VIT
Vellore Institute of Technology

Reg. No. : 22BEC1348

**Final Assessment Test (FAT) - JUNE/JULY 2023**

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| Programme | B.Tech. | Semester | Winter Semester 2022-23 |
| Course Title | ELECTRONIC MATERIALS AND DEVICES | Course Code | BECE201L |
| Faculty Name | Prof. S Shoba | Slot | E2+TE2 |
| | | Class Nbr | CH2022232300110 |
| Time | 3 Hours | Max. Marks | 100 |

**PART- A (6 X 5 Marks)**

**Answer All questions**

01. Calculate the drift mobility and the mean scattering time of conduction electrons in copper at room temperature, given that the conductivity of copper is $5.9 \times 10^5\ \Omega^{-1}\ cm^{-1}$. The density of copper is $8.96\ g\ cm^{-3}$ and its atomic mass ($M_{at}$) is $63.5\ g\ mol^{-1}$. If the mean speed of the conduction electrons in $Cu$ is roughly $1.6 \times 10^6\ m\ s^{-1}$, what is the mean free path between collisions? Note that one mole of copper has $N_A$ (*Avogadro's Number* $= 6.02 \times 10^{23}\ mol^{-1}$) number of atoms. [5]

02. The density of quantum states per unit volume of the crystal as a function of energy for a free electron is given by $g(E) = 4\pi(2m)^{3/2} h^{-3} (E)^{1/2}$. Calculate the density of states per unit volume with energies between 0 and 1 eV. ($m = 9.1 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}\ J\ s$) [5]

03. An n-type silicon sample contains a donor concentration of $N_D = 10^{16}\ cm^{-3}$. The minority carrier hole lifetime is found to be $\tau_{p0} = 20\ \mu s$. Assume $n_i = 1.5 \times 10^{10}\ cm^{-3}$. [5]
    (a) What is the lifetime of the majority carrier electrons?
    (b) Determine the thermal-equilibrium generation rate for electrons and holes in this material.

04. The reverse-biased generation current is caused by the generation of electrons and holes in the space charge region, in addition to the ideal reverse-biased saturation current. Determine the relative magnitudes (ratio) of the ideal reverse-saturation current density ($J_s$) and the generation current density ($J_{gen}$) in a reverse-biased $pn$ junction with voltage $V_R$ at $T = 300\ K$ constituting a depletion region of width $W$. Use the required parameters from below for your calculations: [5]

| | |
|---|---|
| $N_a = N_d = 10^{16}\ cm^{-3}$ | $\tau_0 = \tau_{p0} = \tau_{n0} = 5 \times 10^{-7}\ s$ |
| $n_i = 1.5 \times 10^{10}\ cm^{-3}$ | $V_R = 5\ V$ |
| $D_n = 25\ cm^2/s$ | $W = 1.214 \times 10^{-4}\ cm$ |
| $D_p = 10\ cm^2/s$ | $\varepsilon_r = 11.7$ |

05. Determine Q-operating point ($V_{CEQ}$, $I_{CQ}$) of the *npn* transistor circuit shown in Fig.1. Assume $V_{BE} = 0.7\ V$ and $\beta = 50$. Use $V_{BB} = 4\ V$, $V_{CC} = 18\ V$, $R_B = 17.4\ k\Omega$, $R_C = 5.6\ k\Omega$ and $R_E = 1.2\ k\Omega$. [5]

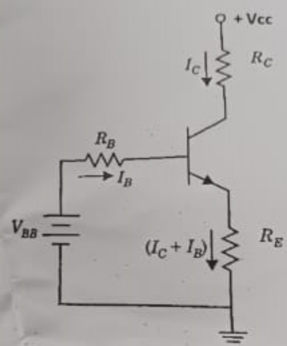


Fig.1

06. Draw and explain the band diagram of an n-channel MOSFET in accumulation, depletion and inversion layer at thermal equilibrium. [5]

## PART - B (7 X 10 Marks)

**Answer All questions**

07. In a Hall effect experiment, a silver slab is placed in a magnetic field. The magnetic field is perpendicular to the largest surface of the slab. The free electron concentration in silver block is $5.85 \times 10^{28}\ m^{-3}$. The current density through the cross section of the slab is $4.4 \times 10^{7}\ Am^{-2}$ and it is perpendicular to the magnetic field. The magnetic field applied is $B = 0.95\ Tesla$. Answer the the following: [10]

(a) Calculate the Hall electric field.

