1. **The electrons of outer most is known as valance electron. How these electrons determine the electrical properties of a material? (20-21)**

Answer:

Valence electrons, the electrons in the outermost shell of an atom, play a crucial role in determining the electrical properties of a material. Here's how:

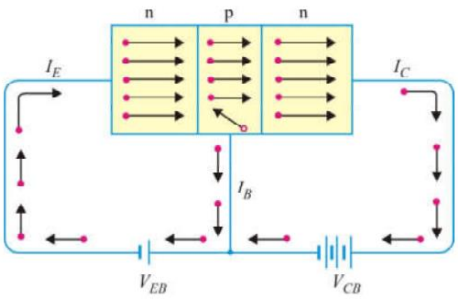
- **Conductors**: In conductive materials, like metals, valence electrons are loosely bound to their atoms and can move freely through the material. These free-moving electrons allow electric current to flow easily when an electric field is applied, making metals good conductors.
- **Insulators**: In insulating materials, such as rubber or glass, valence electrons are tightly bound to their atoms and cannot move freely. This lack of free electrons means there is little to no current flow, making these materials resist electric currents.
- **Semiconductors**: Materials like silicon and germanium have valence electrons that are not as free as in conductors, but also not as restricted as in insulators. Semiconductors' electrical properties can change when they gain or lose electrons through doping, allowing them to conduct electricity under certain conditions. This property is crucial for creating electronic components like diodes, transistors, and integrated circuits.

2. **Explain the working principle of npn transistor.(20-21)**

Answer:

The working principle of npn transistor is given below:

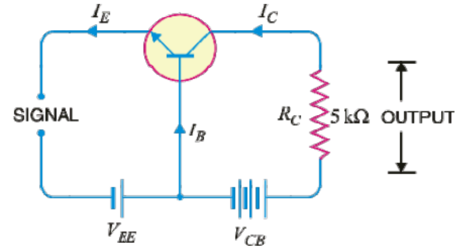
An **npn** transistor operates by using a small base current to control a larger collector current, effectively acting as a current amplifier. When the **emitter-base junction** is forward biased, electrons from the **n-type emitter** flow towards the **p-type base**, creating the **emitter current (I_E)**. As these electrons pass through the base, only a small fraction (less than 5%) combine with holes due to the base being very thin and lightly doped. This small recombination forms the **base current (I_B)**, while the majority of electrons (more than 95%) continue across the reverse-biased **collector-base junction** to the **collector**, forming the **collector current (I_C)**. The total emitter current thus equals the sum of the collector and base currents, expressed as $I_E = I_B + I_C$. This process allows the **npn** transistor to control and amplify currents effectively.



Basic connection of *npn* transistor

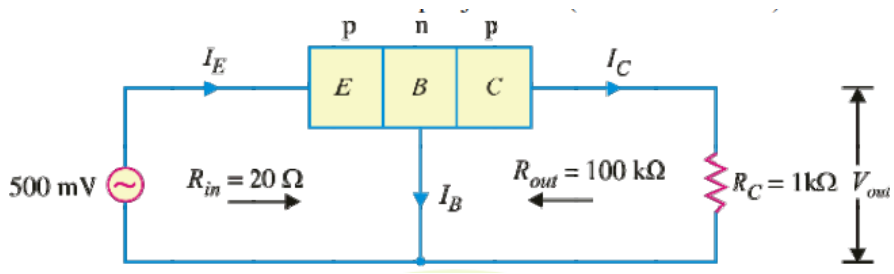
3. **How transistor can be used as an amplifier? With an appropriate diagram.(20-21)**

Answer:



A transistor acts as an amplifier by using a small input signal at the base to control a much larger current between the collector and emitter. In a common-emitter configuration, the base-emitter junction is forward biased, and the collector-base junction is reverse biased. When a small current or voltage is applied to the base, it results in a proportionally larger collector current due to the transistor's current gain (β\betaβ). This means that small changes in the base current produce amplified changes in the collector current, creating a larger output signal across the load connected to the collector.

4. A common base transistor amplifier has an input resistance of 20 ohm and output resistance of 100 kilo ohm. The collector load is 1 kilo ohm. If a signal of 500 mV is applied between emitter and base, find the voltage amplification. Assume α_{ac} to be nearly one. (20-21)



Answer:

Note that output resistance is very high as compared to input resistance. This is not surprising because input junction (base to emitter) of the transistor is forward biased while the output junction (base to collector) is reverse biased. (Transfer + Resistor = Transistor.)

