ENGINEERING SERVICES
EXAMINATION-2015

A-GTD-O-SAAA

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.

Candidate should attempt FIVE questions in all.

Question no. 1 is compulsory.

Out of the remaining SIX questions attempt any FOUR questions.

All questions carry equal marks.

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

Answers must be written in ENGLISH only.

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

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

Values of the following constants may be used as indicated; wherever necessary :

Electronic 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 $= 3 \times 10^{8}$ *m/s*

Boltzmann constant $= 1{\cdot}38 \times 10^{-23}$ *J/K*

Planck constant $= 6{\cdot}626 \times 10^{-34}$ *J-s*

Neat sketches may be drawn, 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 chronological 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 answer book must be clearly struck off.

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1. (a) With the help of *r-k* diagram explain the difference between direct and indirect bandgap semiconductors. Identify the following semiconductors in the above categories. 5

   (i) Si

   (ii) Ge

   (iii) GaAs

   (iv) GaP

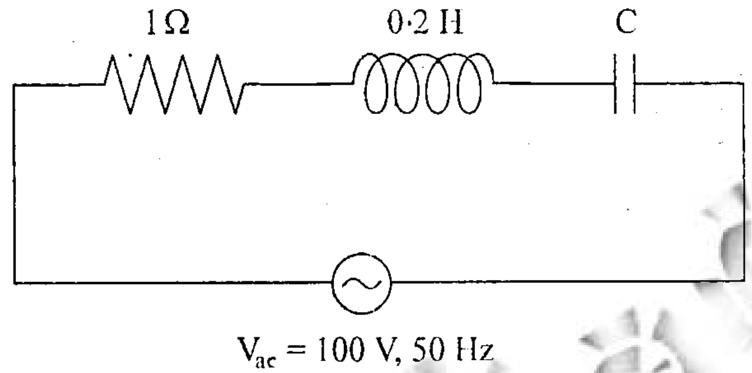
   (v) InSb

(b) (i) Draw the structure of Schottky-barrier photodiode. 1

   (ii) Draw the geometrical structure of an Avalanche Photodiode and its electrical field profile. 2

   (iii) Draw the V-I characteristics of GaAs and explain the significance of negative resistance. 2

(c) Two independent signals $x_1(t)$ and $x_2(t)$ are periodic with a period T_0. Show that the product of the two periodic signals is also periodic with the same time period T_0. 5

(d) 

A series *RLC* circuit with $R = 1\ \Omega$, $L = 0{\cdot}2\ H$ and an unknown C is excited with an a.c. source of 100 V, 50 Hz. For resonance condition, calculate

(i) the capacitance, C;

(ii) the voltage across C, and

(iii) the Q-factor.

Also plot the behaviour of current with frequency. 6

(e) A long copper circular conductor with diameter of 3 mm carries a current of 10 A. What is the time taken for all the conduction electrons in 100 mm long section of the conductor to leave, assuming that there are $8{\cdot}49 \times 10^{28}$ electrons/m^3. 4

(f) A lossless transmission line 100 cm long with operating frequency of 500 MHz having $L = 0{\cdot}2\ \mu$H/m has a phase velocity of 2×10^8 m/sec. Find the line's capacitance per metre. 5

(g) The current from a photodiode changes from 100 μA to 200 μA in a measurement set up. Design an op-amp based conditioning circuit to get a 1 V output. 5

(h) A student, while measuring the frequency of a waveform from a square wave generator, set the trigger input of a CRO in "LINE" mode. He adjusted the input frequency to 396 Hz to get a stable display on the screen. What is the actual frequency of the mains supply ? 5

2. (a) State Wiedemann-Franz-Lorenz Law.

A copper disk with a diameter of 2 cm and thickness of 25 mm has a resistivity of 70 n Ω m. The disk conducts heat from an electronic device to a heat sink at a rate of 10 W. Estimate the value of the temperature drop across the disk neglecting heat losses from the surface. 10

(b) A Si crystal is doped with phosphorous atoms to the extent of 1 part of impurity atom per billion (*ppb*) Si atoms. Estimate the resistance of the silicon sample of length 1 cm and area of cross-section of 1 cm^2. The atomic concentration of Si is $5 \times 10^{28}/m^3$. The mobilities of electrons and holes are respectively 1500 $cm^2/v.s$ and 450 $cm^2/v.s$ respectively. Given $n_i = 1 \cdot 5 \times 10^{10}/cm^3$. 10

(c) (i) What is a soft magnetic material ? Give examples of soft magnetic materials and list their applications. 5

(ii) With the help of magnetization characteristics (M vs. B curves) explain the difference between Type I and Type II superconductors. 5

(d) (i) What is Kerr effect ? How does it differ from Pockels effect ? 5

(ii) What is Fresnel reflection loss ? Light falls on a GaAs substrate at 850 nm from air. Calculate the Fresnel reflection loss at the air-GaAs interface for normal incidence. Given that $\in_r$ (GaAs) = 13·1. 5

