DEPARTMENT OF ELECTRNICS & COMMUNICATION ENGINEERING, KITSW

COURSE: **U14EI 205 - BASIC ELECTRONICS ENGINEERING**	**ECE-I, Semester-II, 2015-16**

ASSIGNMENT-6 HINTS &SOLUTIONS

1. Explain how DC load line is plotted for CE Amplifier.

(refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

2. What is the need of biasing in Transistor circuits?

[You are expected to cover: (i) what is Q-point (ii) write the expression for I_C and mention what parameters cause I_C to vary (iii) explain on thermal runaway (iv) requirements of biasing circuits and (v) List different biasing circuits]

(refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

8. Design a self bias circuit using a Ge transistor with Vcc=16V and Rc=1.5KΩ for obtaining of V_{CE}=8V and Ic=4mA. Assume S=12 & β=50. Ans:

[You are expected to (i) draw the self bias circuit (ii) mark the given data in the circuit (iii) In this design you need to calculate the values of resistive divider network resistors R_1, R_2 and R_E (iv) Thevinise the input side circuit and keep $V_{BB} = V_{CC}\left[\frac{R_2}{R_1+R_2}\right]$ and $R_B = \left[\frac{R_1 R_2}{R_1+R_2}\right]$ (v) write input loop equation (vi) write output loop equation (vii) solve equations to get R_1 and R_2]

(refer to class notes….).

9. For a given fixed bias circuit with R_B=100KΩ, R_C=22KΩ,V_{CE}=4V,find the stability factor.
Ans: S=33.258, I_C=3mA, I_B=93μA.

[You are expected to (i) draw the fixed circuit (ii) Derive the expression for S (iii) mark the given data in the circuit (iii) calculate the missing data required to calculate S as derived in (ii) calculate S]

(refer to class notes….)

10. Design a collector to base bias circuit for the specified conditions:
V_{CC}=15V, V_{CE}=5V, I_C=5mA, β=100. Ans:

[You are expected to (i) draw the collector-base bias circuit (ii) mark the given data in the circuit (iii) In this design you need to calculate the values of resistors R_C and R_B (iv) write input loop equation (v) write output loop equation (vii) solve equations to get R_C and R_B]

(refer to class notes….)

3. Define the stability factor S and derive a general expression for stability factor of a circuit in CE configuration and show that the stability factor for a fixed bias circuit is (1+ β).

The operating point (I_C, V_{CE}) of a transistor shifts as I_C changes with temperature

$$I_C = \beta I_B + I_{CEO} \quad \text{(or)}$$

$$I_C = \beta I_B + (1+\beta) I_{CBO} \quad \text{——— (1)}$$

Here I_{CBO} (simply I_{CO}), the reverse leakage current is temp dependent and doubles for every 10°C rise in temperature.

<u>Stability Factor (S)</u>: The rate of change of collector current w.r.to the collector leakage current (I_{CBO} or I_{CO}) is called stability factor (S).

$$S = \left.\frac{dI_C}{dI_{CO}}\right|_{\beta, I_B = \text{constant}} \quad \text{——— (2)}$$

→ Lower the value of S, better is the thermal stability of the transistor.

<u>Expression for stability factor:</u>

we have $I_C = \beta I_B + (1+\beta) I_{CO}$

differentiating w.r.to I_C, we get

$$1 = \beta \frac{dI_B}{dI_C} + (1+\beta) \frac{dI_{CO}}{dI_C}$$

$$1 = \beta \cdot \frac{dI_B}{dI_C} + (1+\beta)\left(\frac{1}{S}\right)$$

$$\frac{(1+\beta)}{S} = 1 - \beta \cdot \frac{dI_B}{dI_C}$$

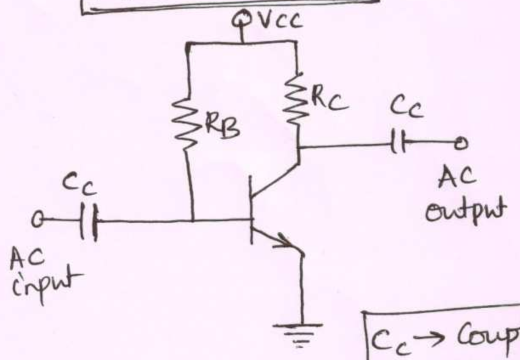
$$S\left(1 - \beta \frac{dI_B}{dI_C}\right) = (1+\beta)$$

