Crude Bias Synthesis Writeup

- The power-supply voltage, the gain, the collector-bias voltage, and the collector-bias current determine the emitter resistance. Show that

\[ R_e = \frac{V_{cc} - V_c}{|g|I_C}, \]

where \( V_{cc} \) is the power-supply voltage, \( V_c \) is the collector-bias voltage, \( I_c \) is the collector-bias current, and \(|g|\) is the absolute value of the gain.

For the purpose of crude analysis, the gain is approximately \( \frac{R_C}{R_E} \). Thus, we have the following equations.

\[ |g| = \frac{R_C}{R_E} \quad (1) \]
\[ V_C = V_{cc} - I_C(R_C) \quad (2) \]

With algebraic manipulation,\( q \)

\[ V_{cc} - V_C = I_C(R_C) \quad (3) \]
\[ \frac{V_{cc} - V_C}{I_C} = R_C \quad (4) \]
\[ \frac{R_E(V_{cc} - V_C)}{I_C} = R_C(R_E) \quad (5) \]
\[ \frac{R_E(V_{cc} - V_C)}{R_C(I_C)} = R_E \quad (6) \]
\[ \frac{V_{cc} - V_C}{I_C|g|} = R_E \quad (7) \]

- The power-supply voltage, the gain, and the swing specification constrain possible values of the collector-bias voltage. Show that

\[ \frac{V_{cc} + (|g| + 1)\Delta v_c + V_{so}|g|}{|g| + 1} < V_C < V_{cc} - \Delta v_c, \]

where \( \Delta v_c \) is the required swing (up or down), and \( V_{so} \approx 0.2 \) Volts is the minimum voltage from the collector to the emitter that allows amplification.

We know that when the collector voltage \( V_C \) increases by \( \Delta v_c \), it has to be less than \( V_{cc} \). So \( V_c + \Delta v_c < V_{cc} \) and the first inequality follows.

On the other hand, when the collector voltage \( V_C \) decreases by \( \Delta v_c \), there is a corresponding increase in the emitter voltage. \( v_E = V_E + \frac{1}{|g|}\Delta v_c \), where \( V_E = I_C * R_E = \frac{V_{cc} - V_c}{R_C}R_E \)

Putting it together,

\[ V_C - \Delta v_c \geq \frac{V_{cc} - V_C}{R_C}R_E + \frac{1}{|g|}\Delta v_c + V_{so} \quad (8) \]
\[ V_C - \Delta v_c \geq \frac{V_{cc} - V_C}{|g|} - \frac{1}{|g|}\Delta v_c + V_{so} \quad (9) \]
\[ V_C(|g| + 1) \geq V_{cc} + \Delta v_c(|g| + 1) + gV_{so} \quad (10) \]
\[ V_C \geq \frac{V_{cc} + \Delta v_c(|g| + 1) + |g|V_{so}}{|g| + 1} \quad (11) \]