3. (a) Draw the cross section of a MESFET and its equivalent circuit (h, f). Why are GaAs MESFETs preferred for very high frequency applications ? 10

(b) An *n*-channel MESFET has been fabricated using GaAs and have $N_D = 10^{18}$ cm^{-3}, $a = 0{\cdot}3$ μm, $L = 1{\cdot}2$ μm if $\in_s = 13 \times 8{\cdot}854 \times 10^{-12}$ F/m. Calculate pinchoff voltage. 10

(c) Explain Floatzone technique to reduce the impurities in the crystalline rod of semi-conductor material. 5

(d) Give reasons for choosing silicon for fabricating general purpose IC chips. 5

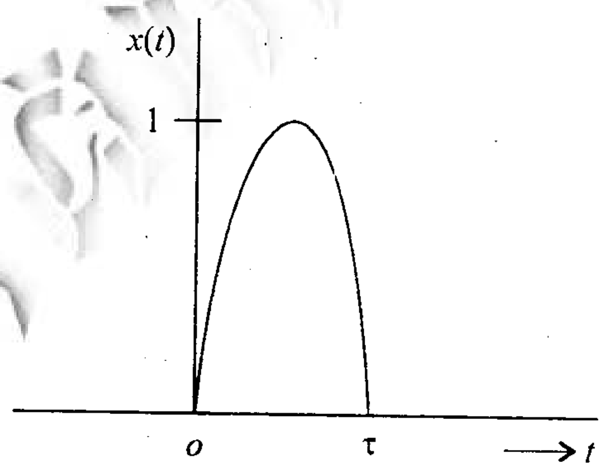
(e) Draw the geometry of a typical tunnel diode and its equivalent circuit. Sketch the V-I characteristics and explain the existence of negative resistance. 10

4. (a) Determine the total energy of a raised cosine pulse $x(t)$ defined as

$$x(t)=\frac{1}{2}[\cos 2\pi ft+1],\quad -\frac{1}{2f}\leq t\leq\frac{1}{2f}.$$

$$= 0 \quad \text{otherwise.}$$ 10

(b)



Find the Fourier transform of the above sinusoidal pulse. 10

(c) Find the discrete-time convolution sum of the following

$$y(n) = 3^n\, u[-n+3] * u[n-2]$$ 10

(d) Determine a particular solution for the systems described by the following differential equations for the given input. 10

$$\frac{d^2y(t)}{dt^2} + 3y(t) = 2\frac{dx(t)}{dt}$$

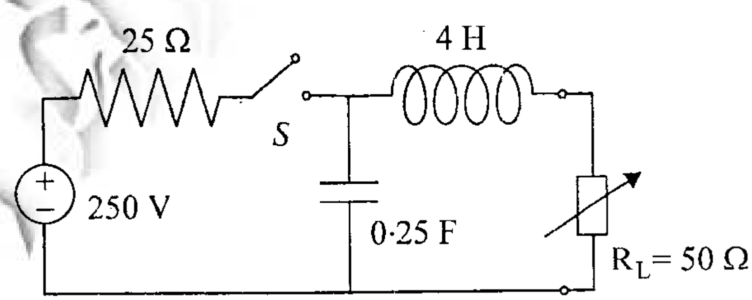
(i) $x(t) = t$

(ii) $x(t) = e^{-t}$

(iii) $x(t) = \cos t + \sin t$

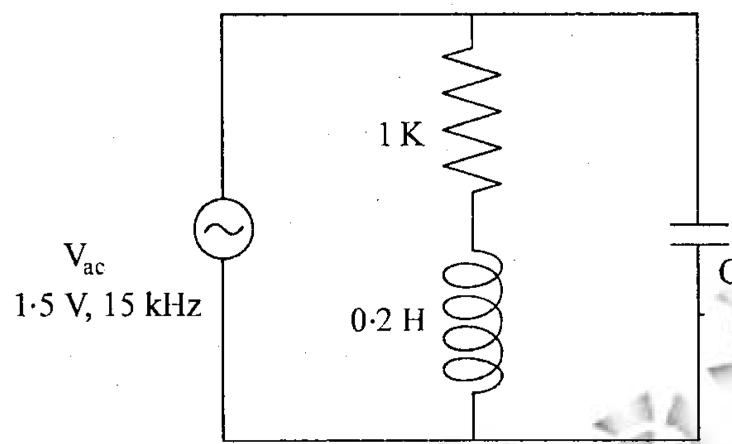
(iv) $x(t) = 2e^{-t}$

5. (a)



Draw the Thevenin equivalent circuit in the s-domain for the network shown above. Hence find the current through the load, $R_L = 50\ \Omega$ when S is closed. 15

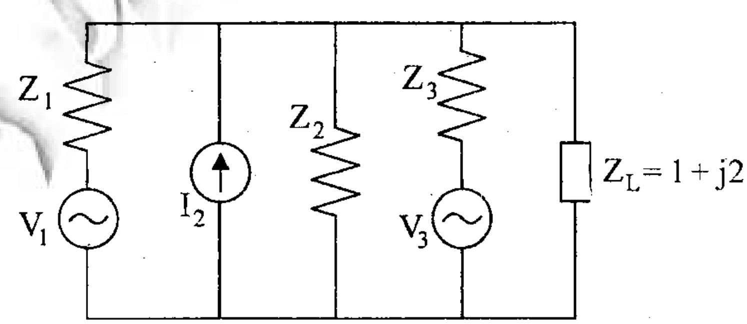
(b)



For the circuit shown above, show that the resonant frequency $f_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$.

