

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 :*

$$\text{Electronic charge} = -1.6 \times 10^{-19} \text{ coulomb}$$

$$\text{Free space permeability} = 4\pi \times 10^{-7} \text{ Henry/m}$$

$$\text{Free space permittivity} = (1/36\pi) \times 10^{-9} \text{ Farad/m}$$

$$\text{Velocity of light in free space} = 3 \times 10^8 \text{ m/s}$$

$$\text{Boltzmann constant} = 1.38 \times 10^{-23} \text{ J/K}$$

$$\text{Planck constant} = 6.626 \times 10^{-34} \text{ J-s}$$

*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

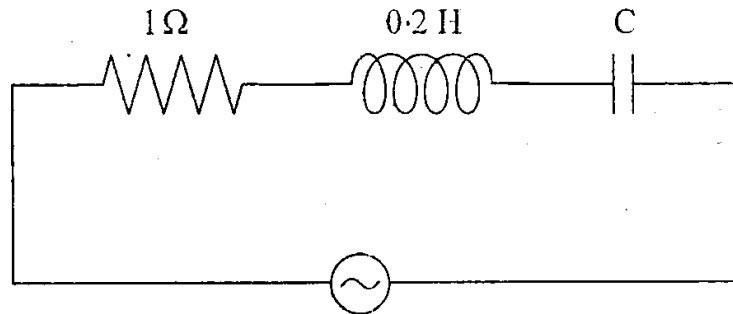
(b) (i) Draw the structure of Schottky-barrier photodiode. 1

(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)



$$V_{ac} = 100 \text{ V}, 50 \text{ Hz}$$

A series  $RLC$  circuit with  $R = 1 \Omega$ ,  $L = 0.2 \text{ H}$  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  $8.49 \times 10^{28}$  electrons/ $\text{m}^3$ . 4
- (f) A lossless transmission line 100 cm long with operating frequency of 500 MHz having  $L = 0.2 \mu\text{H}/\text{m}$  has a phase velocity of  $2 \times 10^8$  m/sec. Find the line's capacitance per metre. 5

(g) The current from a photodiode changes from  $100 \mu\text{A}$  to  $200 \mu\text{A}$  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  $70 \text{ n}\Omega \text{ m}$ . 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  $1 \text{ cm}^2$ . The atomic concentration of Si is  $5 \times 10^{28}/\text{m}^3$ . The mobilities of electrons and holes are respectively  $1500 \text{ cm}^2/\text{v.s}$  and  $450 \text{ cm}^2/\text{v.s}$  respectively. Given  $n_i = 1.5 \times 10^{10}/\text{cm}^3$ . 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  $\epsilon_r(\text{GaAs}) = 13.1$ . 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  $N_D = 10^{18} \text{ cm}^{-3}$ ,  $a = 0.3 \mu\text{m}$ ,  $L = 1.2 \mu\text{m}$  if  $\epsilon_s = 13 \times 8.854 \times 10^{-12} \text{ F/m}$ . Calculate pinchoff voltage. 10

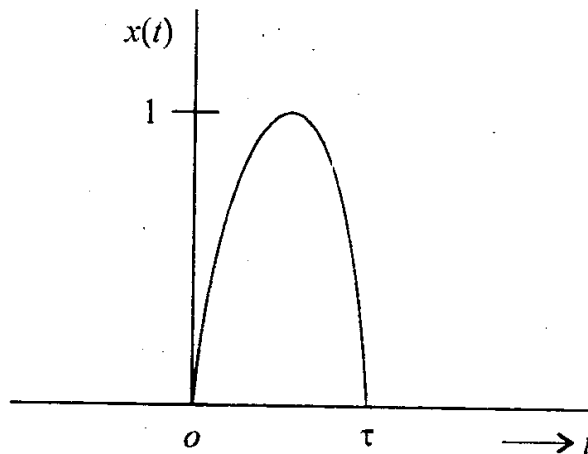
- (c) Explain Floatzone technique to reduce the impurities in the crystalline rod of semiconductor material. 5
- (d) Give reasons for choosing silicon for fabricating general purpose IC chips. 5
- (e) Draw the geometry of a typical tunnel diode and its equivalent circuit. Sketch the V-I characteristics and explain the existence of negative resistance. 10

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

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

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

(b)