Input current, $I_E = \dfrac{\text{Signal}}{R_{in}} = \dfrac{500\text{ mV}}{20\ \Omega} = 25\text{ mA}$. Since α_{ac} is nearly 1, output current, $I_C = I_E = 25\text{ mA}$.

$$\text{Output voltage, } V_{out} = I_C R_C = 25\text{ mA} \times 1\text{ k}\Omega = 25\text{ V}$$

$$\therefore \quad \text{Voltage amplification, } A_v = \frac{V_{out}}{\text{signal}} = \frac{25\,V}{500\,mV} = 50$$

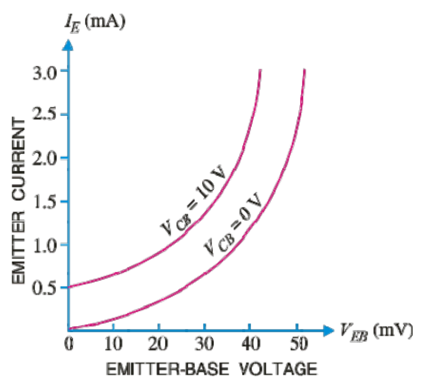
5. Explain the characteristics of Common Base Connection with diagram and equations. (20-21)

Answer:

In a **Common Base (CB) connection** of a transistor, the base terminal is shared by both the input and output circuits. Here are its main characteristics:

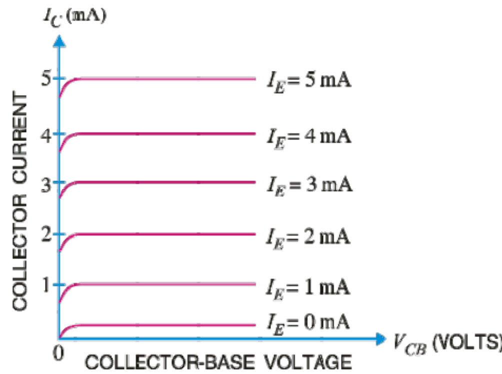
Input Characteristics:

- The input is applied between the **emitter** and **base**, while the output is taken between the **collector** and **base**.
- The **input characteristics** show how the input current (emitter current, I_E) changes with the input voltage (emitter-base voltage, V_{EB}), while the output voltage (collector-base voltage, V_{CB}) is kept constant.
- As V_{EB} increases, IE also increases, similar to how current flows in a diode.



Output Characteristics:

- ❖ The output characteristics show how the **output current** (collector current, I_C) depends on the **output voltage** (collector-base voltage, V_{CB}), for different values of **input current** (emitter current, IE).
- ❖ Beyond a certain V_{CB} value, I_C remains mostly constant, meaning the collector current doesn't change much with the output voltage, which is useful for amplification.



Current Gain (α):

The current gain in CB mode is defined as the ratio of collector current (I_C) to emitter current (I_E):

$\alpha = I_C / I_E$ (**α** is close to 1, so most of the emitter current flows to the collector.)

Input Resistance:

The input resistance in a CB connection is low, meaning a small input voltage change causes a large change in emitter current.

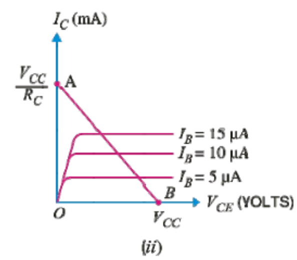
Voltage Gain:

The voltage gain in a common-base amplifier is high, making this setup suitable for amplifying small signals.

6. How would you determine the load line and operating point of a transistor? (20-21)

Answer:

The load line represents all possible combinations of collector current (I_C) and collector-emitter voltage (V_{CE}) in a transistor circuit, limited by the external supply voltage and load resistor.



Determining the Load Line:

Use the equation derived from Kirchhoff's Voltage Law:

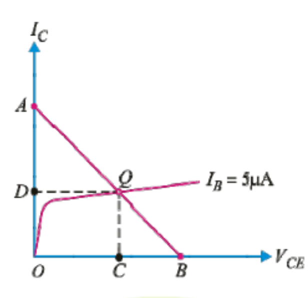
$$V_{CE} = V_{CC} - I_C R_C$$

To plot it on the IC-VCE graph:

- ❖ **When V_{CE} = 0V**, $I_C = V_{CC} / R_C$, representing the maximum collector current.
- ❖ **When I_C = 0**, $V_{CE} = V_{CC}$, representing the maximum collector-emitter voltage.

