Tutorial Sheet-5 (Unit-2)

Question-1:

Given a BJT with a base-emitter voltage drop (V_{BE}) of 0.7 V and a collector current (I_C) of 2 mA, determine the values of base current (I_B) and collector-emitter voltage drop (V_{CE}) for the transistor in the active region. Assume $\beta = 100$.

Solution:

1. Calculate I_B using $I_C = \beta \times I_B$:
   $I_B = \frac{I_C}{\beta} = \frac{2\,\text{mA}}{100} = 0.02\,\text{mA} = 20\,\mu\text{A}$
2. Determine V_{CE} using $V_{CE} = V_{CC} - (I_C \times R_C)$, where V_{CC} is the collector supply voltage and R_C is the collector resistor. For simplicity, let's assume $V_{CC} = 10\,V$ and $R_C = 4\,k\Omega$:
   $V_{CE} = 10\,V - (2\,mA \times 4\,k\Omega) = 10\,V - 8\,V = 2\,V$

So, $I_B = 20\,\mu\text{A}$ and $V_{CE} = 2\,V$.

Question-2:

For a BJT with $\beta = 150$, if the base current (I_B) is 40 µA, calculate the collector current (I_C) and the current gain (α).

Solution:

1. Use the current gain equation $I_C = \beta \times I_B$:
   $I_C = 150 \times 40\,\mu\text{A} = 6\,mA$
2. Calculate α using $\alpha = \frac{I_C}{I_E}$, where I_E is the emitter current. Since $I_E = I_C + I_B$:
   $I_E = I_C + I_B = 6\,mA + 40\,\mu\text{A} = 6.04\,mA$
   $\alpha = \frac{6\,mA}{6.04\,mA} \approx 0.993$

So, $I_C = 6\,mA$ and $\alpha \approx 0.993$.

Question-3:

For an inverting amplifier with an input resistor (R_1) of 10 kΩ and a feedback resistor (R_f) of 20 kΩ, calculate the voltage gain (A_v).

Solution:

The voltage gain for an inverting amplifier is given by $A_v = -\frac{R_f}{R_1}$.

$$A_v = -\frac{20\,k\Omega}{10\,k\Omega} = -2$$

So, the voltage gain is -2.

Question-4:

Given a BJT with a collector current (I_C) of 2 mA, a base current (I_B) of 20 μA, and a collector-emitter voltage drop (V_{CE}) of 5 V, calculate the current gain (β) and the transistor power dissipation (P_{diss}).

Solution:

1. Calculate β using the formula $\beta = \frac{I_C}{I_B}$:
   $\beta = \frac{2\,mA}{20\,\mu A} = 100$
2. Calculate the power dissipation using $P_{diss} = V_{CE} \times I_C$:
   $P_{diss} = 5\,V \times 2\,mA = 10\,mW$

So, $\beta = 100$ and $P_{diss} = 10\,mW$.

Question-5:

For a non-inverting amplifier with an input resistor (R_1) of 5 kΩ and a feedback resistor (R_f) of 15 kΩ, calculate the voltage gain (A_v).

Solution:

The voltage gain for a non-inverting amplifier is given by $A_v = 1 + \frac{R_f}{R_1}$.

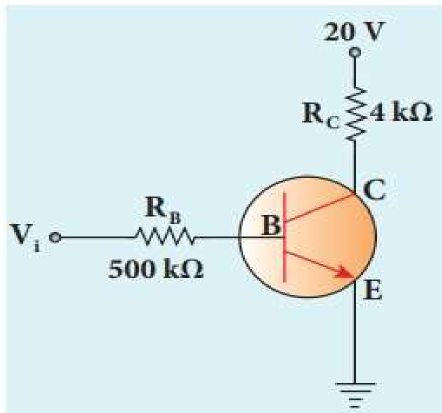
$A_v = 1 + \frac{15\,k\Omega}{5\,k\Omega} = 1 + 3 = 4$

So, the voltage gain is 4.

Question-6:

In the circuit shown in the figure, the input voltage *Vi* is 20 *V*, *VBE* = 0 *V* and *VCE* = 0 *V*. What are the values of *IB* , *IC* , *β*?