Calculate C when the supply current is minimum. 10

(c) State Millman's theorem and illustrate. For the circuit shown below, obtain the Millman's equivalent generator and determine the current in the load, $Z_L = (1 + j2)\ \Omega$. 15

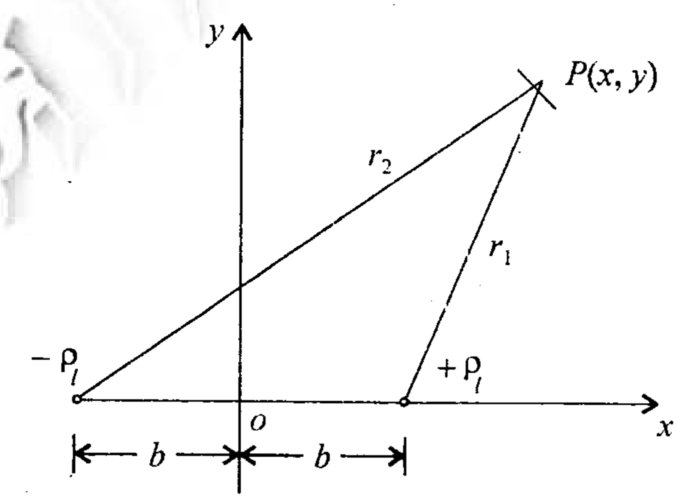


$V_1 = 2\angle 0°$ volts, $I_2 = 1\angle 0°$ Amp

$V_3 = 5\angle 5°$ volts, $Z_1 = 1{\cdot}5\Omega$, $Z_2 = 5\Omega$, $Z_3 = 3\Omega$

6. (a) (i) Find the capacitance per unit length between two uniformly charged long lines of density $+\rho_l$ and $-\rho_l$ parallel to each other which are circular cross section of radius a and conducting whose axes are separated by distance D.

(ii) Prove that equipotential lines at any point $P(x, y)$ at radial distances r_1 and r_2 from these conductors are circles if they are located as shown in the following figure if $\frac{r_2}{r_1} = k$. 15



(b) (i) Why are copper bus-bars at electrical power substations hollow though they are carrying large current magnitudes at 50 Hz.

(ii) Compare the wavelengths of 50 Hz EM wave in air and in copper if σ_{copper} = $5{\cdot}8 \times 10^{-1}$ S/m.

(iii) By what percentage the EM power density at 50 Hz reduces in a copper shield per skin depth.

(iv) Why is the attenuation offered by iron to the EM wave much higher than that of copper ?

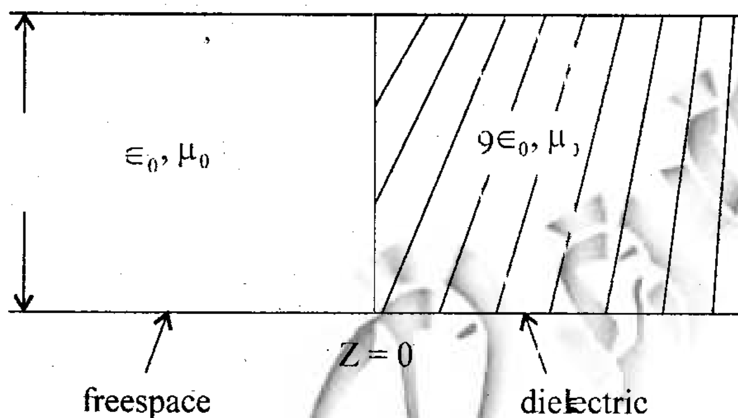
(v) Why is the magnetic field intensity higher than electric field intensity in a good conductor when the EM wave is attenuated ? 5

(c) If a lossless transmission line of length 2 m which is less than quarter wave length has open and short circuit impedances at the input as $-j50\ \Omega$ and $j100\ \Omega$ respectively, find

(i) Z_0 and r of the line

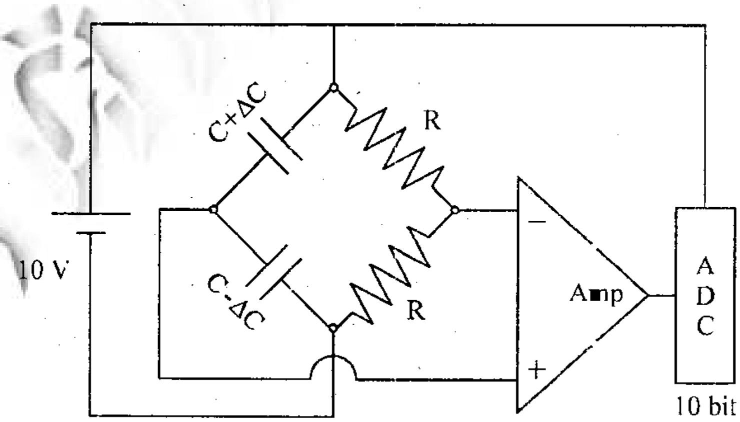
(ii) How long should the short circuited line be in order for it to appear as an open circuit at the input terminals ? 10

