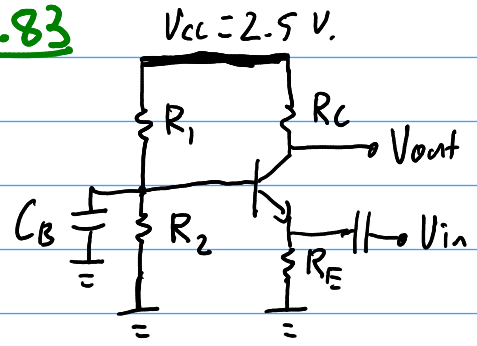
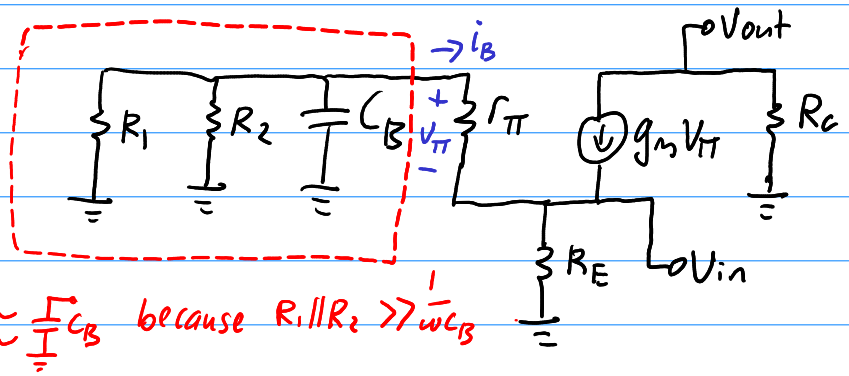
5.83



Design a common base stage for voltage gain of 20, $R_{in} = 50\ \Omega$.
$V(R_E) = 260$ mV.
$I(R_1) = 10\, I_B$
$f_{min} = 200$ Hz.

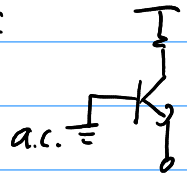
Small signal model:



$\simeq$ C_B because $R_1 \| R_2 \gg \frac{1}{\omega C_B}$

$r_\pi = \frac{\beta}{g_m}$
$g_m = \frac{I_C}{V_T}$.

Since C_B will have a low impedance to AC, we can use the rule:



$R_{in} \simeq \frac{1}{g_m}$.

Also $R_E \gg \frac{1}{g_m}$
$\therefore R_E \| \frac{1}{g_m} \simeq \frac{1}{g_m}$.

$\therefore R_{in} = 50 = \frac{1}{g_m}$ $\therefore g_m = \frac{1}{50}$ S.
$\therefore I_C = g_m V_T = \frac{1}{50} \times 0.026 = 520\ \mu A$.
Since we want $V(R_E) \simeq 0.26$, $R_E \simeq \frac{0.26}{I_C} = 500\ \Omega$.
From the small signal model, V_π is a voltage divider:

$$V_\pi = \frac{-V_{in} r_\pi}{r_\pi + z_B} = \frac{-V_{in} \frac{\beta}{g_m}}{\frac{\beta}{g_m} + z_B} = \frac{-V_{in} \frac{1}{g_m}}{\frac{1}{g_m} + \frac{z_B}{\beta}}$$

$$\therefore V_{out} = -g_m V_\pi R_C = \frac{+V_{in} R_C}{\frac{1}{g_m} + \frac{z_B}{\beta}}$$

$\therefore$ Gain is $\frac{V_{out}}{V_{in}} = \frac{R_C}{\frac{1}{g_m} + \frac{Z_B}{\beta}} \approx g_m R_C$

where we choose $\left|\frac{Z_B}{\beta}\right| \ll \frac{1}{g_m}$.

Since the required gain is 20:

$20 = g_m R_C = \frac{1}{50} \cdot R_C \Rightarrow R_C = 1\ k\Omega.$

Next choose C_B. $\left|\frac{Z_B}{\beta}\right| = \frac{1}{10} \cdot \frac{1}{g_m}$.

Using $f = 200$ Hz: $\frac{1}{2\pi \times 200\, C_B \times 100} = \frac{1}{10} \cdot 50$

$C_B = 1.59\ \mu F.$

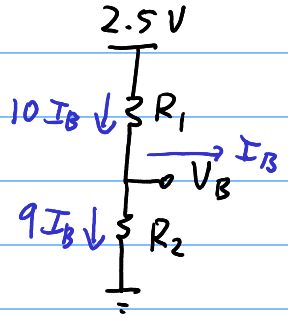
Now design the biasing. $V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right)$

$= 0.7147\ V.$

$\therefore V_B = V_{BE} + V(R_E) = 0.7147 + 0.26 = 0.9749\ V.$

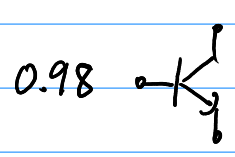
$I(R_1) = 10\, I_B = 10 \cdot \frac{I_C}{\beta} = 52\ \mu A.$

$\therefore R_1 = \frac{2.5 - 0.9747}{52 \times 10^{-6}} = 29.3\ k\Omega.$



Also $R_2 = \frac{V_B}{9 I_B} = \frac{0.9747}{9 \times I_C/\beta} = 20.8\ k\Omega.$

Check for active region. $V_C = 2.5 - I_C R_C = 1.98\ V.$



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