$$= \frac{13 \pm \sqrt{25}}{1600} = \frac{13 \pm 5}{1600} = 5\text{mA or } 11.25\text{mA}$$

If we calculate value of V_{DS} taking I_D =11.25mA we get,

$$V_{DS} = V_{DD} - I_D(R_D + R_S) = 12 - 11.25 \times 10^{-3}(500 + 1.2 \times 10^3)$$

$$= 12 - 19.125 = -7.125$$

Practically, the value of V_{DS} must be positive, hence I_D=11.25mA is invalid.

Now calculating value of V_{DS} taking I_D=5mA,

$$V_{DS} = V_{DD} - I_D(R_D + R_S) = 12 - 5 \times 10^{-3}(500 + 1.2 \times 10^3)$$

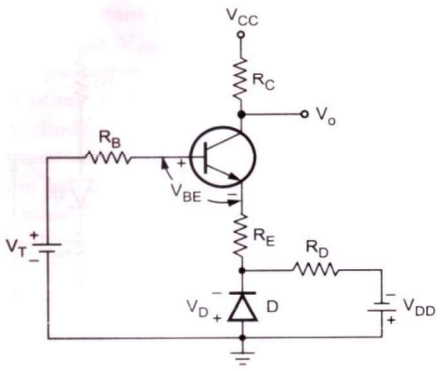
$$= 12 - 8.5 = 3.5\text{V}$$

$$V_{GS} = 3 - I_D R_S = 3 - 5 \times 10^{-3} \times 1.2 \times 10^{-3} = 3 - 6 = -3\text{V}$$

$$V_S = I_D R_S = 5 \times 10^{-3} \times 1.2 \times 10^{-3} = 6\text{V}$$

TWO MARK QUESTIONS AND ANSWERS

1. Give the circuit that offers stabilization of operating point by means of self bias & diode compensation technique.

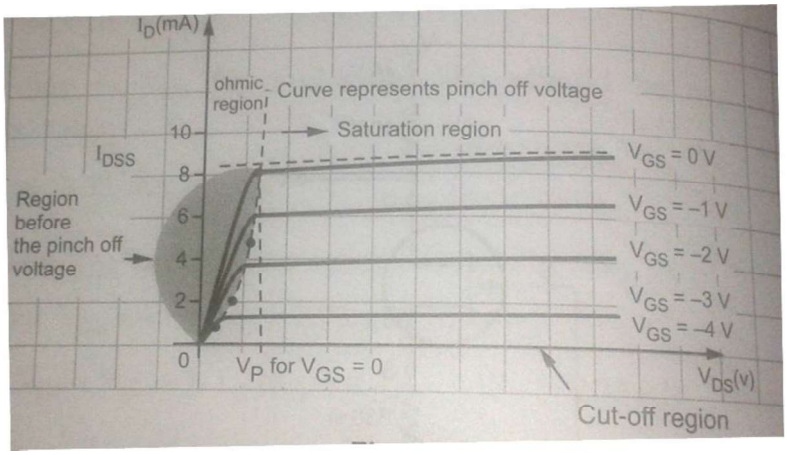


2. What is thermal runaway?

The increase in collector current increases the power dissipated at the collector junction. This in turn further increases the temperature of the junction and hence increase in collector current. The process is cumulative and referred as self heating. The excess heat produced at the collector base junction may even burn and destroy the transistor. This situation is called Thermal Runaway of transistors.

3. Explain the use of JFET as variable voltage resistor.

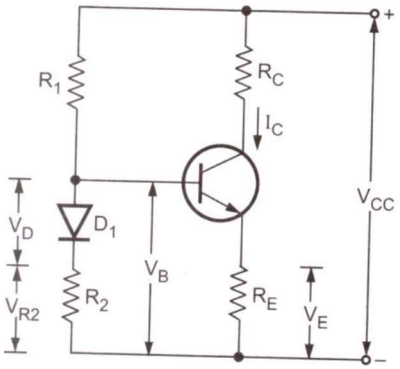
Before pinch off voltage, drain characteristics is linear. The FET operation is linear. In this region, FET is useful as voltage controlled resistor(the drain to source resistance is controlled by bias voltage V_{GS}). The operation of FET in this V_{DD} region is useful in most linear applications of FET. In such application, FET is also referred as voltage variable resistor (VVR) or voltage dependent resistor (VDR).