(d) For a parallel plate wave guide shown in figure below :



Find the power reflection coefficients for TE_{10} and TM_{10} waves of frequency 5 GHz incident on the junction from the free space side. 10

7. (a)



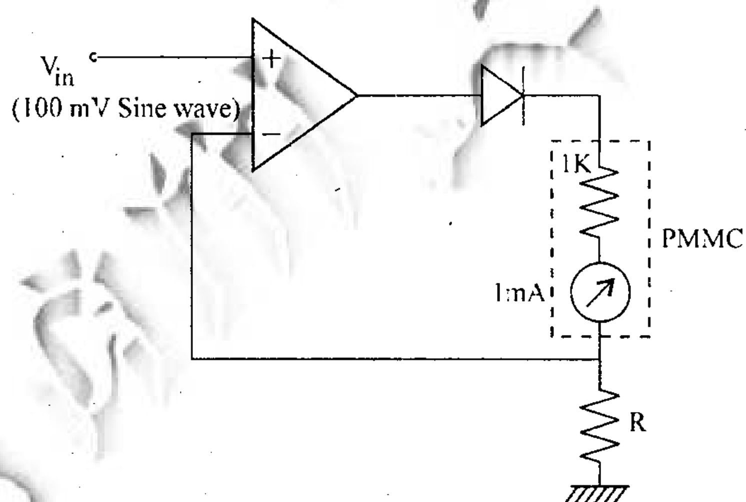
Distinguish between Active and Passive Transducers with examples. A capacitance displacement transducer is interfaced to an amplifier and a 10 bit ADC as shown above. Given the change in the capacitance for a full scale displacement is ± 5%, find the 15

(i) gain of the amplifier

(ii) Resolution of the ADC in volts and the

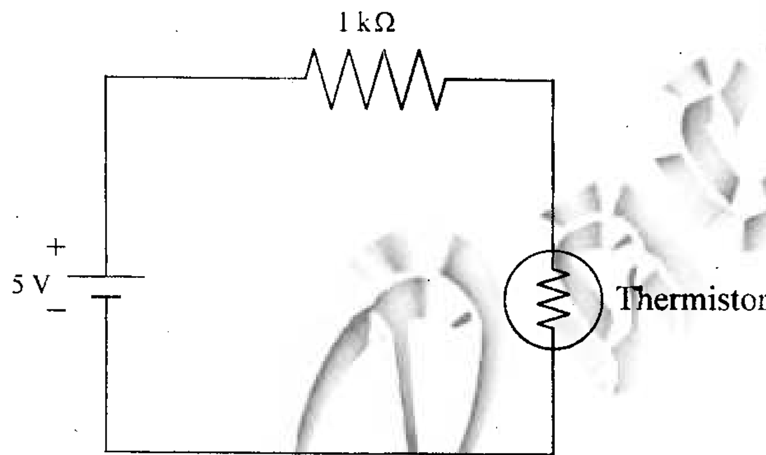
(iii) change in sensitivity of the system when the supply voltage decreases by 5%.

(b)



An electronic voltmeter uses a PMMC ammeter with an FSD of 1 mA and a coil resistance of 1 kΩ as shown above. Calculate R that gives full scale deflection when a sinusoid input of 100 mV is applied. 5

(c)



Calculate the Power dissipated in the thermistor shown in the circuit when operated at 150°C. The resistance of the transducer changes as given in the table.

Temp.	Resistance
25°C	10 kΩ
100°C	1 kΩ

10

(d) In a Telemetry system measurement data is transmitted to a remote location using an 8-bit PCM encoding.

(i) Determine the Channel Capacity if the Bandwidth is 300 kHz and the SNR = 15. 5

(ii) Many transducers data are multiplexed (TDM) with each channel Bandwidth not exceeding 2 kHz. What is the maximum number of channels that can be accommodated in this scheme ? 5

A–GTD–O–SABB

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Paper—II

(Conventional)

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INSTRUCTIONS

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1. *(a)* An amplifier has a high frequency response given by

$$A = \frac{A_0}{1 + j\frac{\omega}{\omega_2}}$$

where $A_0 = 1000$ and $\omega_2 = 10^4$ rad/sec.

