Conventional Paper–I-2012

1. (a) Avalanche breakdown can occur at large reverse voltage whereas Zener breakdown occurs at low voltage. Give reasons.

A 15 V Zener diode is connected in series with a forward-biased silicon diode for constructing a zero-temperature-coefficient voltage reference. The temperature coefficient of the silicon diode is $-1.7\text{mV}/^{o}\text{C}$. Find the required temperature coefficient of the Zener diode in per cent per degree.

(b) (i) Certain metal works as superconductor below the critical temperature $T_C = 7.2^{o}\text{K}$. The critical magnetic field for the metal at 0^{o}K is 7.8×10^{5} Amp / m. What is the critical magnetic field for the metal to be usable as superconductor at 5^{o}K?

(ii) A semiconductor has a band gap of 0.62 eV. Find the maximum wavelength for resistance change in the material by photon absorption

$\left(\text{Note}: 1\text{eV} = 1.6\times10^{-19}\text{ Joules}\right)$

(c) Evaluate the following convolution:

$y[n] = x_1[n] * x_2[n] * x_3[n]$

where $x_1[n] = 0.5^{n}u[n]$

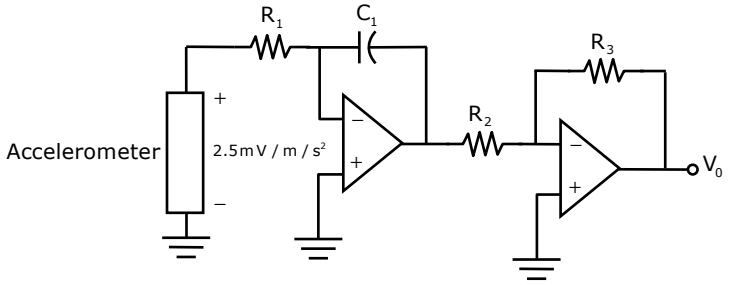
$x_2[n] = u[n+3]$

$x_3[n] = \delta[n] - \delta[n-1]$

(d) Find the potentials at $\gamma_A = 4\text{m}$ and at $\gamma_B = 16\text{m}$ due to a point charge $Q = 900\text{PC}$ at the origin and zero reference at infinity. Also find the potential at γ_A with respect to γ_B

(e) Determine the time taken for the charge density ρ_0 introduced in the interior of a copper conductor to move to the surface and redistribute themselves under equilibrium conditions, if $\sigma = 5.8\times10^{7}\text{ S/m}, \in \simeq 8.85\times10^{-12}\text{ F/m}$ for copper. Assume that the charge redistribution is complete in five time constants. What percentage of ρ_0 is remaining after one time constant.

(f)



A piezoelectric accelerometer is used with the signal conditioning circuit shown above. The accelerometer provides an output of $2.5\,\text{mV}$ per m/s^2

Determine the values of R_1, C_1, R_2 and R_3 such that the system translates this accelerometer output to a velocity output V_0 of 0.25 volt per m/s

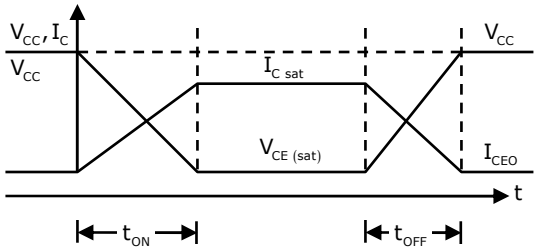
2. (a) Explain the following statements:
   (i) The temperature coefficient of metal resistors is positive
   (ii) The temperature coefficient of resistance in semiconductors is-negative
   (iii) In the linear region operation of MOSFET drain current decreases as the temperature increases
   (iv) In the active region, as temperature increases the current in BJT increases
   (v) The temperature coefficient of resistance in Thermistors is negative

   (b) Discuss the difference in covalent bonding in carbon as
   (i) Diamond
   (ii) Graphite

   (c) What is the basic building block of a CMOS integrated circuit? Draw a neat sketch to illustrate the structure of the basic building block and explain the role of various regions in it

3. (a) Draw E-K diagram of GaAs with two conduction band minima. Hence explain the negative resistance characteristics of Gunn diode.

