Tutorial 4:

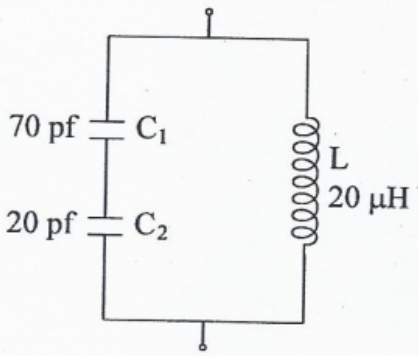
- Intrinsic and extrinsic semiconductors;
- pn-p and n-p-n transistors;
- Amplifiers and oscillators;
- Op-amps;
- FET, JFET and MOSFET

Q1:

. Draw and explain the collector characteristics of a bipolar junction transistor in common emitter configuration. Using the plot, explain how the transistor can be used as an ON-OFF switch. 10 10

2013

Q2:



Explain how the circuit shown above can be a source of oscillations. Use this circuit to construct a transistor oscillator and explain its working. What is the frequency of oscillations of this circuit ? 25

2013

Q3:

An electric field of 100 V/m is applied to a sample of n-type semiconductor whose Hall coefficient is $-0.0125\ m^3$/coulomb. Determine the current density in the sample assuming $\mu_x = 0.36\ m^2\ v^{-1}s^{-1}$. 10

2014

Q4:

Differentiate between n-p-n and p-n-p transistors. Give their device structure and biasing circuits when used as an amplifier. 10

2015

Q5:

Design a transistor based Colpitt oscillator which can oscillate at 9 MHz. Explain how the oscillations are created and sustained. 15

2015

Q6:

Describe an operational amplifier based integrator. Using operational amplifier integrators, design a circuit to solve the following differential equation :

$$\frac{d^2v}{dt^2}+2\frac{dv}{dt}+3v=0.$$ 20

2015

Q7:

Give the basic structure of n-channel depletion type MOSFET. Draw the drain current-drain voltage characteristics both in depletion as well as enhancement modes. 20

2015

Q8:

What is the difference between direct and indirect band gap semiconductors ? Which one is suitable for use in solar cells ? *10+10=20*

2016

Q9:

Consider the operational amplifier circuit given above :

Given, $R_1 = 10\ k\Omega$, $R_2 = 150\ k\Omega$ and the product of the open loop gain of the amplifier and its bandwidth $= 10^6$ Hz. Determine the closed loop bandwidth of the amplifier. 10

2017

Q10:

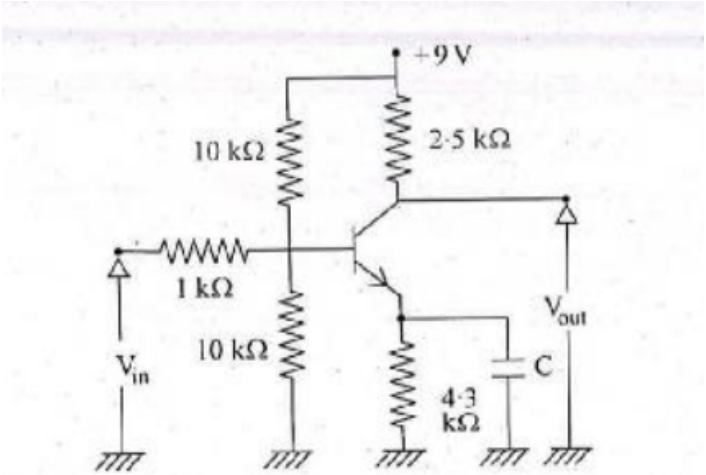
In a semiconductor, the effective masses of an electron and a hole are 0·07 m_0 and 0·4 m_0, respectively, where m_0 is the free electron mass. Assuming that the average relaxation time for the hole is half of that for the electrons, calculate the mobility of the holes when the mobility of the electrons is 0·8 m^2 volt $^{-1}$ s^{-1}. 15

2017

Q11:

An amplifier in common-emitter configuration is shown in the above figure.

If the current gain $\beta = 100$ and the a.c. emitter resistance = 25·0 Ω, determine the input impedance and the voltage gain of the amplifier. 15

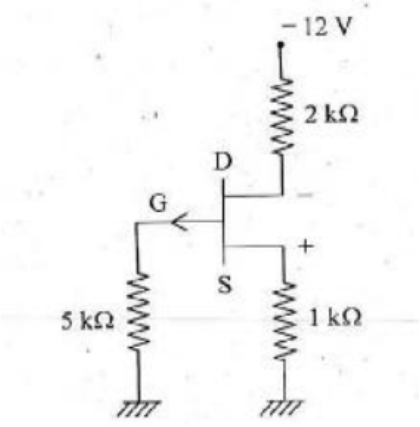


2017

Q12:

Given above is a circuit of self biased *p*-channel JFET.