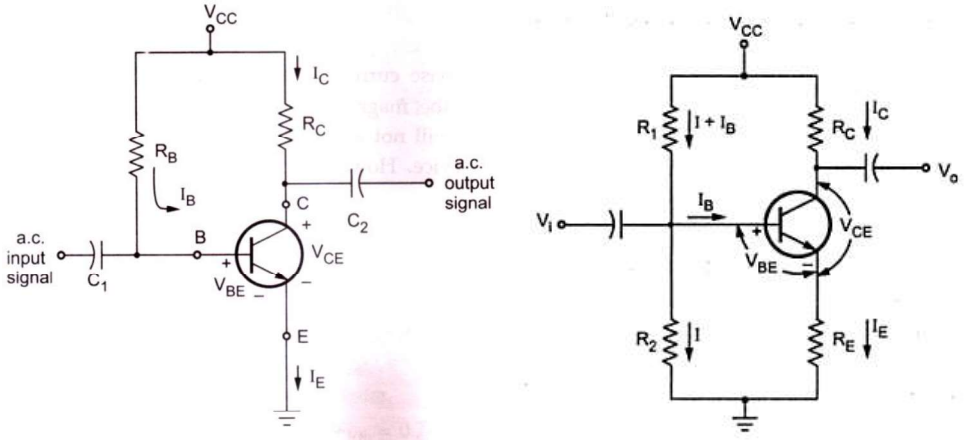
4. What is the advantage of using emitter resistance in the context of biasing?

If collector current increases due to change in temperature or change in β, the emitter current I_E also increases and voltage drop across R_E increases, reducing the voltage difference between base and emitter(V_{BE}).Due to reduction in V_{BE}, base current I_B and hence collector current I_C also reduces. Therefore, negative feedback exists in the emitter bias circuit. This reduction in collector current I_C compensates for the original change in I_C.

5. Draw circuit that minimizes changes in V_{BE} due to temperature variation.



6. Draw the fixed bias & self bias circuit.



a) Fixed bias circuit **b) Self bias circuit**

7. Define three stability factors. Give its ideal value.

Stability factor indicates degree of change in operating point due to variation in temperature. Three stability factors are,

i) $$S = \frac{\partial I_c}{\partial I_{co}}\Big| V_{BE}, \beta \text{ constant}$$

ii) $$S' = \frac{\partial I_C}{\partial V_{BE}}\Big| I_{CO}, \beta \text{ constant}$$

iii) $$S'' = \frac{\partial I_c}{\partial \beta}\Big| I_{CO}, V_{BE} \text{ constant}$$

Ideally stability factor should be perfectly zero to keep operating point stable.

8. What is the need for biasing?

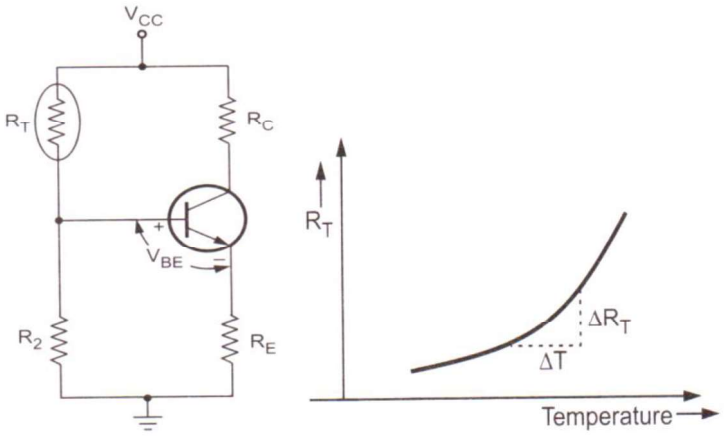
The transistor can be operated in three regions: cut-off, active and saturation. In order to operate transistor in the desired region we have to apply external d.c. voltages of correct polarity and magnitude to the two junction of the transistor. This is called as d.c. biasing of the transistor.

9. Write in brief sensistor compensation for transistor.

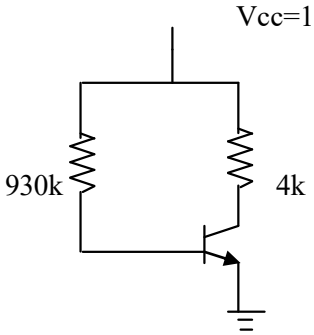
It has positive temperature coefficient, its resistance increases exponentially with increasing temperature.

$$\text{Slope} = \frac{\partial R_T}{\partial T}$$

Temperature coefficient for sensistor & the slope is positive. So we can say that thermistor has positive temperature coefficient of resistance(PTC).



