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

  $$R_{\mathrm{E}} = \frac{V_{\mathrm{CC}} - V_{\mathrm{C}}}{|g| I_{\mathrm{C}}},$$

  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.

  $$|g| = \frac{R_C}{R_E} \tag{1}$$
  $$V_C = V_{cc} - I_C(R_C) \tag{2}$$

  With algebraic manipulation,q

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

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

  $$\frac{V_{\mathrm{CC}} + (|g|+1)\Delta v_{\mathrm{C}} + V_{\mathrm{SO}}|g|}{|g|+1} < V_{\mathrm{C}} < V_{\mathrm{CC}} - \Delta v_{\mathrm{C}},$$

  where Δv_{C} is the required swing (up or down), and $V_{\mathrm{SO}} \approx 0.2$ 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 Δv_c, it has to be less than V_{cc}. So $V_{\mathrm{C}} + \Delta v_{\mathrm{C}} < V_{\mathrm{CC}}$ and the first inequality follows.

  On the other hand, when the collector voltage V_C decreases by Δv_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,

  $$V_C - \Delta v_c \geq \frac{V_{cc} - V_C}{R_C} R_E + \frac{1}{|g|}\Delta v_c + V_{SO} \tag{8}$$
  $$V_C - \Delta v_c \geq \frac{V_{cc}}{|g|} - \frac{V_C}{|g|} + \frac{1}{|g|}\Delta v_c + V_{SO} \tag{9}$$
  $$V_C(|g|+1) \geq V_{cc} + \Delta v_c(|g|+1) + gV_{SO} \tag{10}$$
  $$V_C \geq \frac{V_{cc} + \Delta v_c(|g|+1) + |g|V_{SO}}{|g|+1} \tag{11}$$