Find the –ve feedback factor β which will raise the upper corner frequency ω_2 to 10^5 rad/sec. What is the corresponding overall gain of the amplifier? Find also the gain-bandwidth product in each case. 5

(b) For the circuit shown in Fig. 1 *(b)*, show that the output v_o is given by a differential equation. The input is kept at constant V volts. 5

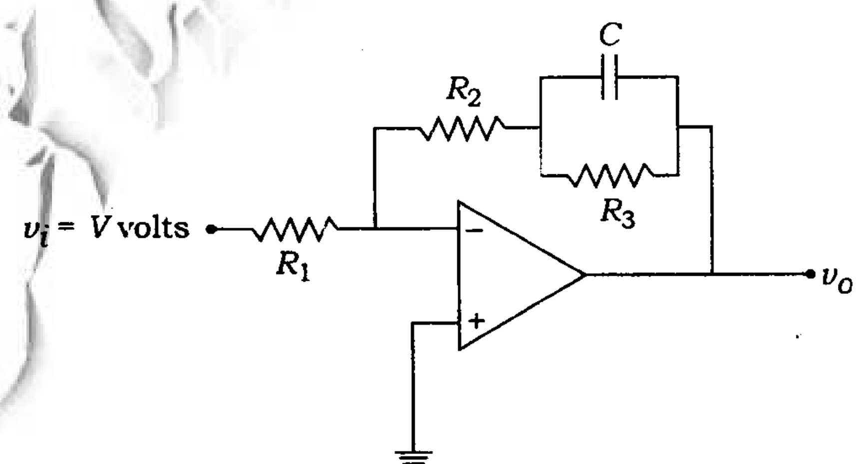

Fig. 1 *(b)*

(c) A digital logic has three inputs A, B and C. The output Y is equal to 1 if two or three inputs are 0.

(i) Write the truth table.

(ii) From the truth table, obtain the Boolean expression for Y.

(iii) Minimize Y and draw the logic block diagram using NAND gates. 5

(d) Reduce the combinational logic circuit shown in Fig. 1 *(d)* such that the desired output can be obtained using only one gate. 5

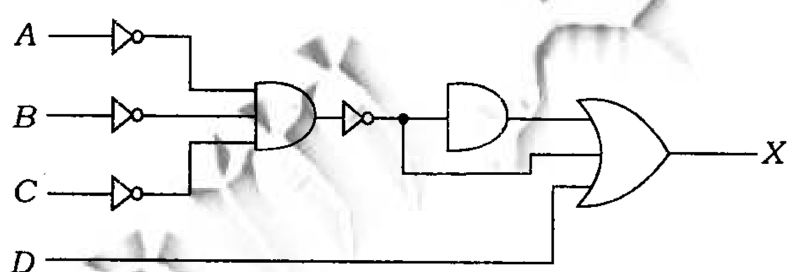

Fig. 1 *(d)*

(e) The transient test on a unity feedback second-order system gave the following data :

Settling time, $t_s = 0{\cdot}8$ sec (2%)
Positional error constant, $K_p = 5{\cdot}25$
Peak overshoot, $M_p(\%) = 16\%$

Find the transfer function of the system. 5

(f) Three students A, B and C are given a problem in Maths. The probabilities of their solving the problem are $\frac{3}{4}$, $\frac{2}{3}$ and $\frac{1}{4}$ respectively. Determine the probability that the problem is solved if all of them try to solve the problem. 5

(g) For a GaAs Gunn diode, following are the major specifications given :

Threshold field $(E_{th}) = 2800$ V/cm

Applied field $(E) = 3200$ V/cm

Frequency of operation $(f) = 10$ GHz

Doping concentration (n_0) $= 2 \times 10^{14} / \text{cm}^3$

Length of Gunn device $(L) = 10$ μm

In the above case, compute—

(i) electron drift velocity;

(ii) current density;

(iii) negative electron mobility. 5

(h) What is the meaning of different parts of the address stored in a pointer under Windows environment? 5

2. *(a)* A common-emitter class–A power amplifier circuit is shown in Fig. 2 *(a)*, where $V_{CC} = 15$ V, $R_L = 1$ K and $R_e = 0{\cdot}5$ K. Calculate the—

(i) power supplied by the collector for symmetrical swing;

(ii) power dissipated in the load and in the emitter resistor;

(iii) power dissipated in the transistor;

(iv) efficiency (η) of the operation. 10

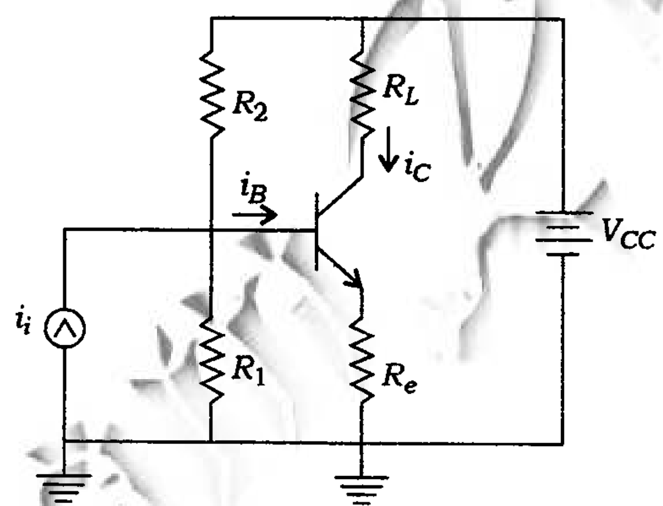

Fig. 2 *(a)*

(b) *(i)* Design a logic circuit to convert Excess-3 code to BCD.