Connect these points to draw a straight line, called the load line, which represents the limits of operation for the transistor in the circuit.

The **operating point** or **Q-point** is the specific point on the load line where the transistor functions under steady-state conditions, defined by a specific collector current and collector-emitter voltage.



Determining the Operating Point:

- ❖ Identify the base current I_B based on the input biasing circuit.
- ❖ Find the transistor's characteristic curve for this I_B.
- ❖ The intersection of this curve with the load line gives the Q-point, showing the actual I_C and V_{CE} values where the transistor will operate.

7. Establish the relation between β and α.(20-21)

Answer:

Current amplification factor (α) and Base current amplification factor (β) i.e.

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{--- (i)}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{--- (ii)}$$

Relation between β and α is given below:

We know,

$$I_E = I_B + I_C$$

$$\Rightarrow \Delta I_E = \Delta I_B + \Delta I_C$$

$$\Rightarrow \Delta I_B = \Delta I_E - \Delta I_C$$

Substituting ΔI_B in exp (ii) we get,

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

$$\Rightarrow \beta = \frac{\frac{\Delta I_C}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} \quad \text{[Dividing numerator and denominator by } \Delta I_E\text{]}$$

$$\Rightarrow \beta = \frac{\alpha}{1 - \alpha} \quad \left[\because \alpha = \frac{\Delta I_C}{\Delta I_E}\right]$$

$\therefore \beta = \frac{\alpha}{1-\alpha}$, This is the required relationship.

8. Breakdown voltage and knee voltage is important concept for pn junction. Why?(20-21)

Answer:

The importance of breakdown voltage and knee voltage for pn junction is given below:

Breakdown Voltage is the reverse voltage at which a p-n junction starts to let a large current flow. If this voltage is exceeded, it can damage the device. Knowing this helps protect circuits from too much reverse voltage.

Knee Voltage is the forward voltage needed to start allowing current through the p-n junction (about 0.7V for silicon, 0.3V for germanium). This voltage is important to set the junction to work correctly.

9. Explain the construction and biasing of a transistor. (19-20)

Answer:

Construction of a Transistor:

A transistor has three layers: emitter, base, and collector.

- **Emitter:** Heavily doped to inject charge carriers (electrons in NPN, holes in PNP).
- **Base:** Thin and lightly doped to allow most carriers to pass through.
- **Collector:** Moderately doped, larger to dissipate heat, collects charge carriers from the base.

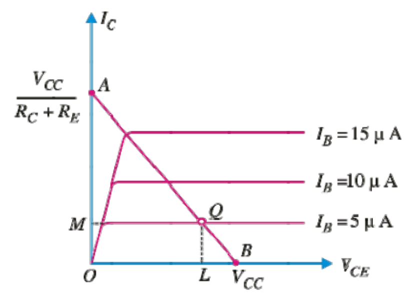
Transistor Biasing involves applying external voltages to control the transistor's operation:

1. **NPN Transistor**:
   - **Emitter-Base Junction**: Forward-biased (base positive relative to emitter) for electron flow from emitter to base.
   - **Collector-Base Junction**: Reverse-biased (collector positive relative to base) to pull electrons into the collector.
2. **PNP Transistor**:
   - **Emitter-Base Junction**: Forward-biased (emitter positive relative to base) for hole flow from emitter to base.
   - **Collector-Base Junction**: Reverse-biased (base positive relative to collector) to pull holes into the collector.

10. Discuss d.c and a.c load lines with the help of the output characteristics of a transistor. (19-20)

Answer:

d.c. load line: It is the line on the output characteristics of a transistor circuit which gives
the values of I_C and V_{CE} corresponding to zero signal or d.c. conditions. **Kirchhoff's Voltage Law** is used in the collector-emitter circuit to find the equation of the d.c. load line:



$V_{CE} = V_{CC} - I_C R_C - I_E R_E$

$V_{CE} = V_{CC} - I_C (R_C + R_E)$ [$\because I_E \sim I_C$]

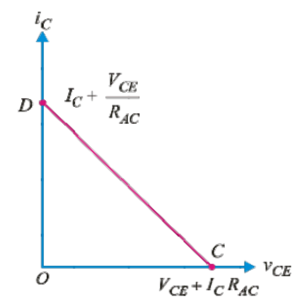
Here V_{CC} and $(R_C + R_E)$ are constant, therefore, it is a first degree *equation and can be represented by a straight line on the output characteristics. This is known as d.c. load line and determines the load of V_{CE} and I_C points in the zero signal conditions.

