Common-Base Example

This solution is done with MathCad. It is available in a student version. There is a link on the class web page to a site where a trial version can be obtained for free. It is good only for 30 days. But the site has a "fix" which will make it work longer. The catch is that you cannot move equations around the work sheet by dragging them. However, they can be cut and pasted to move them. If anyone finds an error in the solutions here, please let me know.

$R_p(x,y) := \left(\frac{1}{x}+\frac{1}{y}\right)^{-1}$ Function for calculating parallel resistors.

The circuit for the example is the same as the one analyzed in class. It is given that:

$R_1 := 100000$ $R_2 := 120000$ $R_c := 2400$ $R_E := 2000$ $R_s := 50$ $R_L := 10000$

$V_{plus} := 20$ $V_{minus} := 0$ $V_{BE} := 0.65$ $V_T := 0.025$ $\beta := 99$ $\alpha := 0.99$

$r_x := 20$ $r_0 := 50000$ $v_s := 1$ With $v_s := 1$, v_o is equal to the voltage gain.

DC Bias Solution

$V_{BB} := \frac{V_{plus} \cdot R_2 + V_{minus} \cdot R_1}{R_1 + R_2}$ $R_{BB} := R_p(R_1, R_2)$ $V_{BB} = 10.909$ $R_{BB} = 5.455 \cdot 10^4$

$I_E := \frac{V_{BB} - V_{BE} - V_{minus}}{\frac{R_{BB}}{1+\beta} + R_E}$ $I_E = 4.03 \cdot 10^{-3}$ $r_e := \frac{V_T}{I_E}$ $r_e = 6.203$

$v_{te} := v_s \cdot \frac{R_E}{R_s + R_E}$ $R_{te} := R_p(R_s, R_E)$ $v_{te} = 0.976$ $R_{te} = 48.78$

$r_{ie} := \frac{r_x}{1+\beta} + r_e$ $r_{ie} = 6.403$ $r_{ic} := \frac{r_0 + R_p(r_{ie}, R_{te})}{1 - \frac{\alpha \cdot R_{te}}{r_{ie} + R_{te}}}$ $r_{ic} = 4.005 \cdot 10^5$

The following is the approximate solution where the current through r_0 is neglected in solving for the Norton collector current and the exact resistance looking into the emitter. The subscript p is used to indicate a prime, i.e. $i_{ep} = i_e$'.

$i_{ep} := \frac{-v_{te}}{r_{ie} + R_{te}}$ $i_{ep} = -0.018$ $i_{cp} := \alpha \cdot i_{ep}$ $i_{cp} = -0.018$

$v_c := -i_{cp} \cdot R_p(R_c, R_p(r_{ic}, R_L))$ $v_c = 33.713$ This is the voltage gain.

$r_{in} := R_P(r_{ie}, R_E) \qquad r_{in} = 6.382$

$r_{out} := R_P(R_c, r_{ic}) \qquad r_{out} = 2.386 \cdot 10^3$

The following is the "full-blown" solution.

$$i_{cp} := \frac{-v_{te}}{R_{te} + R_P(r_{ie}, r_0)} \cdot \frac{\alpha \cdot r_0 + r_{ie}}{r_0 + r_{ie}} \qquad i_{cp} = -0.018$$

$v_c := -i_{cp} \cdot R_P(R_c, R_P(r_{ic}, R_L)) \qquad v_c = 33.714$

This is the voltage gain. Note that this is very close to the gain calculated by the approximate method above.

The output resistance is the same as above.

The exact resistance looking into the emitter is

$R_{tc} := R_P(R_c, R_L) \qquad R_{tc} = 1.935 \cdot 10^3$

$$r := \left[\frac{1}{r_{ie}} + \frac{1}{r_0 + R_{tc}} \cdot \left(1 - \frac{\alpha \cdot R_{tc}}{r_{ie}}\right)\right]^{-1} \qquad r = 6.647$$

Note that this is very close to r_{ie} above.

$r_{in} := R_P(r, R_E) \qquad r_{in} = 6.625$