   (b)



The switching waveforms of collector current I_C and collector to emitter voltage V_{CE} of a power BJT operating at 10 kHz are shown in the above figure.
If $V_{CC} = 200\,\text{V}; I_{csat} = 10\,\text{A}$, turn-on time $t_{ON} = 2$ microsecond, turn-off time $t_{OFF} = 5$ microsecond. Determine
(i) looking at the diagram, the point at which the peak power loss will occur
(ii) average power loss during t_{ON} and t_{OFF}
(iii) total average switching power loss of the device
Neglect $V_{CE(sat)}$, collector to emitter leakage current I_{CEO} and power loss due to base current

   (c) Discuss the capacitance-voltage characteristics of varactor diodes with their applications

4. (a) A continuous time LTI system whose input x(t) and output Y(t) are related by the following differential equation:

$$\frac{d}{dt}y(t)+4y(t)=x(t)$$

Find the Fourier series representation of the output y(t) for the input

$$x(t)=\sin 4\pi t+\cos\left(6\pi t+\frac{\pi}{4}\right)$$

(b) Develop a state-space description of a causal LTI system described by the difference equation

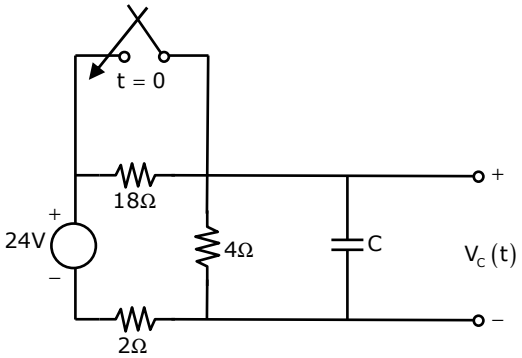
$$y[n]+0.8\ y[n-1]+0.6\,y[n-2]+0.4\,y[n-3]$$
$$=0.4\ x[n]+0.6\,x[n-1]+x[n-2]+0.8\,x[n-3]$$

(c) The z transform of a causal sequence h[n] is given by

$$H(z)=\frac{z(z+2.0)}{(z-0.2)(z+0.6)}$$

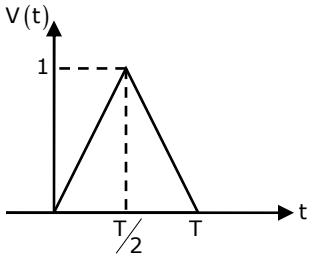
Find h[n]

5. (a)



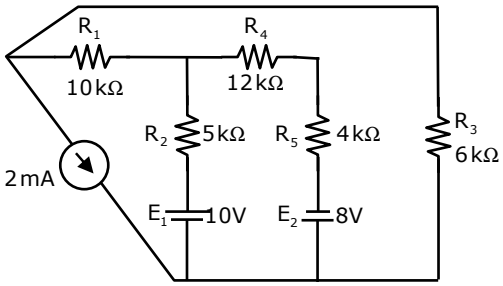
Find the value of capacitor C in the circuit shown above, if the voltage across the capacitor is $v_c(t)=16-12e^{-0.6t}$ for $t>0$ and the switch which was initially open is closed at $t=0$. The circuit had attained steady state before closing of the switch.

(b)



An initially relaxed series R-L circuit is fed from a voltage pulse source of triangular shape as shown in the above figure. Find the current in the circuit, $i(t)$, if $R=1\Omega$ and $L=1H$ and $T=2s$

(c)



Solve for the current through R_2 and R_3 in the circuit shown above.

6. (a) A traveling $\vec{E}$ field in free space of amplitude 100 V / m and frequency of 200 MHz is normally incident on a sheet of silver of thickness $5\mu m$ (micrometers). If conductivity of silver is $61.7\ MS/m$ find the amplitude of $\vec{E}$ field emanating from the opposite surface of the sheet

(b) Two parallel conducting planes in free space are at $y = 0$ and $y = 0.04\,m$, and zero voltage reference is at $y = 0.02m$. If $D = 126\,a_y\ nC/m^2$ between the conductors, determine the conductor voltages

(c) Derive the expression for radiation efficiency of an isolated Hertzian dipole made of copper wire in free space. Calculate its radiation efficiency if the radius of the wire is 1.8 mm, $dl = 2m$, $f = 1.5\,MHz$, and $\sigma = 5.8\times10^7\ S/m$

7. (a) What is the basis for classifying transducers into either 'Active' or 'Passive'? Separate the following list of transducers into 'Active' or 'Passive' categories:

Resistive Strain Gauge	Photodiode
LVDT	Thermocouple
Piezoelectric material	Photoconductive materials
Thermistor	Tachogenerator

(b) Explain how the transfer characteristic of a capacitive displacement transducer may be linearized using
(i) a charge amplifier
(ii) Differential three plate capacitor arrangement with the middle plate sensing displacement

(c) The resistors in the four arms of a strain gauge bridge ABCD with a d.c. supply across A and C are: $R_{AB} = 350\Omega = R_{BC} = R_{CD} = R_{DA}$. R_{BC} constitutes the active gauge (unstrained resistance being 350Ω). R_{CD} is a dummy gauge of the same resistance value. The detector is connected across B and D. The supply voltage is 10V d.c. The active gauge has GF = 2.03. If the gauge in the arm BC is subjected to a strain of $1450\mu m/m$, find the bridge offset voltage.