Chapter 4

DC Biassing BJT's

Using Superposition separate DC, AC

1. \( V_{BE} = 0.7V \) (4.1)
2. \( I_C = (1 + B)I_B \approx I_C \) For large B Values (4.2)
3. \( I_C = B I_B \) (4.3)

**Operating Point**

**Biasing** \( \rightarrow V_{DC} \rightarrow \) Fixed V, I levels

Gives operating point (quiescent point) \( Q \)

- \( I_{CMAX}, V_{CE MAX}, V_{CE SAT} \)
- Cutoff (\( I_B < 0mA \))
- Saturation (\( V_{CE} < V_{CE SAT} \))

Operate where gain is constant (Linear)
4.2 OPERATING POINT

Fig 4.11 OPERATING POINTS

A) NO BIAS - DEVICE OFF

B) INPUT SIGNAL VARIES OUTPUT (I, V) W/O SATURATION, CUT-OFF

C) OPERATION LIMITED (NONLINEARITIES CAN) OCCUR

D) CLOSE TO MAX OPERATING POWER/VOLTAGE LEVELS
Temperature effects

Leakage

Pce, Iceo change

PT + Iceo operating point Q changes

Linear Region

NPN

BE junction Fwd.-biased (P+), 0.6-0.7V

BC junction Rev.-biased (n-region+)

Cutoff Region

BE Rev

BC Rev

I_B ≤ 0 mA

Saturation

BE Fwd

BC Fwd

V_CE ≤ V_CE SAT

S → Stability Factor

Capacitor → Acts like open circuit for DC

\[ Z_C = \frac{1}{j\omega C} \quad \text{as } \omega \to 0, \quad Z_C \to \infty \]
**Fixed Bias**

\[ V_{i_{ac}} \]

\[ V_{cc} \]

\[ I_B \]

\[ V_C \]

\[ V_{CE} \]

\[ R_B \]

\[ R_C \]

\[ V_{BE} \]

\[ V_{CE} = V_{CC} - I_C R_C \]

\[ I_C = B I_B \]

\[ V_{CE} = V_C - V_E \]

\[ V_{BE} = V_B - V_E \]

\[ -V_{CC} + I_B R_B + V_{BE} = 0 \]

\[ I_B = \frac{V_{CC} - V_{BE}}{R_B} \]

\[ -V_{CC} + I_C R_C + V_{CE} = 0 \]

\[ I_C = B I_B \]

*RC determines |V_{CE}|*
Ex 4.1  Fixed BIAS

1. \( I_{BC} \), \( I_{CQ} \)
2. \( V_{CEQ} \)
3. \( V_B \), \( V_C \)
4. \( V_{BC} \)

5. \[ V_{CC} = +12V \]

\[ I_{BQ} = (12 - 0.7V) \]
\[ \frac{240k\Omega}{240k\Omega} = 47.08 \text{mA} \]

Since \( B = 50 \), \( I_C = B \cdot I_B = 50 \cdot (47.08 \text{mA}) = 2.35 \text{mA} \)

6. \[ V_{CC} = 12V \]

\[ V_{CEQ} = \frac{12 - V_{CEQ}}{2.2k\Omega} = I_{CQ} = 2.35 \text{mA} \]

\[ V_{CEQ} = 12V - I_{CQ}(2.2k\Omega) = 6.83V \]

7. \[ V_B - V_E = V_{BE}, V_E = 0 \]

\[ V_{BE} = 0.7V \]

\[ V_{CEQ} = V_C - V_{EQ} \]

\[ V_{CC} = \frac{R_C}{I_C} \]

\[ V_{CC} = I_C \cdot R_C + V_C \]

\[ V_C = \frac{V_{CC} - I_C \cdot R_C}{I_C} = 6.83V \]

8. \[ V_{BC} = V_B - V_C = 0.7V - 6.83V = -6.13V \]
SATURATION

Max Values Reached

\[ \frac{V_{CE}}{I_c} = R_c = 0 \Omega \]

\[ V_{CE} = 0V \]

\[ I_c = I_{C\text{ sat}} \]

\[ I_{C\text{ sat}} = \frac{V_{CC}}{R_c} \]

 load line analysis

How to Determine Q-point

\[ V_{CE} = V_{CC} - I_c R_c \]

straight line function
1. \( V_{CE} = V_{CC} \) \( I_C = 0 \) mA

2. \( I_C = \frac{V_{CC}}{R_C} \) \( V_{CE} = 0 \) V

3. DRAW STRAIGHT LINE

4. BY VARYING \( R_B \), \( I_B \) LEVEL CHANGES \( \therefore \)
   Q POINT MOVES UP OR DOWN LINE

5. CHANGING \( R_C \) MAKES SLOPE OF LINE
   MORE OR LESS NEGATIVE

6. HOLDING \( I_B \) CONSTANT - MOVES Q-POINT
   ALONG \( I_B = \frac{V_{CE}}{I_C} \) GRAPH.

7. VCC LARGER, SLOPE SAME BUT
   MOVES AWAY FROM \((V_{CE},I_C)\) ON GRAPH
Solving for resulting $I_B$ gives $Q_p$.

$V_{ce} = V_{CC} | I_C = 0$ mA

Load line

Figure 4.1

$V_{ce} \rightarrow V_{cc}$

Load line

$V_{ce} = V_{CC}$

$I_C = 0$

$Q$-point

$\frac{V_{ce}}{V_{CC}} = \frac{R_C}{V_{CC}}$
Figure 4.17 BJT BIAS CIRCUIT WITH EMITTER RESISTOR.

Figure 4.18 BASE-EMITTER LOOP.
EMITTER STABILIZED BIAS

1. \[ +V_{cc} -I_B R_B -V_{be} -I_E R_E = 0 \]
2. \[ I_E = (B+1)I_B \]
3. \[ V_{cc} -I_B R_B -V_{be} -(B+1)I_B R_E = 0 \]
4. \[ -I_B (R_B + (B+1)R_E) +V_{cc} -V_{be} = 0 \]

SOLVING

\[ I_B = \frac{V_{cc} -V_{be}}{R_B + (B+1)R_E} \]