The value of V_{CE} will be maximum when $I_C = 0$; Max $V_{CE} = V_{CC}$

And the value of Ic will be maximum when $V_{CE} = 0$; Max $I_c = V_{CC} / (R_c + R_E)$

a.c. load line: This is the line on the output characteristics of a transistor circuit which gives the values of I_C and V_{CE} when signal is applied.

When we add a.c. load line to the output characteristics, we get two end points, one maximum collector-emitter voltage point and the other maximum collector current point.



Max. collector-emitter voltage = $V_{CE} + I_C R_{AC}$

And Maximum collector current = $I_C + (V_{CE} / R_{AC})$

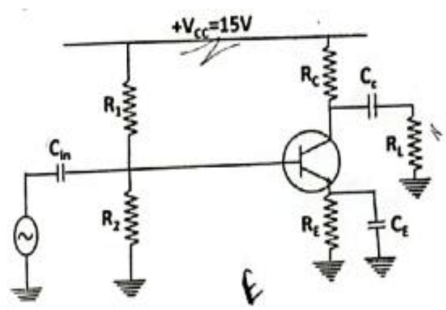
where

$R_{AC} = R_C \parallel R_L = R_C R_L / (R_C + R_L)$

11. The Transistor amplifier shown in figure $R_1 = 10K\Omega$, $R_2 = 5K\Omega$, $R_C = 1K\Omega$, $R_E = 2K\Omega$, $R_L = 1K\Omega$. (19-20)

(i) Draw d.c. load line and

(ii) Determine the operating point.



Answer:

***(i)* d.c. load line :**

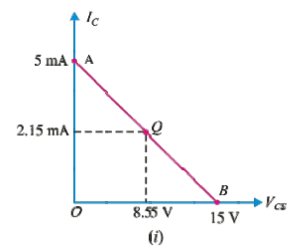
To draw d.c. load line, we require two end points *viz* maximum *VCE* point and maximum *IC* point.

$$\text{Maximum } V_{CE} = V_{CC} = 15\text{ V [See Art. 10.8]}$$

This locates the point *B* (*OB*=15 V) of the d.c. load line.

$$\text{Maximum } I_C = \frac{V_{CC}}{R_C + R_E} = \frac{15\,V}{(1+2)\text{ k}\Omega} = 5\text{ mA} \quad \text{[See Art. 10.8]}$$

This locates the point *A* (*OA* = 5 mA) of the d.c. load line. Fig. 10.16 (*i*) shows the d.c. load line *AB*.



***(ii)* Operating point Q.** The voltage across R_2 (= 5 kΩ) is *5 V *i.e.* $V_2 = 5$ V.

$$\text{Now} \quad V_2 = V_{BE} + I_E R_E$$

$$\therefore \quad I_E = \frac{V_2 - V_{BE}}{R_E} = \frac{(5-0.7)\,V}{2\text{ k}\Omega} = 2.15\text{ mA}$$

$$\therefore \quad I_C = I_E = 2.15\text{ mA}$$

$$\text{Now} \quad V_{CE} = V_{CC} - I_C(R_C + R_E) = 15 - 2.15\text{ mA} \times 3\text{ k}\Omega = 8.55\text{ V}$$

∴ Operating point *Q* is **8.55 V, 2.15 mA.** This is shown on the d.c. load line.

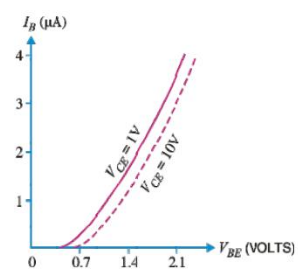
12. Explain input and output characteristics of a common emitter transistor connection. (19-20)

Answer:

The Input and Output Characteristics of a Common Emitter (CE) Transistor Connection is given below,

Input Characteristics:

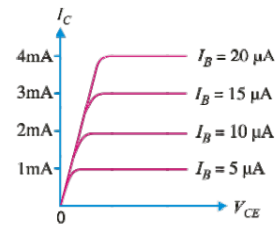
- ❖ Input characteristics show the relationship between **base current (I_B)** and **base-emitter voltage (V_{BE})**.
- ❖ With the **collector-emitter voltage (V_{CE})** kept constant, as V_{BE} increases, I_B increases.
- ❖ The input curve resembles a **diode curve**, showing exponential growth after a threshold.