(ii) Draw the truth table.

(iii) Consider "don't cares" in the simplification.

(iv) Realize using discrete gates. 10

(c) (i) The antenna current of an AM broadcast transmitter, modulated to a depth of 40 percent by an audio sine wave, is 11 amperes. It increases to 12 amperes as a result of simultaneous modulation by another audio sine wave. What is the modulation index due to this second wave? 5

(ii) A certain transmitter radiates 9 kW with the carrier unmodulated and 10·125 kW when the carrier is simultaneously modulated. Estimate the modulation index. If another sine wave, corresponding to 40% modulation, is transmitted simultaneously, find out the total radiated power. 5

(d) Write an 8085 assembly language program to subtract two numbers of 16-bit data stored in memory from 4200 H to 4203 H. The data are stored such that low byte first and then high byte. Store the result in 4204 H and 4205 H. Draw also the flowchart for the program. 10

3. *(a)* Figure 3 *(a)* shows a two-transistor current source.

The circuit parameters are

$$V^+ = 5\text{ V},\ V^- = -5\text{ V and } R_1 = 9{\cdot}3\text{ k}\Omega$$

The transistor parameters are

$$\beta = 50,\ V_{BE(on)} = 0{\cdot}7\text{ V and } V_A = 80\text{ V}$$

Determine the change in load current I_O when V_{CE_2} changes from 0·7 V to 5 V. 10

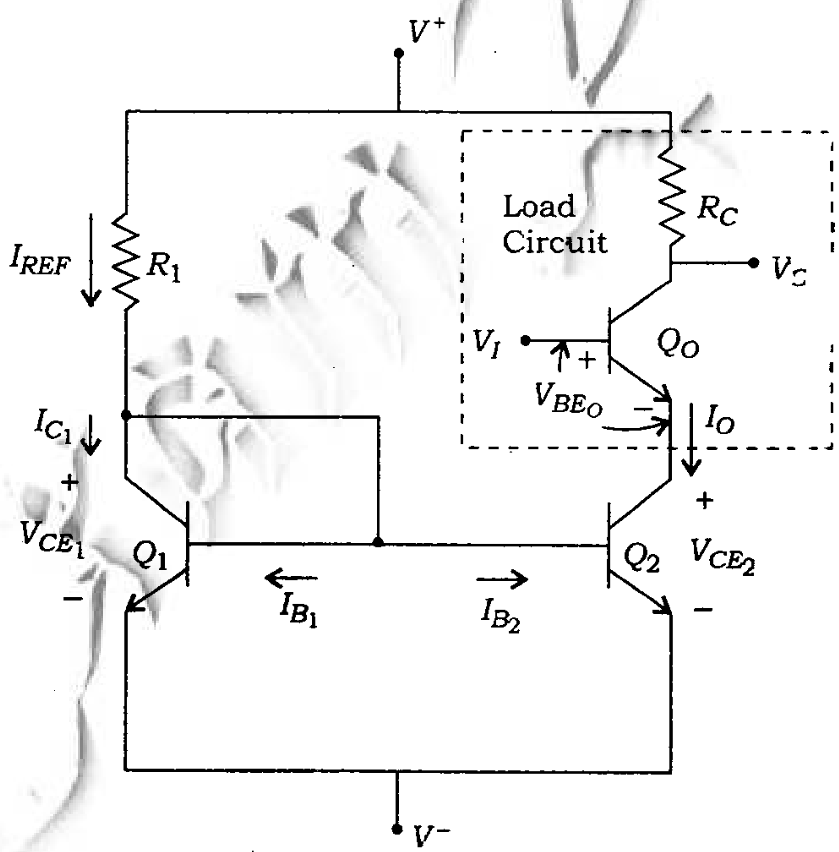

Fig. 3 *(a)*

(b) The truth table for *AB* flip-flop is shown below. Design this flip-flop using *J-K* flip-flops and additional logic gates. 10

Truth table

A_n	B_n	Q_{n+1}
0	0	$\overline{Q}_n$
0	1	Q_n
1	0	1
1	1	0

(c) Calculate the ratio of the cross-section of a circular waveguide to that of a rectangular one if each is to have the same cutoff wavelength for its dominant mode. 10

(d) *(i)* What is multiplexing and what is its advantage? 3

(ii) How is clock signal generated in 8086? What is the maximum internal clock frequency of 8086? 5

(iii) Write the flags of 8086. 2

4. *(a)* The open-loop transfer function of a feedback control system is given by

$$G(s)\,H(s) = \frac{K(s+8)(s+10)}{s(s+1)(s+2)}$$

(i) Using Routh-Hurwitz criterion, prove that the system is a conditionally stable system and determine the range of value of K for which the system is stable. 5

(ii) Determine the values of K which will cause sustained oscillations in the closed-loop system. What are the frequencies of oscillations? 5