10. For the circuit shown in the figure, determine the operating point β=100.



Solution:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$$I_B = \frac{10 - 0.7}{930 \times 10^3} = 10\mu A$$

The magnitude of the collector current is,

$$I_C = \beta I_B = 100 \times 10\mu A = 1mA$$

Applying KVL around collector loop,

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

$$V_{CE} = 20 - (1 \times 10^{-3})(4 \times 10^3) = 16V$$

The operating point is at V_{CEQ}=16V & I_{CQ}=1mA.

11. What is the condition for thermal stability?

1. It is necessary to avoid the thermal run away.

2. The required condition to avoid thermal is that the rate at which heat is released at the collector junction must be exceed the rate at which the heat can be dissipated.

It is given by,

$$\frac{\partial P_C}{\partial T_j} < \frac{\partial P_D}{\partial T_j}$$

12 .What is meant by Quiescent point in an amplifier?

When we bias a transistor, we establish a certain current and voltage conditions for the transistor. These conditions are known as d.c operating point or quiescent point. Operating point must be stable for proper operation of transistor. The operating point shifts with changes in transistor parameters such as I_{CO} , V_{BE} , β.

13. What are the advantages of self bias over other type of biasing circuits?

Self bias provides greatest stability against h_{fe} variations compared to other types of biasing circuits. The stability of self bias is unity.

14. Why do you fix the operating point in the middle of D.C load line?

When transistor is used as an amplifier ,the Q point should be selected at the center of d.c load line to prevent any possible distortion in the amplified output signal. Hence ,the output is sinusoidal waveform without any distortion.

15. What is reverse saturation current?

When emitter is open circuited, the base and collector act as a reverse biased diode, and the collector current I_C equals the reverse saturation current I_{CO}.

16. Why is bias compensation required?

The collector to base bias and voltage divider bias use negative feedback to do the stabilization action. This negative feedback reduces the amplification of the signal. If this loss in signal amplification is intolerable and extremely stable biasing conditions are required, then it is necessary to use compensation techniques. Compensation techniques use temperature sensitive devices such as diodes, thermistors, transistors, etc. Compensation techniques are used to maintain operating point constant.

17. Why are CE amplifiers more popular?

1. The CE configuration is the only configuration which provides both voltage gain as well as current gain greater than unity.

2. The power gain of the CE amplifier is much greater than the power gain provided by other two configurations.

3. In CE circuit,the ratio of output resistance to input resistance is small,may range from 10Ω to 100Ω.This makes configuration an ideal for coupling between various transistor stages.

18. What are the types of transistor biasing?

1. Fixed Bias Circuit
3. .Collector to base bias circuit
3. Voltage divider/self bias circuit

19. What are the factors that affect the Q-point of a circuit using BJT?

1. Temperature (The change in temperature affect the parameters of the transistor like I_{CO}, V_{BE}, β_{dc})

2. Variation of h_{fe} (β) within manufacture tolerance

20. How can collector current be stabilized with respect to I_{co} variations?

$$I = \frac{V_{CC} - V_{BE}}{R_1}$$

$$I = I_B + I_O \qquad \because I_B = I - I_O$$

$$I \approx \frac{V_{CC}}{R_1}$$

W. K. T $\qquad I_C = \beta I_B + (1+\beta) I_{CBO}$

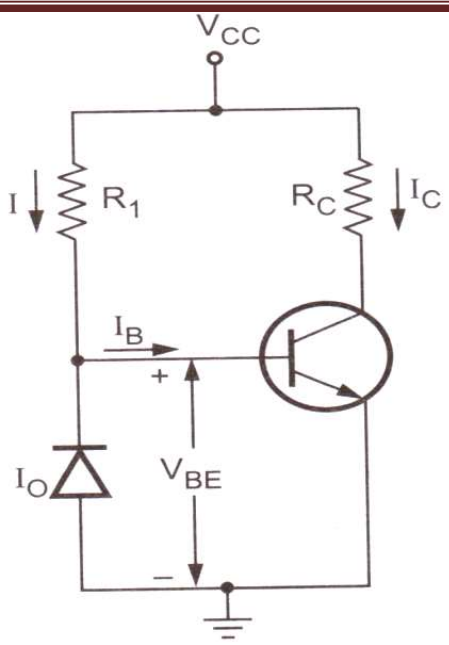
$$I_C = \beta I - \beta I_O + (1+\beta) I_{CBO}$$

