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.

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

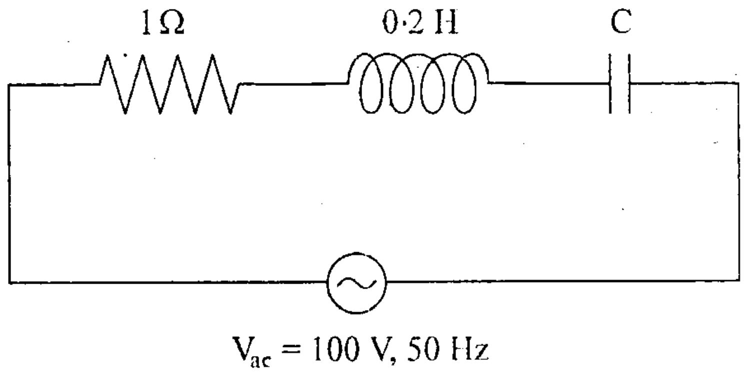
   (b) (i) Draw the structure of Schottky-barrier photodiode. 1

   (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 nΩ 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}, $a = 0{\cdot}3\ \mu$m, $L = 1{\cdot}2\ \mu$m 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

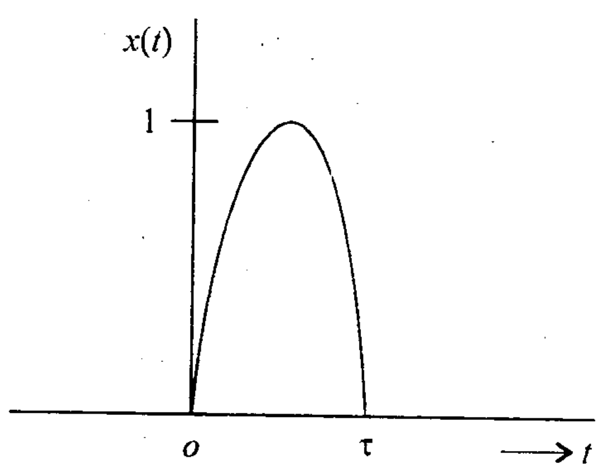
(e) Draw the geometry of a typical tunnel diode and its equivalent circuit. Sketch the V-I characteristics and explain the existence of negative resistance. 10

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

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

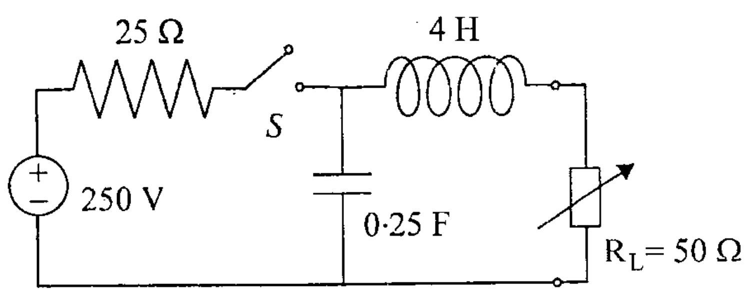
(i) $x(t) = t$

(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

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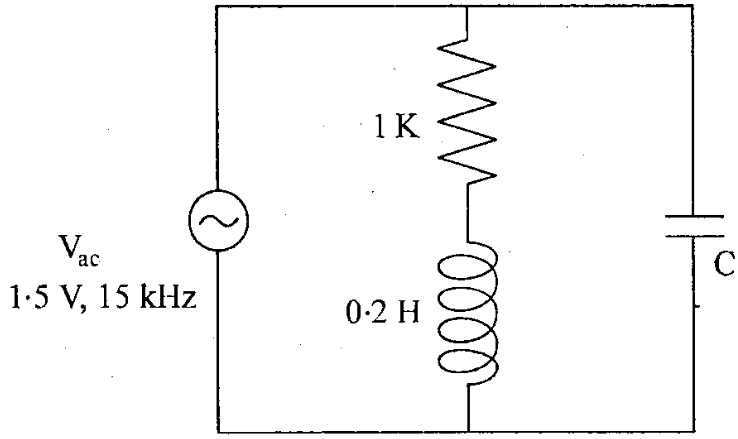
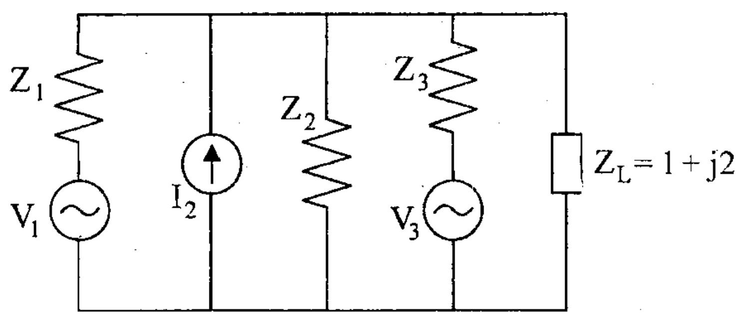
(b)



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

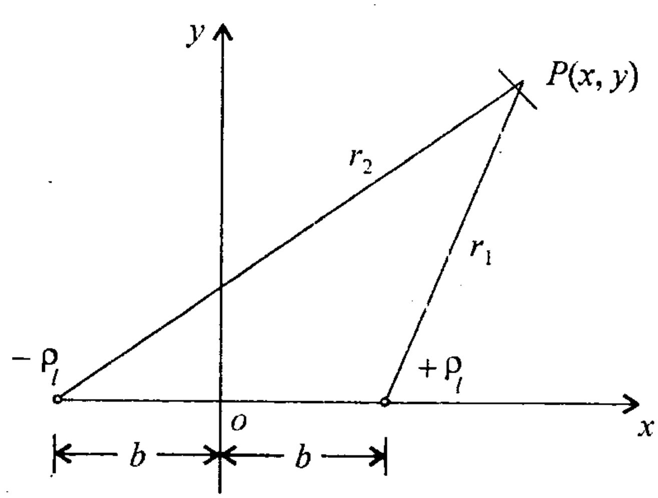


$V_1 = 2\angle 0°$ volts, $I_2 = 1\angle 0°$ Amp

$V_3 = 5\angle 5°$ 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 $\sigma_{copper} = 5 \cdot 8 \times 10^{-1}$ 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 ?

