Transistor Circuits II

Common-Base, Basic AC operation
The Common-Base Amplifier
DC equivalent of input

- Diode represents emitter-base junction
  - $V_{EB}$ should be equivalent to forward biased diode
AC equivalent of input

- Internal resistance of source considered to be negligible
- Current flow in system would be labeled $i_e$ (all lower case to represent AC; upper case represents DC considerations)
- Reactance of capacitor considered negligible
- Dynamic emitter resistance of forward-biased emitter-base junction labeled $r_e'$

\[ i_e = \frac{v_s}{r_e'} = \frac{v_{eb}}{25\Omega} \]

\[ h_{fb} = \frac{i_c}{i_e} \]
What an amplifier does...

- \( A_v = \frac{v_o}{v_{in}} \)
AC considerations – CB Amplifier

- $v_s = v_{eb} = r_e' i_e$
- $v_o = v_{cb} = r_L i_c$
- $A_v = \frac{v_o}{v_{in}}$
- $A_v = \frac{v_{cb}}{v_{eb}}$
- $A_v \approx \frac{r_L i_c}{r_e' i_e} = \frac{r_L}{r_e'}$
- (presumes $h_{FB} = h_{fb} = 1$)
- $r_L = R_C$
Simplification of previous concept
Characteristic curves and Load lines
Simplified version

• Values of $I_C$ dependent on input current $I_E$
Ideal Characteristics

- Curves drawn as perfectly straight lines
  - Presumes $\alpha = 1$
Load line applied to Characteristic curves

![Graph showing Load Line and operating point]
For DC the voltage law dictates:

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

so the equation for the current becomes

$$I_C = \frac{V_{CC} - V_{CB}}{R_C}$$

This is the load line equation.

Operating point
The operating point is placed at the midpoint by the choice of bias resistors.

$V_{CB} = 9 \text{ volts}$

$I_C = 4.5 \text{ mA}$
A steeper load line gives higher current gain. It requires a smaller $R_C$.

A flatter load line gives a higher voltage gain. It requires a larger $R_C$.

Normally the operating point will be chosen along the vertical line where the collector voltage is half the collector supply voltage. This gives maximum output swing without clipping.
The two main formulas:

\[ I_{C(sat)} = \frac{V_{CC}}{R_C} \]

\[ V_{CB(cutoff)} = V_{CC} \]
Circuit example

- In the following circuit, $-V_{EE} = -9\, \text{V}$, $V_{CC} = 12\, \text{V}$, $R_E = 8.2\, \text{k}\Omega$, and $R_C = 6\, \text{k}\Omega$. The transistor’s $V_{EB} = 0.8\, \text{V}$, and $h_{FB} \approx 1$. (a) Find $I_E$, $I_C$, $I_{C(sat)}$ and $V_{CB(\text{cutoff})}$. (b) Sketch the load line and place the letter $Q$ at the point where the projection for current $I_C$ crosses the load line. (c) Graphically estimate the value of $V_{CB}$ below point $Q$ and compare it with $V_{CB}$ found in the equation $V_{CB} = V_{CC} - I_CR_C$. 
Example drawing
Part (a) solution

\[ I_E = \frac{V_{EE} - V_{EB}}{R_E} = \frac{9V - 0.8V}{8.2k\Omega} = \frac{8.2V}{8.2k\Omega} = 1mA; \]

\[ I_E = I_C = 1mA; \quad I_C(sat) = \frac{V_{CC}}{R_C} = \frac{12V}{6k\Omega} = 2mA; \]

\[ V_{CB(cutoff)} = V_{CC} = 12V \]
Part (b) solution
Part (c) solution

- \( V_{CB} = V_{CC} - I_C R_C = 12\text{V} - (1\text{mA})(6\text{k}\Omega) = 12\text{V} - 6\text{V} = 6\text{V} \)
Any questions?

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