$$I_C = \beta I - \beta I_O + \beta I_{CBO} \qquad \because \beta \gg 1$$

Now if $I_O = I_{CBO}$ we get,

$$I_C = \beta I$$

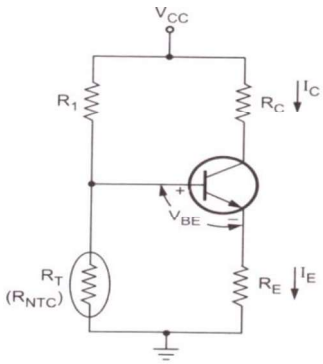
As I is constant, I_C remains constant.

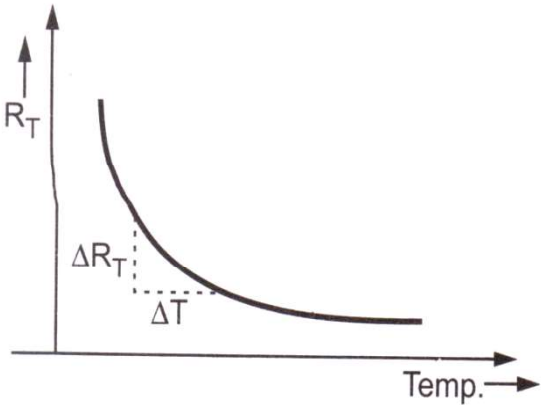


21. What is bias compensation using thermistor?

This method of transistor compensation uses temperature sensitive resistive elements, thermistors rather than diodes or transistors. It has a negative temperature coefficient, its resistance decreases exponentially with increasing temperature.

$$\text{Slope} = \frac{\partial R_T}{\partial T}$$





22. Why thermal runaway is not in FETs?

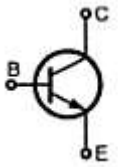
The FET has a positive temperature coefficient of resistivity. In FET, as temperature increases, its drain resistance also increases, reducing the drain current. Thus, unlike BJT ,thermal runaway does not occur with FET.

23. What are the types of transistors?

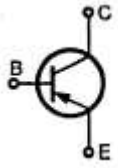
1. **Unipoalr junction transistor(UJT):** The current conduction is only due to one type of charge carriers, majority carriers.
2. **Bipolar junction transistor(BJT):** The current conduction is due to both the types of charge carriers, holes and electrons.

24. What are the types of BJT?

1. **PNP transistor:** A thin layer of N-type silicon material is sandwiched between two layers of P-type silicon.
2. **NPN transistor:** A layer of P-type material is sandwiched between two layers of N-type material.



(a) NPN transistor



(b) PNP transistor

25. Define thermal resistance.

The steady state temperature rise at the collector junction is proportional to the power dissipated at the junction.

$$\partial T = T_j - T_A = \theta P_D$$

Where, T_j=junction temperature in °C

T_A=Ambient temperature in °C

P_D= Power in watts dissipated at the collector junction

θ= Constant of proportionality thermal resistance

$$\theta = \frac{T_j - T_A}{P_D} °C/watt$$

26. What are the advantages of transistor?

1. It is used in amplifier and oscillator circuits, and as a switch in digital circuits.
2. It has wide applications in computers, satellites and other modern communication systems.

27. Calculate the value of feedback resistor(Rs) required to self bias an n-channel JFET with I_{DSS}=40mA, Vp=-10&VGSQ=-5V.

Solution:

$$I_{DQ} = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$= 40 \times 10^{-3}\left[1 - \frac{(-5)}{(-10)}\right]^2 = 10\text{mA}$$

$$V_{GSQ} = -I_{DQ}\, R_s$$

$$R_S = \frac{-V_{GSQ}}{I_{DQ}} = \frac{-(-5)}{10\text{mA}} = 500\Omega$$

REVIEW QUESTIONS

1. What is the need for biasing BJT? Explain the different types of biasing circuits?(16)
2. What is DC load line, how will you select the operation point, explain it using CE amplifier characteristics as an example(8)
3. Explain the voltage divider bias circuit for n-channel JFET give its DC analysis(8)
4. Prove that self bias is better bias compared to collector to base bias(8)
5. Design a fixed bias circuit to have operating point of (10v, 3mA). The circuit is supplied with 20V & uses a Si transistor of h_{fe}=250(8)
6. Locate the operating point of the circuit shown.h_{fe}=225 (6)