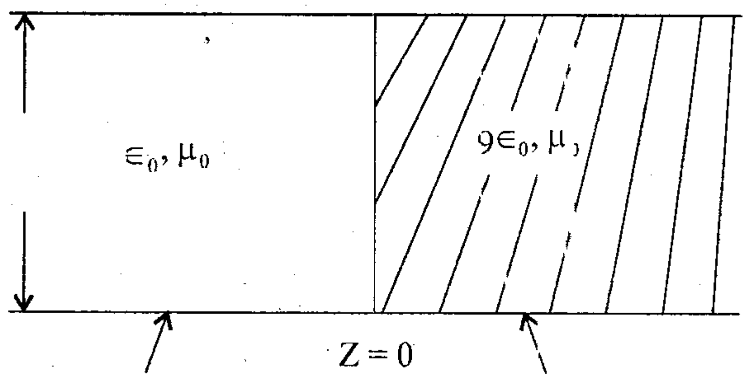
(v) Why is the magnetic field intensity higher than electric field intensity in a good conductor when the EM wave is attenuated ? 5

(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 Ω and j100 Ω respectively, find

(i) Z_0 and r of the line

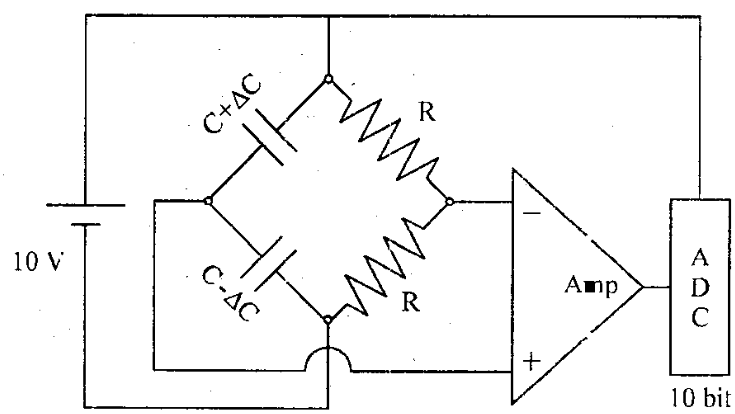
(ii) How long should the short circuited line be in order for it to appear as an open circuit at the input terminals ? 10

(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)



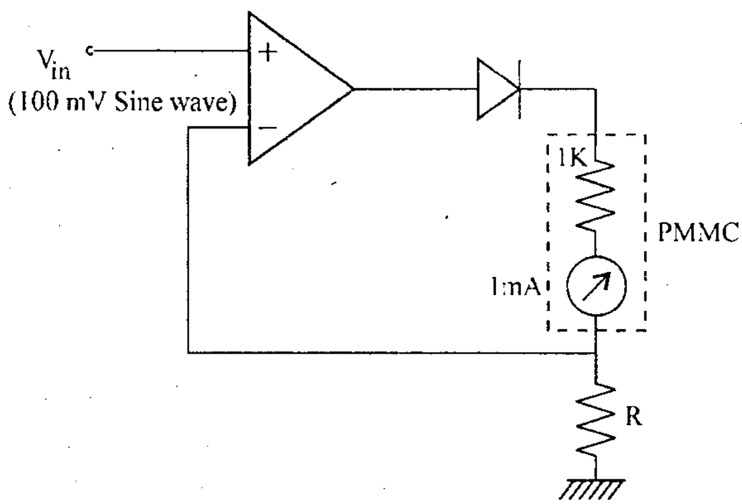
Distinguish between Active and Passive Transducers with examples. A capacitance displacement transducer is interfaced to an amplifier and a 10 bit ADC as shown above. Given the change in the capacitance for a full scale displacement is ± 5%, find the 15

(i) gain of the amplifier

(ii) Resolution of the ADC in volts and the

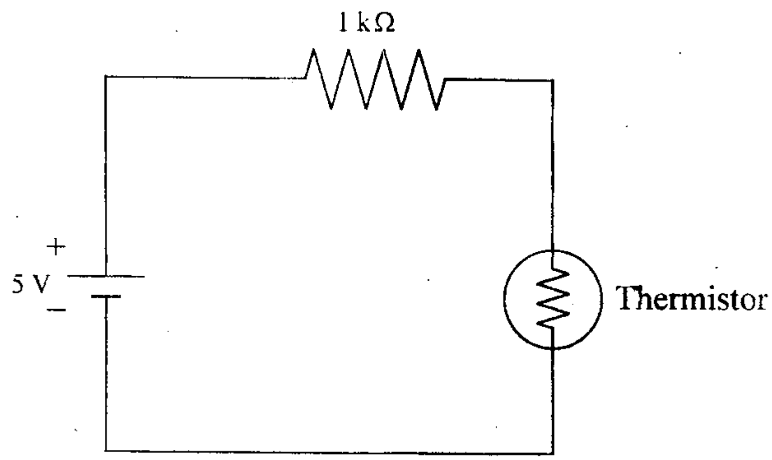
(iii) change in sensitivity of the system when the supply voltage decreases by 5%.

(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