(b) Construct the root locus for a feed-back control system whose open-loop transfer function is given by

$$G(s)\,H(s) = \frac{K}{s(s+4)(s^2+4s+8)}$$

Show all the salient points in the sketch. 15

(c) The open-loop transfer function of a feedback control system is given by

$$G(s)\,H(s) = \frac{50}{s(1+0\cdot1\,s)(1+0\cdot2\,s)}$$

Determine stability using Nyquist plot. 15

5. *(a)* Obtain the mathematical expression for the output voltage v_o of the circuit shown in Fig. 5 *(a)*. Hence identify the function of the circuit. 10

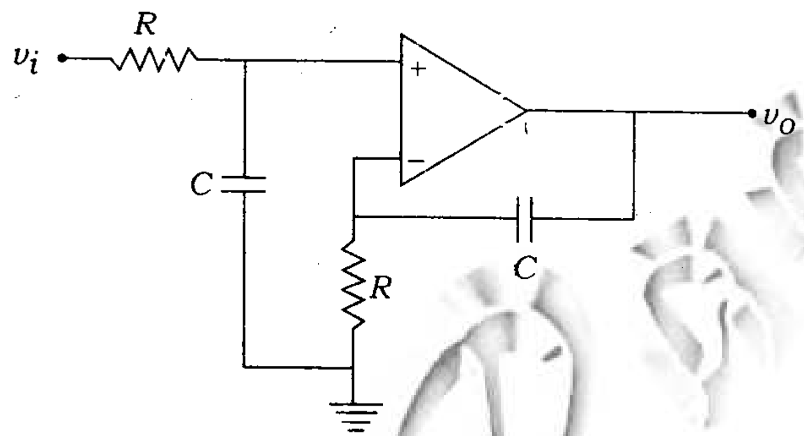

Fig. 5 *(a)*

(b) Design a logic circuit that controls an elevator door in a three-storied building. The circuit shown in Fig. 5 *(b)* has four inputs. M is a logic signal that indicates when the elevator is moving ($M = 1$) or stopped ($M = 0$). $F1$, $F2$ and $F3$ are floor indicator signals that are normally LOW, and they go HIGH only when the elevator is positioned at the level of that particular floor. For example, when the elevator is lined up with the second floor, $F2 = 1$ and $F1 = F3 = 0$. The circuit output is the OPEN signal which is

normally LOW and is to go HIGH when the elevator door is to be opened. 10

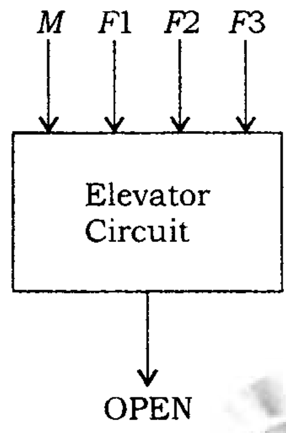

Fig. 5 *(b)*

(c) A PCM system uses a uniform quantizer followed by a 7-bit binary encoder. The bit rate of the system is equal to 50×10^6 bits/sec.

(i) What is the maximum message signal bandwidth for which the system operates satisfactorily? 5

(ii) Calculate the output signal to quantization noise ratio, when a full-load sinusoidal modulating wave of frequency 1 MHz is applied to the input. 5

(d) *(i)* What are the characteristics of EPROM? 2

(ii) Compare the memory mapped I/O and standard I/O mapped I/O. 5

(iii) What is masking and why is it required? 3

6. *(a)* The amplifier shown in Fig. 6 *(a)* utilizes an n-channel FET for which $V_p = -2 \cdot 0$ V and $I_{DSS} = 1{\cdot}65$ mA. It is required to bias the circuit at $I_{DS} = 0{\cdot}8$ mA using $V_{DD} = 24$ V. Assume $r_d >> R_d$.

Find *(i)* V_{GS}, *(ii)* g_m, *(iii)* R_S and *(iv)* R_d such that the voltage gain is at least 20 dB with R_S bypassed with a very large capacitor C_S. 10

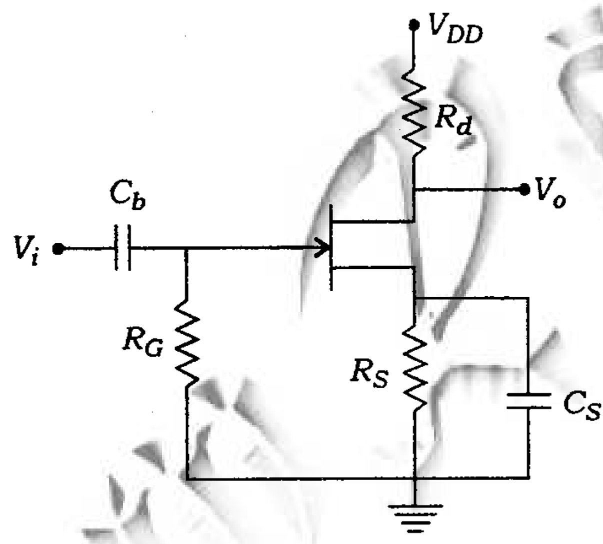

Fig. 6 *(a)*

(b) *(i)* Draw the circuit of MOD-6 Johnson counter (twisted ring counter) using D FFs.

