\[ p = \frac{1}{q} \]

\[ x = \frac{1 + p}{q} \]

\[ q = \frac{1}{p} \]

\[ v_{cc} > 0 \quad v_{ee} < 0 \]

Circuit Configuration
Common Emitter
Common Base
Active Region (npn)

Active Region (npp)

Last Time

Lecture
\[ I_T = \frac{3.015}{1.5} = 2.01 \text{mA} \]
\[ V_T = 200 \times 1.5 \text{mA} = 300 \text{V} \]

\[ V_6 = \frac{220k}{15} = 14.7 \text{mA} \]

\[ V_{CE} = V_T - V_6 = 300 - 14.7 = 285.3 \text{V} \]

\[ I_C = \frac{V_T}{R_C} = \frac{300}{2k} = 150 \mu A \]

\[ I_C = \frac{V_T}{R_C} = \frac{300}{2k} = 150 \mu A \]

\[ V_{BB} = V_T - V_{BE} = 300 - 0.7 = 299.3 \text{V} \]

\[ I_E = \frac{V_T}{R_E} = \frac{300}{200k} = 1.5 \mu A \]

\[ I_E = \frac{V_T}{R_E} = \frac{300}{200k} = 1.5 \mu A \]

For active region:
\[ V_{CE} > 0, \quad V_{BE} > 0 \]
\[ V_{BB} > V_{BE} = V_{BC} > 0 \]

As long as:

DC Analysis
$$R_e = \frac{V_{cc} - V_{ce}}{I_e} = \frac{3.3 - 0.7}{0.7} = 4 - 0.7 = 3.3 \text{ V}$$

$$I_e = \frac{V_{ce}}{R_e} = \frac{3.3}{4} = 0.825 \text{ mA}$$

$$I_C = I_e (1 + \beta) = 3.3 \text{ mA}$$

$$I_B = \frac{V_{bb} - V_{be}}{R_B} = \frac{15}{200} = 0.075 \text{ A}$$

$$R_B = 200 \text{ kΩ}$$

$$V_{ee} = 4 \text{ V}$$

$$V_{ce} = 0 \text{ V}$$

$$V_{bb} = 4 - 0.7 = 3.3 \text{ V}$$

$$V_{ce} = 3.3 \text{ mA} \times 2 \times 0.7 = 4.5$$

**Note:** The circuit is not properly drawn. The expressions for $V_{ee}$, $V_{ce}$, and $V_{bb}$ are given, indicating that the circuit is powered, but the connections are not shown. The calculation for $I_B$ is based on a given $V_{bb}$ and $R_B$, but without a proper circuit diagram, it is unclear how these values are derived. The circuit diagram is missing, so it's not possible to accurately interpret the circuit's behavior.
Modes of Operation

Load Line

\[ I_C = \frac{V_C}{R_C} = \frac{1}{R_C} V_C \]

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

\[ V_B = V_{BB} - I_B R_B \]

Notice: We can choose "any" bias (R-point) on which the transistor is to operate.
\[ I_c = 10 - 0.2 = 9.8 \text{ mA} \]
\[ V_c = 0.2 = 10 - 0.2 = 9.8 \text{ V} \]

**Transition: Saturated**

**Case:**

\[ V_{cc} = 10 - I_c R_c = 10 - 13.28 \]

\[ I_c = \frac{V_{cc}}{R_c} = \frac{3.32}{13.28} \]

\[ A = 3.2 V \]

Assuming "Active Region"

\[ V_{gs} = \frac{20}{20} = 1 \]

\[ V_{gs} = \sqrt{V_{cc} - \frac{1}{2} V_{gs}} = 8 - 0.7 \]

\[ f = 100 \]

\[ f_{cc} = 10 \]

Non-linear region, reversed bias, cut-off region.

Saturation if (Regious) cut-off point

**Notes:** What happens if we change R?
\[ I_e = 12 \times \beta = 5.71 \text{ mA} \]

\[ V_{cc} = 6 \text{ V} \]

\[ I_c = 3.71 \times 6 = 22.26 \text{ mA} \]

\[ V_{bb} = 6 \text{ V} \]

\[ R_e = 0.6 \text{ kΩ} \]

\[ R_f = 0.1 \text{ kΩ} \]
\( V_{CE} = 6.32V \)

\[ I_{Q} = 75.1mA \]

\[ I_{C} = 5.63 \]

\[ V_{CE} \text{ (max)} = 12 \text{ V, } I_{C} = 11.3mA \]

\[ V_{CE} = \frac{10}{12 - 1} \sqrt{I_{C}} \]

\[ V_{CE} = \frac{V_{CE} - I_{C}R_{E}}{R_{E}} = \sqrt{V_{CE} - \frac{I_{C}R_{E}}{R_{E}}} \]

\[ \text{Low Line: } V_{CE} = V_{CC} - I_{C}R_{E} - I_{C}R_{E} = V_{CE} - (R_{E} + (\frac{1}{\beta + 1})R_{F})I_{C} \]