Find the Fourier transform of the above sinusoidal pulse. 10

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

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

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

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

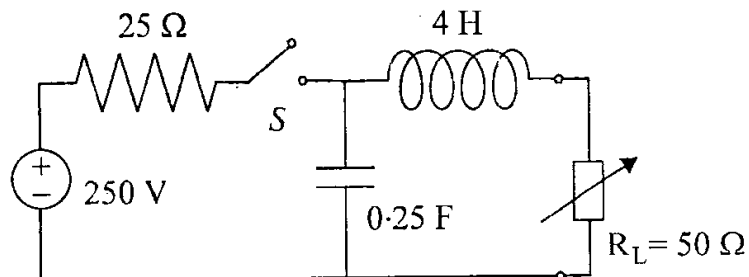
(i)  $x(t) = t$

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

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

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

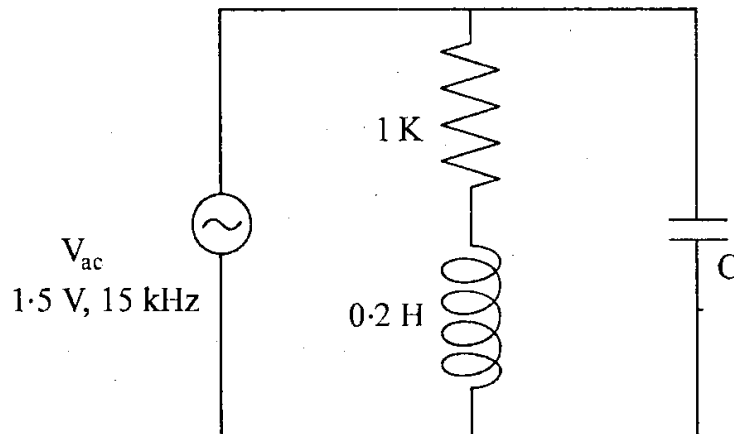
5. (a)



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)

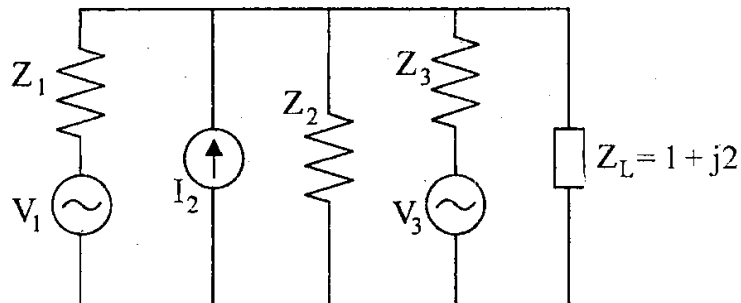


For the circuit shown above, show that the

$$\text{resonant frequency } f_o = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

Calculate  $C$  when the supply current is minimum. 10

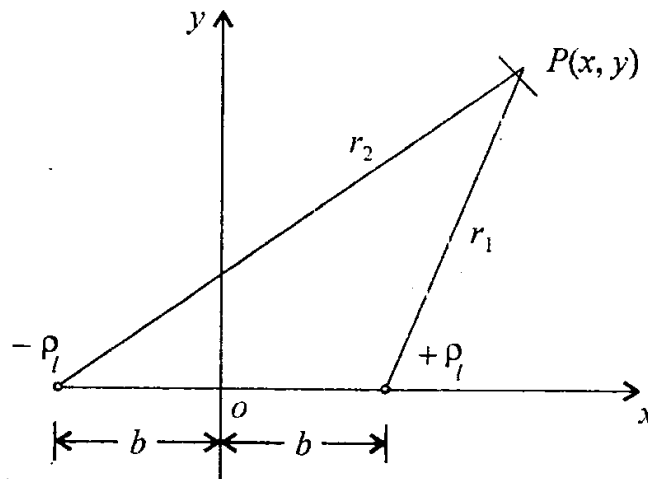
(c) State Millman's theorem and illustrate. For the circuit shown below, obtain the Millman's equivalent generator and determine the current in the load,  $Z_L = (1 + j2) \Omega$ . 15



$$V_1 = 2 \angle 0^\circ \text{ volts}, I_2 = 1 \angle 0^\circ \text{ Amp}$$

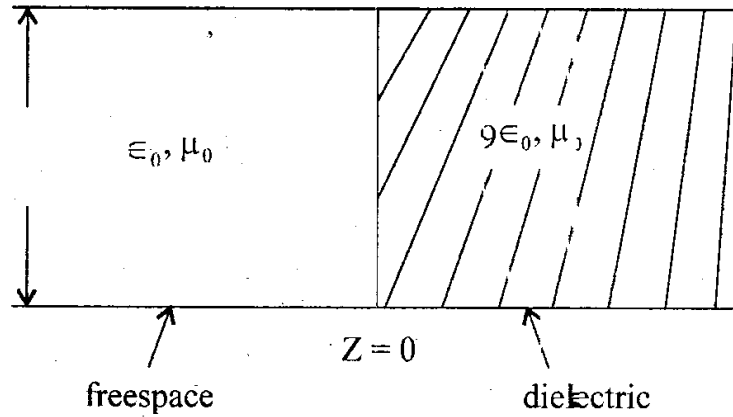
$$V_3 = 5 \angle 5^\circ \text{ volts}, Z_1 = 1.5 \Omega, Z_2 = 5 \Omega, Z_3 = 3 \Omega$$