(or)

$$\boxed{S = \frac{1+\beta}{1 - \beta \frac{dI_B}{dI_C}}}$$

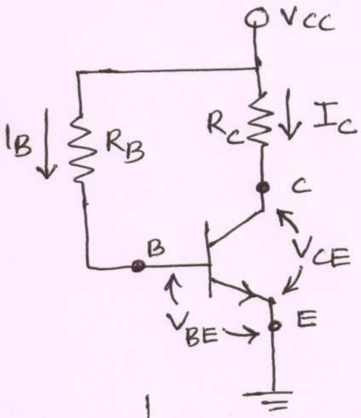
//

Fixed Bias circuit ✓



$C_C \rightarrow$ Coupling capacitors

DC equivalent circuit



KVL to input loop:

$$V_{CC} = I_B R_B + V_{BE}$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \quad \text{—— ①}$$

$$I_C = \beta I_B$$

KVL to output loop

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

$$V_{CE} = V_{CC} - I_C R_C \quad \text{—— ②}$$

$$S = \frac{1+\beta}{1-\beta\frac{dI_B}{dI_C}}$$

- Expression for I_B is to be obtained and then it is to be differentiated w.r.to I_C

∴ The Q-point of transistor in fixed bias is (I_C, V_{CE}) as given by ① and ②.

For Stability factor:

$$S = \frac{1+\beta}{1-\beta\frac{dI_B}{dI_C}}$$

differentiating ②, we get

$$\frac{dI_B}{dI_C} = 0$$

Hence $S = \frac{1+\beta}{1-\beta(0)}$

Stability factor of fixed bias circuit $\boxed{S = 1+\beta}$

Comment: $S = 1+\beta \Rightarrow \frac{dI_C}{dI_{CO}} = 1+\beta$

(or) $dI_C = (1+\beta)\, dI_{CO}$

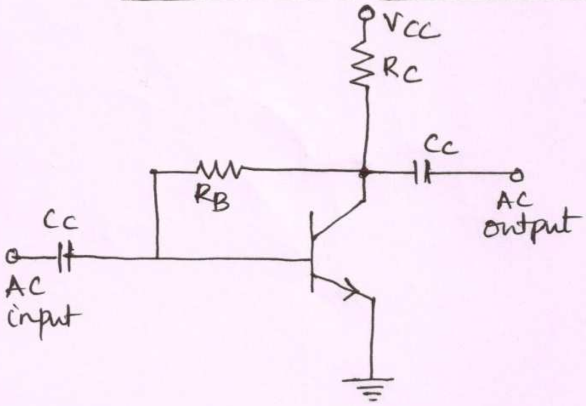
i.e, I_C changes $(1+\beta)$ times as much as I_{CO} changes.

Hence, the fixed bias circuit provides poor thermal stability.

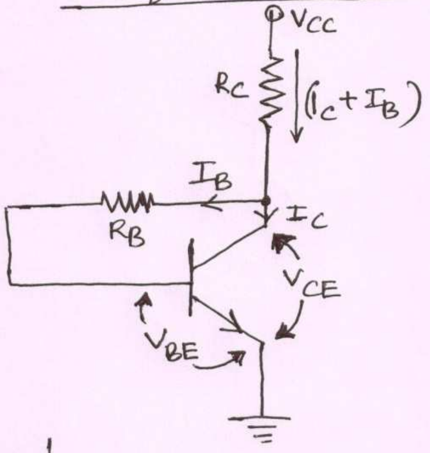
Hence prone to thermal runaway.

4. For a collector to base bias circuit, derive the expression for stability factor.

Stability factor of Collector-to-Base bias circuit:



DC equivalent circuit



KVL to input loop:

$$V_{CC} = R_C(I_B + I_C) + I_B R_B + V_{BE}$$

$$V_{CC} = I_B(R_B + R_C) + I_C R_C + V_{BE}$$

$$I_B(R_B + R_C) = V_{CC} - V_{BE} - I_C R_C$$

(or) $$I_B = \frac{V_{CC} - V_{BE} - I_C R_C}{R_B + R_C} \quad \text{--- (1)}$$

and $$I_C = \beta I_B \quad \text{--- (2)}$$

KVL to output loop:

$$V_{CC} = R_C(I_B + I_C) + V_{CE}$$

(or) $$V_{CE} = V_{CC} - R_C(I_B + I_C) \quad \text{--- (3)}$$

The operating point of Collector-to-Base bias circuit is given by (I_C, V_{CE}) as given by equations (2) and (3).

