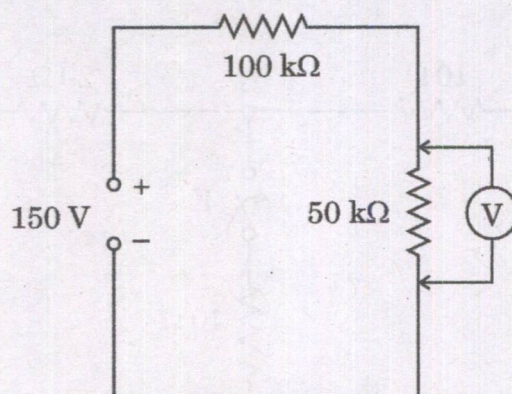

Q6. (a) For the circuit shown in the figure below, MOS and BJT are operating in saturation and active mode, respectively. The capacitor C is very large and V_M is small. The parameters of the transistors are : $\mu_n C_{ox} = 100 \ \mu A/V^2$, $V_{TN} = 1 \ V$, $L = 2 \ \mu m$, $V_T = 25 \ mV$, $\beta_F = 100$, $V_{BE} = 0.7 \ V$ and quiescent output voltage is 5 V. Size the MOSFET and calculate the small signal voltage gain $A_v = \dfrac{V_{ow}}{v_s}$ 20
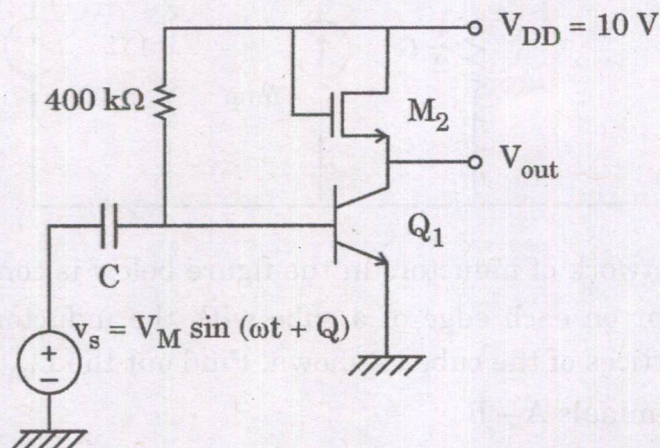

(b) (i) Prove that the true power $= \dfrac{\cos \phi}{\cos \phi . \cos(\phi - \beta)} \times$ actual watt meter reading for electrodynamometer type of watt meters, where, $\cos \phi$ = power factor of the circuit, $\beta = \tan^{-1} \omega L/R$ where, L and R are the inductance and resistance of the pressure coil of the circuit. 10