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



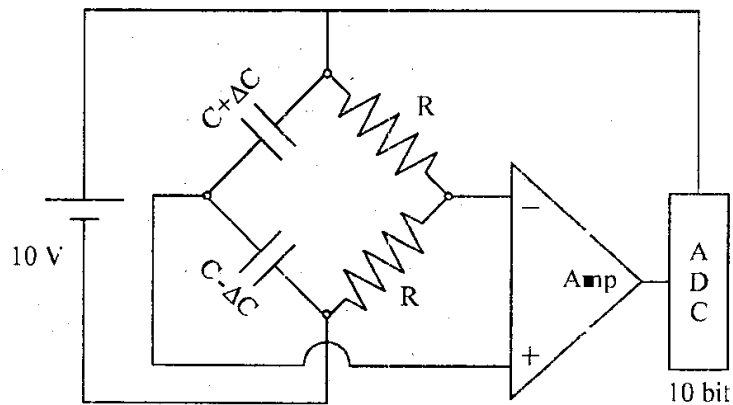
- (b) (i) Why are copper bus-bars at electrical power substations hollow though they are carrying large current magnitudes at 50 Hz.
- (ii) Compare the wavelengths of 50 Hz EM wave in air and in copper if  $\sigma_{\text{copper}} = 5.8 \times 10^{-1} \text{ S/m}$ .
- (iii) By what percentage the EM power 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

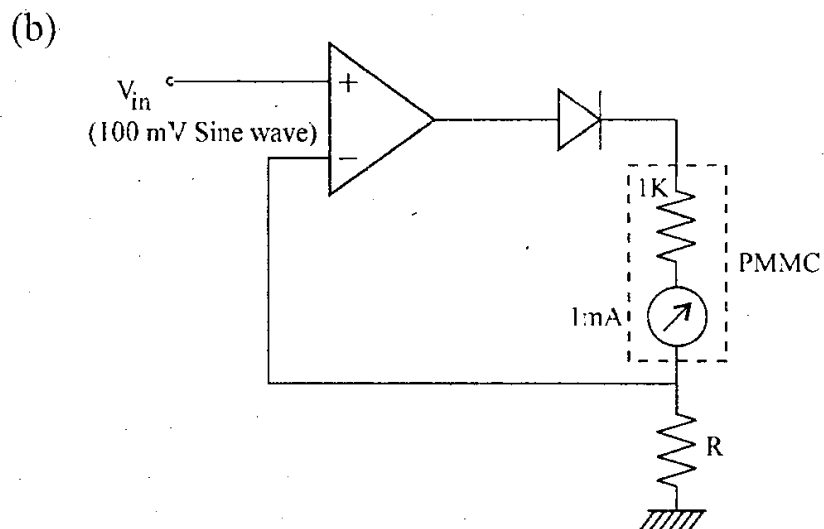
7. (a)



Distinguish between Active and Passive Transducers with examples. A capacitance

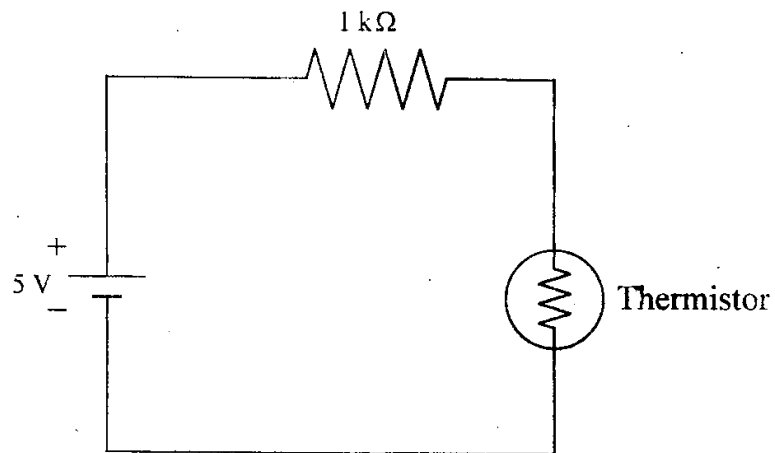
displacement transducer is interfaced to an amplifier and a 10 bit ADC as shown above. Given the change in the capacitance for a full scale displacement is  $\pm 5\%$ , find the 15

- (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%.



An electronic voltmeter uses a PMMC ammeter with an FSD of 1 mA and a coil resistance of 1 k $\Omega$  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  $150^\circ\text{C}$ . The resistance of the transducer changes as given in the table.

Temp.	Resistance
$25^\circ\text{C}$	$10\text{ k}\Omega$
$100^\circ\text{C}$	$1\text{ k}\Omega$

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