Input Resistance(R_i) is calculated as:

$$R_i = \Delta V_{BE} / \Delta I_B \quad \text{,where } V_{CE} \text{ is constant}$$

Output Characteristics:



- ❖ Output characteristics show the relationship between **collector current (I_C)** and **collector-emitter voltage (V_{CE})** for different base currents (I_B).
- ❖ For a constant I_B, I_C increases with V_{CE} initially but levels off, indicating **saturation** and **active regions**.
- ❖ At higher V_{CE}, I_C is almost constant, showing **high output impedance**.

Output Resistance (R_O) is calculated as:

$$R_O = \Delta V_{CE} / \Delta I_C$$, where I_B is constant.

13. A transistor is connected in a common emitter configuration in which the collector supply is 8V and the voltage drop across resistance Re connected in the collector circuit is 0.5V. The value of Re=8002 if a=0.96 determines (i) VCE and (ii) I_B
Answer: (19-20)

Example 8.12. *A transistor is connected in common emitter (CE) configuration in which collector supply is 8V and the voltage drop across resistance R_C connected in the collector circuit is 0.5V. The value of $R_C = 800\ \Omega$. If $\alpha = 0.96$, determine :*

(i) collector-emitter voltage

(ii) base current

Solution. Fig. 8.22 shows the required common emitter connection with various values.

(i) Collector-emitter voltage,

$$V_{CE} = V_{CC} - 0.5 = 8 - 0.5 = 7.5\ V$$

(ii) The voltage drop across $R_C (= 800\ \Omega)$ is 0.5 V.

$$\therefore \quad I_C = \frac{0.5\ V}{800\ \Omega} = \frac{5}{8}\ mA = 0.625\ mA$$

Now $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$$

$$\therefore \text{ Base current, } I_B = \frac{I_C}{\beta} = \frac{0.625}{24} = 0.026\ mA$$

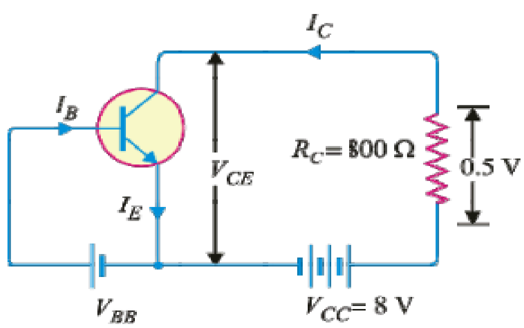


Fig. 8.22

14. Among CB, CE and CC connection which is most popular. Why?(18-19)

Answer:

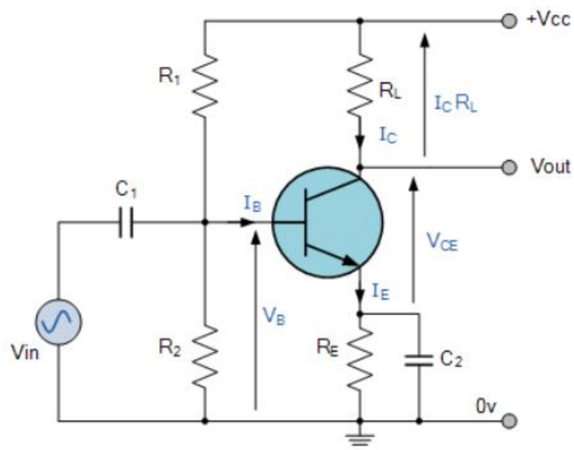
The **common emitter (CE)** connection is the most popular among CB, CE, and CC connections. This is because:

- ❖ **High Voltage and Power Gain**: The CE configuration provides good voltage gain and high power gain, making it suitable for amplifiers.
- ❖ **Phase Inversion**: It produces a 180° phase shift, useful in many applications.
- ❖ **Moderate Input and Output Resistance**: It has a balance of input and output resistance, making it versatile for various circuits.

15. Draw the circuit diagram of the common emitter amplifier and hence show that the output voltage of a single-stage common emitter transistor amplifier is 180º out of phase with the input voltage. (19-20)

Answer:

The most common amplifier configuration for an NPN transistor is that of the Common Emitter Amplifier circuit.



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