(ii) Explain why errors are large when the power factor is low. 10

(c) (i) Find the Thevenin's equivalent for the circuit at terminals a − b. **10**
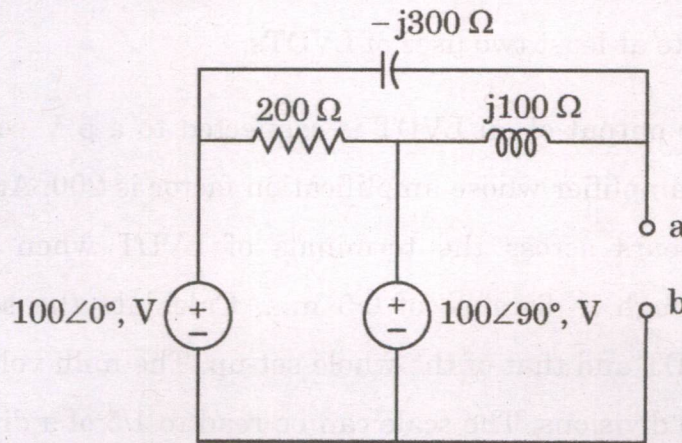
(ii) For the ladder network determine the g parameters in the s domain. **10**
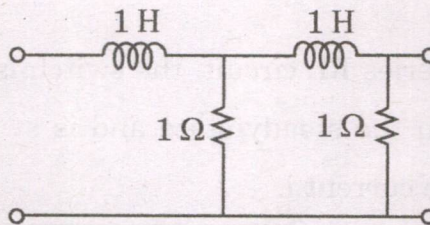
Q7. (a) The parameters of the amplifier shown in the figure below are $R_{C_1} = 4$ kΩ, $R_E = 2$ kΩ, $R_{C_2} = 5$ kΩ, $R_F = 4$ kΩ and $R_S = 200$ Ω. The DC bias currents of the transistor are $I_{C_1} = 0\cdot5$ mA, $I_{C_2} = 1$ mA. The transistor parameters are $h_{fe} = h_{fe1} = h_{fe2} = 150$. Use the techniques of feedback analysis to calculate the input resistance R_{IF}, the output resistance R_{OF} and the closed loop transresistance gain A_f. Assume $V_T = 25$ mV. **20**
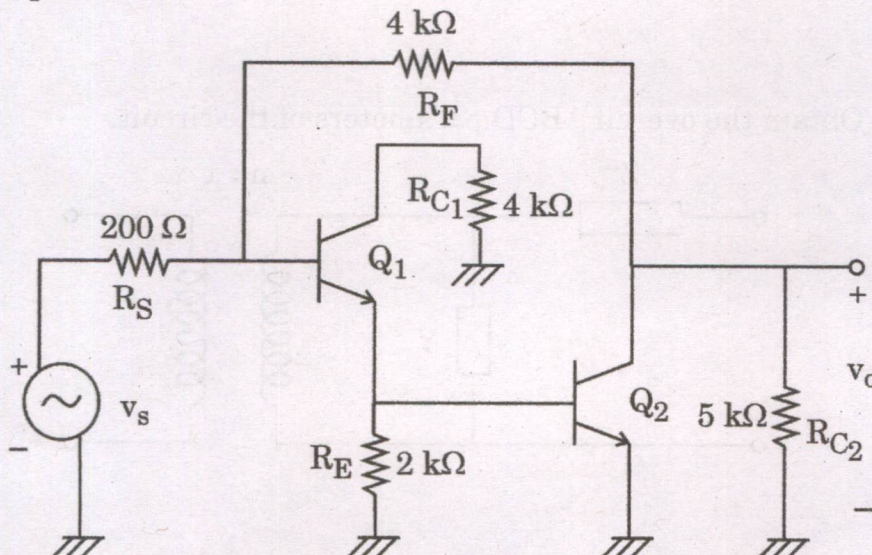
(b) (i) Explain at least five advantages and disadvantages of LVDT. State at least two uses of LVDTs.   *10*

(ii) The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 200. An output of 2 mV appears across the terminals of LVDT when the core moves through a distance of 0·5 mm. Calculate the sensitivity of the LVDT and that of the whole set-up. The milli voltmeter scale has 100 divisions. The scale can be read to 1/5 of a division. Calculate the resolution of the instrument in mm.   *10*

(c) (i) In the series RL circuit, the switch is in position 1 long enough to establish the steady state and is switched to position 2 at t = 0. Find the current i.   *10*
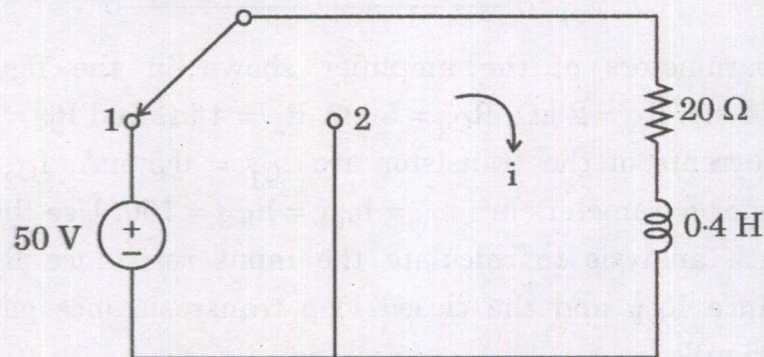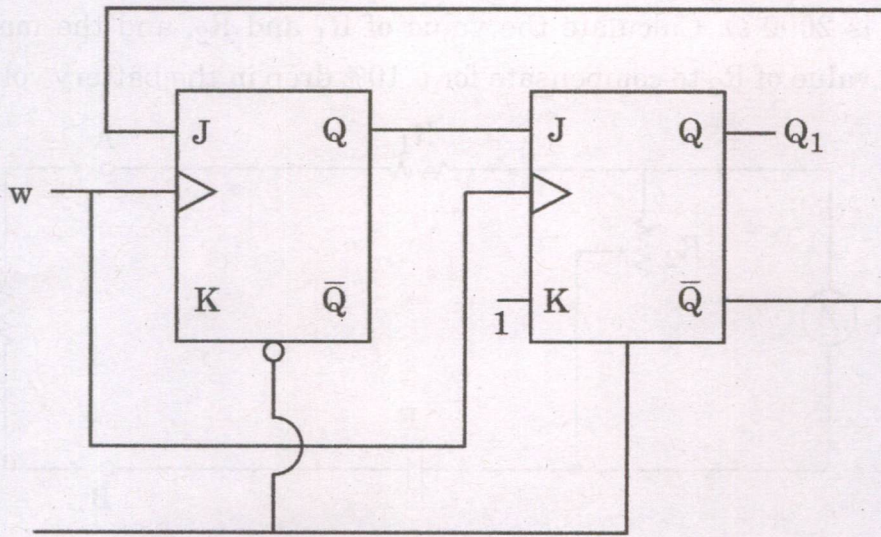