If the pinch off voltage is 5·0 V and V_{DS} = 6·0 V, calculate the saturation current I_{DSS}. 15



2017

Q13:

What are intrinsic and extrinsic semiconductors? Show that in the intrinsic semiconductors, Fermi level lies exactly in the middle of bottom of conduction band and top of valence band. 15

2018

Q14:

What are operational amplifiers? How can it be used as an inductor? Prove it mathematically. 15

2018

Q15:

A silicon semiconductor sample at $T = 300\,K$ having cross-sectional area of $0{\cdot}5\,\mu m^2$ has a pentavalent donor doping profile given by $C(x) = 5 \times 10^{16}\, e^{(-x/L_n)}\ cm^{-3}$. Given, the mobility of the electrons in the sample is $1250\ cm^2\ V^{-1}\ s^{-1}$ and the diffusion length of the electrons, L_n, is $4\,\mu m$. Calculate the diffusion current in the sample at distance $x = 2\,\mu m$. 10

2019

Q16:

Sketch the cross-sectional structure of an enhancement mode MOSFET and explain its principles of operation with the help of its output characteristics. 15

2019

Q17:

A silicon semiconductor sample is doped with $6 \times 10^{16}\ cm^{-3}$ of aluminium and $7 \times 10^{15}\ cm^{-3}$ of phosphorus atoms. Given at $T = 300\,K$, the intrinsic carrier concentration, $n_i = 1{\cdot}5 \times 10^{10}\ cm^{-3}$; the band gap, $E_g = 1{\cdot}1\ eV$; the electron mobility, $\mu_n = 1250\ cm^2\ V^{-1}\ s^{-1}$ and the hole mobility, $\mu_p = 480\ cm^2\ V^{-1}\ s^{-1}$. Determine in the sample of the following :

(i) The type of the semiconductor, n or p

(ii) The hole carrier concentration

(iii) The electron carrier concentration

(iv) The position of the Fermi level in the sample with respect to the bottom of the conduction band

(v) The conductivity of the sample 20

2019

Q18:

A $5\,cm^2$ Ge solar cell with a dark reverse saturation current of 2 nA has solar radiation incident upon it, producing 4×10^{17} electron-hole pairs per second. The electron and hole diffusion lengths are given to be $5\,\mu m$ and $2\,\mu m$, respectively. Calculate for the cell of the following :

(i) The short-circuit current

(ii) The open-circuit voltage 10

2019

Q19:

What is an intrinsic semiconductor? Intrinsic silicon has a band gap of 1·1 eV and yet at $T = 300$ K, the conductivity is non-zero. Explain. Comment, with the help of relevant expression, on the position of the Fermi level of an intrinsic semiconductor. 15

2020

Q20:

Consider an amplifier with an open-loop (no feedback) gain of A and a feedback factor β. Derive the expression for the gain with feedback, A_f. Derive the condition for the amplifier with feedback to act as an oscillator. Comment on the change in A_f with a change in A. 15

2020

Q21:

Why is the Field Effect Transistor (FET) called Unipolar Transistor ? Discuss how it is superior than Bipolar Junction Transistor. 10

2022

Q22:

An *n-p-n* transistor with $\beta = 49$ is used in common-emitter amplifier mode with $V_{cc} = 10V$ and $R_L = 2\,k\Omega$. If a 100 kΩ resistor is connected between the collector and the base of the transistor, calculate the quiescent collector current. Assume $V_{BE} = 0$. 20

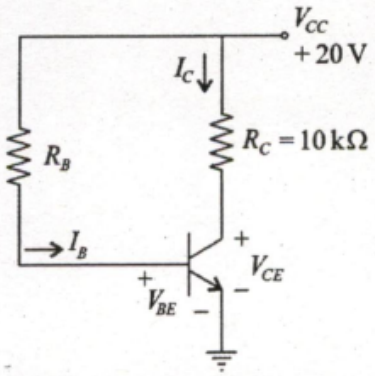
2021

Q23:

Calculate the pinch-off voltage for n-channel silicon FET with a channel width of 6×10^{-4} cm and a donor concentration of 10^{15} cm^{-3}. Given that dielectric constant of silicon is 12. 10

2021

Q24:



Sketch the dc load line for the circuit shown. 10

2021

Q25:

Show that for an n-type semiconductor, the Fermi level lies midway between the donor states and the conduction band edge at low temperature (assuming $E_v = 0$). 20

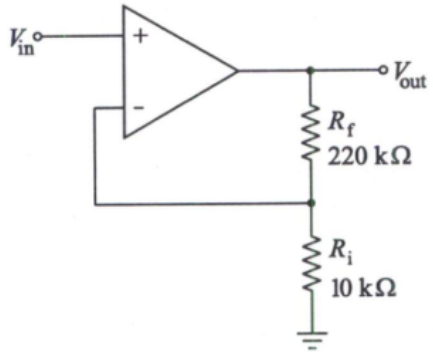
2022

Q26:

With a neat circuit diagram, explain the working of Wien-Bridge oscillator. 15

2023

Q27:



(i) Determine the input and output impedances of the amplifier in given figure. The op-amp datasheet gives $Z_{in} = 2\ M\Omega$, $Z_{out} = 75\ \Omega$ and $A_{ol} = 200{,}000$ (open loop voltage gain). 10

(ii) Find the closed-loop voltage gain. 5

2023

Q28.

(i) What is the concept of effective mass of the electron ?

(ii) The energy near a valence band edge is given by $E(k) = -1 \times 10^{-26}\ k^2$ ergs. An electron is removed from the orbital $k = 1 \times 10^7\ k_x\ cm^{-1}$. Find the sign and magnitude of effective mass of the hole. *10+10=20*

2024

Q29.

An RC-coupled transistor amplifier has mid-frequency gain $A_{vm} = 100$. The values of the lower and upper cut-off frequencies are $f_1 = 20$ Hz and $f_2 = 50$ kHz. Find the frequencies at which the gain is reduced to 80. *15*

2024

Q30.

Compare the working of FET and MOSFET with their structure, I – V curve and transfer characteristics. *15*

2024

Q25.

(i) FET (JFET) व MOSFET के वैद्युत अभिलक्षणों में क्या अन्तर हैं?

What are the differences in electrical characteristics of FET (JFET) and MOSFET? 7

(ii) *n*-चैनल का FET, *p*-चैनल के FET से किस प्रकार भिन्न है?

How does *n*-channel FET differ from *p*-channel FET? 3

2025