(b) Calculate the Hall coefficient.

(c) A brief discussion on any one of the applications of Hall effect device.

08. Explain the energy band structure (E-k) in semiconductor materials. Using E-k diagrams, distinguish between direct and indirect band gap semiconductors. Explain the band-to-band absorption and recombination processes in both direct and indirect band gap semiconductors using E-k diagrams. [10]

09. The total current in a semiconductor is constant and equal to $J = -10\ A/cm^2$. The total current is composed of a hole drift current and electron diffusion current. Assume that the hole concentration is a constant and equal to $10^{16}\ cm^{-3}$ and assume that the electron concentration is given by $n(x) = 2 \times 10^{15} e^{-x/L}\ cm^{-3}$ where $L = 15\ \mu m$. The electron diffusion coefficient is $D_n = 27\ cm^2/s$ and the hole mobility is $\mu_p = 420\ cm^2/V\text{-}s$. Calculate the following: [10]

(a) the electron diffusion current density for x = 50 µm.

(b) the hole drift current density for x = 50 µm.

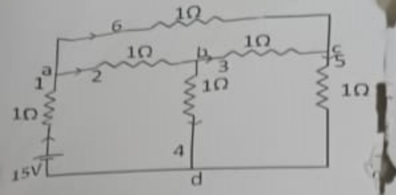

Fig.3

07. In the bridge circuit of Fig.4, $I_1 = 10$ A and $I_2 = -4$ A. [15]

(a) Find $V_1$ and $V_2$ using $y$ - parameters. [10 Marks]

(b) Confirm the results in part (a) using z – parameters [5 Marks]

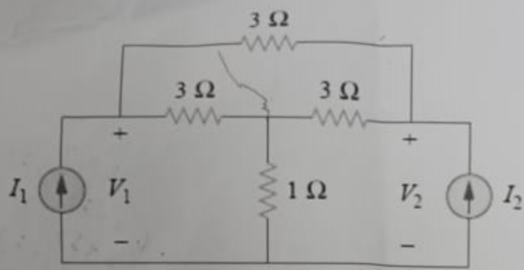

Fig.4

08. Calculate following values in the circuit of Fig.5 using Laplace transform. Assume $v_o(0)$=5V. [15]

(a) $v_o(t)$ **[10 Marks]**, (b) the current flow through the 5Ω and 10Ω resistors. **[5 Marks]**

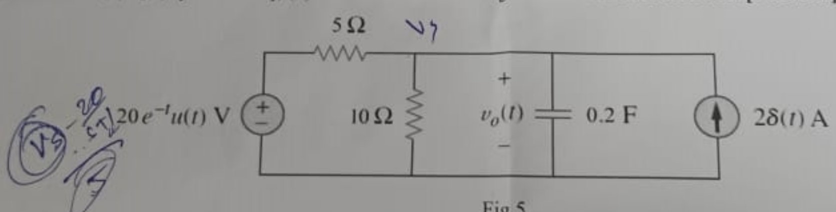

Fig.5

09. (a) Obtain the Fourier series for the periodic function shown in Fig.6. Discuss the evolution of the original function from its Fourier components. Discuss what is meant by the amplitude and phase spectra of the series. **[10 marks]** [15]

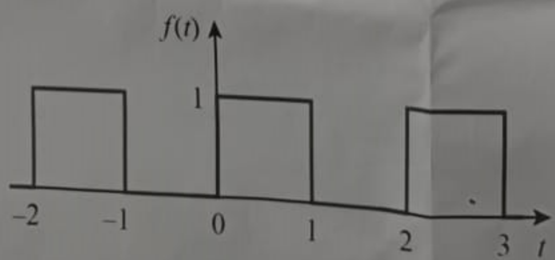

Fig.6

(b) Find $v_0(t)$ in the circuit of Fig.7 using Fourier transform, where $i_s = 5e^{-t}u(t)$ A. **[5 marks]**

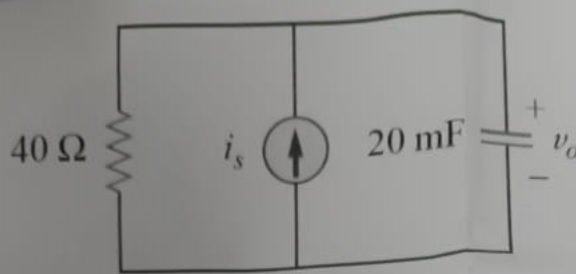


Fig.7