(ii) Obtain the overall ABCD parameters of the circuit.   *10*
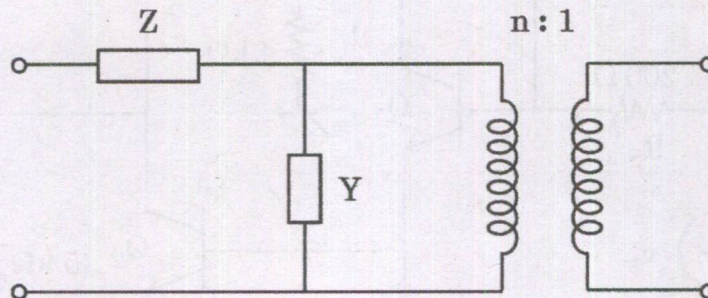
Q8. (a) (i) Determine the functional behaviour of the circuit. Assume that input w is driven by a square wave signal. **10**
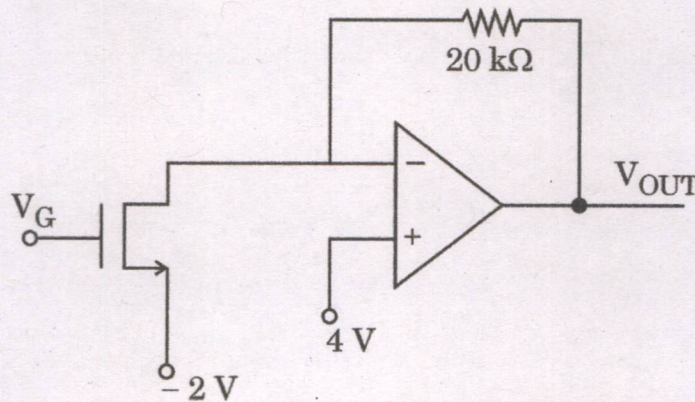

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(ii) In the circuit shown in the figure below, the gate voltage V_G is very small. Assume op amp is an ideal op amp, $V_{TN} = 1\,V$ and $\dfrac{\mu_n\, C_{ox}\, w}{L} = \dfrac{200\ \mu A}{V^2}$. Calculate output voltage. **10**


(b) (i) Describe the construction and working of a shunt type ohmmeter. Write down its design equations. **10**

(ii) The ohmmeter shown in the figure uses a 100 Ω basic movement requiring a full-scale current of 1 mA. The internal battery voltage is 3 V. The desired scale marking for half-scale deflection is 2000 Ω. Calculate the value of R_1 and R_2, and the maximum value of R_2 to compensate for a 10% drop in the battery voltage. *10*
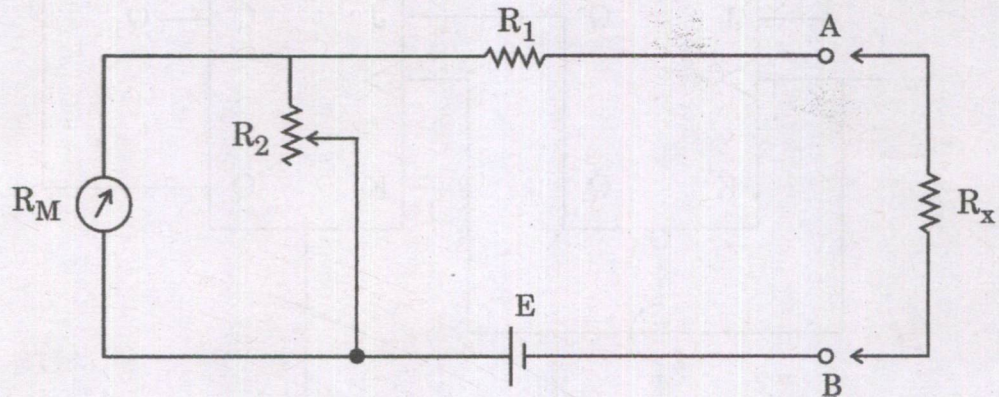
(c) A series resonant network consists of a 50 Ω resistor, a 4 mH inductor and a 0·1 μF capacitor. Calculate values for (a) ω_0, (b) f_0, (c) Q_0, (d) BW, (e) ω_1, (f) ω_2, (g) Z_{in} at 45 k rad/sec, and (h), the ratio of magnitude of the capacitor impedance to resistor impedance at 45 k rad/sec. *20*