Solution:



$$I_B = \frac{V_i}{R_B} = \frac{20V}{500k\Omega} = 40\ \mu A\ [\because V_{BE} = 0V]$$

$$I_C = \frac{V_{CC}}{R_C} = \frac{20V}{4k\Omega} = 5\ mA\ [\because V_{CE} = 0V]$$

$$\beta = \frac{I_C}{I_B} = \frac{5\ mA}{40\ \mu A} = 125$$

HomeWork

Question-1:

In a transistor connected in the common base configuration, α=0.95, I_E =1 *mA*. Calculate the values of I_C and I_B .

Solution: α= I_C/I_E

I_C =α I_E =0.95×1=0.95 *mA*

$I_E = I_B + I_C$

∴ $I_B = I_C - I_E$ =1−0.95=0.05 *mA*

Question-2:

In a BJT, the emitter current id 8 mA and I_B= I_C/100. Determine I_C and I_E.

Example 15.1

In a BJT, the emitter current is 8 mA and $I_B = I_C/100$. Determine I_C and I_B.

Solution

$$I_E = I_C + I_B$$

$$I_E = I_C + \frac{1}{100} I_C = \frac{101}{100} I_C$$

$$I_C = 8 \times \frac{1}{101} = 7.92 \text{ mA}$$

$$I_B = \frac{1}{100} I_C = 0.0792 \text{ mA}$$

Question-3:

Find the output voltage for the circuit shown in Fig. below.

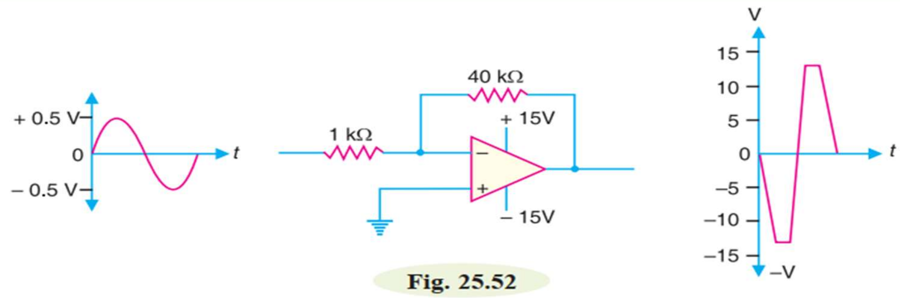


Fig. 25.52

Solution. Voltage gain, $A_{CL} = -\dfrac{R_f}{R_i} = -\dfrac{40\ \text{k}\Omega}{1\ \text{k}\Omega} = -40$

Question-4:

For the noninverting amplifier circuit shown in Fig., find peak-to-peak output voltage.

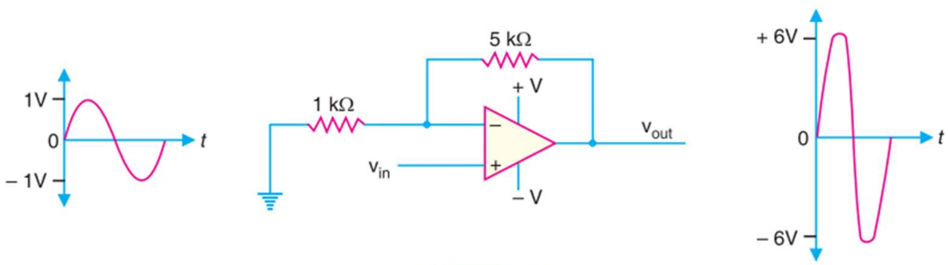


Fig. 25.59

Solution. The input signal is 2 V peak-to-peak.

$$\text{Voltage gain, } A_{CL} = 1 + \frac{R_f}{R_i} = 1 + \frac{5\ \text{k}\Omega}{1\ \text{k}\Omega} = 1 + 5 = 6$$

$\therefore$ Peak-to-peak output voltage $= A_{CL} \times v_{inpp} = 6 \times 2 =$ **12 V**

Question-5:

Consider an op-amp subtractor circuit with two input voltages, $V_1 = 3\ V$ and $V_2 = 1\ V$, and resistors $R_1 = 5\ k\Omega$ and $R_2 = 2\ k\Omega$ in the feedback loop.

Determine the output voltage (V_{out}).

Solution:

The output voltage (V_{out}) in an op-amp subtractor circuit is given by the formula:

$$V_{\text{out}} = -\left(\frac{R_f}{R_1} \cdot V_1 - \frac{R_f}{R_2} \cdot V_2\right)$$

In this case, R_f is the feedback resistor, which is $R_f = R_2 = 2\ k\Omega$.