Stability factor $$S = \frac{1+\beta}{1 - \beta \frac{dI_B}{dI_C}}$$

∴ differentiating eqn (1) w.r.to I_C, we get

$$\frac{dI_B}{dI_C} = -\frac{R_C}{R_B + R_C}$$

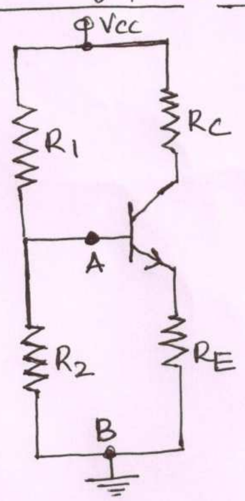
$$\therefore \boxed{S = \frac{1+\beta}{1 + \beta\left(\frac{R_C}{R_B + R_C}\right)}}$$

Comment:

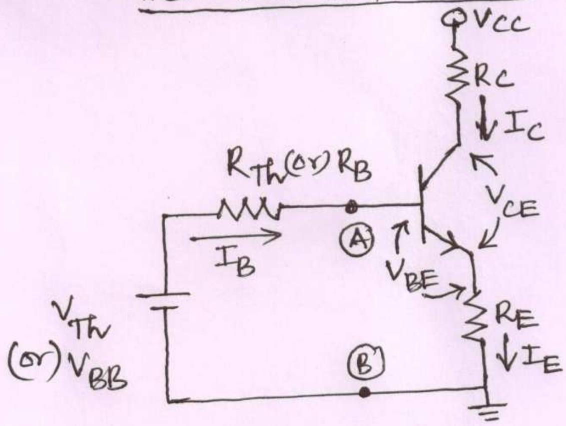
- ✓ If $R_B \ll \beta R_C$, $$S \approx \frac{1+\beta}{1+\beta\left(\frac{R_C}{R_C}\right)} \approx 1$$
- ✓ Provides better thermal stability by making $R_B \ll \beta R_C$
- ✓ Stability factor is very much less than that of fixed bias circuit //

5. Derive the expression for stability factor of a Self Bias circuit.

Stability factor of a self-bias circuit (or) Voltage Divider Bias



- The resistors R_1 and R_2 will divide the supply voltage and voltage across R_2 will forward bias the Emitter-Base junction.
- Applying Thevenin's theorem across points A & B, we can replace the circuit across points A & B with a single voltage source (V_{Th}) and single resistance (R_{Th}).
- The Thevenised circuit is shown below.



Here, $V_{BB} = V_{CC}\left(\frac{R_2}{R_1+R_2}\right)$

and $R_B = R_1 \| R_2 = \frac{R_1R_2}{R_1+R_2}$

KVL to input loop:

$$V_{BB} = I_BR_B + V_{BE} + I_ER_E$$

$$= I_BR_B + V_{BE} + (I_B+I_C)R_E$$

$$V_{BB} = I_B(R_B+R_E) + V_{BE} + I_CR_E$$

$$I_B(R_B+R_E) = V_{BB} - V_{BE} - I_CR_E$$

$$\text{(or)} \quad I_B = \frac{V_{BB} - V_{BE} - I_CR_E}{R_B+R_E} \quad \text{——} (1)$$

Also $I_C = \beta I_B$ —— (2)

KVL to output loop:

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

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E = V_{CC} - I_C R_C - (I_B + I_C) R_E$$

If I_B is not known, we can go for approximation $I_B << I_C$

$$\therefore V_{CE} \approx V_{CC} - I_C R_C - I_C R_E \text{ (or) } V_{CC} - I_C (R_C + R_E) \quad \text{—(3)}$$

The operating point of self-bias circuit is given by (I_C, V_{CE}) values as provided by eqns (2) and (3).

Stability factor of self-bias circuit

$$S = \frac{1+\beta}{1 - \beta \cdot \frac{dI_B}{dI_C}}$$

Differentiating eqn (1)

$$\frac{dI_B}{dI_C} = -\frac{R_E}{R_B + R_E}$$

$$\therefore \boxed{S = \frac{1+\beta}{1-\beta\left(\frac{-R_E}{R_B+R_E}\right)} = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_B+R_E}\right)}}$$

→ If we select $R_B << R_E$, then $S \approx 1$

→ This self bias ckt is also called "biasing circuit independent of β of transistor"

→ How it provides stable operating point

✓ If I_C ↑ due to ↑ in I_{CO},

- the $I_E R_E$ drop ↑
- as per (2), the I_B ↓
- as $I_C = \beta I_B$, the I_C ↓ and is maintained constant

Hence self bias circuit is the most widely used biasing circuit and the operating point remains where it was fixed //

6. With the help of circuit diagram, explain the operation of a BJT as a switch.

(refer to notes uploaded during class time….)

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