"MONSTERRIFIC" Problem # 1

\[ h_{fe} = 100 \text{ each for the Darlington Pair, } 200 \text{ for the remaining 3.} \]

Find: \( Z_{in} \) of system, \( A_v \) of system.

To find \( Z_{in} \) and \( A_v \), we need to find the \( Z_{in(base)} \) and \( r_e' \) of each stage. This requires us to find \( I_E \). Let's get this stuff out of the way first for later use.

\[ I_{E_1} = \frac{40V - 1.4V}{47K} = 0.821mA \quad r_{e_1}' = 2 \cdot \frac{26mV}{0.821mA} = 63.3 \Omega \]

\[ I_{E_2} = \frac{10V - 7V}{4K} = 2.27mA \quad r_{e_2}' = \frac{26mV}{2.27mA} = 11.5 \Omega \]

\[ I_{E_3} = \frac{40V - (26.4V + 7V)}{2K} = 6.35mA \quad (\text{note } V_{C_2} = V_{B_3} - 26.4V) \]

\[ r_{e_3}' = \frac{26mV}{6.35mA} = 4.10 \Omega \]

\[ I_{E_4} = \frac{15.88V - 7V}{505 \Omega} = 30.1mA \quad (\text{note } V_{C_3} = V_{B_4} = 15.88V) \]

\[ r_{e_4}' = \frac{26mV}{30.1mA} = 0.864 \Omega \]

\[ Z_{in(base)_4} = 200(52r + 764) = 11K173 \Omega \]

\[ Z_{in(base)_3} = 200(30 \Omega + 4.10) = 6K82 \Omega \]

\[ Z_{in(base)_2} = 200(100 + 11.5) = 22K3 \Omega \]

\[ Z_{in(base)_1} = 100 \cdot 100 \left( \frac{63.3 + 47K}{10K} || 30K || 22K3 \right) = 50M73 \Omega \]
CONTINUED.

Note that \( R_E \) is in parallel with the biasing resistors and \( z_{in(b)} \) of stage 2. This is \( R_E \).

\( Z_{in} \) of system.

This is equal to \( Z_{in 1} \)

\[
Z_{in 1} = z_{bias} // z_{in(b)} = 1.1M \Omega // 50M \Omega = 981k \Omega
\]

Note: ignoring \( r_c \) of Darlington pair.

\( A_N \) of system

There are 5 gains to be considered, first of which is the input loading.

\[
A_L = \frac{Z_{in}}{Z_{in} + R_s} = \frac{981k}{50k + 981k} = 0.952
\]

Note: 50kΩ is quite high for a typical generator impedance, however, this could easily represent the internal impedance of a high Z microphone. Note how the Darlington follower minimizes loss.

\[
A_{N_1} = \frac{r_E}{r_E + r_E} = \frac{4.7k // 10k // 30k // 22k}{63.3 \Omega + 4.7k // 10k // 30k // 22k} = 0.988
\]

\[
A_{N_2} = \frac{r_c}{r_c + r_c} = \frac{6k // z_{in(b)} // 3}{11.5 + 100} = \frac{3k19}{111.5} = 28.6
\]

\[
A_{N_3} = \frac{r_c}{r_c + r_c} = \frac{2k5 // z_{in(b)} // 4}{30 + 4.1} = \frac{798.2}{34.1 \Omega} = 23.4
\]

\[
A_{N_4} = \frac{r_c}{r_c + r_c} = \frac{200 // r_L}{1864 // 5} = \frac{66.7}{5.864} = 11.4
\]

\[
A_{N_5} = A_L \cdot A_{N_1} \cdot A_{N_2} \cdot A_{N_3} \cdot A_{N_4} = 0.952 \cdot 0.988 \cdot 28.6 \cdot 23.4 \cdot 11.4 = 7176
\]