MCQs

Q1. In a common-emitter configuration, the phase difference between the input and output signals is:

a.0 degrees
b. 45 degrees
c. 90 degrees
d. 180 degrees
Answer: d. 180 degrees

2. The current gain (β\betaβ) of a BJT in the common-emitter configuration is given by:

a. IE/IB
b. IB/IE
c. IC/IB
d. IB/IC
Answer: c. IC/IB

3. **In a BJT, the region of operation where both the emitter-base junction and the collector-base junction are forward biased is called:**

a. Active region
b. Cutoff region
c. Saturation region
d. Breakdown region
Answer: c. Saturation region

4.**In a BJT, the majority charge carriers in the base region of an NPN transistor are:**

a. Electrons
b. Holes
c. Ions
d. None
Answer: b. Holes

5.**For a BJT to operate in the active region, the emitter-base junction must be:**

a. Forward biased, and the collector-base junction must be forward biased
b. Reverse biased, and the collector-base junction must be forward biased
c. Forward biased, and the collector-base junction must be reverse biased
d. Reverse biased, and the collector-base junction must be reverse biased
Answer: c. Forward biased, and the collector-base junction must be reverse biased

6.**The primary difference between enhancement-mode and depletion-mode MOSFETs is:**

a. The type of substrate used
b. The gate structure

c. The threshold voltage
d. The channel formation
Answer: d. The channel formation

7.**In an n-channel MOSFET, the channel is formed when:**

a. The gate-source voltage is less than the threshold voltage
b. The gate-source voltage is equal to the threshold voltage
c. The gate-source voltage is greater than the threshold voltage
d. The gate-source voltage is zero
Answer: c. The gate-source voltage is greater than the threshold voltage

8. In a MOSFET, the region where the drain current is almost constant and independent of the drain-source voltage is called:

a. Ohmic region
b. Active region
c. Saturation region
d. Cutoff region
Answer: c. Saturation region

9.**The primary function of the gate terminal in a MOSFET is to:**

a. Control the source voltage
b. Control the drain current
c. Control the body current
d. Provide a reference voltage
Answer: b. Control the drain current

10.**In a MOSFET, the body effect refers to the:**

a. Effect of the gate voltage on the body
b. Effect of the source voltage on the body
c. Effect of the drain voltage on the body
d. Effect of the body voltage on the threshold voltage
Answer: d. Effect of the body voltage on the threshold voltage

Q11. In a MOSFET, the polarity of the inversion layer is the same as that of the

a. Charge on the gate electrode
b. Minority carriers in the drain
c. Majority carriers in the substrate
d. Majority carriers in the source

Answer: d

Q 12. The threshold voltage of an n-channel MOSFET can be increased by

a. Increasing the channel dopant concentration.
b. Reducing the channel dopant concentration.

c. Reducing the gate oxide thickness.
d. Reducing the channel length.

Answer: a

Q13. The transit time of the current carriers through the channel of an FET decides……………. Characteristics

Answer: Switching

Q14. When a bipolar junction transistor is operating in the saturation mode, which one of the following is TRUE about the state of its collector-base (CB) and base-emitter (BE) junctions?

a. The CB junction is forward biassed, and the BE junction is reverse biased.
b. The CB junction is reverse biassed, and the BE junction is forward biased.
c. Both CB and BE junctions are forward biassed
d. Both CB and BE junctions are reverse biassed

Answer: c

15.**In an ideal op-amp, the open-loop gain is:**

a. 1
b. 100
c. Infinite
d. Zero
Answer: c. Infinite

16. **In an inverting amplifier configuration, the input signal is applied to:**

a. The non-inverting terminal
b. The inverting terminal
c. Both terminals
d. The output terminal
Answer: b. The inverting terminal

17.**The primary difference between inverting and non-inverting op-amp configurations is:**

a. The type of feedback used
b. The phase relationship between input and output
c. The gain of the amplifier
d. The bandwidth of the amplifier
Answer: b. The phase relationship between input and output

18. **In an op-amp integrator circuit, the output voltage is proportional to:**

a. The integral of the input voltage
b. The derivative of the input voltage
c. The sum of the input voltages
d. The difference between the input voltages
Answer: a. The integral of the input voltage