(ii) Draw the waveform.

(iii) Write the sequence table.

(iv) Draw the state diagram.

(v) Develop the decoding circuit for MOD-6 Johnson counter using 2-input AND gates. 10

(c) When the mean optical power launched into an 8 km length of fibre is 120 μW, the mean optical power at the fibre output is 3 μW. Now evaluate the following :

(i) Overall signal attenuation or loss in decibels through the fibre, assuming there are no connectors or splices 4

(ii) Signal attenuation per kilometre for the fibre 2

(iii) Overall signal attenuation for a 10 km optical link using the same fibre with splices at 1 km intervals, each giving an attenuation of 1 dB 4

(d) (i) What is RS–232 C standard? How is the RS–232 C serial bus interfaced to TTL logic device? 4

(ii) Write the different operating modes of port–A of 8255 (PPI). 3

(iii) Explain the working of handshake input port. 3

7. *(a)* A two-stage voltage series feedback amplifier circuit is shown in Fig. 7 *(a)*. The parameter values of the transistors used are

$$h_{fe} = 50, \quad h_{ie} = 1 \cdot 1 \text{ K}, \quad h_{re} = h_{oe} = 0$$

Assume that $R_S = 0$. The values of the resistors and capacitors used are also shown in the figure. Calculate A_{vf}, R'_{of} and R_{if} for the feedback amplifier. 10

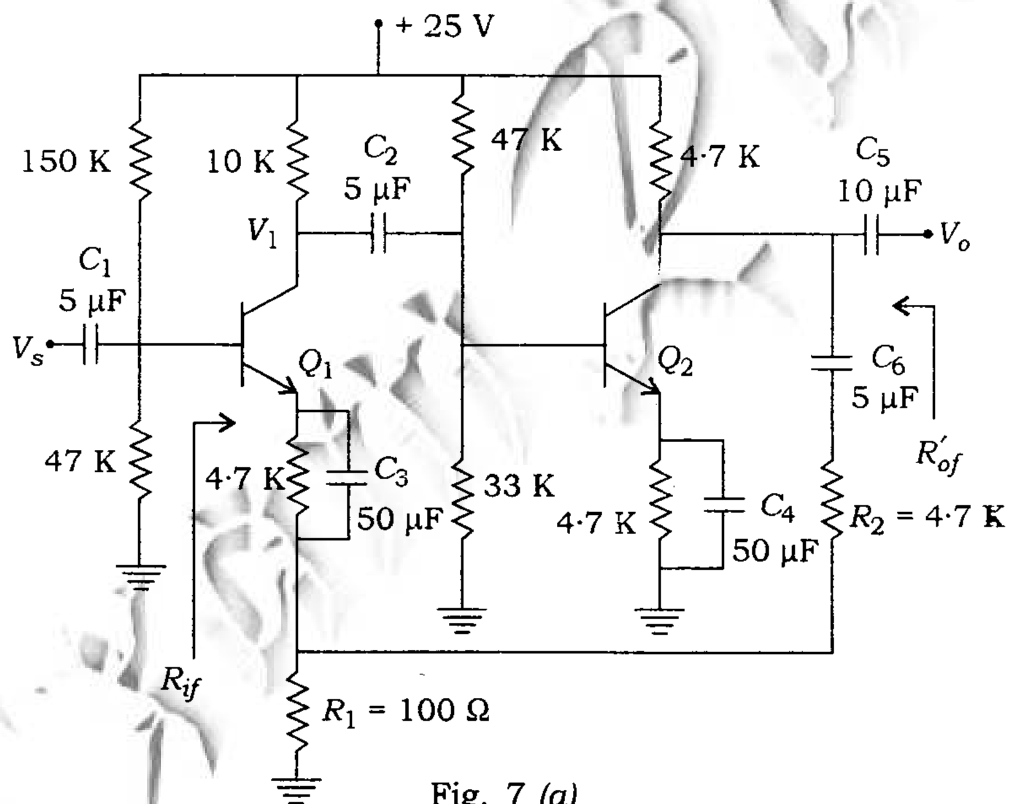

Fig. 7 *(a)*

(b) What is the 'magic' in a magic tee? How does a Faraday four-port circulator work? Why are slow-wave structures essential for the operation of TWT? Give sketches of three slow-wave structures. 10

(c) (i) Draw an electronic circuit of a PID controller where the three different gains may be controlled independently. 5

(ii) Explain the effect of different controllers (P, I and D) on the transient and steady-state performance of feedback control system. 5

(d) (i) A rectangular waveguide with a 5 cm × 2 cm cross-section is used to propagate TM_{11} mode at 10 GHz. Calculate the cutoff wavelength and the characteristic impedance. 5

(ii) Sketch an experimental setup to measure the frequency of a microwave signal without using a frequency meter, and explain its measurement technique. 5

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